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EXPERT SOLUTIONS

Establishing Leaching Environmental Impact Assessment Framework Tools in the Development of a WA Framework for By-product Re-use and Classification

MRIWA PROJECT M451

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FINAL REPORT

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PREPARED FOR

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EXECUTIVE SUMMARY

The rapid development and urbanisation of the Swan Coastal Plain in Western Australia (WA), the shortage of basic raw materials for construction and landfill and the poor quality of sandy soils are issues of significant environmental, economic and social importance to the State Government. The use of by-products to address these issues provides potential benefits including reducing environmental degradation and assisting the sustainability of many land uses. It also addresses the issue of the limited number of sites that are available for landfill.

In Western Australia, the large volumes of by-products from mineral processing and related industries and from the Water Corporation have potential to be valuable commodities. Many of these by-products are currently stockpiled, taking up significant land volume.

Use of these by-products therefore has potential to provide both economic benefit and reduced environmental impact for industry, agriculture and the wider community. However, there is currently no formal or rigorous assessment process for by-products within the WA regulatory framework to give both regulators and the industry confidence around commercialising and re-using these materials.

As a first step toward developing such a framework for WA, it was proposed that rigorous assessment and validation be performed on existing tools that have been used overseas for the assessment of by-products following the European Union (EU) and US EPA adopted methodologies known as LEAF (Leaching Environmental Assessment Framework). As industry and regulators' confidence in the applicability of the methodology grows, a regulatory framework similar to that in the EU could be developed for WA.

This project aimed to:

- Assess and validate the LEAF tests and modeling tools (LeachXS) for their application to determine any long-term environmental impact of using by-products under WA conditions with a focus on the Swan Coastal Plain region; and
- Develop local capability in WA, currently not available elsewhere in Australia, to provide a complete testing, data interpretation and predictive modeling service to the EU and USA methods known as LEAF for use in assessing the suitability of by-products derived from Western Australian waste-derived materials and recycle materials.

The project delivered the following:

- Validation of LEAF methods 1313, 1314 and 1316 performed successfully by obtaining excellent comparisons via a detailed inter-laboratory trial with the Energy Research Centre of The Netherlands (ECN). ChemCentre is now accredited by the National Association of Testing Authorities (NATA) for the LEAF tests 1313, 1314, 1315 and 1316. As a result, Western Australian industry, researchers and government regulatory agencies now have local access to these assessments from a NATA accredited provider.
- Large laboratory column studies, field lysimeter trials and data mining were successfully performed using industry by-products on local soil types;

- Characterisation through the large column laboratory studies of the four WA soil types studied as controls (with no by-products);

- On-site training for predictive modeling and data analysis using the LeachXS modelling tool, and an industry informational workshop were completed with the training delivered by acknowledged global experts Dr Hans van der Sloot (The Netherlands) and Dr David Kosson (USA);

- Validation of the LEAF approach through successful comparison of LeachXS model predictions with experimental data;

- Establishment of an initial LeachXS database of Western Australian local soils and by-products suitable for the development of chemical speciation fingerprints to allow robust predictions of the potential environmental impact of proposed or potential by-product uses. ChemCentre capability will readily allow database expansion as other soil types and materials are tested in the future;

- Identification of some opportunities to expand the current LeachXS database as applied to Western Australian soils, for example additional thermodynamic data for key minerals not yet represented in the LeachXS database; and

- The LEAF tools can provide more certainty regarding the characteristics of by-products and the long-term environmental impact of their potential use for specific applications in WA. Some examples of this are provided (Sections 5.3, 5.4.1 and 5.5.1).

ACKNOWLEDGMENTS

The research team and authors of this report wish to acknowledge the following:

- The funding support for this project from Alcoa of Australia Limited (Alcoa), Iluka Resources Limited (Iluka), Aroona Alliance of the Water Corporation (Aroona) and the Mineral Research Institute of Western Australia (MRIWA);
- The in-kind support provided by Alcoa, Iluka, Aroona, the Department of Water and Environmental Regulation (DWER) and the Environmental Protection Authority (EPA) by providing staff to participate in the scientific advisory panel of this project;
- The expert technical input of Dr Hans van der Sloot and Professor David Kosson; and
- The significant In-kind contributions to this project from ChemCentre and MBS Environmental.

GLOSSARY

Term	Explanation
ASS	Acid sulfate soil, natural soils containing very pyrite (FeS_2) that are likely to oxidise when disturbed and exposed to air and water
CoPC	Constituent of Potential Concern
DAF	Dilution and Attenuation Factor
DWER	(WA) Department of Water and Environmental Regulation
DAFWA	(WA) Department of Food and Agriculture
DOC	Dissolved Organic Carbon
DoH	(WA) Department of Health
EC	Electrical conductivity
eluent	The term used in laboratory leaching column experiments as the solution used for leaching
eluate	The term used in laboratory leaching column experiments as the solution recovered from the leaching column
EQG	Environmental Quality Guideline
EQO	Environmental Quality Objective
HFO	Hydrous ferric oxides in the solid material. This parameter refers to amorphous hydrous oxide minerals containing iron, aluminium and manganese.
IC	Ion chromatography
ICP/AES	Inductively Coupled Plasma – Atomic Emission Spectrometry
ICP/MS	Inductively Coupled Plasma – Mass Spectrometry
IMG	Ironman Gypsum® (also known as Neutralised Used Acid), a residue produced from mineral sand mining
ITV	Investigative Trigger Value
Leach Number	Tall column leachate sampling event for a total of three sampling events (Leach Number 1, 2 and 3) discussed in Section 4.10.2.1
LEAF	Leaching Environmental Assessment Framework
LRTV	Low Risk Trigger Values
L/S	Liquid to solid ratio
Method 1313	A LEAF test method designed to measure the effect of eluent pH on solubility of component elements in the test material
Method 1314	A LEAF test method designed to measure the effect of L/S on solubility of component elements in the test material using an upward percolating column procedure
Method 1316	A LEAF test method designed to measure the effect of L/S on solubility of component elements in the test material using a controlled batch extraction procedure
SHA	Solid Humic Acid
TDS	Total Dissolved Solids

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The rapid development and urbanisation of the Swan Coastal Plain in Western Australia (WA), the existing shortage of basic raw materials for construction, landfill and the poor quality of sandy soils are issues of significant environmental, economic and social importance to the State Government. The use of by-products to address these issues provides potential benefits of reducing environmental degradation and assisting the sustainability of many land uses.

There are currently no specific regulatory frameworks or standards in Australia to enable the routine utilisation of industrial by-products in commercial infrastructure and development projects. In contrast, countries with high re-use rates of these materials such as USA, New Zealand and parts of Europe, have well established regulatory frameworks.

As a first step toward developing such a framework for WA, it is proposed that rigorous assessment and validation be performed on existing tools that have been used overseas for the assessment of by-products following the European Union (EU) and US EPA adopted methodologies known as LEAF (Leaching Environmental Assessment Framework). As industry and regulators' confidence in the applicability of the methodology grows, a regulatory framework similar to that in the EU could be developed for WA.

LEAF is a collection of laboratory leaching tests, data management tools and leaching assessment approaches developed to identify detailed characteristic leaching behaviours of a wide range of solid materials, including by-products. The results can then be applied and used to compare scenarios representing a range of plausible management options for the test materials. Assessing the applicability and accuracy of the predictive LEAF approach in WA requires evaluation through the use of pilot and full-scale field studies, so that the leaching predictions for a test material based on laboratory testing may be compared with the measured leachate concentrations for that material collected under field conditions.

With the earlier support and funding from Alcoa of Australia Limited (Alcoa), ChemCentre has successfully set up capability in WA to provide a testing service using LEAF to assess the suitability of by-products. These tests were considered to be generally applicable to industrial by-products.

Although the LEAF approach has been validated and applied in Europe, the soil and climatic conditions of the Swan Coastal Plain in WA are significantly different and therefore the LEAF approach needs to be validated for application on representative soil types of the Swan Coastal Plain.

ChemCentre, being a scientific government agency, together with the project sponsors Alcoa, Iluka, Aroona and MRIWA have taken the initiative through this project to validate the LEAF approach to address the by-product characterisation requirements for WA in the development of a WA framework for by-product re-use and classification. In its initiative ChemCentre has; (i) made a significant in-kind contribution ($150K over 2 years) to manage this project and develop local expertise that is currently not available in Australia; (ii) been leading significant progress in the field of leaching environmental impact assessment for industrial by-products in WA and in this Nation; and (iii) brought a diverse range of industry and the government regulatory agencies together to work towards a common achievable goal – maximising resource utilisation, minimising wastage through by-product use and reducing virgin material demand in an environmentally sound manner.

It is the ChemCentre's view that a rigorous validation regime on materials relevant for WA (both soils and by-products) will be required to satisfy the WA Government regulatory agencies and to move forward to developing a regulatory framework, building on existing experiences with test validation and test application in US EPA and in EU (CEN – European Standardisation Organisation).

This project addresses the needs of industry and the WA Government regulatory agencies to enable the beneficial re-use of by-products to; (i) encourage recycling, (ii) reduce landfill requirements an (iii) encourage sustainable industrial practices. The use of by-products would also address issues arising from (i) rapid development and urbanisation of the Swan Coastal Plain in Western Australia, (ii) the potential shortage of quality basic raw materials for construction and fill and (iii) the poor quality of sandy soils that have limited capacity to retain fertilisers and to attenuate the leaching of contaminants. In addition, the Swan Coastal Plain region is underlain by extensive groundwater resources that are extremely vulnerable to contamination from poor soil management practices. All this has significant environmental, economic and social importance to the community of WA.

This project aimed to assess and validate the LEAF tests and modeling tools for their application to determine the long-term environmental impact of using by-products derived from waste-derived materials and recycle materials originating in WA with a focus on the Swan Coastal Plain region. Field evaluation cases consisted of combinations of laboratory column testing and field analysis for materials supplied by the industry sponsors of this project and encompassed by-products from Alcoa, Iluka and the Aroona Alliance of the Water Corporation.

2 OBJECTIVES

The project aimed to address the requirements for the development of specific regulatory frameworks or standards in WA to enable the routine utilisation of industrial by-products in commercial infrastructure and development projects.

As a first step toward developing such a framework for WA, it was proposed that in this project rigorous assessment and validation be performed on existing tools that have been used overseas for the assessment of by-products following the EU and US EPA adopted methodologies known as LEAF (Leaching Environmental Assessment Framework).

The assessment and validation process in this project compared results from laboratory testing of each material using the LEAF tests, laboratory large column testing on field-like conditions, and long-term field leaching studies of the material. Field evaluation cases consisted of combinations of laboratory column testing and field analysis for materials supplied by the industry sponsors of this project and encompassed by-products from Alcoa, Iluka and from Aroona of the Water Corporation.

The major project objectives were to:

Assess and validate the LEAF tests and the potential application of modelling tools to determine the long-term environmental impact of using by-products under Western Australian (WA) conditions with a focus on the Swan Coastal Plain region. This encompassed comparison of laboratory testing data with field leachate data collected for the test materials; and

Develop local capability in Western Australia (WA), currently not available in Australia, to provide a complete testing, data interpretation and predictive modelling service to the EU and USA methods known as LEAF for use in assessing the suitability of by-products derived from WA by-product materials.

The project proceeded according to the following objectives:

1. Perform field studies on selected by-products to include; (i) leachate from field lysimeters, (ii) eluate from large leach column tests on field-like conditions and (iii) data mining of existing field data;
2. Perform the LEAF tests (methods 1313, 1314 and 1316) and sample characterisation on a wide range of by-products.
3. Perform the LEAF test method 1313 and sample characterisation on four soils representing approximately 80% of the soil types of the Swan Coastal Plain.
4. Perform inter-laboratory comparison trial with the Netherlands Energy Research Centre (ECN) by performing LEAF tests 1313 and 1314 (in duplicate each) on reference materials supplied by ECN;
5. Development of a LeachXS database for WA soils by characterising, performing LEAF 1313 test (in triplicate each) and LeachXS chemical speciation fingerprints of WA soils;

6. Organise and run on-site training on LeachXS modelling and data analysis together with an informational workshop delivered by experts Dr Hans van der Sloot (Netherlands) and Professor David Kosson (USA);
7. Perform data interpretation and modelling according to the LEAF methods on the sample by-products; and
8. Validate the LEAF tests and modelling tools for their suitability for WA applications and modify as required.

3 BACKGROUND

The Government of Western Australia (WA) recognises that the Perth and Peel regions have significant environmental values and that important environmental, social and economic benefit may be derived from implementing a high-level strategic plan that establishes a vision for future growth of these regions[1]. A strategic assessment[1] has been developed for the protection of matters of national environmental significance in these regions and it would provide a framework to guide the detailed planning and delivery of housing, infrastructure and services necessary to accommodate that growth.

The rapid development and urbanisation of the Swan Coastal Plain in WA would need to address (i) the potential shortage of quality basic raw materials for construction and landfill and (ii) the poor quality of sandy soils for agriculture typical of the Perth and Peel regions.

Many of the Swan Coastal Plain sandy soils have very low water holding capacity, are water repellent and also have limited nutrient retention capacity. Thus, nutrients such as nitrogen and phosphorus can leach into the river systems. Excess nutrients in rivers, estuaries and lakes can cause algal blooms, which reduce public amenity and can be toxic to humans and aquatic organisms. The use of soil amendments and conditioners to solve these problems has been intensively researched in WA. ChemCentre has participated in a number of studies over recent years[2-5] in collaboration with industry, in particular Alcoa and Water Corporation, as well as universities and governments departments. Projects involving the Department of Agriculture and Food WA and the Swan River Trust investigated the use of various bauxite residues and lime amended biosolids (LAB), primarily for the application in soil amendment[5]. The key focus of the research has been to demonstrate that these test materials can improve soil quality, i.e. phosphorus retention, cation exchange capacity, pH buffering capacity and soil structure.

Agriculture also suffers from very poor and acidic soils on the Swan Coastal Plain. The use of by-products as soil conditioners and for soil amendment present an opportunity to reduce the loss of contaminants from impoverished coastal soils and increase productivity through the provision of improved retention of water and nutrients and as alternative liming materials for addressing soil acidity.

Another significant issue in Western Australia is the large areas required for landfill sites as part for land development. Currently alternatives are sourced from existing fragile natural sources and/or substandard fill is used that has insufficient capacity to retain nutrients.

The Western Australian Waste Strategy[6] *Creating the Right Environment* (March 2012) identified that the State's performance in reducing waste volumes historically sent to landfill and increasing waste recovery rates is poor when compared against other mainland states. As identified in the Waste Strategy, in the period 2008–09 WA had the lowest rate for recovery and diversion from landfill of any mainland state, with only 32% of material being recovered and the remaining 68% sent to landfill. The Waste Strategy also identified that in 2008–09, WA had the highest rate of waste generation in the country at 2.6 tonnes per capita. With WA's rapidly growing population and economic growth, this is likely to further increase. The Waste Strategy set ambitious targets for the diversion of municipal waste, construction and demolition waste, and commercial and industrial waste from landfill by 2015 and 2020.

Existing shortage of basic raw materials for fill and for treatment of acidic soils (including acid sulfate soils), particularly sand and lime could possibly be substituted with by-products such as treatment process sediments and sludges from the Water Corporation.

Using by-products has the potential to reduce environmental degradation and assist the sustainability of many land uses. It also addresses the issue on the limited number of sites that are available for landfill. This will also provide economic benefit and reduced environmental impact for industry, agriculture and the wider community.

In Western Australia, the large volumes of by-products from mineral processing and related industries and from the Water Corporation have the potential to be valuable commodities[7]. Many of these by-products are currently stockpiled, taking up significant land volume. Currently, there is no formal or rigorous assessment process for by-products within the current WA regulatory framework to give both regulators and the industry confidence around commercialising and re-using these materials.

A regulatory review carried out in 2008[8] found that there were no specific regulatory frameworks or Standards in Australia to enable the routine utilisation of industrial by-products in commercial infrastructure and development projects. This contrasted with some overseas experience, where countries with high re-use rates for these materials, such as the USA, parts of Europe and New Zealand, have well-established regulatory frameworks.

In the EU and by the USEPA a parallel development of standardised methods for the analysis and assessment of materials has taken place. These methods have been validated by the USEPA and in parallel by CEN/TC 292 as standards for the analysis and characterisation of waste materials[9]. The methodology has also garnered support from the International Alumina Institute (IAI) as a method for assessing by-product materials from the refining of bauxite[7,10].

Some states in Australia have taken steps toward establishing a regulatory framework for the assessment of by-products. Examples include;

- NSW (EPA NSW), Guidelines on Resource Recovery Exemptions (Land Application) (April 2008), Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage 2010; and
- Queensland (Department of Environment and Heritage Protection), Waste Reduction and Recycling Regulation 2011, Waste Reduction and Recycling Act 2011 - Approval of a resource for beneficial use in 2012.

However, no such framework exists in Western Australia.

In July 2014, the Department of Environmental Regulation (DER) released a *Consultation Paper - Draft Guidance Statement: Regulating the use of waste-derived materials*[11] for public consultation in Western Australia. In this guidance document DER states “DER recognises that other jurisdictions both within Australia and overseas have mechanisms in place that support and encourage the use of waste-derived materials. It would serve the interest of more sustainable waste management in this state to encourage the use of such materials, where their use does not pose an unacceptable risk to human health and the environment”. ChemCentre submitted a response to this consultation paper and through Dr Silvia Black has been participating in DER workshops to help inform the development of material guidelines. Sponsors of this project also participated in the DER consultation process.

As a first step toward developing a framework for Western Australia, it is proposed that rigorous assessment and validation be performed on existing tools that have been used overseas for the assessment of by-products following the EU and USEPA adopted methodologies known as LEAF. As industry and regulators' confidence in the applicability of the methodology grows, a regulatory framework similar to that in the EU could follow.

LEAF is a collection of leaching tests, data management tools and leaching assessment approaches developed to identify detailed characteristic leaching behaviours of a wide range of solid materials, including by-products. The results can then be applied and used to compare scenarios representing a range of plausible management options for the test materials.

Presently, the Australian Standard Leaching Procedure (ASLP) is widely used in Western Australia and Australia. The ASLP method was based on the USEPA Toxicity Characteristic Leaching Procedure method 1311 (TCLP), a procedure designed to simulate leaching of industrial wastes under acidic conditions within a putrescible landfill. The main limitation of the ASLP test is that it only provides leaching data for only one pH value chosen out of three (pH 2.9, 5.0 or 9.2), and therefore may not provide information on the long-term leaching behaviour of the material. Other limitations of the current ASLP test are;

- It does not consider how the concentrations of constituents in leachate will vary as the liquid to solid ratio changes;
- It does not take into account the amphoteric nature of compounds such as those of As and Se;
- It does not account for the buffering capacity of materials; and
- It provides no information about the release rate of constituents from fill materials.

The Leaching Environmental Assessment Framework (LEAF) tests (Methods 1313, 1314, 1315 and 1316) enable a continuum-based approach to leaching by considering key factors that impact long-term leaching under in-situ conditions, such as; pH, liquid to solid ratio (L/S), rate of mass transport, kinetics and soil fabric effects. For instance, in comparison to the ASLP test, the pH dependence test (Method 1313) involves leaching at nine specified target pH values (pH 2.0, 4.0, 5.5, 7.0, 8.0, 9.0, 10.5,12.0 and 13.0), plus the sample natural pH and thus covering a wider pH range (2 to 13).

With support and funding from Alcoa, ChemCentre has successfully set up facilities in WA to provide a testing service using the EU and USA standard methods (LEAF) to assess the suitability of by-products.

Although the LEAF approach has been validated and applied in Europe, the soil and climatic conditions of the Swan Coastal Plain in WA are substantially different and therefore the LEAF approach needs to be validated for application on representative soil types of the Swan Coastal Plain in WA.

This project addresses the urgent needs of industry and the WA Government regulatory agencies to enable the beneficial re-use of by-products to; (i) encourage recycling, (ii) reduce landfill requirements and (iii) encourage sustainable industrial practices. The use of by-products would also address issues arising from (i) rapid development and urbanisation of the Swan Coastal Plain in Western Australia, (ii) the potential shortage of quality basic raw materials for construction and fill and (iii) the poor quality of sandy soils that have limited capacity to retain fertilisers and to attenuate the leaching of contaminants. In addition, the Swan Coastal Plain region is underlain by extensive groundwater resources that are extremely vulnerable to contamination from poor soil management practices. All this has significant environmental, economic and social importance to the community of Western Australia.

3.1 LEAF Test Methodology

LEAF laboratory methods are based on US EPA SW-846[11], Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, and include Test Methods 1313, 1314, 1315 and 1316. Each method is described below.

Test Method 1313 determines how liquid-solid partitioning varies with the pH of the leaching solution using a parallel batch extraction method. This test method applies a full range of pH conditions that by-product materials may be exposed to in the environment, thereby providing a high level of confidence in predicting the likely concentrations of constituents in leachates from these materials in various settings.

Test Method 1314 determines how liquid-solid partitioning (LSP) varies with varying liquid to solid ratios (L/S) using an up-flow percolation column procedure. This test method considers how the concentration of leachate will vary as the liquid to solid ratio changes.

Test Method 1315 determines mass transfer rates of chemical constituents in leachate from monolithic and compacted granular materials (e.g. construction materials) using a semi-dynamic tank leaching procedure.

Test Method 1316 determines how liquid-solid partitioning varies with L/S using a parallel batch extraction procedure.

3.1.1 Test Method 1313

The procedure is comprised of nine parallel batch extractions of particle-size reduced material over a pH range between 2 and 13 by the addition of pre-determined amounts of acid or base to achieve specified final pH values.

A known mass of solid material is placed in each of nine extraction vessels and mixed with deionised water at L/S of 10 mL/g. Nitric acid or potassium hydroxide is added to each vessel to obtain a specified final pH value based on a pre-test pH-dose rate titration curve. The nine vessels are tumbled in an end-over-end fashion for a time commensurate with the maximum particle-size. Eluate pH and electrical conductivity (EC) are recorded. Analytical samples are filtered and preserved for chemical analysis.

Constituent leachate concentrations (mg/L) or mass release (mg/kg) are usually plotted as a function of eluate pH. Constituent concentrations over the pH range typically show characteristic liquid-solid partitioning behaviour for cationic, amphoteric, oxyanionic and highly soluble species such as dissolved organic carbon (DOC).

The results of this test are used to:

- Provide maximum (available) solute release values (“Total Available Content”); and
- Provide equilibrium concentrations when environmental conditions control solution pH. Results may then be used for geochemical speciation modelling to identify likely solute release-controlling mineral phases.

3.1.2 Test Method 1314

Method 1314 is based on a percolation column test designed to obtain liquid-solid partitioning (LSP) information as a function of L/S). L/S is represented as the cumulative volume of leaching solution (in litres) passing through a column containing a known mass of material (in kilograms). For some materials, particle size reduction may be required to meet column dimension considerations and facilitate the approach to equilibrium.

Solid sample is loosely packed into a glass column and leached with a percolating eluent solution at low flowrate. Eluent is pumped in an up-flow direction to minimise preferred flow pathways and air entrapment. Eluates are collected at specific cumulative L/S values between 0.2 and 10 mL/g. Eluate concentrations and solute cumulative release masses are plotted as a function of L/S.

Method 1314 results provide an estimate of porewater concentrations at low L/S and demonstrate how LSP changes as solutes are released during successive pore volumes.

3.1.3 Test Method 1315

Method 1315 is used to determine mass-transfer based release rate information from either monolithic or compacted granular materials in a sequential tank test. Mass transport is the dominant solute release mechanism when water flows around a material with low hydraulic conductivity relative to surrounding materials. This test is suitable for determining the leaching behaviour in monolithic materials such as concrete and geopolymers.

As the test materials in this study do not possess the appropriate physical characteristics, the test method was not used for this assessment.

3.1.4 Test Method 1316

Method 1316 is designed to provide the LSP characteristics of inorganic constituents (such as heavy metals, metalloids and nutrients relevant to IMG and non-volatile organic constituents (e.g. polycyclic aromatic hydrocarbons, PAHs), analysed as dissolved organic carbon (DOC) at the natural pH of the solid material as a function of L/S under conditions that approach liquid/solid chemical equilibrium.

The eluate concentrations at a low L/S provide insight into pore solution composition either in a granular bed (e.g., soil column) or in the pore space of low-permeability material (e.g., solidified monolithic or compacted granular fill). In addition, analysis of eluates for DOC and of the solid phase for total organic carbon (TOC) allow for evaluation of the impact of organic carbon release and the influence of DOC on the LSP of inorganic constituents.

3.2 Utilisation of LEAF Tests Data and LeachXS Modelling Tools

When assessing the environmental risks associated with beneficial re-use of by-products for application to soil, WA regulators will consider predicted changes to water quality at a “point of compliance” (Figure 1). Depending on the setting, the point of compliance will vary, depending on site specific environmental values (discussed further in Section 3.3). The LEAF testing package (LEAF test data and LeachXS modelling tools) can be used to predict the composition of the “source term” (i.e. the concentrations of chemical constituents that are likely to occur in soil pore water) and does not directly indicate impacts on an environmental receptor which regulators may consider as either:

- Groundwater quality at the water table immediately beneath the soil profile where the amendment has been used;
- A compliance point comprising groundwater quality at the site boundary where the soil amendment has been used; or
- Concentrations in groundwater at a specific offsite receptor (e.g. water supply bore or wetland).

The DWER Contaminated Site Investigation guidelines[9] set out the steps for undertaking soil amendment risk assessment scenario. The first step in the procedure is to develop a conceptual site model (CSM) which is usually a simple geological cross section through the application area that identifies features such as:

- The thickness and characteristics of the unsaturated zone beneath the site;
- The position of the water table and groundwater flow direction;
- The characteristics of the aquifer; and
- The locations of key offsite receptors.

As stated earlier, LEAF test data and LeachXS modelling tools may be used to predict concentrations of leachate from the material of interest passing through the underlying vadose (unsaturated) zone of the soil at the point at which it reports to groundwater. If the predicted concentrations are below the corresponding adopted water quality guideline for each constituent, then little or no further assessment may be required. In practice, it is common for one or more constituent concentrations to exceed the adopted water quality guideline; as a consequence of either higher than ambient concentrations in the original soil, or mobilisation of constituents added to the soil through previous land use management by means of changed geochemical conditions (notably pH and redox).

However, such exceedances do not preclude acceptability of the material as there is potential for concentrations of the constituent(s) to decrease in groundwater by attenuation or dilution between the source and point of compliance. Hydrological transport modelling using programs such as MODFLOW, may be used to predict concentrations of these constituents at the point of compliance.

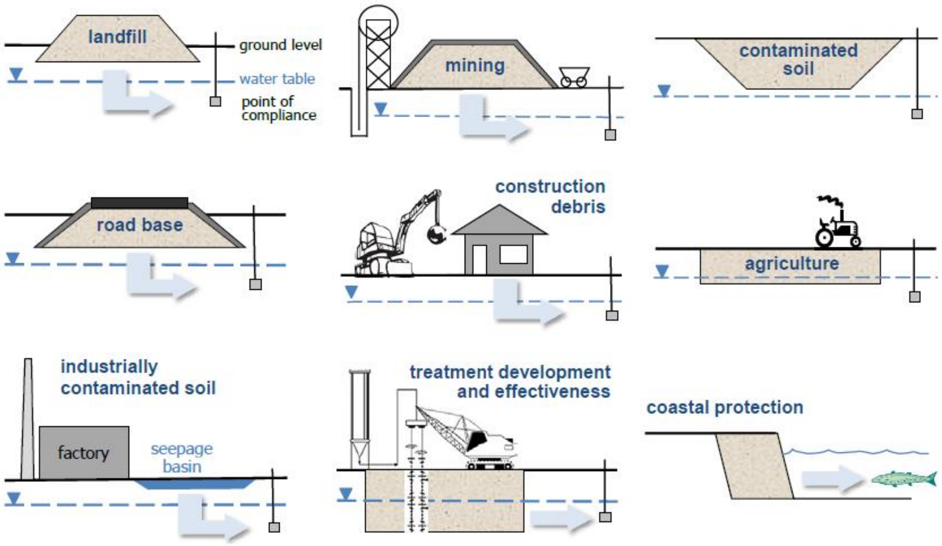


Figure 1: Various environmental assessment scenarios showing a source term for leaching with transport to the water table and subsequent transport via groundwater flow to a point of compliance. Adapted from van der Sloot, Kosson and Hjelmar (2003).

3.3 Water Quality Guidelines

The overarching management objective for the intended use of by-product materials on the Swan Coastal Plain is to protect the integrity of receiving environments in which the material is used. Components of the receiving environment requiring protection include the following:

- Groundwater resources; and
- Surface water, including rivers, creeks, lakes, estuaries and wetlands.

MBS Environmental and ChemCentre recommend an assessment framework based on, and consistent with the National Water Quality Management Strategy (NWQMS)[8], which adopts a tiered approach for environmental quality management. The tiered components of this framework comprise:

Identification of relevant Environmental Values to be protected, which may include:

  - Aquatic ecosystem health (especially for Ramsar wetlands with the Peel-Yalgorup region);
  - Groundwater dependent vegetation health and biodiversity;
  - Water supply for current and future mining projects;
  - Potential for future primary industry use;
  - Recreational and aesthetic values; and
  - Cultural and spiritual values.

Definition of Environmental Quality Objectives (EQO), which may include:

- Maintenance of ecosystem integrity;
- Aesthetic values protected;
- Suitability for drinking by livestock and/or native fauna (including birds);
- Suitable for desalination to produce potable water or untreated water for mining use; and
- Cultural/spiritual values protected or enhanced.

Desired level of protection:

- High: appropriate for sites that have little or no history of human impact, such as Unallocated Crown Land or proximity to areas of high conservation significance (Ramsar wetlands);
- Moderate: appropriate for sites that have had some impact from human activity such as agriculture, pastoralism and mining; and
- Low: appropriate for sites with a history of substantial human impacts, such as heavy industry, intensive agriculture or industrial ports.

Environmental Quality Criteria:

- Low Risk Trigger Values (LRTV), exceedance of which indicates a measured change to background water quality that may be caused by changes in land use practices; and
- Investigative Trigger Values (ITV), exceedance of which indicates a change to background water quality that may result in compromised EQO.

The Australian and New Zealand Guidelines for Fresh and Marine Waters, or ANZECC 2000 (updated in 2018),[8] recognise the inherent variability that exists in complex ecosystems and suggest development of site-specific guidelines for key contaminants and may need to consider local environmental characteristics when protecting ecosystem function and diversity.

Environmental quality guidelines (EQG) are usually minimum (or maximum in the case of pH parameters) threshold numerical values or narrative statements which, if complied with, indicate with a high degree of certainty that the associated EQO has been achieved. On the other hand, if the EQG has not been met, then there is uncertainty as to whether the associated EQO has been achieved and a more detailed assessment or management response is triggered. EQGs may be considered equivalent to the water quality guidelines (trigger values) presented in ANZECC and ARMCANZ (2000)[8] and other State and National guideline documents.

EQGs are generally relatively simple and easy to measure as indicators of environmental quality. Field and laboratory measurements of physicochemical parameters such as pH, total dissolved solids (TDS), major ions, petroleum hydrocarbons and dissolved metals and metalloids are generally used for surface and groundwater environments. Compliance indicates a low risk that the EQO are not being achieved. If an EQG is exceeded there is an increased risk that the associated EQO may not be met and this signals the need for a more comprehensive and evidence-based assessment against the EQOs.

EQGs relevant to the intended use of by-product materials on the Swan Coastal Plain need to be related to the protection of:

- Groundwater resources for:
    - Agricultural use including irrigation (short term and long term) and livestock stocking water;
    - Domestic non-potable use including washing, garden use and swimming pools;
    - Industrial use (e.g. process water, cooling water, dust suppression, vehicle washing);
    - Groundwater dependent ecosystems (aquatic and vegetation); and
    - Human drinking water (Gnangara and Jandakot Mounds).
- Surface water, including rivers, creeks, lakes, estuaries and wetlands.

The relevant published EQGs are collated in Table 1 and they are as follows:

- ANZECC and ARMANZ 2000[12] guidelines for protection of freshwater aquatic ecosystems (typically 95% protection of species, which is relevant to slightly to moderately disturbed ecosystems);
- Australian Drinking Water Guidelines (ADWG) (NH&MRC 2011);
- WA Department of Health guidelines for non-potable groundwater use (NPGU) (DoH 2014);
- ANZECC and ARMCANZ 2000 guidelines[12] for irrigation water use, both short term (less than 20 years) and long term (up to 100 years); and
- ANZECC and ARMCANZ 2000 guidelines[12] for livestock drinking water. Guidelines for beef cattle drinking water are used for comparison for Swan Coastal Plain assessments.

For the purpose of this report, the term “constituent of potential concern” (CoPC) is used to identify constituents present in by-products or naturally present in soil that have measured leachate concentrations exceeding one or more of these guideline values. Whether or not this leads to unacceptable contamination of the receiving environment is very much site specific, and therefore needs to consider the EQO’s for that site.

In general, the most appropriate EQO’s are likely to be as follows:

- Rural areas used for low level grazing, cropping or horticulture; long term irrigation guidelines (ANZECC and ARMCANZ 2000). This is directly relevant to materials used as soil amendments;
- Residential, commercial and industrial areas; DoH non-potable groundwater guidelines. This is mainly relevant to materials intended for use as fill (e.g. groundwater treatment residues); and
- Human drinking water catchment areas; human drinking water quality guidelines and, in some cases, ANZECC and ARMCANZ 2000 freshwater ecosystem protection guidelines (Jandakot and Gnangara mounds).

Table 1: Water Quality Criteria Relevant to Land Management Activities on the Swan Coastal Plain.

Analyte	**Fresh Water Aquatic Ecosystems**[a]	**Human Drinking Water**[b]	**Non-potable Groundwater Use**[c]	**Short-Term Irrigation**[d]	**Long-Term Irrigation**[e]	**Livestock Drinking Water**[f]
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Aluminium	0.055	-	0.2	20	5	5
Antimony	-	0.003	0.03	-	-	-
Arsenic	0.024 (0.013[g])	0.01	0.1	2	0.1	0.5
Barium	-	2	20	-	-	-
Beryllium	-	0.06	0.6	0.5	0.1	-
Boron	0.37	4	40		0.5	5
Cadmium	0.0002	0.002	0.02	0.05	0.01	0.01
Chromium[h]	-	-	-	1	0.1	1
Chromium (VI)	0.001	0.05	0.5	-	-	-
Cobalt	-	-	-	0.1	0.05	1
Copper	0.0014	2	20	5	0.2	1
Iron	0.3	-	0.3	10	0.2	-
Lead	0.0034	0.01	0.1	5	2	0.1
Lithium	-	-	-	2.5[i]	2.5[i]	-
Manganese	1.9	0.5	5	10	0.2	-
Mercury	0.00006[k]	0.001	0.01	0.002	0.002	0.002
Molybdenum	-	0.05	0.5	0.05	0.01	0.15
Nickel	0.011	0.02	0.2	2	0.2	1
Selenium	0.005[k]	0.01	0.1	0.05	0.02	0.02
Silver	0.00005	0.1	1	-	-	-
Uranium	-	0.017	0.17	0.1	0.01	-
Vanadium	-	-	-	0.5	0.1	0.2
Zinc	0.008	-	3	5	2	20

Analyte	**Fresh Water Aquatic Ecosystems**[a]	**Human Drinking Water**[b]	**Non-potable Groundwater Use**[c]	**Short-Term Irrigation**[d]	**Long-Term Irrigation**[e]	**Livestock Drinking Water**[f]
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Ammonia (NH_3-N)	0.9	-	0.5	-	-	-
Chloride	-	-	250	[j]	[j]	-
Fluoride	-	1.5	15	2	1	2
Nitrate (as NO_3)	-	50	500	-	-	-
Sulfate (as SO_4)	-	500	1000	-	-	1000

Notes:

[a] ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.

[b] NHMRC and ARMCANZ (2011) Australian Drinking Water Guidelines.

[c] DoH (2014) Contaminated Sites Ground and Surface Water Chemical Screening Guidelines.

[d] Short-term irrigation guidelines are considered appropriate for irrigation periods up to 20 years, refer to Table 4.2.10 of ANZECC and ARMCANZ (2000).

[e] Long-term irrigation values are applicable to the application of irrigation water for up to 100 years in a non-domestic setting.

[f] Livestock drinking water guidelines for metals and metalloids, ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality Table 4.3.2.

[g] Trigger values are provided for trivalent arsenic (As III, 0.024 mg/L) and pentavalent arsenic (As V, 0.013 mg/L). ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality.

[h] Short term and long-term irrigation values and livestock drinking water guidelines for chromium refer to total chromium (particulate, soluble trivalent and hexavalent form). ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality

[i] A lower value (0.075 mg/L) is recommended for lithium in irrigation water used for citrus crops.

[j] Refer to ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality for recommended values for chloride in irrigation water. Tolerance to elevated chloride concentrations in irrigation water varies with plant species and soil types.

[k] DER have set the freshwater quality criteria for (total) selenium and mercury at 0.005 mg/L and 0.00006 mg/L, respectively, which correspond to 99% protection of species according to ANZECC and ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality. Fresh water quality criteria for other metals and metalloids correspond to 95% protection of species.

3.4 Receiving Environment Characteristics

3.4.1 Surface Water

Major rivers that flow through the Swan Coastal Plain towards the coast include the Swan, Canning, Serpentine, Murray and Harvey rivers; most of which have their head waters to the east within the Darling Plateau. The Serpentine, Murray and Harvey Rivers discharge into the Peel-Harvey Estuary, which is the largest inland water body in south-western Australia (Brearley 2005 as cited in EPA 2008)[13].

The Swan Coastal Plain includes an extensive system of wetlands, covering over one quarter of the total land area[14]. Wetlands range from intermittent through to seasonally or permanently waterlogged soils or inundated land. Many of these are sustained largely by regional or localised groundwater tables. Others within the Peel-Yalgorup area are recognised internationally as Ramsar wetlands.

3.4.2 Groundwater

Groundwater within the Swan Coastal Plain originates mainly from direct rainfall recharge with a small component being derived from local runoff from the Darling and Dandaragan Plateaus to the east[15]. Several large groundwater aquifers within the Swan Coastal Plain discharge to the surrounds, which are hydraulically connected at a local scale[15]. These are the:

- Superficial aquifer;
- Rockingham aquifer;
- Kings Park aquifer;
- Mirrabooka aquifer;
- Leederville aquifer; and
- Yarragadee aquifer.

Water quality of receiving bodies on the Swan Coastal Plain, including wetlands and the Peel Harvey and Swan-Canning estuaries, is influenced by surrounding land uses, notably agriculture. Some of these important sites (including Ramsar wetlands)have suffered from periodic pollution events, algal blooms and fish kills resulting from several factors, including an excess of phosphorus from rural and urban land use practices entering from the catchments.

The Superficial aquifer is considered the most significant aquifer with respect to impacts from agricultural land uses, including turf farming. Typical groundwater quality beneath the Bassendean sands is characterised by moderately acidic to slightly alkaline pH values, low salinity and often elevated concentrations of DOC. Although chloride is usually the dominant anion, elevated sulfate concentrations are frequently observed and are attributed to oxidation of acid sulfate soil (ASS) materials exposed in the subsoil profiles by lowering of the water table.

3.4.3 Soil Types

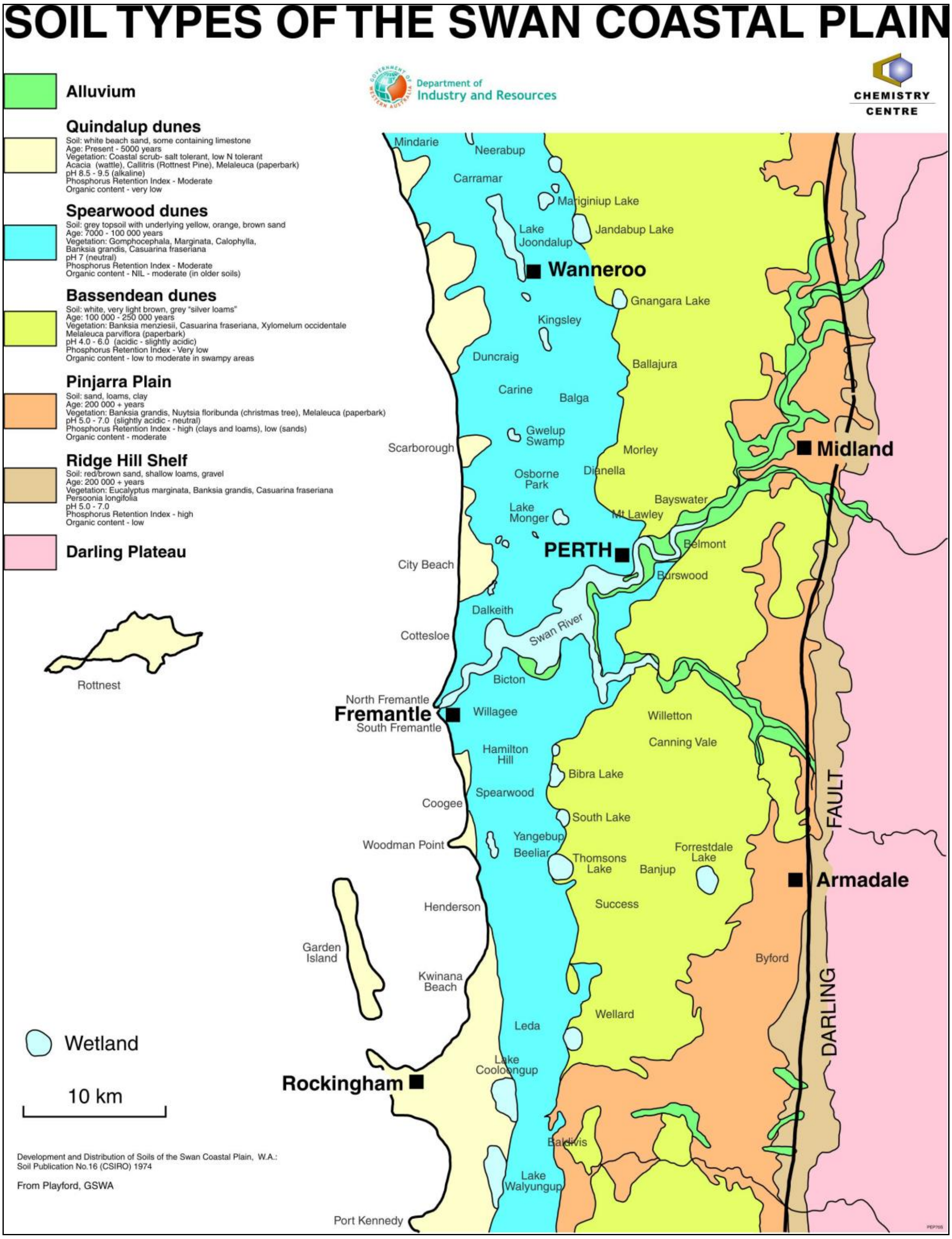
The Swan Coastal Plain consists of a series of distinct landforms[16], aligned roughly parallel with the coast (Figure 2). These relict dunal systems have formed as a series of shoreline deposits. Tamala Limestone underlies the undulating Quindalup and Spearwood dune systems running along the coast, adjoined in the east by the undulating aeolian sand plain of the Bassendean Dune System and the predominantly alluvial Pinjarra Plain[15].

The Bassendean sands are the dominant soil type currently utilised by turf farmers, the main reasons being their free draining properties and relatively cheap land prices compared to other, more fertile soil types. Bassendean sands are characterised by an extended geological history of weathering, which has resulted in almost complete leaching of iron, aluminium, calcium, major nutrients and metals. In their native conditions, they are characterised by low pH, very low salinity, very low nutrient retention properties and a tendency to become hydrophobic (non-wetting). Amendment of Bassendean sands with organic and inorganic materials is well suited to ameliorating most of these characteristics, which are considered detrimental to growth of introduced pasture and turf grasses[17].

The more fertile Spearwood sands have a shorter history of weathering than the Bassendean sands and consequently retain more calcium carbonate minerals, which in turn results in circum-neutral to alkaline pH values. Spearwood sands subsoil is well suited as clean fill for land development. It is widely used for construction requirements such as production of concrete and other cement products.

The youngest dune system is the Quindalup Dune System, which has a history of <10,000 years of weathering. The corresponding soils are characterised by high concentrations of calcium carbonate and are invariably alkaline.

Sandy soils are preferred for forestry, recreational turf and horticulture as they are free-draining and easy to manage. The pH requirements for beneficial use in terms of maximising soil biological activity and nutrient availability is typically 5.5 to 7.5 (measured in a 1:5 soil:water extract).



Development and Distribution of Soils of the Swan Coastal Plain, W.A.: Soil Publication No.16 (CSIRO) 1974

From Playford, GSWA

Figure 2: Major Soil Types of the Swan Coastal Plain.

4 EXPERIMENTAL APPROACH

The project plan is summarised as followed:

- Perform LEAF tests in triplicate on seven industry by-product materials;
- Inter-laboratory trial with ECN – Perform LEAF tests in duplicate on reference materials supplied by ECN;
- LEAF tests data – Scientific evaluation and statistical analysis;
- On-site training on predictive modelling and data analysis – This includes:
  - Computer laboratory set up at ChemCentre;
  - Training of staff (from ChemCentre and MBS Environmental. Project stakeholders were also invited to participate) by Netherlands expert Dr Hans van der Sloot; and
  - Informational workshop delivered by Dr van der Sloot and Professor David Kosson (USA expert) for government and industry stakeholders.
- Perform field and laboratory validation trials – This involves setting up field plots and performing large column laboratory studies;
- Validation – Compare LeachXS model predictions based on LEAF test data with field and laboratory leachate data.

4.1 By-products Description

Samples of the following seven by-product materials were received for this study.

Mineral processing by-products:

- Alkaloam (“red mud”) - The sample provided was a sample of filtered, air dried red-mud that is a by-product of alumina refining, supplied by Alcoa.
- NRP - The sample provided was a sample of filtered, air dried red-mud combined with some additional material, supplied by Alcoa.
- IMG - The sample provided was a sample of neutralised unused acid residue from processing of mineral sands supplied by Iluka.

Groundwater treatment residues supplied by Aroona:

- Groundwater treatment residue from the Wanneroo Groundwater
- Groundwater treatment residue from the Jandakot Groundwater

Process description - The groundwater treatment plants remove contaminants from the raw water sourced from production bores and then chlorinate the treated water to meet Australian Drinking Water Guidelines health and aesthetic criteria. Contaminants are removed using flocculation and settling with the resultant sludge directed to drying beds for future reuse. The sludge/residue quality is typically higher in iron, sodium and manganese.

Biosolids supplied by Aroona:

- Biosolids cake – biosolids spread out in the field and allowed to dry over seven days
- Lime amended biosolids (LAB).

The reference materials supplied by ECN for the inter-laboratory trial were described as followed;

1. Reference material BA (bottom ash) – for LEAF 1313 test (in duplicate) only; and
2. Reference material, MSWI-BA standard bottom ash – for LEAF 1314 test (in duplicate) only.

4.2 Soil Samples Description

The following four soil types were collected for laboratory analysis, LEAF testing and used in the tall column laboratory leaching trial:

1. **Bassendean sand** that has a history of fertiliser application in support of low intensity agriculture. The sample was sourced from a property that has been used for an earlier field trial in Ellenbrook assessing three by-product materials (including Alkaloam and IMG) as soil amendments.
2. **Spearwood sand**, which is associated with a younger dune system to the Bassendean system, and is characterised by circum-neutral to slightly acidic surface soil overlying alkaline yellow sand subsoil. These sands are widely used on the Swan Coastal Plain for urban development, horticulture, construction and supply of clean fill. The test sample was sourced for commercially supplied material purchased for construction uses by Curtin University.
3. **Bassendean sand from the low-lying Joel series**, characterised by lower elevation and therefore increased risk of seasonal inundation than the other Bassendean sand sample described above. The test sample was sourced from a location that has a history of low intensity grazing.
4. **Duplex sandy surface soil** overlying the clay loam soils of the Pinjarra Plain system. The test sample was sourced from a location (Fairbridge Farm) that has been used for low intensity agriculture.

Samples of soil (surface soil and shallow subsoil) from the field trial sites for the groundwater treatment plants as Wanneroo and Jandakot were also characterised, but not tested by the LEAF methods. The dominant soil type at both sites is described as Bassendean sand. Both sites were highly disturbed, but not contaminated, by operational activities and the soils used for the field trials are expected to be more typical of Bassendean sand subsoils rather than natural profiles.

Locations of the samples are shown in Figure 3. These soil types account for approximately 80% of the soils of the Swan Coastal Plain.

Figure 3: Map showing the location of the four soil types collected for this study. Note: (i) 2a represents Bassendean Joel series and duplex soil collection location, (ii) 2b represents Ellenbrook trial site where Bassendean sand was collected.

4.3 Sample Preparation

All samples tested were dried at 40ºC in a fan forced oven and mixed to produce a homogenous sample. A moisture determination at 105ºC was done on all dried samples to calculate dry weights for samples to be used in the LEAF tests.

The reference materials from the Netherlands (BA Referentine Materialen, and MSWI-BA Standard bottom ash) were distinctly non-homogenous with distinctly different particles, even after thorough mixing. A sub sample of each dried material was sieved to determine particle size. For LEAF test 1313, 85% of the sample had to pass through either a 0.3 mm, 2 mm, or 5 mm sieve. For LEAF test

1314, 85% had to pass through a 2.38 mm sieve. All the soil samples complied with the required sieve sizes, a larger mass being taken for testing for the coarser sizes.

The LAB sample provided could not pass through the 5 mm sieve. It consisted of large fibrous lumps present in the original material that did not mill well i.e. size reduction by milling was partially successful, but the sample became matted and resisted further size reduction. Eventually 85% passed through a 16 mm sieve, much larger than specified for the methods but the smallest practical size that could be obtained. The air-dried biosolid cake had 85% pass through the 5 mm sieve.

4.4 Sample Characterisation

The laboratory test work performed for "sample characterisation" on the seven by-product samples included the following:

- Total moisture (105 °C);
- TOC; and
- Total elemental concentration by X-ray fluorescence (XRF) and 4-acid digestion by inductively coupled plasma atomic emission spectrometry (ICP/AES) for: Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Sn, Ti, Th, Tl, U, V, Zn. Also analysed for total Cl and F.

Characterisation of the four soil types included the following;

- pH in water and 0.01 M $CaCl_2$ (1:5, sample : solution ratio);
- Particle size distribution (it includes clay, silt and sand fractions);
- Organic carbon;
- Inorganic (carbonate) carbon concentration;
- Oxalate-extractable iron and aluminium;
- Phosphorus retention index (PRI);
- Exchangeable cations and cation exchange capacity (CEC);
- Total and bio-available nutrients (nitrogen, phosphorus, potassium and sulphur);
- Total moisture (105 °C); and
- Total elemental concentration by XRF and 4-acid digestion by ICP/AES for: Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Si, Sn, Ti, Th, Tl, U, V, Zn, Cl, F.

4.5 Leachate Solution Analyses

All leachate solutions derived from LEAF tests, large column study and field plots study were analysed for the following;

- pH;
- electrical conductivity (EC);
- Eh;
- DOC;

- ICP/AES and/or inductively coupled plasma mass spectrometry (ICP/MS) analysis for: Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Sn, Ti, Th, Tl, U, V, Zn; and
- Anions by ion chromatography (IC): Br, Cl, SO_4 and F.

Note, regarding metal and metalloid concentrations being measured by neither ICP/MS and / or ICP/AES, ICP/MS is the more sensitive method and was utilised where possible. The ICP/MS has a lower tolerance for dissolved salts than ICP/AES and solutions with high salt concentrations had to be diluted prior to reading. This is responsible for any variable detection limits for the same analyte.

Typical method limits of reporting (LOR) for each analyte (in low TDS solutions) are presented in Table 2. The LOR is defined as 10 times the standard deviation of the mean of the blank value.

Table 2: Analytes Limit of Reporting (LOR).

Analyte	Method Code		Units	Limit of Reporting	Method 1313	Method 1314	Method 1316
pH	iPH1WASE						
Conductivity	iEC1WZSE		mS/m	0.2			
Eh	iEH1WASE		mV				
Dissolved Organic Carbon, DOC	iCTO1WDCO		mg/L	1			
Silver, Ag	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	
Aluminium, Al	iMET1WCICP		mg/L	0.005			Not detected
Arsenic, As	iMET1WCMS		mg/L	0.001		Not detected	Not detected
Boron, B	iMET1WCICP		mg/L	0.02			
Barium, Ba	iMET1WCMS		mg/L	0.0001			
Beryllium, Be	iMET1WCMS		mg/L	0.0001		Not detected	Not detected
Calcium, Ca	iMET1WCICP		mg/L	0.1			
Cadmium, Cd	iMET1WCMS		mg/L	0.0001			Not detected
Cobalt, Co	iMET1WCMS		mg/L	0.0001			
Chromium, Cr	iMET1WCMS		mg/L	0.0005			
Copper, Cu	iMET1WCMS		mg/L	0.0001			
Iron, Fe	iMET1WCICP		mg/L	0.005		Not detected	
Mercury, Hg	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	Not detected
Potassium, K	iMET1WCICP		mg/L	0.1	*		
Magnesium, Mg	iMET1WCICP		mg/L	0.1			
Manganese, Mn	iMET1WCICP		mg/L	0.001			
Molybdenum, Mo	iMET1WCMS		mg/L	0.001			
Sodium, Na	iMET1WCICP		mg/L	0.1			
Nickel, Ni	iMET1WCMS		mg/L	0.001			Not detected
Phosphorus, P	iMET1WCICP		mg/L	0.1	Not	Not	Not

Analyte	Method Code		Units	Limit of Reporting	Method 1313	Method 1314	Method 1316
					detected	detected	detected
Lead, Pb	iMET1WCMS		mg/L	0.0001		Not detected	Not detected
Sulfur, S	iMET1WCICP		mg/L	0.1			
Antimony, Sb	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	Not detected
Selenium, Se	iMET1WCMS		mg/L	0.001	Not detected	Not detected	Not detected
Tin, Sn	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	Not detected
Thorium, Th	iMET1WCMS		mg/L	0.0001		Not detected	Not detected
Titanium, Ti	iMET1WCMS		mg/L	0.0005			Not detected
Thallium, Tl	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	Not detected
Uranium, U	iMET1WCMS		mg/L	0.0001			
Vanadium, V	iMET1WCMS		mg/L	0.0001	Not detected	Not detected	Not detected
Zinc, Zn	iMET1WCICP		mg/L	0.005			
Bromide, Br	iANIO1WAIC		mg/L	0.1	Not detected	Not detected	Not detected
Chloride, Cl	iANIO1WAIC		mg/L	0.5			
Fluoride, F	iANIO1WAIC		mg/L	0.1		Not detected	
Sulfate, S	iANIO1WAIC		mg/L	0.1			

* Potassium hydroxide was used to adjust pH for alkaline extracts (Section 3.1.1) and results for potassium in pH13, 12, 10.5, 9 and 8 should be ignored.

4.6 Method 1313: Liquid – Solid Partitioning (LSP) as a Function of Extract pH

The procedure for this method consisted of nine parallel extractions of a solid material (the test sample) in dilute acid or base and reagent water. Particle-size reduction of the material to be tested was not required, except for the LAB sample (Section 4.3). A schedule of acid and base additions was formulated from a pre-test titration curve indicating the required equivalents of acid or alkali per gram of sample to be added to the series of extraction vessels so as to yield a series of eluates having nominal target pH values of 2.0, 4.0, 5.5, 7.0, 8.0, 9.0, 10.5, 12.0 and 13.0 ± 0.5. Also, a sample natural pH extract was performed, i.e. no pH adjustment was performed on the sample. In addition to the ten test extractions, three method blanks without solid samples were carried through the procedure in order to verify that analyte interferences were not introduced as a consequence of reagent impurities or equipment contamination. Thirteen bottles (i.e. nine test positions, natural sample pH and three method blanks) for each sample were extracted using the extraction parameters highlighted in green in Table 3. The nominal L/S was 10:1, after considering reagent addition and moisture content of the solid sample. The tumbling apparatus was digitally set at 30.0 rpm and kept in a room at a constant temperature of 22 ± 5 °C. After equilibration, the liquid and solid phases were separated by centrifugation (at 12,000 rpm for 15 minutes) and filtration. Analytical samples of the filtered eluate were collected and preserved where appropriate for the chemical analyses described in Section 4.5.

Table 3: Extraction Parameters as a Function of the Sample's Maximum Particle Size**.**

Particle Size (85% less than) (mm)	**Minimum Dry Mass (g)**	**Contact Time (hours)**
0.3	20 ± 0.02	24 ± 2
2.0	40 ± 0.02	48 ± 2
5.0	80 ± 0.02	72 ± 2

4.7 Method 1314: LSP as a Function of L/S Using an Up-Flow Percolation Column

This test method is intended as a means for obtaining a series of extracts (i.e. the eluates) of a granular solid material (the test sample) which may be used to show eluate concentrations and/or cumulative release as a function of L/S. This can then be related to a time scale when data is available on mean infiltration rate, density and height of application.

Milli-Q water (Vacuum filter) was the eluent introduced into a column (following the US EPA method[11]) of moderately-packed test material in an up-flow pumping mode, except biosolid and LAB where 0.05 M $CaCl_2$ solution was used due to the concern of deflocculation and dissolution of organic carbon, with eluate collection performed as a function of the cumulative L/S. Note: in case of biosolids cake and LAB, both materials were diluted with acid washed sand before proceeding to the percolation LEAF 1314 test. The use of 0.05M $CaCl_2$ as column eluent solution for Biosolids cake and LAB was chosen following preliminary testing using varying $CaCl_2$ concentrations (0.001, 0.005, 0.01, 0.05 and 0.1 M), where only 0.05M $CaCl_2$ allowed flow through the packed column.

Up-flow pumping was used to minimise air entrainment and flow channelling. The eluent flow rate was maintained between 0.5-1.0 L/S per day to increase the likelihood of local equilibrium between the solid and liquid phases, due to residence times longer than 1 day. For the purposes of chemical speciation modelling, the entire eluent volume up to 10 mL/g dry sample (g-dry) was collected in six specific aliquots of varying volume. Hence, a scheduled set of eluate fraction collections was performed over 12 days to achieve end point L/S values of 0.2, 0.5, 1.0, 2.0, 5.0 and 10.

Eluate volumes were chemically analysed for the parameters described in Section 4.5.

4.8 Method 1315: Mass Transfer Rates in Monolithic and Compacted Granular Materials Using a Semi-dynamic Tank Leaching Procedure

Method 1315 is a semi-dynamic tank leaching procedure used to determine the rate of mass transport either from monolithic materials or compacted granular materials as function of time. In this method monolith samples are placed in a tank where at least 98% of the surface area is accessible to the eluant which is totally exchanged at prescribed intervals with fresh solution, finishing 64 days after commencement. The recovered eluate is then analysed for the desired analytes.

As the test materials in this study do not possess the appropriate physical characteristics, the test method was not used for this assessment.

4.9 Method 1316: LSP as a Function of L/S Using Parallel Batch Extraction

This method is a batch extraction procedure with five parallel extractions designed to provide information on the liquid-solid partitioning of constituents as a function of L/S ratio. A mass of “as tested” solid material equivalent or greater than to a specified minimum dry mass is added to five extraction vessels. Reagent water is added such that the final L/S ratio in the five extractions is 0.5, 1.0, 2.0, 5.0, and 10.0, respectively. Extracts are tumbled in an end-over-end fashion for a specified contact time (highlighted in green in Table 3) that depends on the particle size of the sample. The extract liquid is separated from the solid phase by centrifugation, followed by filtration and preservation of analytical solutions. The eluate samples were analysed for the parameters described in the Section 4.5.

4.10 Comparative Field and Laboratory Studies

The field studies approach, summarised in Table 4, is based on the by-product application and it involves field plots where possible, field data mining (from published research, section 4.10.1.3) and large column laboratory tests.

Table 4: Field Study Approach for Seven By-products.

Industry Sponsor	By-Product	Potential By-Product Application	Field Evaluation Methods		
			Field Plot	Large Column	Data Mining
Alcoa	Alkaloam	Soil amendment	To continue the existing Ellenbrook field trial	Yes	Yes
	NRP	Soil amendment, landscaping & residential	No	Yes	No
Iluka	IMG	Soil amendment	To continue the existing Ellenbrook field trial	Yes	Yes
Aroona (Water Corp.)	Jandakot Sediment	Inert fill	Aroona set up Jandakot field trial	Yes	No
	Wanneroo Sediment	Inert fill	Aroona set up Wanneroo field trial	Yes	No
	Biosolids cake	Soil amendment	No	Yes	No
	LAB	Soil amendment	No	Yes	No

4.10.1. Field Studies

4.10.1.1 Ellenbrook Field Trial for Alkaloam and Ironman Gypsum® (IMG)

Ellenbrook Field Trial – Care and maintenance of the existing soil amendment field trial at Ellenbrook was officially transferred to the ChemCentre from the Swan River Trust. The Ellenbrook trial has been running since 2012 and details of the field plots set-up are in the project's final report[5]. The Ellenbrook trial was conducted over 1 ha (including small plots 3 m x 3 m; total nine plots) of land and initially monitored over four winter and spring seasons to assess the effectiveness of three soil amendments from widely different sources; Alkaloam, IMG and lime amended biosolid clay (LaBC). These amendments were applied to leaching sandy soils of the Ellenbrook catchment. Note: these amendments were applied to the soil surface and were not incorporated into the soil profile. Three lysimeters were installed within each of the small plots to collect leachate from soil over different rain events during winter and spring from 2012 to 2015 (Figure 4 and 5). The field study was continued for year 2016-17 in the current MRIWA project, only the small plots (3 m x 3 m) with the soil amendment materials Alkaloam and IMG was studied by collecting leachate samples from each lysimeter twice per annum after major rain events in winter and spring. The leachate data produced from 2012-15 from Ellenbrook Project was mined and incorporated in the current study.

Figure 4: Layout of small plots in the Ellenbrook field trial. Each plot has three lysimeters at varying depths.

Figure 5: Drum lysimeters to be used to collect samples of leachate from beneath soil amendment treatment plots.

4.10.1.2 Aroona Field Trials for Groundwater Treatment Residues

Aroona established small test plots at the Jandakot and Wanneroo groundwater treatment plants to test the leaching potential of constituents in the corresponding groundwater treatment residues.

As the intended use of these groundwater treatment residues is as clean fill, each material was applied as a 300 mm cover followed by compaction at natural moisture content. Each material was applied to triplicate small plots, nominally 3 by 3 metres. Drum lysimeters (Figure 6) were installed at depths approximately 300 mm and 500 mm below the natural soil surface level to collect leachate from the underlying soil profile following significant rainfall events over two years.

Figure 6: Layout of small plot in the Wanneroo field trial. The plot has three lysimeters at varying depths.

Ellenbrook Field Trial – Lysimeter leachate (21 sample batches) and analysis - "In the field" leachate collections were performed in July and November 2016 and in March and September 2017. Note that the March 2017 collection is additional in this project due to the unusual heavy rainfall event of February 2017.

Aroona Field Trials – Lysimeter leachate (eight sample batches) and analysis - "In the field" leachate collections were performed in August and November 2016 and in September 2017.

The Aroona field lysimeters were decommissioned at the end of this study. The Ellenbrook field plots and lysimeters are still in place.

4.10.1.3 Data Mining from past Bullsbrook Turf Field Trials Using IMG

In 2008, CSIRO conducted a field trial investigating trace element and radionuclide mobility in soil amended with IMG at a turf farm in Bullsbrook, WA[18]. Leachate samples were collected from lysimeters placed in amended and non-amended (control) soils for a period of three and a half years. The IMG was applied to the experimental plot at the rate of 150 dry tonnes per ha incorporated into the soil to a depth of approximately 10 to 15 cm using a rotary hoe with a roller mounted on the back. The soil type was a structure-less pale yellow to grey, medium to coarse sand typical of siliceous sandy soils on the Swan Coastal Plain.

4.10.2 Large Column Study

The aim of this exercise was to perform large column tests on field-like conditions that mimic climatic conditions such as an average rainfall season.

The leaching columns were constructed from acrylic plastic with two taps and lid. The column dimensions were 1 m height and 15 cm diameter and the experimental configurations differed according to the by-product application (Table 4, Figures 7 and 8).

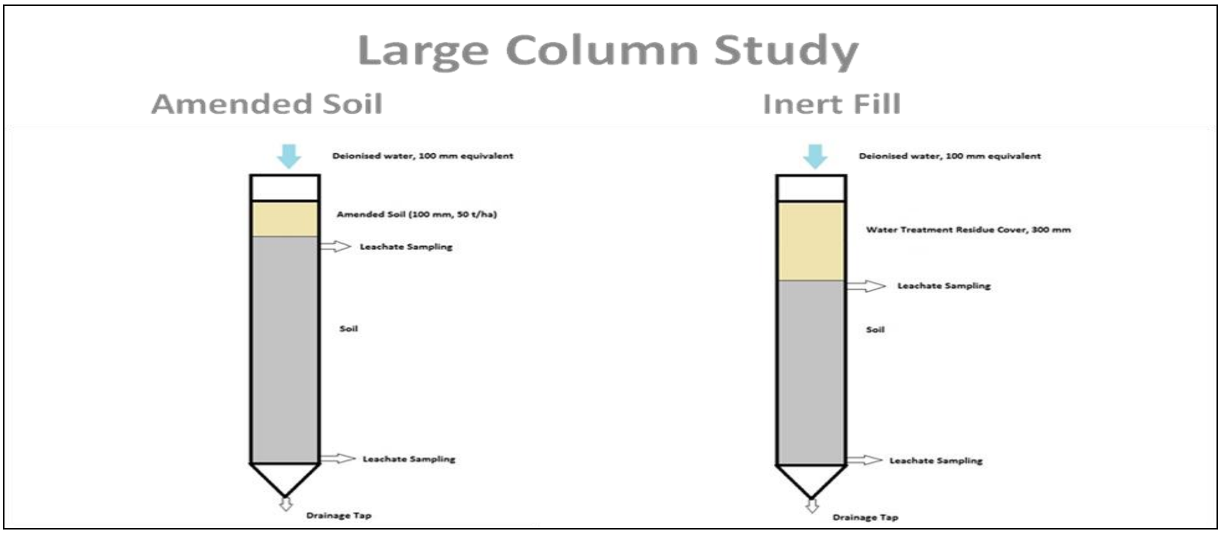


Figure 7: Large columns study designs.

Figure 8: Large columns prior to use in the study.

A total of 32 large leaching columns were run comprising of seven materials by four soil types, plus "control" columns for each soil type. For each column, two leachate samples were collected per event for three leaching events at leaching times 0, 4 months and 8 months. In the case of the two biosolids materials (biosolids cake and LAB), the leaching times were 0, 3 months and 6 months.

The general principles of this study were developed during a pilot column test (Figure 9) conducted prior to commencing the 6-8 months large column leaching studies. The pilot column test was used to confirm (i) pore volumes and drainage times for each layer and (ii) the absence of preferred flow pathways. The principles of the large columns study are described below and illustrated in Figures 7 and 8;

- Each column was charged with 100 mm of amended soil (or 300 mm of fill material) containing the equivalent of 50 tonnes per hectare of the amendment material.

- Underlying the amended soil layer was 800 mm of gently compacted unamended soil, corresponding to each of the four soil types described earlier. In the case for "inert fill" application, the underlying soil layer was 600 mm.

- Leachate samples were collected from sampling ports located at:

    - 100 mm below the base of the amended soil layer; and

    - Just above the base of the unamended soil layer.

- Leachate was collected following application of the equivalent of 150 mm rainfall as deionised water. The corresponding L/S ratio was approximately 2.0. This is based on 12 kg soil in the column (the weights of by-product layer, soil and leaching fluid were recorded for all columns) leached with approximately 6 L of water.

    Note: column characteristics such as water holding capacity and drainage times were determined during the pilot column study (Figure 9) using a rhodamine solution as a visual tracer.

- After the initial leaching event, excess leachate was removed via the lower drainage tap and the columns stored at room temperature for three months.

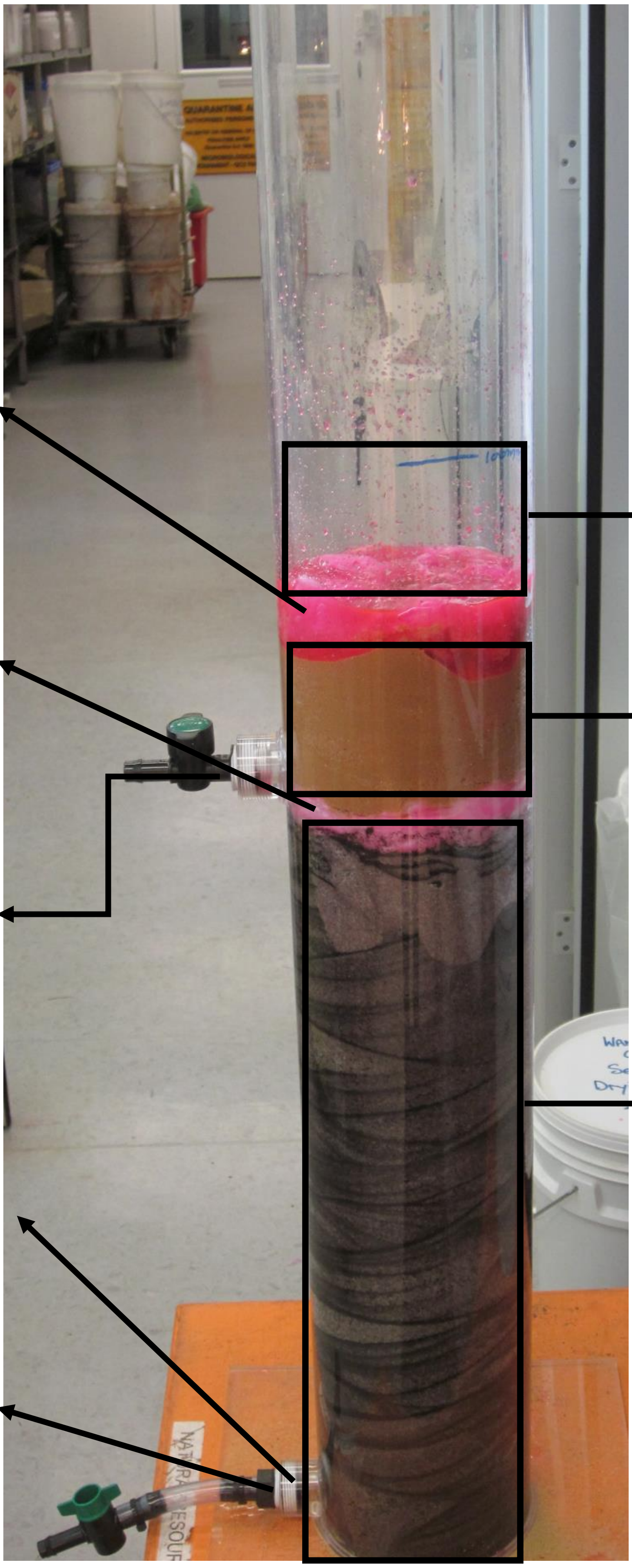
- The columns were leached with a second 150 mm rainfall equivalent event after three months (cumulative L/S ratio approximately 4.0).

- A third and final leaching event was conducted after a further three months (cumulative L/s ratio approximately 6.0).

- "Control" columns containing each of the four selected soil types were also set up and sampled in parallel to the amended soil columns.

- Each leachate sample was tested immediately for pH, EC, temperature, and redox potential (reported as Eh, milliVolts).

- Each leachate was analysed in the laboratory for the same parameters as the LEAF test leachates, Section 4.5.



Glass wool layer to prevent disruption of amended soil layer

Glass wool layer facilitate leachate sampling at amended soil – natural soil interface

1st leachate sample collection of 200 mL after 150 mm of water application by using syringe

2nd leachate sample collection from interstitial soil water

3rd leachate collection after application of 150 mm of water over by-product

150 mm of water was applied (approximately 2.7 L)

2 kg of by-product amended soil or 4 kg by-product (500/1000 ml of water was applied to wet the material)

12 kg of soil (Approximately 2L water was applied to saturate the soil)

Figure 9: Dye Tracer Study to Characterise Column Hydrology.

4.10.2.1 Large Column Study Procedure

The detailed large column leaching procedure is described below.

1. Glass wool was added at the bottom of the column.
2. Then 12 to 13 kg of dry soil was added.
3. Approximately 2.0 L deionised (DI) water was poured to saturate the soil.
4. Glass wool was placed on the top of soil layer to separate the soil from the amended soil layer and for the collection of clear extract at upper outlet from the amended soil – natural soil interface using a syringe.
5. 2 kg of amended soil was placed on the top of soil.
6. To wet the 2 kg of amendment material, 0.5 L deionised water was applied. Leave overnight.
7. The following day, approximately 2.7 L deionised water was applied in the column, which is equivalent to approximately 150 mm of rainfall.
8. Approximately 200 mL of 1st leachate sample was taken at the upper outlet. (Time difference was 15 min).
9. 2nd leachate was collected at the bottom of the column, which corresponded to interstitial water applied to the sand prior to leaching the column with simulated rainfall.
10. Lastly 3rd leachate sample was collected after 150 mm of equivalent rainfall water application. (Start time of flow 24 min).

Note: During standing, the columns were capped tightly to prevent any evaporative loss.

Leachate sampling stages/events:

For each column, three leachate samples were collected per event for three leaching events at leaching times 0, 4 months and 8 months. In the case of the two biosolids materials, the leaching times were 0, 3 months and 6 months.

1. Leach Number (event) 1 - First leachate sampling was conducted at the start of the column study (at 0 leaching time). During this stage, three leachate collections were performed as explained above in the procedure.
2. Leach Number (event) 2 - After 3 months, a 2nd leaching event was conducted at 150 mm of equivalent rainfall. Soils were at the field capacity during three/four months' time interval. During this event, firstly 500 mL of water was applied to saturate the amendment material and next day 150 mm of equivalent rainfall was performed as explained in the procedure. Three leachate collections were performed as explained above in the procedure.
3. Leach Number (event) 3 - The 3rd leaching event was conducted after 6/8 months' time intervals, following the same procedure as in the step 2 above.

4.11 Comparison of LEAF Tools, Laboratory Column Leaching and Field Studies Data

In order to simplify comparative assessment and interpretation of a large amount of experimental data relating to seven by-products, four soils, three assessment methods (LEAF tests, laboratory tall column leaching trial and three field trials) and 39 water quality parameters (Table 2), a visual “risk screening profile” tool was developed for the purposes of this project (Section 2).

The tool, as presented for the four soils used in this study (Tables 6 and 7), ranks constituents of potential concern (CoPCs) based on threshold criteria (Table 6) shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

The authors note that these by-products are not intended for unrestricted use on the Swan Coastal Plain, as is currently the case for other soil products including fertilisers, composts, clays and loams, agricultural lime and gypsum. Should these by-product materials be promoted for restricted use, an individual assessment by each provider, based on site specific water quality guidelines and intended use guidelines, will need to be prepared as part of the approvals application process.

The intended use of this “risk screening profile” tool, is limited to:

- Rank constituents of each material in terms of their potential risk to water quality on the Swan Coastal Plain. The highest ranked constituents were then selected for further assessment using the LeachXS modelling tool; and
- Demonstrate the predictive capacity, or otherwise, of the LEAF tools for each combination of by-product and soil type against results from the tall column and field trial experiments.

5 RESULTS AND DISCUSION

5.1 LEAF Tests Method Validation and Quality Assurance

Samples were dried to constant weight with difference between weighing within the larger of 0.02 g or 0.2%. Accurate dry weight determinations were critical to correct execution of the LEAF tests.

The LEAF tests were performed in triplicate on each by-product and soil sample.

The only well characterised materials available for LEAF method comparison and validation are reference materials developed by ECN. Unfortunately, only a limited amount of such material was available and as a result only duplicate (as opposed to the preferred triplicate) analyses were performed. This has no significant impact on the method comparison and validation.

The lack of readily available certified reference material or additional reference or control samples represents a limitation in the application of LEAF tests in Western Australia that needs to be addressed.

All the test eluents were analysed at ChemCentre Laboratory according to standard analytical methods and QA/QC protocols for each analyte of interest.

5.1.1 Method 1313

Method Summary

Samples of the test material (ECN-Ref material, BA bottom ash) were reacted with aliquots of acid and base at a liquid to solid ratio of 10:1 to achieve a desired pH between pH 2 and pH 13. The liquid fraction was separated from the solid by centrifuging and filtration. The filtrate was then split into two portions for analysis.

Some of the leaching pH targets could not be achieved due to the lack of test material availability.

Method Blank Analysis

Blank extractions (i.e. extractions without solid material) were carried out to assess potential sources of contamination. Three blanks were run for each sample: Milli-Q water, acid blank in Milli-Q water equal to maximum acid addition and alkaline blank in Milli-Q water equal to maximum addition of KOH. No comparisons between filtered and non-filtered blanks were performed.

Repeatability and Reproducibility

The intra-laboratory repeatability (repeatability of ChemCentre determinations) was assessed by performing independent duplicate analysis. The results are presented in Appendices A1 and A1.1 with illustrative examples shown in Figure 10. Overall, there was excellent agreement between the duplicate analysis indicating that the ChemCentre methods were internally consistent.

Inter-laboratory reproducibility (comparison between ChemCentre and ECN) was assessed by comparing the ChemCentre determinations to previous ECN determinations. The results are presented in Appendices A1.2 and A3 with illustrative examples shown in Figures 11 and 12. Figure 11 shows the typically close agreement between ChemCentre and ECN. Figure 12 shows the

ChemCentre data falling within the 95 % confidence intervals determined from the prior ECN analysis.

In general, there was a good agreement between the ChemCentre and ECN data, a view confirmed by LEAF expert Dr Hans van der Sloot in his review of the work (unpublished report to Alcoa, 2018).

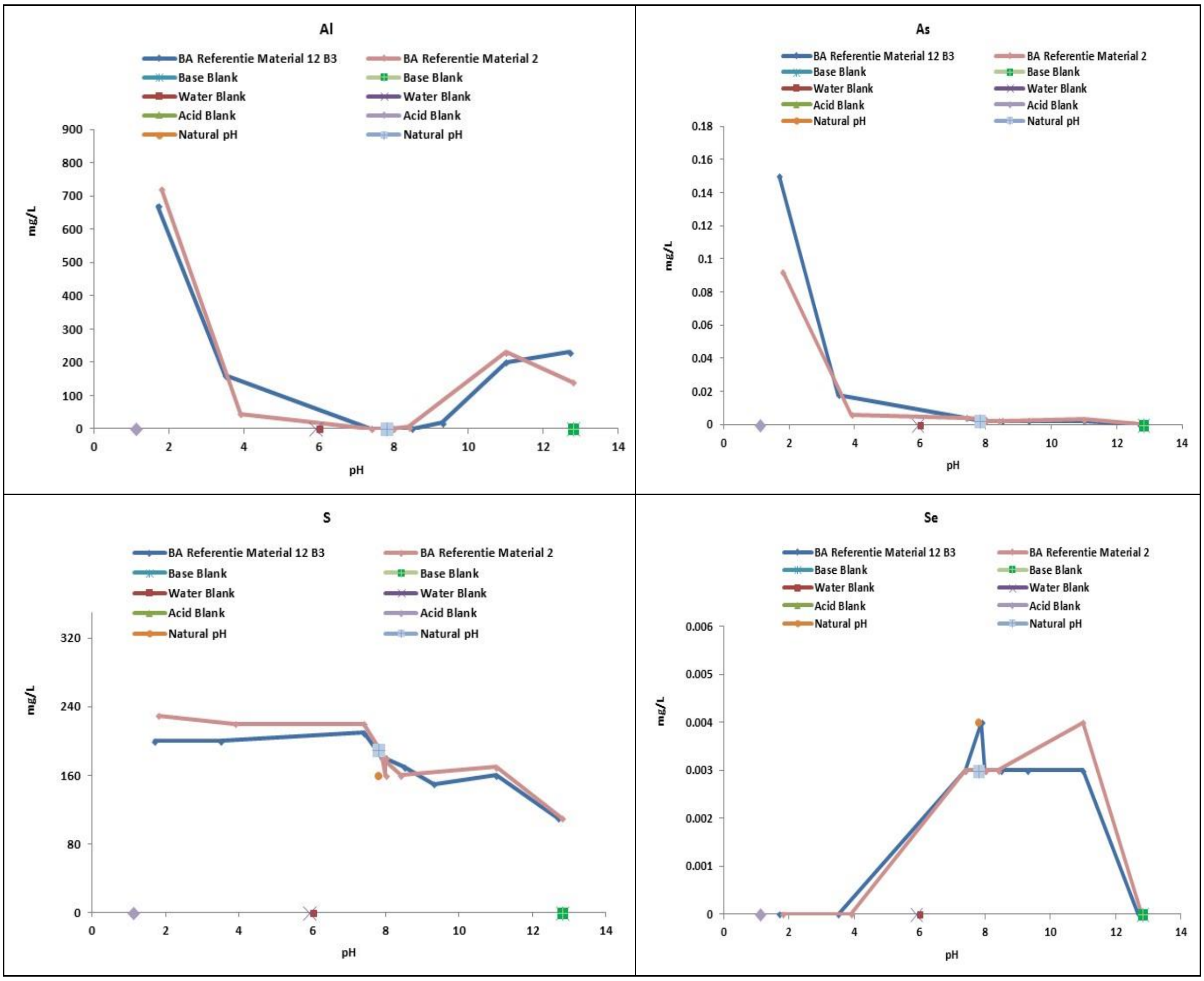


Figure 10: Eluate concentration of aluminium, arsenic, sulfur and selenium from the replicates of Method 1313 testing of validation study material (ECN Reference Material). Intra-laboratory results obtained by ChemCentre.

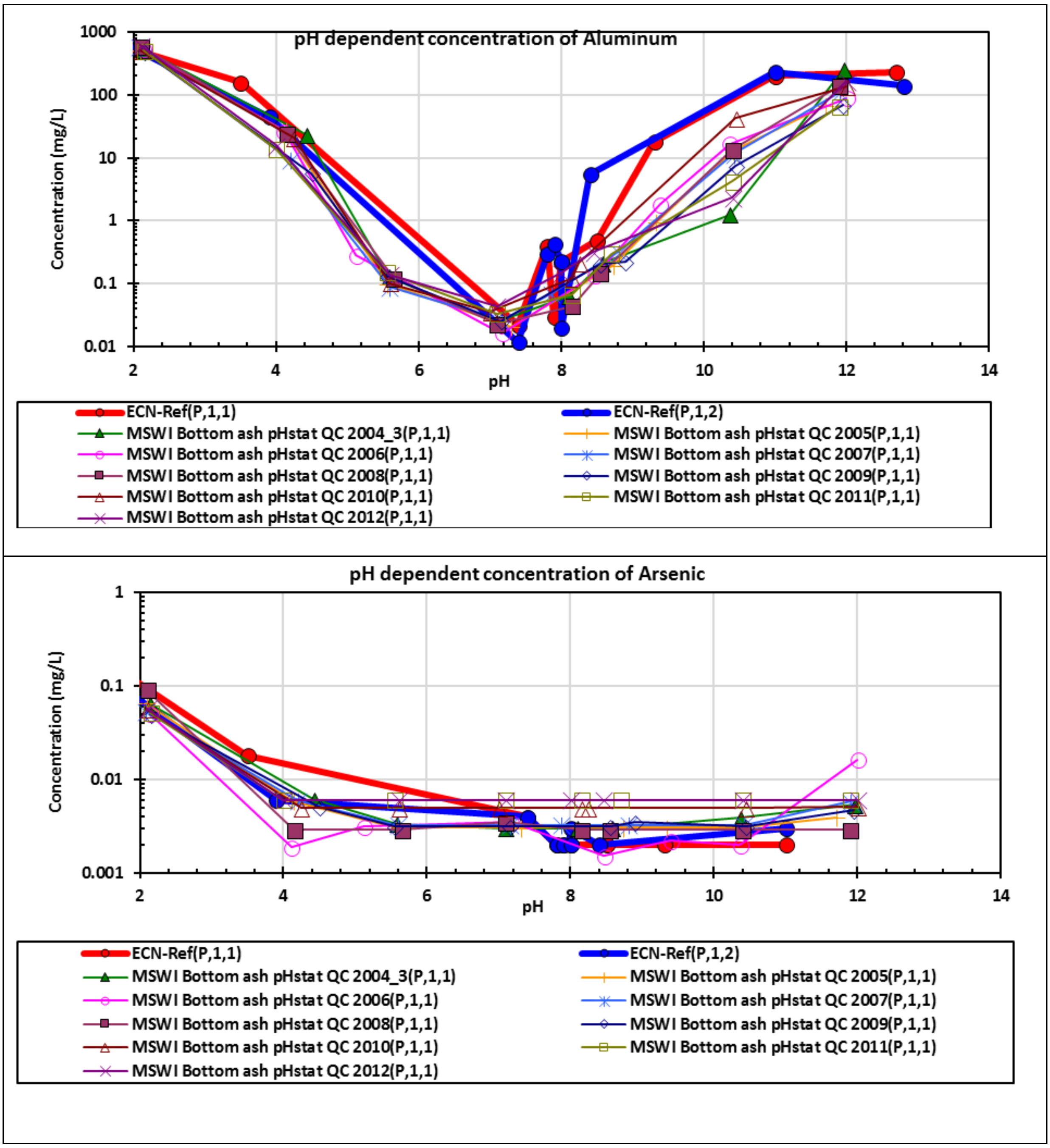


Figure 11: Method 1313 repeatability and reproductivity for antimony and arsenic.

Note: highlighted red and blue lines indicate the Method 1313 performed at ChemCentre (ECN-Ref) on ECN Reference materials and other data lines are from the ECN data on the same reference material.

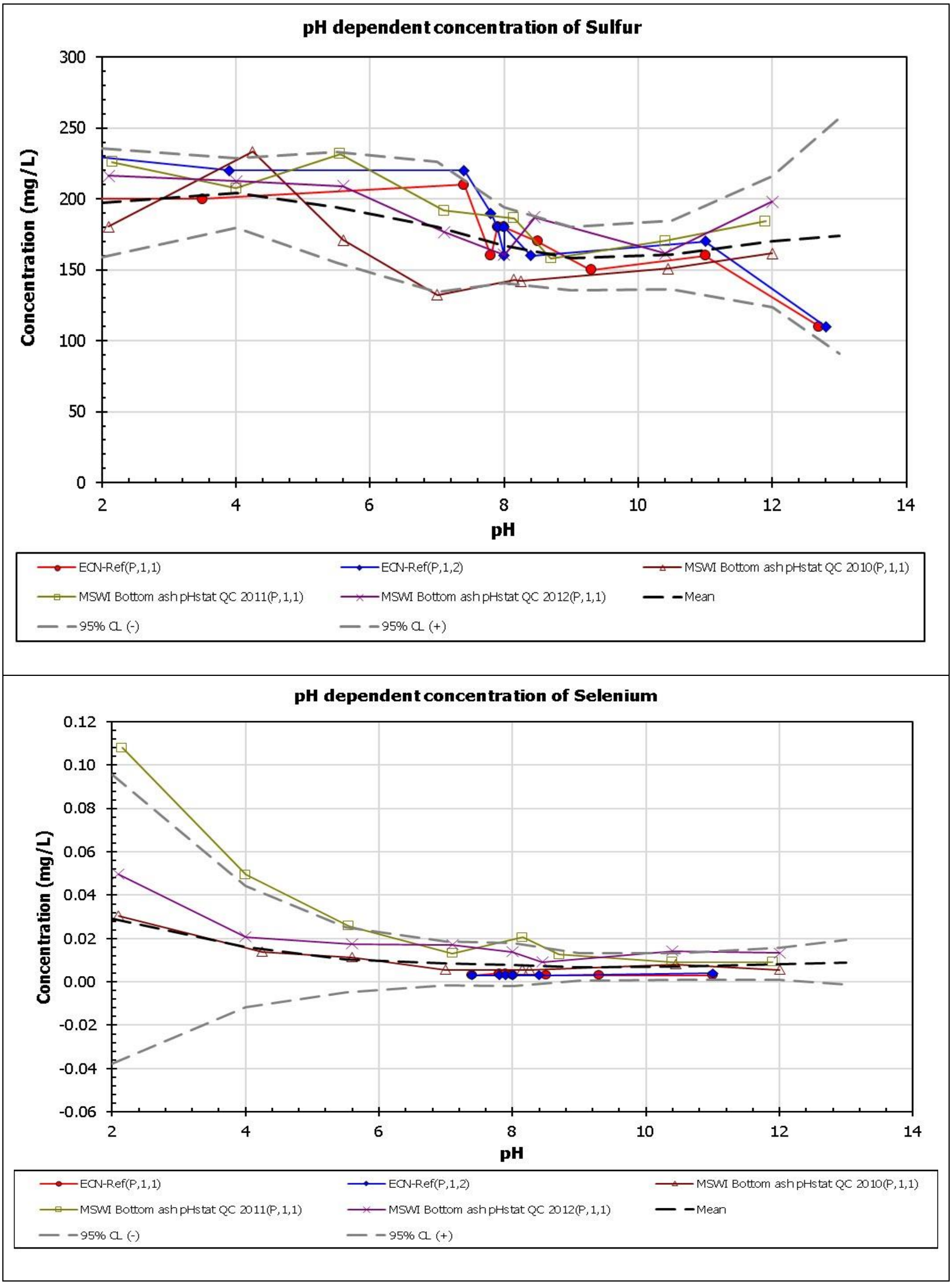


Figure 12: Inter-laboratory results. Agreement between 95% confidence limits (95% CL) about the mean of the reference materials. **Note: ECN-Ref belongs to the Method 1313 performed at ChemCentre on ECN Refence materials and other data lines are from the ECN data on the same reference material.**

5.1.2 Method 1314

Method summary

Method 1314 is an up-flow column procedure used to evaluate the release of constituents from solid materials as a function of cumulative liquid to solid ratio (L/S) from 0.5 to 10 mL eluent/g of dry material. Relative to the field conditions, L/S can be a useful surrogate measure for time when infiltration rates are considered. In the context of the column test, L/S is defined as the volume of liquid passing through the column relative to dry equivalent mass of test material in the column bed and is expressed in units of mL/g-dry. The test material (ECN-Ref material (MSWI bottom ash) was treated (section 4.7) and the collected leachate was filtered and split into two portions for analysis of multiple analytes.

Method Blank Analysis

For Method 1314, the required method blanks were simply a sample of the leaching solutions used in the column test. Method blanks were chemically analysed along with the test extractions and the results were evaluated to identify potential sources of contamination (e.g. contact surfaces, contaminated reagents) that might bias the results of the test extraction.

Repeatability and Reproducibility

The intra-laboratory repeatability (repeatability of ChemCentre determinations) was assessed by performing independent duplicate analysis. The results are presented in Appendices A2 and A2.1 with illustrative examples shown in Figure 13. Overall there was excellent agreement between the duplicate analysis indicating that the ChemCentre methods were internally consistent.

Inter-laboratory reproducibility (comparison between ChemCentre and ECN) was assessed by comparing the ChemCentre determinations to previous ECN determinations. The results are presented in Appendices A2.2 and A4 with illustrative examples shown in Figures 14 and 15. Figure 14 shows the typically close agreement between ChemCentre and ECN. Figure 15 shows the ChemCentre data falling within confidence intervals determined from the prior ECN analysis.

Overall there was a good agreement between the ChemCentre and ECN data, a view confirmed by Professor van der Sloot in his assessment of the work (unpublished report to Alcoa, 2018).

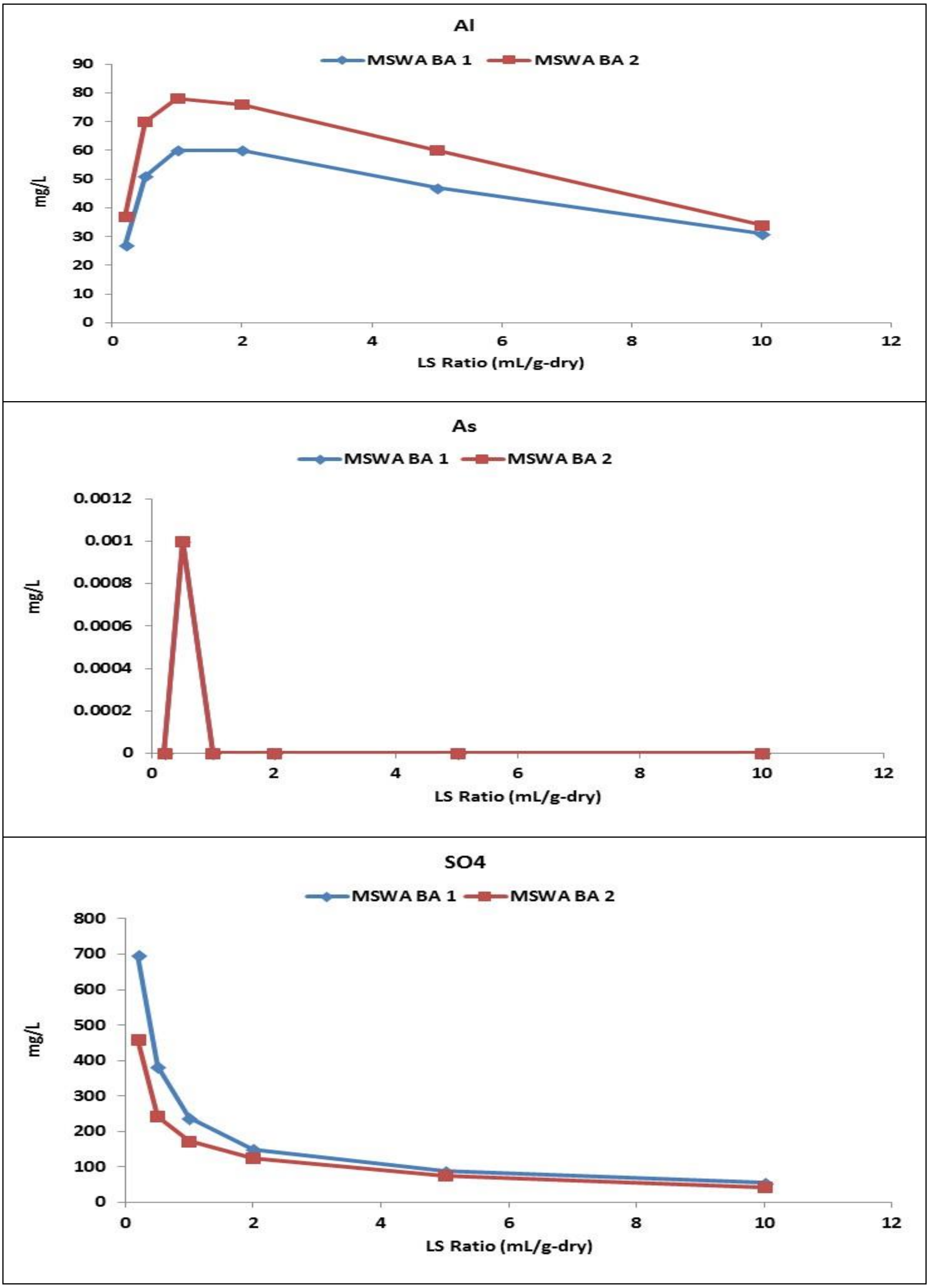


Figure 13: Eluate concentration of aluminium, arsenic and sulfate from the replicates at different L/S ratio from Method 1314 testing of validation study material (ECN Reference Material). Intra-laboratory results obtained by ChemCentre.

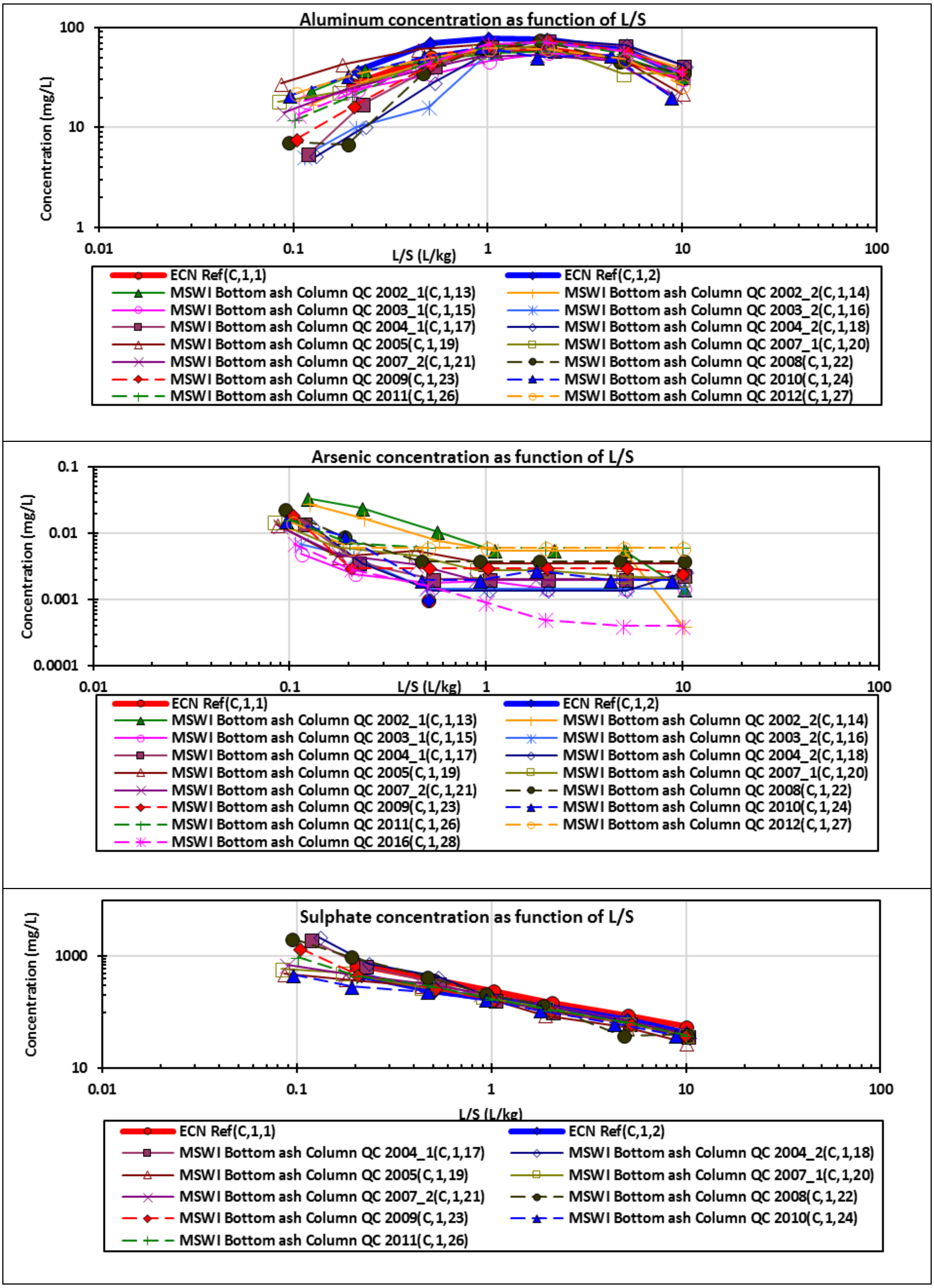


Figure 14: Method 1314 repeatability and reproductivity for aluminium, arsenic and sulfate.
Note: highlighted red and blue lines indicate the Method 1314 performed at ChemCentre on ECN reference materials and other data lines are from the ECN data on the same reference material.

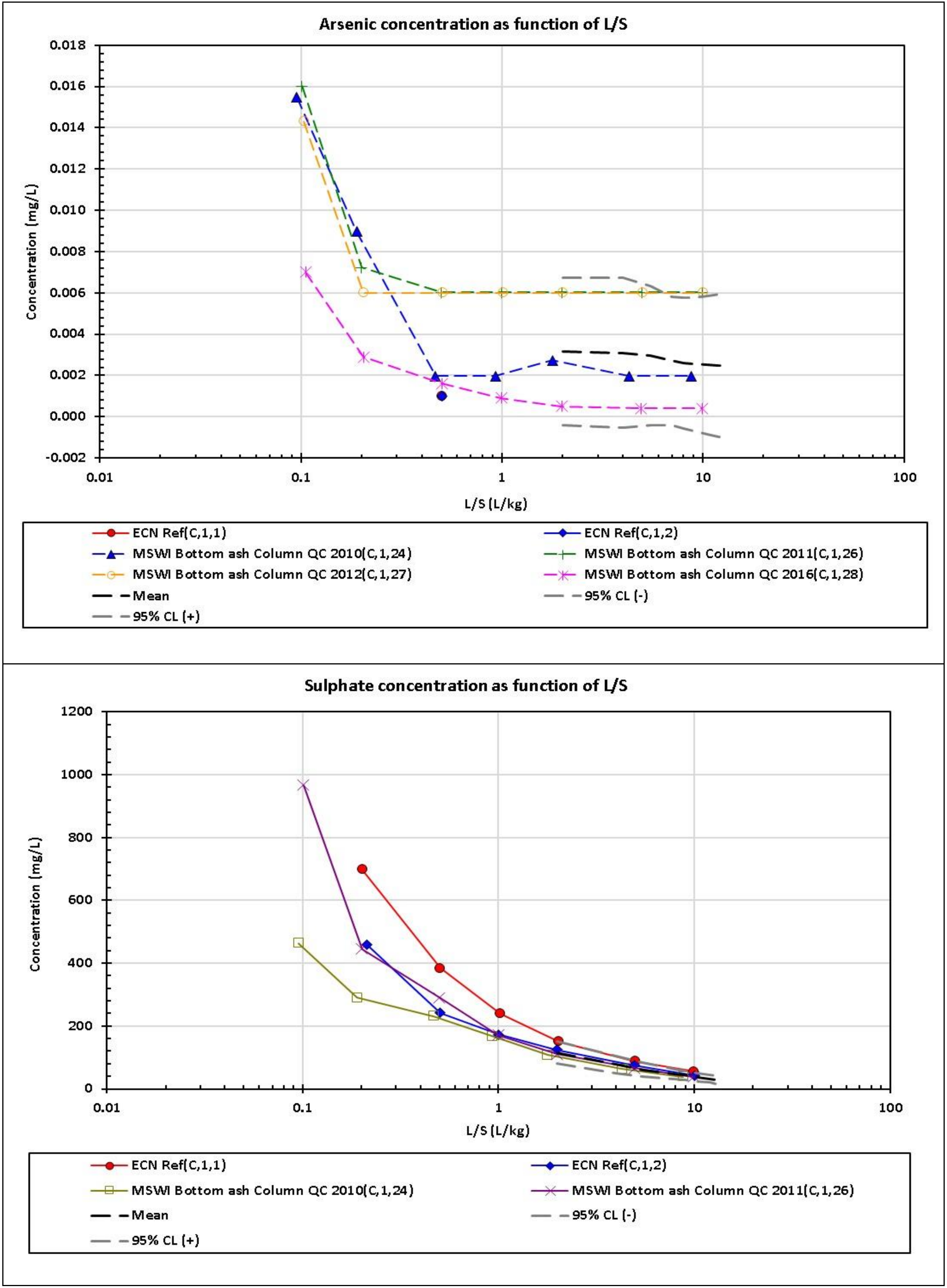


Figure 15: Inter-laboratory results. Agreement between 95% confidence limits (95% CL) about the mean of the reference materials.

Note: ECN-Ref belongs to the Method 1314 performed at ChemCentre on ECN Refence materials and other data lines are from the ECN data on the same reference material.

5.1.3 Summary – LEAF Tests Method Validation and Quality Assurance

The inter-laboratory comparison trial with ECN showed good agreement between the ChemCentre and ECN for both LEAF 1313 and LEAF 1314.

With robust method validation and quality assurance performance ChemCentre is now accredited by the National Association of Testing Authorities (NATA) for the LEAF tests 1313, 1314, 1315 and 1316. As a result, Western Australian industry, researchers and government regulatory agencies now have access to accredited LEAF testing.

There is no certified reference material (CRM) or other reference or control for LEAF testing in Australia. Suitable certified reference materials (preferably applicable to local conditions) should be developed, noting that CRM development is complex and time consuming.

5.2 Swan Coastal Plain Soils

5.2.1 Soil Characterisation

The four soil samples described in Section 4.2 were analysed for key soil characteristics (Section 4.4). Results for these tests are presented in Table 5.

Results relevant to the potential of these soils to interact with soluble constituents of soil amendment materials are summarised below:

- All soils were non-saline, as indicated by very low values for EC (1 to 8 mS/m) and chloride concentrations (<0.01%).
- Soil pH values were variable, ranging from 4.3 (as pH in 0.01 M $CaCl_2$) for the Bassendean sand from Ellenbrook to 8.2 for Spearwood sand. The Spearwood sand was the only one to contain inorganic carbonate, with a concentration of 0.33% inorganic carbon equivalent to a calcium carbonate content of approximately 3%.
- Both Bassendean sands (Ellenbrook and Joel) were similar in texture, characterised by very low silt and clay contents. The soils differed by the Joel soil having higher nutrient contents as a consequence of history of fertiliser and possibly lime use.
- The Fairbridge duplex soil contained significantly more organic carbon (1.77%) than the others. The organic carbon content of Spearwood sand (0.18%) is considered very low.
- The Fairbridge duplex soil contained much more total (and extractable) phosphorus than the other soils as a consequence of a long history of fertiliser use.
- Both Bassendean sands (Ellenbrook and Joel) had effectively zero capacity to retain anionic nutrients (and contaminants) by surface adsorption, as indicated very low values for Phosphorus Retention Index (PRI) (0.1 and 0.0 mL/g for the Ellenbrook and Joel soils, respectively). Spearwood sand had a moderate adsorption capacity, as indicated by a PRI of 5.2 mL/g.
- The Fairbridge duplex soil had substantial Cation Exchange Capacity (CEC) (6 cmol (+)/kg). The other soils had (low) CEC of 3 cmol (+)/kg provided by both clay minerals (Spearwood sand) and organic matter (Bassendean sands).
- Calcium was the dominant exchangeable cation in all samples, with very low exchangeable sodium (very low sodicity).
- The Fairbridge duplex soil, and to a lesser degree the Joel Bassendean sand, had accumulated various micronutrients and heavy metals, mainly by application of fertilisers. Spearwood sand was effectively devoid of these elements. Of particular note:
    - Fairbridge duplex soil contained slightly elevated concentrations of extractable cadmium, cobalt, copper and manganese;
    - Joel Bassendean sand contained slightly elevated concentrations of extractable copper, zinc and boron; and
    - None of the soils contained significant concentrations of extractable molybdenum, nickel, arsenic or selenium.

Table 5: Characterisation Data for Swan Coastal Plain Soils.

Parameter	Units	Bassendean (Ellenbrook)	Bassendean (Joel)	Duplex	Spearwood
pH (H2O)	pH units	5.7	8.0	6.8	8.9
pH (CaCl2)	pH units	4.3	7.1	6.1	8.2
EC (1:5)	mS/m	1	5	8	7
Chloride	%	<0.01	<0.01	<0.01	<0.01
Total sulfur	%	0.01	0.01	0.03	0.01
Total organic C	%	0.70	0.57	1.77	0.18
Total inorganic C	%	<0.05	<0.05	<0.05	0.33
Total N	%	0.028	0.038	0.132	0.006
Sand	%	98.5	98.5	94.0	97.5
Silt	%	0.5	0.5	2.0	0.5
Clay	%	1.0	1.0	4.0	2.0
NH4-N	mg/kg		<1	3	<1
NO3-N	mg/kg		4	21	1
Total P	mg/kg	17	45	240	36
PRI	mL/g	0.1	0.0	2.8	5.2
Oxalate Fe* (HFO)	mg/kg	45	66	737	147
Oxalate Al* (HFO)	mg/kg	<100	<100	363	330
CEC	cmol(+)/kg	3	3	6	3
Exch Ca	cmol(+)/kg	0.8	2.4	3.7	1.1
Exch Mg	cmol(+)/kg	0.22	0.65	0.57	0.10
Exch Na	cmol(+)/kg	0.04	0.11	0.08	<0.02
Exch K	cmol(+)/kg	0.02	0.11	0.26	0.05
Extr Al (M3)	mg/kg	38	44	420	410
Extr B(M3)	mg/kg	<0.1	0.7	<0.1	<0.1
Extr Ca (M3)	mg/kg	240	550	1000	3000
Extr Cd(M3)	mg/kg	0.01	0.02	0.06	<0.01
Extr Co (M3)	mg/kg	0.01	0.01	0.05	0.01
Extr Cu (M3)	mg/kg	0.1	0.9	0.4	<0.1
Extr Fe(M3)	mg/kg	32	43	310	35
Extr K(M3)	mg/kg	8	43	14	110
Extr Mg (M3)	mg/kg	38	94	88	100
Extr Mn (M3)	mg/kg	0.5	0.9	5.6	0.7
Extr Mo (M3)	mg/kg	<0.01	0.01	<0.01	<0.01
Extr Na (M3)	mg/kg	4	23	16	12
Extr Ni (M3)	mg/kg	<1	<1	<1	<1
Extr P (M3)	mg/kg	2	23	95	9
Extr S (M3)	mg/kg	1	10	11	9
Extr Zn (M3)	mg/kg	3.0	3.4	2.5	0.4
Extr As (M3)	mg/kg	<0.1	<0.1	0.1	0.1
Extr Pb(M3)	mg/kg	0.5	0.2	0.8	0.3

Parameter	Units	Bassendean (Ellenbrook)	Bassendean (Joel)	Duplex	Spearwood
Extr Se (M3)	mg/kg	<0.1	<0.1	<0.1	<0.1
Total Ag	mg/kg	<0.5	<0.5	<0.5	<0.5
Total Al	mg/kg	447	507	13133	7993
Total As	mg/kg	<3	<3	<3	<3
Total Ba	mg/kg	19	10	80	25
Total Be	mg/kg	<0.5	<0.5	<0.5	<0.5
Total Ca	mg/kg	287	797	1487	15500
Total Cd	mg/kg	<1	<1	<1	<1
Total Co	mg/kg	31	39	21	17
Total Cr	mg/kg	<10	<10	17	10
Total Cu	mg/kg	<5	<5	<5	<5
Total Fe	mg/kg	380	847	6383	4893
Total K	mg/kg	<100	150	2656	603
Total Mg	mg/kg	60	140	220	653
Total Mn	mg/kg	6	15	121	18
Total Mo	mg/kg	<5	<5	<5	<5
Total Na	mg/kg	72	100	267	235
Total Ni	mg/kg	<5	10	7	6
Total P	mg/kg	<20	58	305	37
Total Pb	mg/kg	5	<5	11	6
Total S	mg/kg	57	100	190	65
Total Sb	mg/kg	<2	<2	<2	<2
Total Se	mg/kg	<10	<10	<10	<10
Total Sn	mg/kg	<2	<2	<2	<2
Total Ti	mg/kg	1343	1887	6203	1977
Total Th	mg/kg	<10	<10	<10	<10
Total U	mg/kg	<10	<10	<10	<10
Total V	mg/kg	2	3.7	18	14
Total Zn	mg/kg	6.5	9	15	7.5
Total Tl	mg/kg	<0.1	<0.1	<0.1	<0.1
Total B	mg/kg	<20	<20	<20	<20
Si (by XRF)	%	46.0	45.9	42.8	44.0
Mercury	mg/kg	0.1	0.1	<0.1	<0.1
Chlorine	mg/kg	37.5	32	<25	<25
Fluorine	mg/kg	<25	35	37	50

5.2.2 Soil Samples - LEAF 1313 Test Results

In order for LEAF to be used to predict leachate concentrations in situations where the product is intended for use as a soil amendment material or clean fill substitute, it is necessary to use pH dependence data for each constituent of potential concern in the corresponding soil. This section presents results from an assessment of pH dependence data (LEAF 1313 Method) for four common sandy soils, which represent the majority of soil types encountered on the Swan Coastal Plain (sections 3.3.3 and 4.2). Note that LEAF can be subsequently used to predict leachate concentrations for soil-derived constituents of potential concern in specific soils with slightly different characteristic soil properties (such as pH, clay content and soil organic matter) to those assessed in this section. Note also that if LEAF methodology is to be used on soils with substantially different chemical properties (such as Darling Range loams and gravels, tropical Pindan soils and sodic clays of the wheatbelt region), then samples of these soil types will also require analysis using LEAF 1313 methodology.

Results for analysis of the four soil samples are presented as graphs in Appendix A5-7. Characteristics of the pH dependent leaching characteristics by analyte for these materials are summarised as follows:

- Silver: All leachates recorded silver concentrations below the method reporting limit.

- Aluminium: Aluminium in all samples indicated amphoteric characteristics. However, there was also wide variation with the pH range associated within typical soil environments (pH 4.5 to 9), with concentrations decreasing in the order Fairbridge duplex > Bassendean Joel > Bassendean Ellenbrook > Spearwood. Soil organic carbon appears to be important in aluminium release from these soils. Concentrations between 0.1 and 1 mg/L were recorded in leachates of Fairbridge duplex and both Bassendean soil types with the pH range of 6 to 8.

- Arsenic concentrations were very low for all soil types across the pH range associated within typical soil environments (pH 4.5 to 9). Slightly elevated concentrations were present in highly alkaline leachates of Spearwood sand (maximum 0.025 mg/L at pH 13).

- Boron concentrations were low (approximately 0.1 mg/L) for all soil types across the pH range associated within typical soil environments (pH 4.5 to 9).

- Barium concentration maxima were recorded at low pH (pH 2) and decreased in order Fairbridge duplex > Bassendean Ellenbrook ~ Spearwood sand > Bassendean Joel. Leachate concentrations within the pH range associated within typical soil environments (pH 4.5 to 9) were much lower (<0.01 mg/L), indicating the leaching of barium from these soils presents very low environmental risk.

- Beryllium: measurable concentrations were only recorded in acidic (pH 2-4) leachates of Spearwood sand.

- Calcium concentrations were extremely variable, ranging from 0.1 to 1,000 mg/L. For each soil sample, maximum concentrations were recorded at the lowest pH (pH 2) and decreased from 1,000 mg/L from the slightly calcareous Spearwood sand to 10 mg/L to the highly leached Bassendean sand from Ellenbrook.

- Cadmium: the Fairbridge duplex soil containing appreciable concentrations of soluble cadmium (0.01 to 0.001 mg/L), but only at very low (pH 2) and very high pH (pH >12). The presence of cadmium may be associated with a long history of superphosphate use at this site.

- Chromium: maximum chromium concentrations were variable and pH dependent. The highest soluble concentration was approximately 0.03 mg/L in Spearwood sand at low pH (pH 2). Solubility maxima of approximately 0.01 mg/L were recorded at high pH (pH 13) for the Fairbridge duplex and Bassendean Ellenbrook samples. The other Bassendean (Joel) sand recorded lower concentrations at all pH values, with a maximum of approximately 0.001 mg/L at pH 2.

- Copper concentrations were extremely variable and generally indicated amphoteric behaviour. Maximum concentrations were recorded at pH 13 for all soils, with values decreasing from approximately 0.1 mg/L for the Fairbridge duplex and Bassendean Joel soils to 0.01 mg/L for Spearwood sand. As with aluminium, chromium, iron and other metals, the relative concentrations and pH-dependent solubility of copper are controlled by interaction with dissolved organic carbon (DOC) and particulate organic carbon (POC). It is important to note that not all the DOC and POC are reactive towards metals, hence a fractionation is needed in the modelling to address the respective reactive parts; dissolved humic acid (DHA) and solid humic acid (SHA).

- Iron concentrations were also variable and dependent on pH and soil type, with concentrations ranging from 0.01 to approximately 10 mg/L. While indicating amphoteric behaviour, the maximum concentration for each soil sample was recorded in the pH 13 leachate. Concentrations decreased from approximately 10 mg/L for the Fairbridge duplex soil, to approximately 5 mg/L for Spearwood and sand and 1 mg/L for both Bassendean sand samples.

- Potassium concentrations with the range of 4 to 8 pH units were between 1 and 10 mg/L and generally reflected the fertiliser history at each location. A significantly higher concentration (approximately 100 mg/L) was recorded for Spearwood sand at pH 2, which may be a consequence of partial dissolution of potassium feldspar minerals present in this soil type.

- Magnesium concentration in the pH dependence curves were recorded maximum at pH 2. Much higher concentrations (approximately 600 mg/L) were dissolved by acid from Spearwood sand compared with the other naturally acidic soil samples (<10 mg/L).

- Manganese concentrations were highly variable, ranging from approximately 0.0001 to 1 mg/L. At acidic pH values, the order of manganese solubility decreased in the order Fairbridge duplex> Spearwood > both Bassendean sands, while the order under strongly alkaline conditions was Fairbridge duplex > both Bassendean sands > Spearwood sand.

- Molybdenum concentrations were generally very low for all samples, with the only concentrations slightly above the reporting limit (0.001 mg/L) recorded in slightly alkaline leachates of the Fairbridge duplex sample. As molybdenum is an essential micronutrient, the presence of soluble molybdenum in the Fairbridge sample may result from fertiliser residues.

- Sodium concentrations were generally low (1 to 10 mg/L) and did not vary significantly with pH. The observed concentrations are considered typical of leachates from non-saline soil types.

- Nickel: except for the low pH leachates, nickel was only recorded at very low concentrations (approximately 0.03 mg/L) in leachates of Fairbridge duplex and Spearwood sand samples.

- Phosphorus: leachates of all samples except Spearwood sand contained soluble phosphorus at levels likely to contribute to eutrophication of surface waterbodies on the Swan Coastal Plain. The highest concentrations (up to 10 mg/L) were from alkaline leachates of the Fairbridge duplex sample. Concentrations of approximately 1 mg/L were recorded in acidic (pH 2 to 6) and highly alkaline (pH 13) leachates of the Bassendean Joel sample. Lower concentrations were recorded for the Bassendean Ellenbrook sample, reflecting lower fertiliser usage at that location. Concentrations in leachates of Spearwood sand were very low except for a value of 1 mg/L in the pH 13 leachate.

- Lead concentrations were both pH and soil type dependent. All samples indicated amphoteric behaviour. The highest concentrations of approximately 0.05 mg/L were recorded in acid leachates of Spearwood sand and both acid and alkaline leachates of the Fairbridge duplex sample. Much lower values were recorded at the natural pH of each sample, with the lowest concentration of 0.0001 mg/L recorded for Spearwood sand. The highest natural pH lead concentration was recorded for the Fairbridge duplex sample.

- Sulfur (and sulfate) concentrations generally increased with increasing pH, with values generally between 0.1 and 1 mg/L within the pH range associated within typical soil environments (pH 4.5 to 9). Concentrations decreased in the order Fairbridge duplex ~ Bassendean Joel > Bassendean Ellenbrook > Spearwood sand, which reflects fertiliser history and soil fertility.

- Tin, antimony, thallium and uranium concentrations were generally low to extremely low and unlikely to present significant risks to the environment. Slightly elevated concentrations of tin (0.01 to0.05 mg/L) were recorded in strongly alkaline leachates of Spearwood sand and Fairbridge duplex samples. Uranium concentrations between 0.001 and 0.01 mg/L were recorded in alkaline (pH >8) leachates of Fairbridge duplex soil and may be derived from phosphate fertiliser residues.

- Vanadium concentrations were highly variable and strongly dependent on both leachate pH and soil type. Slightly elevated concentrations of 0.01 to 0.1 mg/L were recorded for the acidic and alkaline leachates of Fairbridge duplex and Spearwood sand samples, while concentrations in circum-neutral leachates of all samples, but particularly Spearwood sand and Bassendean an Ellenbrook samples were extremely low (less than 0.001 mg/L).

- Zinc: the maximum concentration of zinc was approximately 0.2 mg/L in pH 2 leachates of Fairbridge duplex and both Bassendean sand samples. Zinc exhibited amphoteric behaviour, although concentrations in the alkaline leachates (pH >10) were an order of magnitude lower the that of the acidic (pH 2) leachate of these samples. Much lower concentrations were recorded in Spearwood sand leachates, with concentrations typically less than 0.01 mg/L. The presence of leachable zinc in these soils appears to be related to both fertiliser history and soil organic carbon contents.

- Dissolved organic carbon: concentrations of DOC were highly variable as related to soil type and leachate pH. Solution minima were associated with slightly acid pH Values (pH 4 to 6), while maxima were recorded in pH 13 leachates. The DOC values decreased in the order

Fairbridge duplex (approximately 200 mg/L) > Bassendean Ellenbrook > Bassendean Joel > Spearwood sand (approximately 50 mg/L).

The pH dependent leaching data (LEAF 1313) for the Swan Coastal Plain soils are presented in Figure 16 for aluminium, copper, phosphorus and zinc. The data indicates that these soil samples have potential to leach aluminium and phosphorus at notable levels. (Section 3.3 and Table 1). Copper and zinc (Figure 16) may also leach at notable levels under acidic (pH <5) conditions. Fairbridge duplex soil contains relatively higher concentrations of several constituents, probably as a consequence of its long fertiliser usage history. However, the solubility of these elements is typically low as a consequence of circum-neutral to slightly acid pH conditions, and possibility stable interactions with soil organic matter.

These findings suggest that for some constituents the natural soils (as opposed to the by-products) may significantly contribute to overall leaching characteristics of the by-product/soil mixture.

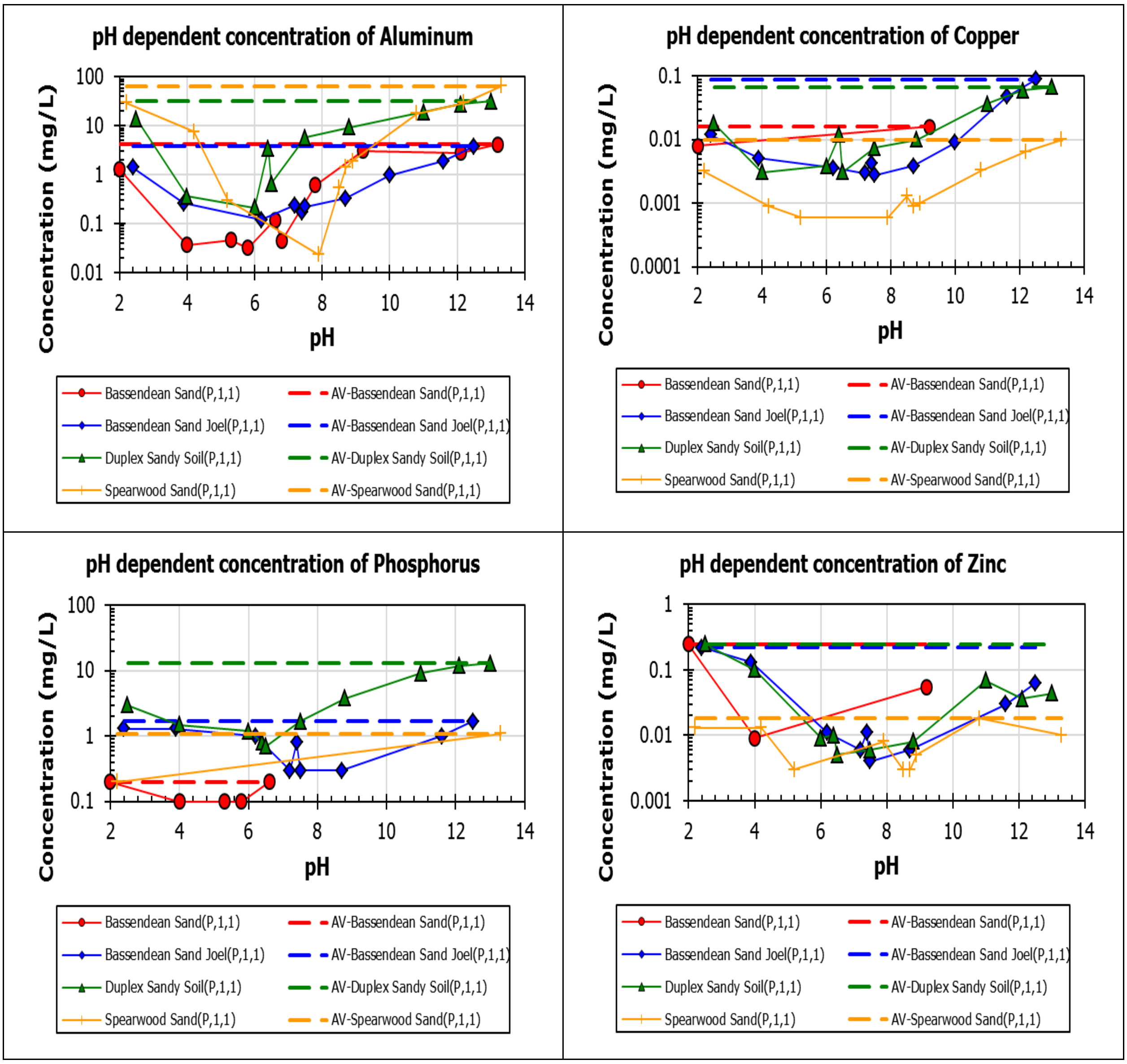


Figure 16: Graphical presentation LEAF 1313 results for aluminium, copper, phosphorus and zinc for Swan Coastal Plain soils.

5.2.3 LeachXS Predictive Modelling- Chemical Speciation Fingerprint

LeachXS includes a flexible set of laboratory test and field simulation model scenarios that can be used for parameter estimation (laboratory test simulations) and evaluating leaching under a variety of field conditions (prediction scenarios). In general, the user can adjust the material characteristics, initial conditions and boundary conditions for within each scenario.

The predicted chemical speciation fingerprints of soils and by-product amendment materials, and percolation parameters may be used to evaluate the results of percolation column tests using a conceptual model comprising mobile and immobile zones. The conceptual model (Figure 17) consists of two zones segmented along the flow path, with one zone containing a mobile fluid phase in local equilibrium with the solid phase and the second zone containing an immobile fluid phase in local equilibrium with the solid phase. Within each column segment, each of the mobile and immobile zones are well mixed (i.e., uniform distribution of constituents within each of the solid phase and liquid phase orthogonal to the flow direction), and the mobile and immobile zones exchange dissolved constituents based on mass transfer coefficients that can be considered an effective diffusion distance. This model is insensitive to percolation flow rate because homogeneity within the immobile zone is assumed. This model can be used for a first-order approximation of the effects of preferential flow in a percolation system, as well as the impacts of changes in redo potential and influent solution chemistry on the leaching of constituents.

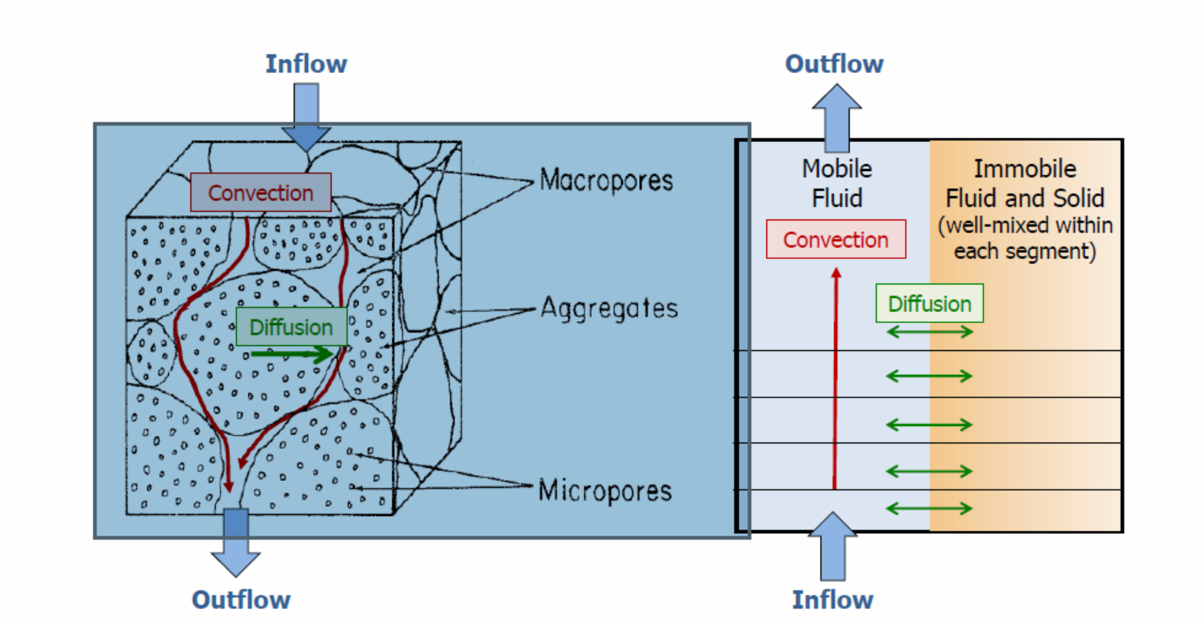


Figure 17: Conceptual model of percolation with mobile and immobile zones shown for soil aggregates (left; van Genuchten and Dalton, 1986)[17] and as a 1-dimension approximation in ORCHESTRA (right). Adapted from LXS Pro User's Guide provided by workshop training.

In order for LeachXS to predict leaching characteristics of amended soils, the concept of a "virtual material" was developed. For the purpose of this project, a "virtual material" may be considered as a representation of a blend of a by-product with a sandy soil in a ratio equivalent to typical field application rates. Typically, this is 5% by mass which is approximately equivalent to 30 to 50 tonnes of dry material per hectare applied to soil and mixed by incorporating to a depth of 100 mm.

LeachXS has a capability for generating chemical speciation fingerprints of a virtual material (amended soil layer) by combining the chemical speciation fingerprints of each component at the assigned mixing ratio. This is demonstrated under sections 5.3, 5.4.1 and 5.5.1.

5.2.4 LeachXS Material Characterisation and Chemical Speciation Fingerprints of Bassendean Ellenbrook Soils

In order to produce a chemical speciation fingerprint for a by-product, soil or "virtual material", LeachXS requires input of the following data and parameters:

- LEAF Method 1313 leachate composition (including DOC).
- LEAF Method 1314 leachate composition.
- "Clay" content of the solid material. Clay content in soil materials is routinely analysed using a hydrometer method to measure the density of soil suspensions. However, the notion of "clay" content of some industry by-products and, in particular, organic materials, is not applicable. In such cases, ChemCentre chose to use nominal values ("best guess estimates") and adjust the values to provide the best predicted versus measured leachate concentrations for key analytes. It is important to note that LeachXS does not differentiate between two distinct classes of clay minerals, being Low Activity Clays (clay-sized minerals such as kaolinite and quartz, which have low permanent charge density) and reactive clays (such as smectite, illite and zeolite minerals, which have high permanent charge density).
- Hydrous ferric oxides or "HFO" in the solid material. This parameter refers to amorphous hydrous oxide minerals containing iron, aluminium and manganese. These minerals are able to develop substantial (but variable) surface charge (positive charge at low pH and negative charge at high pH), which is responsible for surface adsorption of several metals and metalloids, notably those forming stable oxy-anions (such as phosphate, molybdate, arsenate/arsenite, selenate/selenite and vanadate). ChemCentre has a validated method for measuring hydrous aluminium and iron oxides in WA soil using acidic (pH 3) ammonium oxalate as a selective extractant. The method, however, is not suited to alkaline soils, alkaline by-products or organic materials, in which case nominal values are used as discussed in the preceding dot-point. Alternative methods, such as that using a citrate-dithionite extractant, may be used. However, previous work by ChemCentre has demonstrated this method to be inferior to the oxalate method for predicting anion adsorption characteristics of WA soils. In addition to high-surface area hydrous oxide minerals, the citrate-dithionite method partially dissolves crystalline oxide minerals (such as gibbsite, hematite and goethite), which have much less anion adsorption capacity to the anhydrous minerals.
- Solid Humic Acid or SHA in the solid material. Solid humic acid refers to the high molecular fraction of humified soil organic matter that forms stable ionic complexes with hydrated metal ions. Previous work by ChemCentre has shown that SHA accounts for approximately 20% of total organic carbon (TOC) in Swan Coastal Plain sandy soils. As the laboratory method is tedious (and therefore expensive), SHA was not measured on these soil samples, or on any waste materials. A default value of 22% of TOC was used as the initial nominal SHA value for all materials, which was then able to be adjusted slightly (±20%) to provide the best CFS curve fit for copper and chromium, for which their pH dependent solubility is mainly controlled by association with either dissolved or particulate organic matter.
- Dissolved humic acid (DHA) in each leachate of the LEAF 1313 (pH dependence) test method. This value is expressed as a fraction of DOC. As this parameter is not routinely measured in commercial laboratories, a value of 20% of DOC in each leachate was selected as a nominal value for this parameter. This value was derived from earlier studies by Alcoa and its relevance to soil and other by-product materials

has not been demonstrated. As for HFO and SHA, values of DHA contents were adjusted to provide the best curve fit for measured and predicted metal (particularly Cu and Cr) concentrations.

- pE. pE is defined as the chemical potential of the electron and is an important parameter required for predictive chemical speciation modelling of element that are sensitive to redox conditions (as measured in the laboratory by Oxidation Reduction Potential (ORP) or Eh). As such, pE is not an inherent characteristic of a material as it cannot be measured directly. Therefore, only nominal values were able to be used in LeachXS modelling. Advice supplied to ChemCentre during the 2017 training workshop was to derive an initial nominal value calculated from the "rule of thumb" relationship that pH + pE ~ 14 in the laboratory environment. As with other parameters required for LeachXS modelling, this approach was adopted for pE, with values subsequently modified to provide the best chemical speciation fingerprints for redox sensitive elements such as manganese and iron.

LeachXS was used to generate chemical speciation fingerprints for all four soil samples used in the tall column experiments. However, data are only presented for the Bassendean Ellenbrook Soil in Appendix A9 of this report, as this was sole soil material used in the predictive leachate modelling for all by-products assessed.

Preliminary LeachXS modelling for Bassendean (Ellenbrook) sand was undertaken using LEAF test experiment data for the sample collected for this project, but with values for clay, HFO, SHA, DHA and pE used in an earlier study by Alcoa. These findings are presented below to demonstrate the sensitivity of clay and HFO contents on LeachXS predictions. Modelled values comprised:

- Clay content; 1% and 10%;
- HFO; 3,450 mg/kg; and
- SHA; 1,000 mg/kg.

One aspect of LeachXS modelling that became apparent while modelling the four soil samples was the ability to improve alignment of predicted and experiment leachate concentration data by altering input values for parameters including pE (as discussed for groundwater treatment residues), HFO, clay and SHA contents. As an example, Figure 18 shows chemical speciation fingerprint predictions for aluminium in Bassendean Ellenbrook soil using nominal clay contents of 10,000 mg/kg (1%) and 100,000 mg/kg (10%). Although LeachXS predicted a better description of experimental results using 10% clay content, adoption of this value is not considered appropriate as it does not reflect the properties of Bassendean sand. The sample of Bassendean Ellenbrook sand used in the tall column experiment (and Method 1313) contained 1.0% clay (and 0.5% silt), as presented in Table 5.

Other key observations relating to the chemical speciation fingerprint for aluminium in Bassendean Ellenbrook sand presented in Figure 18 are:

- Predicted free aluminium concentrations of approximately 1 mg/L for leachates with pH values less than 5 (at L/S = 10), well above the ANZECC 2000 guideline for protection of freshwater ecosystems 0.055 mg/L (Table 1).

- Substantial proportions of aluminium are associated with soil organic matter, both in soluble (DOC-bound) and soil matrix (POM-bound).
- As expected, the fraction of aluminium associated with clay minerals increases with the nominal clay content adopted for LeachXS modelling. At the unrealistic value of 10% clay, more than 90% of aluminium is associated with clay between 2.5 and 5 pH units; and
- Under circum-neutral to alkaline conditions, which are not present in natural Bassendean sand profiles, LeachXS predicts formation of mixed calcium-aluminium oxide phases similar to those present in cement and concrete products.

These predictions are not consistent with findings from studies on Bassendean sands and other sandy soils from the southwest of WA[17,21,22], which indicate that most of the low concentrations of aluminium are present in association with soil organic matter or hydrous iron/aluminium oxide coatings of silica sand grains.

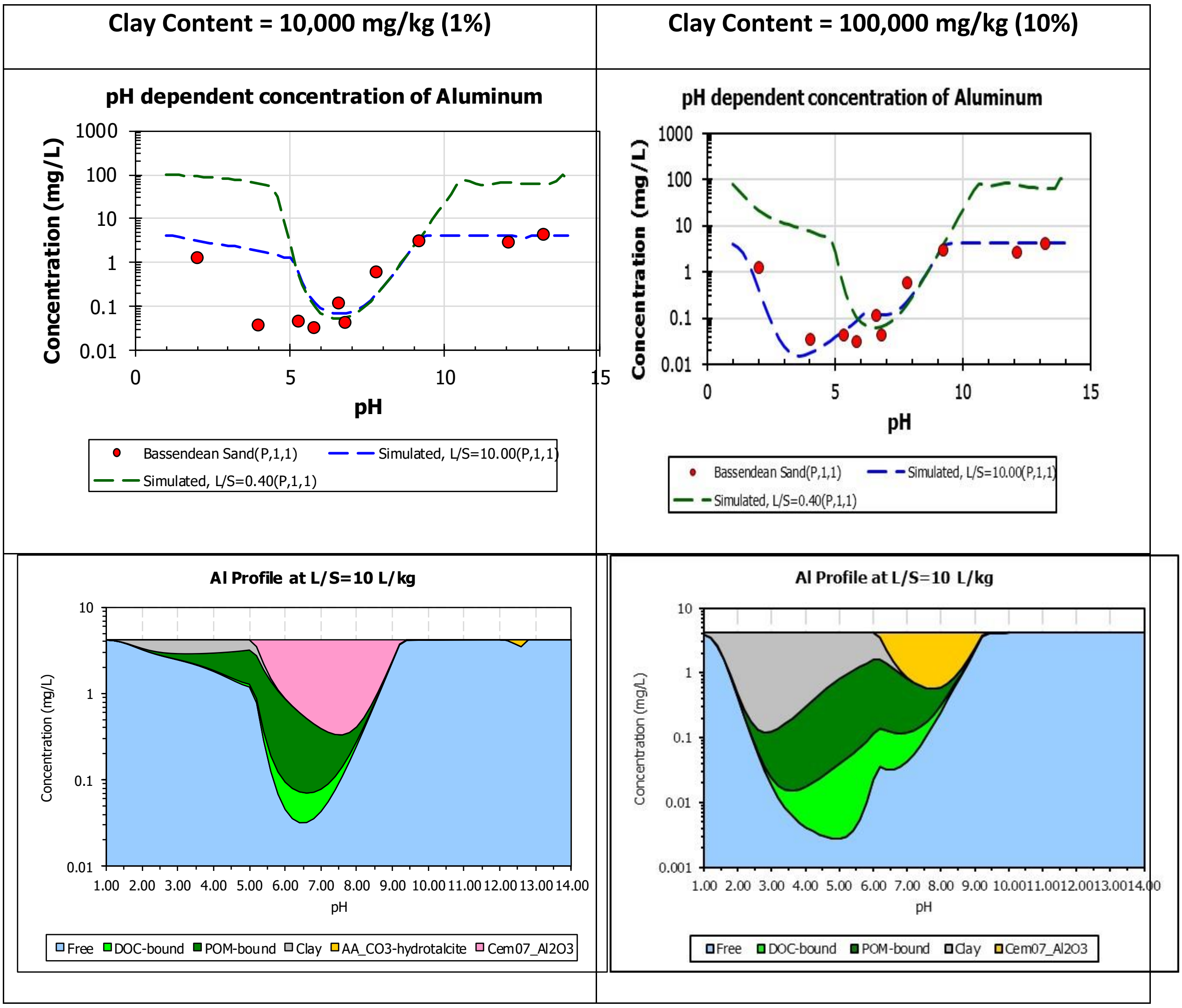


Figure 18: LeachXS Model Output for the Chemical Speciation Fingerprint of Aluminium in Bassendean (Ellenbrook) Sand.

The chemical speciation fingerprint charts for phosphorus are presented in Figure 19 at a clay content of 10% and HFO of 3,450 mg/kg – both of which are considered excessive in comparison to analytical data presented in Table 5 for this soil. Key predictions presented in these charts indicate the following:

- LeachXS predicts very low concentrations of soluble phosphorus (<0.0001 mg/L at L/S =10) between 2 and 7 pH units. This prediction is not consistent with Method 1313 experimental data, tall column leachate quality (Section 5.2.4.1) and Ellenbrook field trial results; and
- LeachXS predicts that most of the phosphorus in Bassendean Ellenbrook sand is associated with the FeOxide-bound soil phase. Note however that the nominal value of 3,450 mg/kg for HFO is much higher than the experimentally derived value of 100 mg/kg. The corresponding chart in Appendix A9 indicate much lower proportions of this fraction (and correspondingly higher values of “free” (leachable) phosphate).

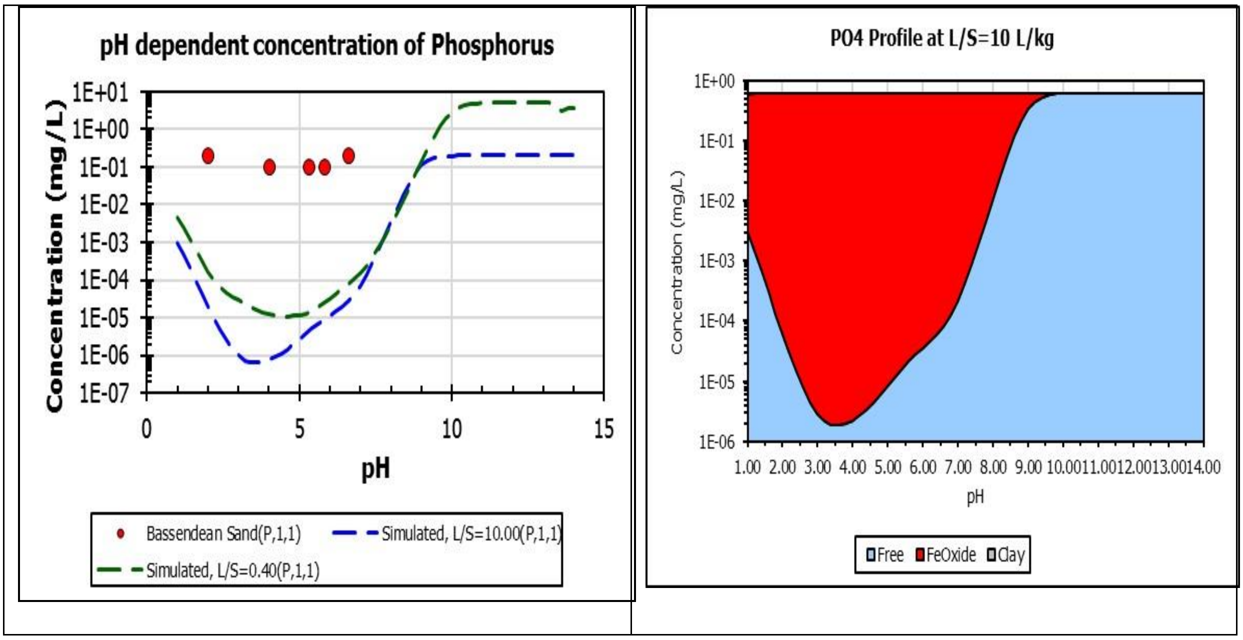


Figure 19: LeachXS Model Output for the Chemical Speciation Fingerprint of Phosphorus in Bassendean (Ellenbrook) Sand.

Values used to generate the chemical speciation fingerprints for Bassendean (Ellenbrook) sand presented in Appendix A9 were:

- pH; 6.1 (natural pH).
- Clay; 1% (experimental value).
- HFO; 100 mg/kg (oxalate extraction)
- SHA; 1,500 mg/kg (same ratio to TOC as for Alkaloam)
- pE; 8 (calculated from pH + pE ~ 14).

These values were also used to derive the chemical speciation fingerprints for the “virtual materials” corresponding to 5% blends of Alkaloam (Section 5.4.1.3.1) and IMG (Section 5.3.1.4), and subsequent solute transport modelling for these materials and Jandakot groundwater residue (Section 5.5.1.5).

5.2.5 Laboratory Data

5.2.5.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A control was performed in the tall column experiment by using soil at the top 10 cm layer.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the soil layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A1-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the “control” columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations from the flushed column samples were below the “lower threshold” values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 7), some of these are discussed in Section 5.2.5.2.

In many cases, it is observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Table 6: Tall Column Study – Analyte Concentration Threshold Values.

Analyte	Units	Lower Threshold	Upper Threshold
pH	pH units	4.5[1]	8.5[1]
Salinity, as EC	µS/cm	300[1]	1500[1]
DOC	mg/L	100[8]	300[9]
Al	mg/L	0.055[2]	0.55[3]
As	mg/L	0.024[2](trivalent)	0.01[5]
B	mg/L	0.37[2]	4[5]
Ba	mg/L	2[5]	20[7]
Cd	mg/L	0.0002[2]	0.002[5]
Co	mg/L	0.0014[2] (low reliability)	0.05[6]
Cr	mg/L	0.001[2] (hexavalent)	0.05[5] (hexavalent)
Cu	mg/L	0.0014[2]	0.014[3]
F	mg/L	1.5[4]	15
Mn	mg/L	1.9[2]	5[7]
Mo	mg/L	0.0034[2] (low reliability)	0.05[5]
Ni	mg/L	0.011[2]	0.02[5]
P	mg/L	0.06[1]	0.6[3]
Pb	mg/L	0.0034[2]	0.01[5]
SO_4	mg/L	1000[4]	-
Se	mg/L	0.011[2]	0.1[3]
U	mg/L	0.017[5]	0.17[7]
V	mg/L	0.1[6]	0.2[4]
Zn	mg/L	0.008[2]	3[7]

Notes:

[1] ANZECC 2000, physical and chemical stressor for southwest WA wetlands
[2] ANZECC 2000
[3] 10x ANZECC 2000 value
[4] ANZECC 2000 livestock drinking water
[5] Australian drinking water guidelines
[6] ANZECC 2000 long-term irrigation water guideline
[7] Non-potable groundwater use
[8] Slightly discoloured water
[9] Highly discoloured water

5.2.5.2 Potential for mobilisation of specific constituents from soils

Using Table 7 as a guide, the potential for mobilisation of specific constituents from soils are summarised below.

In their "natural" state, seepage from the four soils selected for the study is predicted to contain concentrations of certain constituents with potential to impact environmental receptors in very close proximity to the surface soil. Potential constituents from soil include:

- Aluminium at concentrations exceeding the ANZECC freshwater aquatic guideline of 0.055 mg/L (Table 7) for two Bassendean soils and the duplex soil. Geochemical modelling of leachates (PHREEQC and LeachXS) predict most of the aluminium in soil extracts is associated with DOC, which is considered to be less toxic to sensitive receptors (such as plants and fish) than the free hydrated ion;
- Copper and zinc in the three fertilised soils, which is attributed to the presence of trace element fertiliser residues. The alkaline, unfertilised Spearwood sand did not leach significant concentrations of these metals;
- Slightly elevated concentrations of soluble chromium above the ANZECC guideline for hexavalent chromium (0.001 mg/L[1]) were present in leachates of Bassendean Joel and duplex soil samples (information obtained from the solution speciation module of LeachXS). However, the predicted form of soluble chromium is DOC-bound trivalent chromium, which is far less toxic than the hexavalent form; and
- Leachates from both Bassendean soil samples, and to a lesser degree the duplex soil, contain elevated concentrations of phosphorus. As discussed in Section 3, a need to reduce phosphorus leaching potential from sandy soils on the Swan Coastal Plain is a major driver for the need to evaluate by-products as potential soil amendments.

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[1] Note that trigger value for certain metals and metalloids have changed as a result of the ANZECC and ARMCANZ 2000 water quality guidelines being updated in 2018 (ANZG 2018). The revised trigger value for hexavalent chromium in slightly to moderately disturbed freshwater aquatic ecosystems has been reduced to 0.0004 mg/L (0.4 µg/L).

Table 7: Tall Column Leachate Analysis Summary – Soil Samples.

Analyte	**Control Soils**			
	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩
TDS/EC	🟩	🟩	🟩	🟩
DOC	🟩	🟩	🟩	🟩
Al	🟧	🟧	🟥	🟩
As	🟩	🟩	🟩	🟩
B	🟧	🟧	🟩	🟧
Ba	🟩	🟩	🟩	🟩
Cd	🟩	🟩	🟩	🟩
Co	🟩	🟩	🟧	🟩
Cr	🟩	🟧	🟧	🟩
Cu	🟧	🟧	🟧	🟩
Mn	🟩	🟩	🟩	🟩
Mo	🟩	🟩	🟩	🟧
Ni	🟩	🟩	🟩	🟩
P	🟥	🟥	🟧	🟩
Pb	🟩	🟩	🟩	🟩
SO_4	🟩	🟩	🟩	🟩
Se	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩
Zn	🟧	🟧	🟧	🟧

Note: Level of potential environment risk, based on threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.3 Example 1: How LEAF Can Be Used to Assess an Iluka By-product - Ironman Gypsum®

5.3.1 By-product Ironman Gypsum® (IMG) Characterisation

Iluka produces high grade synthetic rutile by processing ilmenite ore using a modified Becher process. This process removes iron coatings from ilmenite sand grains. In the final stages of the process the synthetic rutile is washed with sulfuric acid to remove iron and manganese impurities.

The iron-rich acid leach leach solution is neutralised by alkali addition, which results in precipitation of soluble iron, manganese, sulfate and minor constituents as hydrous iron and manganese oxides and sulfate minerals. The resulted precipitated residue is used as a re-use by-product with trade name Ironman Gypsum® (IMG).

Analysis of an earlier sample of IMG by CSIRO[19] indicated a composition of primarily gypsum ($CaSO_4.2H_2O$), with lesser quantities of magnetite/maghemite (Fe_3O_4/ϒ-Fe_2O_3), quartz and bassanite ($CaSO_4.½H_2O$). Geochemical analysis also showed that the IMG contained substantial Fe_2O_3 (present as poorly crystalline hydrous Fe-oxides not detected using X-Ray Diffraction) in addition to CaO and SO_3, both present in gypsum.

Results for analysis of the sample of IMG provided by Iluka for this study are presented in Table 8.

Table 8: Iluka By-product Ironman Gypsum® (IMG) Characterisation Data.

Element	LOR	Units	IMG
Ag	0.5	mg/kg	<0.5
Al	100	mg/kg	2500
As	3	mg/kg	8.00
Ba	5	mg/kg	32.0
Be	0.5	mg/kg	<0.5
Ca	50	mg/kg	151000
Cd	1	mg/kg	<1
Co	1	mg/kg	153
Cr	10	mg/kg	85.0
Cu	5	mg/kg	37.0
Fe	100	mg/kg	142000
K	100	mg/kg	630
Mg	20	mg/kg	5900
Mn	5	mg/kg	26500
Mo	5	mg/kg	<5
Na	50	mg/kg	60.0
Ni	5	mg/kg	64.0
P	20	mg/kg	260
Pb	5	mg/kg	105
S	20	mg/kg	109000
Sb	2	mg/kg	<2
Se	10	mg/kg	<10

Element	LOR	Units	IMG
Sn	2	mg/kg	8.00
Ti	10	mg/kg	19700
Th	10	mg/kg	115
U	10	mg/kg	<10
V	1	mg/kg	70.0
Zn	5	mg/kg	71.0
Tl	0.1	mg/kg	0.20
B	20	mg/kg	<20
Hg	0.1	mg/kg	<0.1
Cl	25	mg/kg	<50
F	25	mg/kg	<25
LOI	-10	%	<0.1
TOC	0.05	%	<0.05
$H_2 0$	0.1	%	13.00
Si	0.01	%	1.98

Note; LOR-limit of reporting; IMG-Ironman Gypsum®; LOI-loss of ignition; TOC-total organic carbon

5.3.2 LEAF Tests 1313, 1314 and 1316

5.3.2.1 LEAF 1313 Test

Results for analysis of IMG are presented as graphs in Appendix A5-3. Characteristics of the pH dependent leaching characteristics by analyte for this material are summarised as follows:

Silver: Apart from one slightly elevated value (approximately 0.0008 mg/L) IMG at pH 8, concentrations were extremely low and did not vary with pH.

Aluminium: IMG indicated characteristic amphoteric behaviour for aluminium, with elevated concentrations at both very low and very high pH values. The pH value for minimum solubility was between 7 and 8 pH units.

Arsenic: In general, the highest arsenic concentrations were recorded at the higher pH values, although solubility at low pH (2 and 4) was higher than those at circum-neutral values. The solubility minima were between 6 and 8 pH units.

Boron: Boron concentrations were low and indicated very little dependence with leachate pH.

Barium: Leachate concentrations were typically <0.01 mg/L at leachate pH values above 7. Barium concentrations increased with decreasing pH.

Beryllium: Concentrations of extractable beryllium were very low (0.0001 mg/L) at pH values above 6 but increasing with increasing acidity below pH 6.

Calcium: Concentrations of extractable calcium decreased slightly with increasing pH, with leachate concentrations ranging from approximately 2,000 mg/L at pH 2 to 800 mg/L at pH 13. The measured concentrations and pH-dependent behaviour are consistent with dissolution of gypsum.

Cadmium: Concentrations of extractable cadmium very low, ranging between 0.001 and 0.0001 mg/L within the pH range of 5 to 11, with higher concentrations (maximum 0.003 mg/L) at low pH.

Cobalt: IMG recorded elevated cobalt concentrations, notably at low pH (>5 mg/L at pH 2). Much lower concentrations (<0.0001 mg/L) were recorded in alkaline (pH >8) leachates.

Chromium: Elevated chromium concentrations (>0.1 mg/L) were recorded at both very low and very high pH values. Much lower concentrations were recorded for leachates with pH values between 6 and 8.

DOC: Very low DOC concentrations (approximately 1 mg/L) were shown at all pH values.

Copper: Copper leachates indicated characteristic amphoteric behaviour. The pH minimum for copper solubility was approximately at 6 pH.

Fluoride: Fluoride leaching was relatively constant (approximately 0.2 mg/L) across the pH range.

Iron. IMG recorded consistent iron concentrations of approximately 0.01 mg/L between pH 4 and 12. Very high values (>10 mg/L) of soluble iron were recorded at very low pH.

Mercury: Apart from minor anomalous concentrations between 0.0001 and 0.001 mg/L, most mercury concentrations were <0.0001 mg/L across the pH range.

Potassium: Potassium concentrations were similar and consistent (approximately 5 – 10 mg/L) for pH values below 8. Higher concentrations at pH >8 were an analytical artefact arising from use of KOH to adjust leachate alkalinity.

Magnesium: Magnesium leaching characteristics were similar to those described earlier for calcium, i.e. maximum solubility at low pH with concentrations decreasing with increasing leachate alkalinity (to <0.005 mg/L at pH >10).

Manganese: Leachate concentrations decreasing with increasing pH. IMG showed leachate concentrations exceeding 10 mg/L for pH values below 6.

Molybdenum: Leachate concentrations were very low at low pH but increased with increasing pH at values greater than 6.

Sodium: As expected for a conservative ion such as sodium, leachate concentrations did not vary with pH. IMG released very little soluble sodium (typically <5 mg/L).

Nickel: Nickel was similar to cobalt in that IMG recorded elevated concentrations (>0.5 mg/L at low pH, but much lower concentrations under circum-neutral and alkaline conditions.

Phosphorus: Phosphorus concentrations were low (<0.1 mg/L) in all leachates.

Lead: Lead was not leached at elevated concentrations. Concentrations in circum-neutral and alkaline leachates were generally below the reporting limit (<0.0002 mg/L). Values of approximately 0.01 mg/L were recorded in the most acidic leachates (pH 2).

Sulfur: The pH dependence curves for sulfur indicated concentrations of approximately 700 to 800 mg/L between 4 and 10 pH units, and slightly higher concentrations at pH 2 and pH >10.

Antimony: Concentrations of antimony in leachates were at or below the limit of detection (<0.0001 to <0.001 mg/L) at all pH values.

Selenium. Selenium concentrations in IMG leachates were low and not pH dependent.

Silicon: Silicon concentrations were variable and decreased with increasing pH. The maximum concentration was 100 mg/L at pH 2, while the minimum concentration was 0.2 mg/L at pH 12.

Tin: Tin concentrations were at or below the method reporting limit between pH values of 6 and 11.

Titanium: Titanium concentrations were below the method report limits at all but the most acidic pH (pH 2). Concentrations in pH 2 leachates ranged from 0.006 to 0.009 mg/L, which is consistent with the depletion of titanium-containing minerals in this process residue stream.

Thallium: Thallium concentrations in all leachates were below the method reporting limit (0.0001 mg/L)

Uranium: Uranium concentrations in leachates of IMG were 0.01 to 0.02mg/L over the pH interval of 4 to 10. Higher concentrations (approximately 0.2 mg/L) were recorded in pH 2 leachates.

Vanadium: Concentrations in IMG leachates were below the method reporting limit across the pH range.

Zinc: IMG contained elevated concentrations (concentrations (0.1 to 0.3 mg/L) of zinc in pH 2 leachates. Concentrations decreased with increasing pH up to pH 12.

Results from the LEAF Method 1313 were used to identify constituents of potential concern (CoPC) in IMG based on methodology discussed in a document published by the US-EPA in October 2017 (refer also to Section 4.11). This methodology is based on LEAF test results for:

- The Available Content, defined as the maximum concentration at end-point eluate pH values of 2, 9 and 13.
- The maximum eluate concentration over the defined “applicable scenario pH domain”. For application of IMG as a soil amendment of Swan Coastal Plain sandy soils, the applicable scenario pH domain was considered to be 5.5 to 9.0 pH units.

The adopted methodology is summarised as follows:

- Calculate the leachate concentrations based on:
    - Available Content (mg/kg) or;
    - Applicable scenario pH domain (mg/kg);
    - L/S ratio of 10 (for Method 1313);
    - Dilution and Attenuation Factor (DAF) using a non-specific nominal value of 10, which accounts for reduced concentrations between the leachate source (i.e leaching from IMG) and the point of compliance in the receiving

environment (which may be down-gradient groundwater or a surface waterbody, depending on location); and

- Upper and lower threshold constituent values listed in Table 6, for assessment of soil leachate concentrations from the tall column study (Section 5.2.4).

Analytes where all concentrations were below the “lower threshold” values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 9), some of these are discussed below.

It is important to note that this approach to risk screening is based on that used in Europe and elsewhere mainly for materials stored as waste, and not for beneficial re-use as soil amendment products. Factors such as intended application rates and interaction of product constituents with soil (both mobilisation and attenuation) have not been considered. In effect, this method provides a first pass, high level assessment of constituents of potential concern that require further evaluation, as discussed in subsequent sections.

Table 9: Risk Screening Profile Table for CoPCs from LEAF Test Data – IMG.

Constituent of Potential Concern	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟧	🟧
DOC		🟩	🟩
Al	740	🟧	🟨
As	0.69	🟩	🟩
B	3.4	🟩	🟩
Ba	2.3	🟩	🟩
Cd	0.03	🟨	🟩
Co	15	🟧	🟨
Cr	6.6	🟧	🟨
Cu	16	🟧	🟩
Mn	4,200	🟧	🟧
Mo	0.43	🟨	🟩
Ni	35	🟧	🟧
P	<0.01	🟩	🟩
Pb	0.13	🟩	🟩
SO_4	56,800	🟩	🟩
Se	<0.001	🟩	🟩
U	0.7	🟩	🟩
V	<0.001	🟩	🟩
Zn	12	🟨	🟩

Note: Level of potential environment risk, based on threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Based on these results, IMG constituents that may leach at potentially environmentally significant concentrations under typical soil pH conditions (pH 5.5 to 9), as predicted by LEAF Method 1313 data, are summarised (in no particular order of risk) as follows:

- Aluminium.
- Cobalt.
- Chromium.
- Manganese.
- Nickel.
- Salinity (as calcium and sulfate).

In addition, LEAF 1313 data suggests that cadmium, copper, molybdenum and zinc may leach at elevated concentrations at very low pH conditions (pH 2 to 4).

5.3.2.2 LEAF Test Results, Methods 1314 and 1316, L/S Dependence

Results for analysis of by-products (IMG) using method 1314 (up-flow percolation) are presented as charts in Appendix A6-3. Corresponding results using method 1316 (batch equilibration) are presented in Appendix A7-3.

For most analytes present in measurable concentrations, leachate concentrations usually decrease with increasing L/S ratio. This observation is indicative of “solute wash out” behaviour, that is a substantial proportion of each solute occurs in “free” form, and not associated with a specific mineral phase (other than association with dissolved organic carbon).

The other type of leachate behaviour occurs in the presence of sparingly soluble mineral phases, which form saturated solutions containing comparable analyte concentrations at all L/S ratios. Results presented for calcium and sulfate in Figures 21 and 22 provide an example of mineral control for dissolution of these constituents (most likely as gypsum, $CaSO_4.2H_2O$).

Results presented in Appendix A6-3 indicate typically leachate concentrations between these two types of solute behaviour. Analytes indicating predominantly ‘conservative ion’ behaviour include bromide, chloride, sodium and potassium, regardless of material type. Analytes indicating predominantly ‘sparingly soluble mineral phase’ behaviour include barium, silicon, fluoride and importantly calcium and sulfur in IMG (which contains gypsum as the principal constituent), Figures 20 and 21.

Many analytes demonstrate behaviour between these type extremes. This behaviour is likely to occur when other processes affect solute behaviour, such as:

- Ion exchange reactions, particularly with clay and humic phases.
- Surface adsorption to variably charged amorphous mineral phases, especially hydrous ferric, aluminium and manganese oxides (collectively referred to as “hydrous ferric oxides – HFO”).
- Changes in leachate pH in response to increasing L/S ratio.
- Changes in ionic strength (salinity) of leachate, which decreases with increasing L/S of materials containing significant amounts of soluble salts.
- Changes in leachate concentrations of solutes capable of forming stable complexes with metal ions as a function of L/S, especially dissolved organic carbon, and also ions including fluoride, sulfate and phosphate.

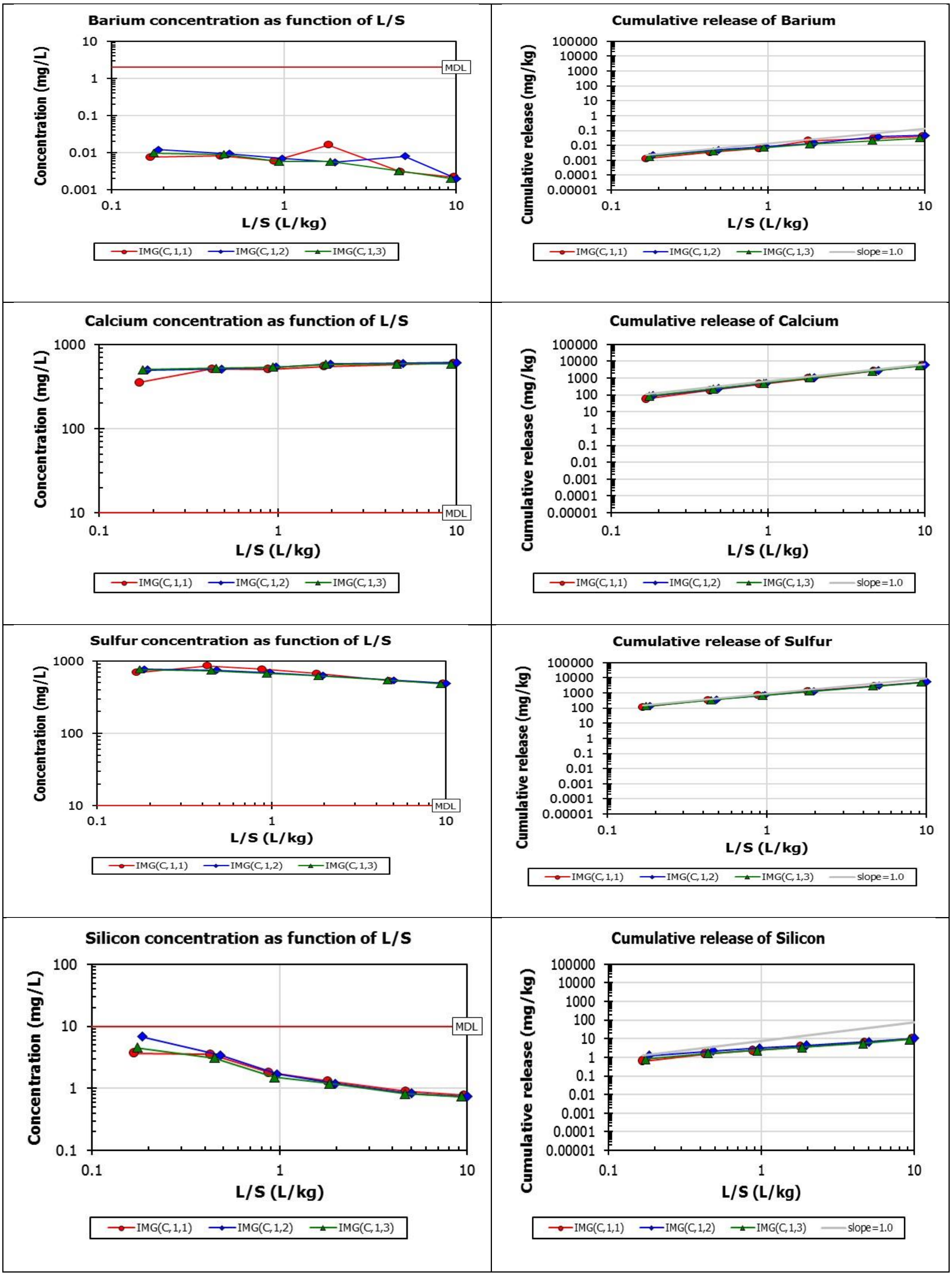


Figure 20: Barium, calcium, sulfur and silicone Concentrations in Leachates of IMG as a Function of L/S (Method 1314).

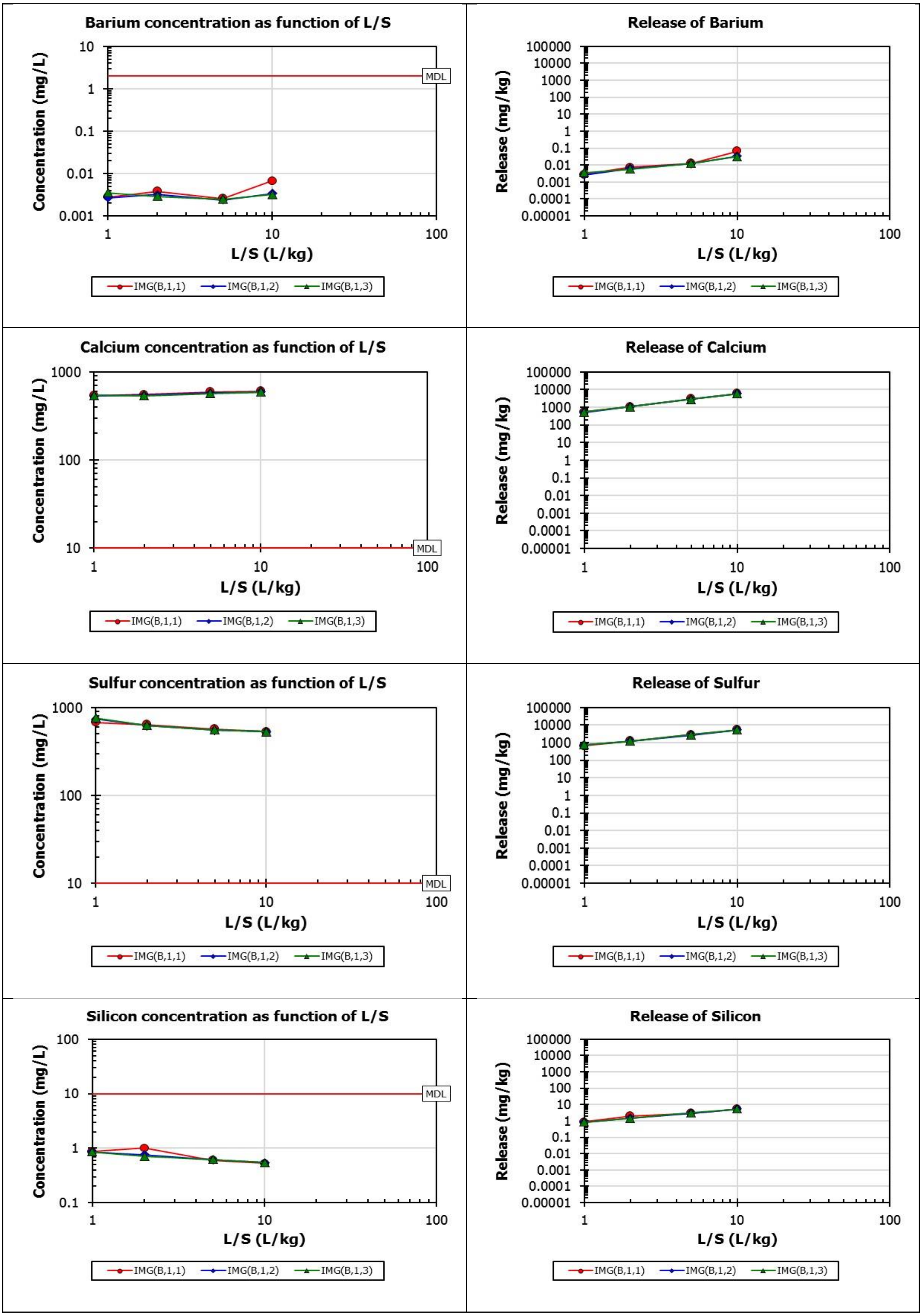


Figure 21: Barium, calcium, sulfur and silicone Concentrations in Leachates of IMG as a Function of L/S (Method 1316).

5.3.3 LeachXS material characterisation and Chemical Speciation Fingerprints

LeachXS is a computer software package that supports LEAF test data management by:

- Graphical and tabular presentation of data;
- Statistical analysis of data;
- Providing a tool for quality control;
- Chemical speciation analysis, i.e. identifying key mineral phases that control the dissolution/precipitation over the pH range of 2 to 13; and
- Scenario modelling, such a solute transfer from single stream by-products, blends of different by-product materials, or blends of by-products and soil.

This Section presents results obtained from LeachXS modelling to create geochemical speciation “fingerprints” of IMG. LeachXS uses the following information to generate the geochemical “fingerprint”:

- pH dependence (Method 1313) leachate analysis data.
- The relationship between leachate pH and the amount of acid or alkali added, i.e. the material’s pH titration curve.
- Dissolved humic acid (DHA) content in each leachate, which is calculated as a fraction of dissolved organic carbon (typically 20% to 40%). DHA has the capacity to form soluble complexes with many transition metals, notably copper, cadmium, nickel and lead.
- Clay content (mg/kg). Clay minerals have a net negative charge, which results on solid phase interactions with cationic species.
- Hydrous ferric oxide (HFO). These materials, which include hydrous aluminium and manganese oxides, have very high surface areas and variable surface charge (which is pH dependent). They can therefore retain anionic species by surface adsorption at low pH and cationic species by surface adsorption at high pH.
- A thermodynamic database containing data for oxide, carbonate, silicate, sulfide and DHA mineral phases of potentially environmentally significant metals and metalloids. Minteq version 4 was used as the thermodynamic database for this study.
- Initial pH and pE (redox potential) values. The pE values were estimated from a “rule of thumb” relationship (Equation 1)[18] applied for LeachXS modelling in the absence of reliable experimental data.

Equation 1 $\quad pH + pE \sim 14$

Table 10 shows the nominal values applied for fingerprinting of each test material and Table 11 lists some of the key mineral phases adopted for the chemical speciation fingerprint models using LeachXS.

Table 10: Input Parameters for LeachXS Geochemical Speciation Modeling for IMG and Bassendean Sand. Note: "nominal" means estimated, not measured.

Material	**pH (pH units)**	**pE (pE units)**	**Solid HA (mg/kg)**	**Clay (mg/kg)**	**HFO (mg/kg)**
IMG	7.7 (natural pH)	10 (nominal)	50 (nominal, TOC below LOR)	3,000 (based on Al content)	8,400 (nominal)
Bassendean Ellenbrook	6.1 (natural pH)	8 (nominal)	1500 (nominal)	10,000 (measured)	100 (measured)

Table 11: Mineral Phases Adopted for Chemical Speciation Fingerprint Models using LeachXS.

Mineral Phase	**Formula**	**Function**
Calcite	$CaCO_3$	pH buffering, calcium dissolution
Dolomite	$CaMg(CO_3)_2$	pH buffering, calcium and magnesium dissolution
Magnesite	$MgCO_3$	pH buffering, magnesium dissolution
Brucite	MgO	Magnesium dissolution
Gypsum	$CaSO_4.2H_2O$	Calcium and sulfur (sulfate) dissolution
Gibbsite	$Al(OH)_3$	Aluminium dissolution
Boehmite	AlO(OH)	Aluminium dissolution
Kaolinite	$Al_2Si_2O_5(OH)_4$	Aluminium and silicon dissolution
Ferrihydrite	"$Fe(OH)_3$"	Iron dissolution
Goethite	FeOOH	Iron dissolution
Hematite	Fe_2O_3	Iron dissolution
Siderite	$FeCO_3$	Iron dissolution
Strengite	$FePO_4$	Iron and phosphorus dissolution
Fluorite	CaF_2	Calcium and fluoride dissolution

Mineral Phase	Formula	Function
Albite	$NaAlSi_3O_8$	Aluminium, sodium and silicon dissolution
Ettringite	$Ca_6Al_2(SO_4)_3(OH)_{12}.26H_2O$	Calcium, aluminium and sulfate dissolution
Barite	$BaSO_4$	Barium and sulfate dissolution
Witherite	$BaCO_3$	Barium dissolution
Strontianite	$SrCO_3$	Strontium dissolution
Celestite	$SrSO_4$	Strontium dissolution
Manganite	$MnO(OH)$	Manganese dissolution, redox potential
Rhodocrosite	$MnCO_3$	Manganese dissolution, redox potential
Hausmannite	Mn	Manganese dissolution, redox potential
Quartz	SiO_2	Silicon dissolution
Chalcedony	SiO_2	Silicon dissolution
Halloysite	SiO_2	Silicon dissolution
Wulfenite	$PbMoO_4$	Lead and molybdenum dissolution
Tenorite	CuO	Copper dissolution
Smithsonite	$ZnCO_3$	Zinc dissolution
Zinc hydroxide	$Zn\ (OH)_2$	Zinc dissolution
Nickel hydroxide	$Ni\ (OH)_2$	Nickel dissolution
Bunsenite	NiO	Nickel dissolution
Tricalcium phosphate	$Ca_3(PO4)_2$	Calcium and phosphorus dissolution
Carnotite	$K_2(UO_2)_2(VO_4)_2\cdot 3H_2O$	Uranium dissolution

5.3.3.1 Ironman Gypsum® (IMG)

Discussion in this section focuses on three of the constituents of IMG that were identified in Section 5.3.2.1 with potential for (site-specific) environmental impacts; manganese, chromium and sulfate (as salinity). Copper is also included in this discussion as it provides a good example of the LeachXS capacity for providing chemical speciation fingerprints.

The chemical speciation fingerprint charts for manganese are presented in Figure 22. Key predictions presented in these charts indicate the following:

- LeachXS modelling provides a reasonable description of the solubility of manganese under acidic (pH <6) conditions, but under-estimates solubility at high pH (>8 pH units);
- Manganese behaves predominantly as a conservative soluble species at low pH (pH <6), with increasing mineral phase solubility control under alkaline conditions;
- "Free" manganese is the exclusive phase at low pH (<6 units) and at L/S = 10. Although not included in LeachXS predictions (although suggest capability exists), most of the soluble manganese is expected to be present as the divalent ion (Mn^{2+});
- DOC-bound manganese is the dominant form of soluble manganese at high pH, although concentrations of soluble manganese are predicted to be very low (<0.00001 mg/L at pH 12 and L/S = 10);
- The solid phase present at alkaline pH values consists mainly of the oxide mineral pyrolusite, MnO_2 in which manganese is present in the tetravalent state (at pE = 10). At lower pE (pE = 6, chart not shown), another manganese oxide, manganite, MnOOH, in which manganese is present in the trivalent state, was predicted to be the stable mineral in this pH/pE domain. Manganese associated with iron oxide phases is a secondary component; and
- At very high pH (>13 pH units), a solid mineral phase designated at "ettr_ss" is predicted to form. This is related to the mineral ettringite (hydrated $Ca_6Al_2(SO_4)_3(OH)_{12}$) by partial substitution of aluminium by trivalent manganese (or calcium by divalent manganese).

It is important to note that other stable manganese minerals, such as psilomelane, $Ba(Mn^{2+})(Mn^{4+})_8O_{16}(OH)_4$, or birnessite, $(Na_{0.3}Ca_{0.1}K_{0.1})(Mn^{4+},Mn^{3+})_2O_4.1.5\ H_2O$) were predicted to be stable under the nominal redox conditions (pE = 10) adopted for the LeachXS model. These minerals, which are common constituents of manganese ore in WA, are stable under oxic conditions.

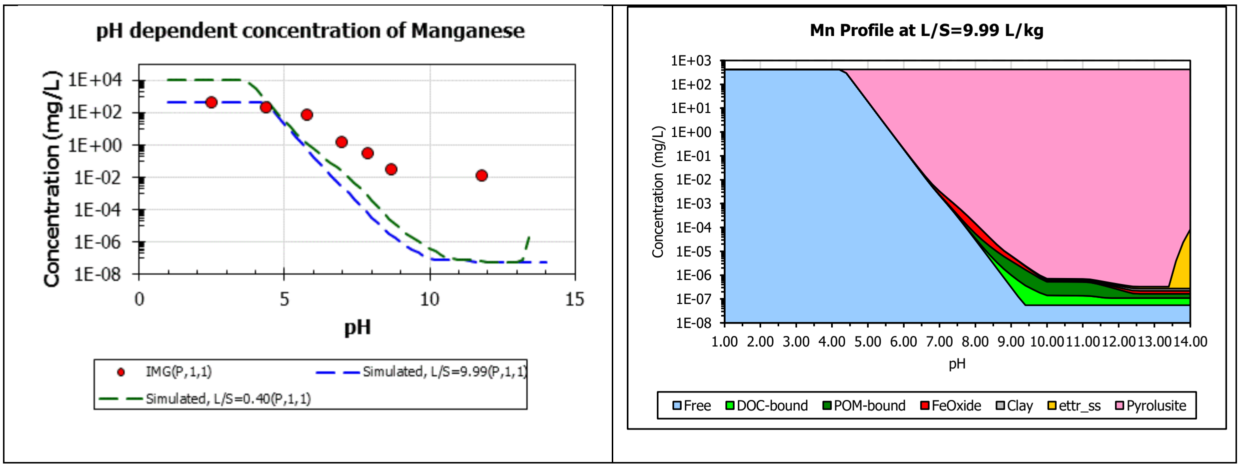


Figure 22: LeachXS Model Output for the Chemical Speciation Fingerprint of Manganese in IMG.

The chemical speciation fingerprint charts for chromium in IMG are presented in Figure 23. Key predictions presented in these charts indicate the following:

- LeachXS modelling provides a reasonable description of the solubility of chromium under acidic and slightly alkaline conditions (pH <8) conditions, but over-estimates the solubility at high pH (>10 pH units);
- Chromium behaves predominantly as a conservative soluble species at very low pH (pH <4), with increasing mineral phase solubility control under alkaline (8 to 10 pH units) conditions;
- "Free" chromium is the exclusive phase at low pH (<3 units) and high pH (>10 pH units) at L/S = 10. Although not included in these LeachXS predictions, most of the soluble chromium is expected to be present as the trivalent ion (Cr^{3+}) in acidic conditions and varying proportion of trivalent ($Cr(OH)_4^-$) and hexavalent (CrO_4^{2-}) oxyanions at high pH, depending on redox (pE) conditions (information obtained from the solution speciation module of LeachXS);
- DOC-bound chromium is the dominant form of soluble chromium between pH 4 and 6, with predicted concentrations of approximately 0.01 mg/L (at L/S = 10) in leachates with pH within this range; and
- The dominant solid phase, which represents most of the available chromium within the pH range 4 to 8.5, is that associated with iron oxides.

It is important to note that LeachXS does not include the common chromium mineral chromitite, $FeCr_2O_4$, which is a common, highly stable chromium mineral present in WA soils.

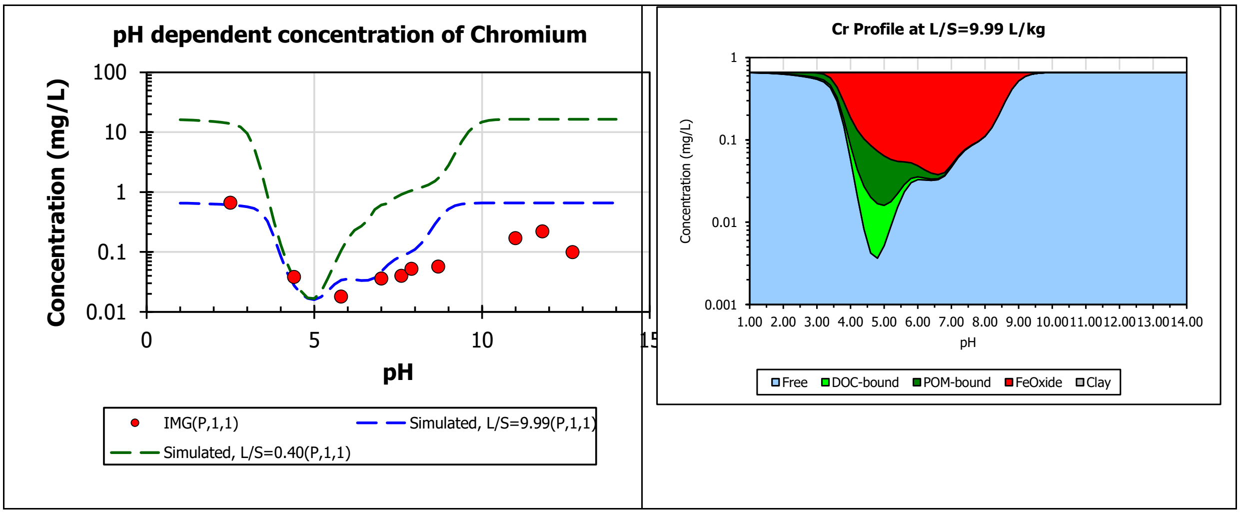


Figure 23: LeachXS Model Output for the Chemical Speciation Fingerprint of Chromium in IMG.

The chemical speciation fingerprint charts for copper (which is not considered as a CoPC in IMG) in IMG are presented in Figure 24. Key predictions presented in these charts indicate the following:

- LeachXS modelling provides a reasonable description of the solubility of copper only under strongly acidic (pH ~2) conditions and overestimates the solubility under slightly acidic, circum-neutral and alkaline conditions;

- Copper behaves predominantly as a conservative soluble species at low pH (pH <4), with increasing mineral phase solubility control with increasing pH, and especially under alkaline (>10 pH units) conditions;

- "Free" copper is the exclusive phase at low pH (<4 units) and very high pH (>13 pH units) at L/S = 10. Although not included in these LeachXS predictions, most of the soluble copper is expected to be present as the divalent hydrated ion (Cu^{2+}) in acidic conditions and the hydroxide complex anion $[Cu(OH)_4]^{2-}$, which is only stable in strongly alkaline solutions. Depending on redox conditions, some copper may be present as the monovalent cuprous ion (Cu^{+}), which is only stable under strongly reducing conditions;

- Most of the dissolved copper in leachates with pH values between 7 and 11 is predicted to be present in association with DOC compounds, at predicted concentrations of approximately 0.01 mg/L (at L/S = 10); and

- Most of the available copper is predicted to apportion to solid phases at pH values between 4 and 13 units. The dominant predicted phase at pH 5 to 9 pH units is copper associated with iron oxide phases. The oxide mineral tenorite (CuO) is predicted to be the dominant mineral phase at leachate pH >9 pH units.

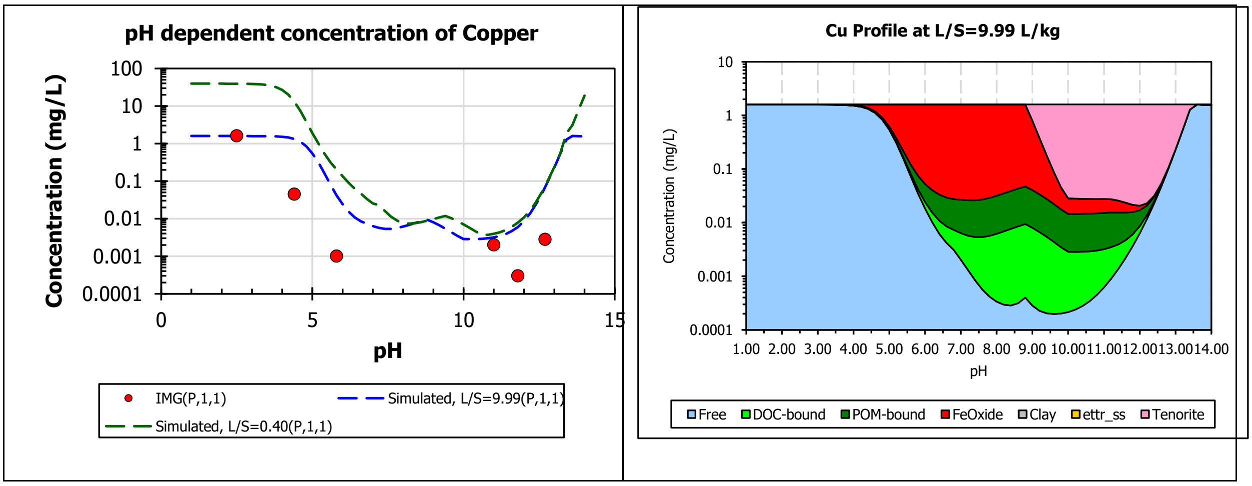


Figure 24: LeachXS Model Output for the Chemical Speciation Fingerprint of Copper in IMG.

The chemical speciation fingerprint charts for sulfate-sulfur in IMG are presented in Figure 25. Key predictions presented in these charts indicate the following:

- LeachXS modelling generally overestimates the solubility of sulfate-sulfur at all pH values, but especially within the range of 8 to 11 pH units;

- Sulfate-sulfur is predicted to behave as a conservative species across the complete pH range;

- At L/S = 10, sulfate-sulfur is predicted to be present mainly in the solid phase as the mineral gypsum, with solution concentrations of approximately 2,000 mg/L; and

- Under alkaline (pH >7) conditions, gypsum is predicted to dissolve with release of its sulfate-sulfur component (with concentrations up to 5,000 mg/L at L/S = 10). This may be explained by the calcium in gypsum precipitating at less soluble carbonate minerals (such as calcite, $CaCO_3$) as the concentrations of carbonate and bicarbonate ions increase with increasing pH.

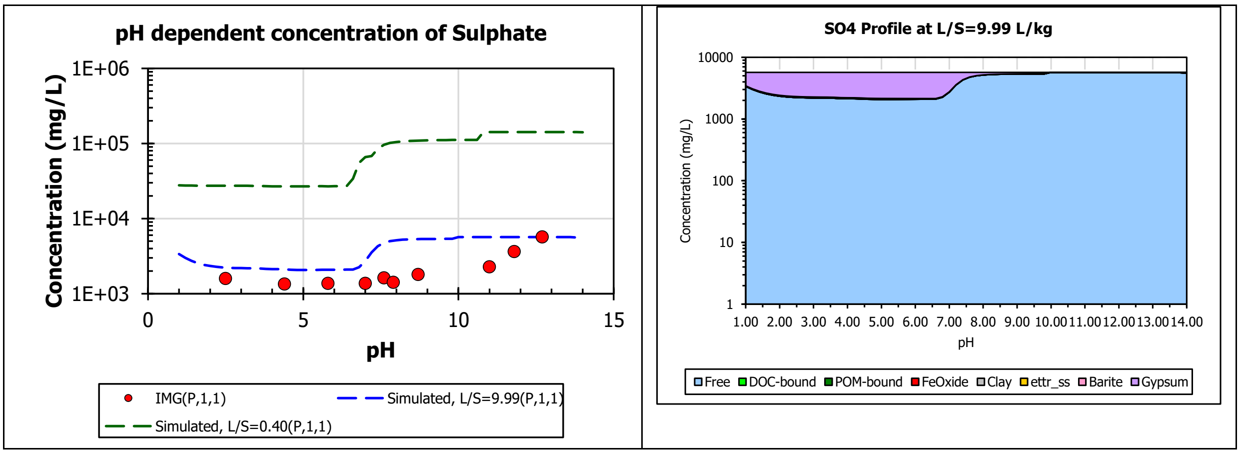


Figure 25: LeachXS Model Output for the Chemical Speciation Fingerprint of Sulfate in IMG.

The Chemical Speciation Fingerprint for aluminium in IMG (Figure 26) predicts the solubity of aluminium in mainly controlled by the clay mineral kaolinite. While IMG may release substantial concentrations of aluminium at very low pH (pH >4) or very high pH (pH >11), the predicted concentrations of dissolved aluminium between pH 6 and 9 is very low (<0.001 mg/L), with substantial contributions of the less toxic DOC-bound form.

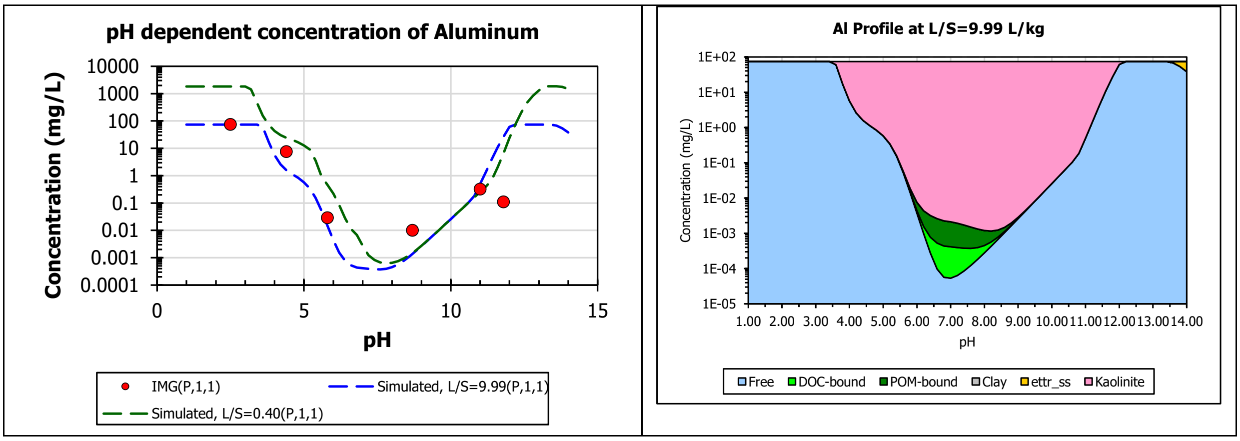


Figure 26: LeachXS Model Output for the Chemical Speciation Fingerprint of Aluminium in IMG.

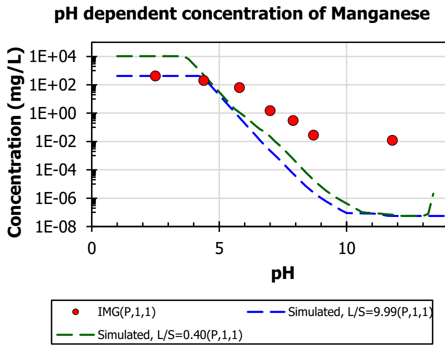
5.3.4.1 Ironman Gypsum® and Bassendean Ellenbrook Soil Blend

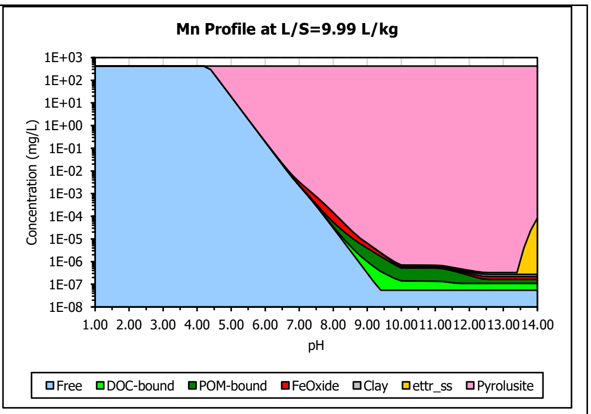
Predicted chemical speciation fingerprints for the virtual material comprising a blend of IMG (5% by weight) with Bassendean Ellenbrook sand are presented in Appendix A10-2. For many analytes, the chemical speciation fingerprints are mainly influenced by the Bassendean Ellenbrook sand component. Exceptions also arise in the case of analytes that are a major component of IMG and a minor component of the soil – as indicated in Figure 27 for manganese and Figure 28 for sulfate. The chemical speciation fingerprint for the blended soil has characteristics of both the natural soil and IMG, which is to be expected given that manganese is a major component of IMG, but only present in trace amounts in Bassendean Ellenbrook soil.

Similarly, the solution and mineral phase concentrations of sulfate in IMG is controlled by dissolution of gypsum; predicted leachate concentrations of sulfate (L/S = 10, pH =7) from IMG is predicted to be approximately 2,000 mg/L up to pH 8 and increases thereafter. Much lower concentrations (approximately 10 mg/L) are predicted in leachates of Bassendean (Ellenbrook) sand over the entire pH range, with only minimal control by solid phases (FeOxide, clay and particulate organic matter, POM). Note that LeachXS does not predict the much lower sulfate concentrations (0.01 to 0.02 mg/L) observed in acidic (pH <6) leachates of Bassendean sand. The chemical speciation fingerprint predicted by LeachXS for the blended soil indicate leachate concentrations (at L/S = 10) of approximately 300 mg/L, which is below solubility control by gypsum. Interestingly, the only discrete solid mineral phase predicted by LeachXS in the blended soil is barite ($BaSO_4$), which was not predicted by LeachXS to occur in either IMG or Bassendean (Ellenbrook) sand.

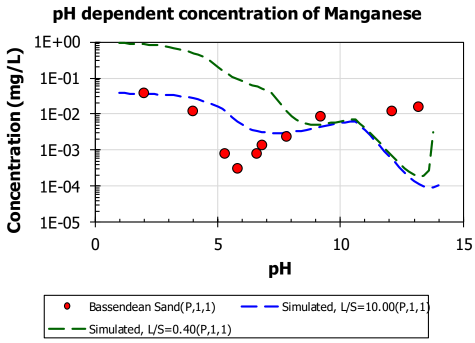
It is important to note that the available content of sulfate was determined to be 56,800 mg/kg (as SO_4), which is based on the maximum solubility of sulfur at L/S ratio. As IMG contains approximately 60% gypsum by weight, the actual available content (assuming complete dissolution of gypsum) is calculated to be 327,000 mg/kg. Therefore, it is expected that the actual available content of sulfur (and calcium) is approximately 5.8 times that calculated by LeachXS from LEAF Method 1313 data (L/S = 10).

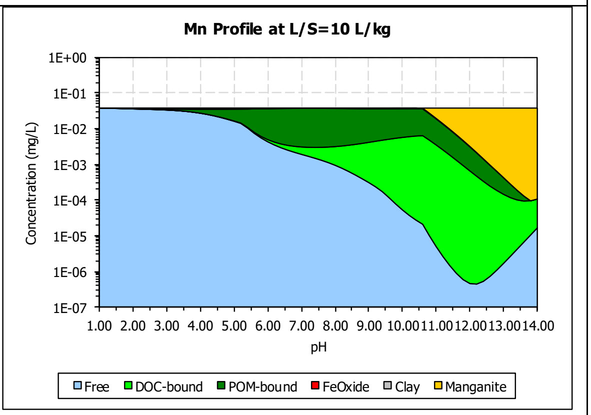
IMG



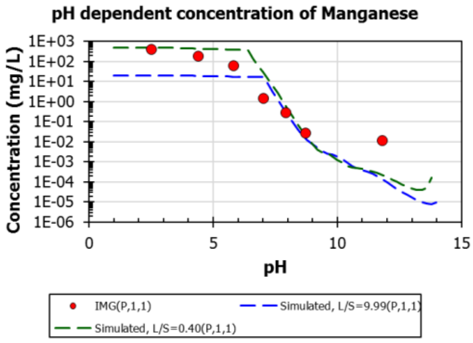


Soil





Blended soil



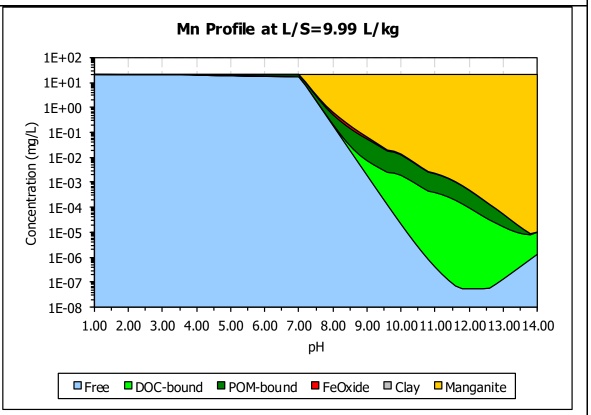


Figure 27: Chemical Speciation Fingerprints for manganese in a virtual material relating to a blend of IMG and Bassendean Ellenbrook sand.

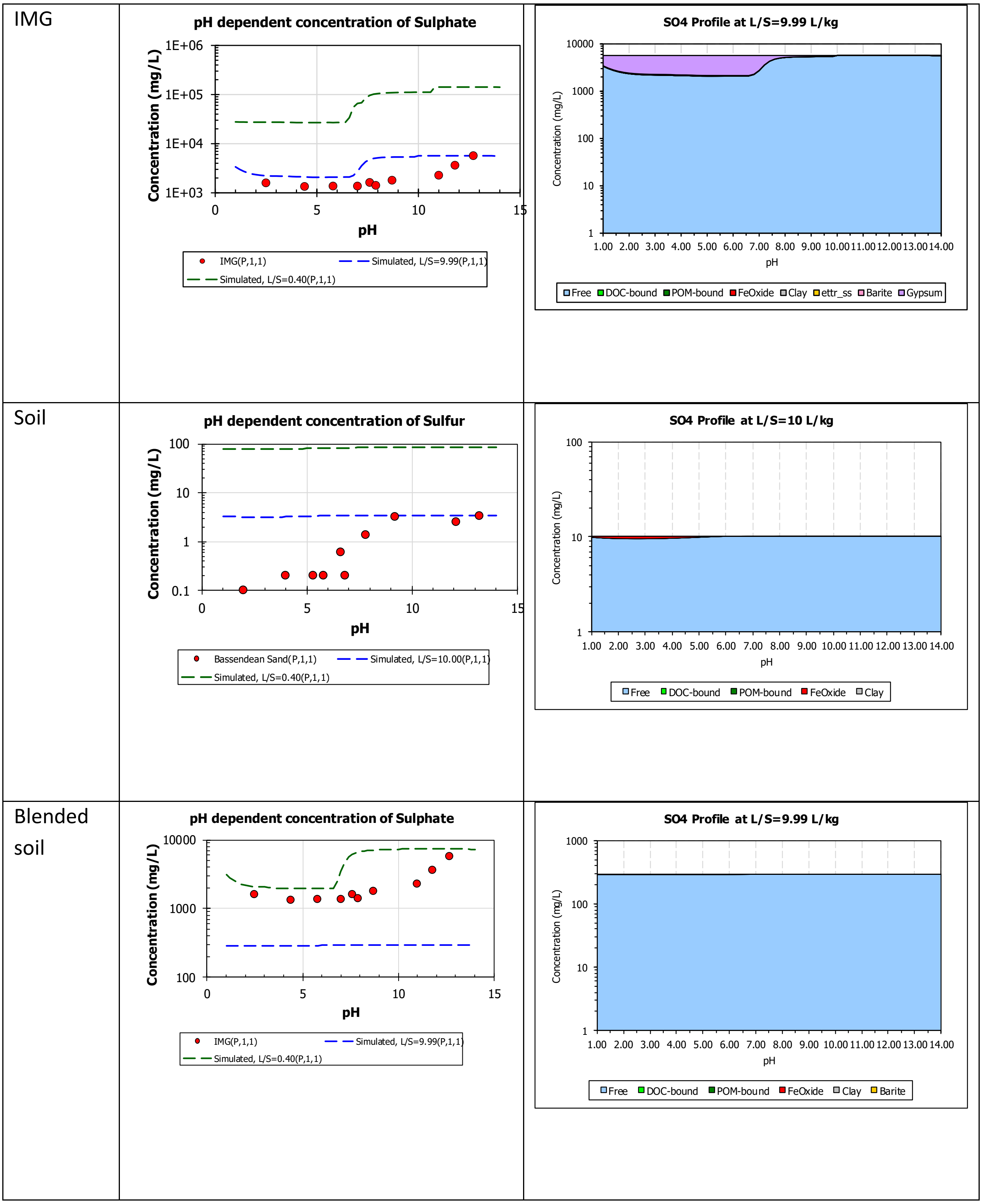


Figure 28: Chemical Speciation Fingerprints for sulfate in a virtual material relating to a blend of IMG and Bassendean Ellenbrook sand.

5.3.5 Laboratory and Field data

5.3.5.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A surface layer of either amended soil (using IMG materials as amendment) was applied at the application rate equivalents to 50 t/ha/10 cm layer for the soil amendment materials.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the amended soil/material layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A11-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the "control" columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations from the flushed column samples were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 12), some of these are discussed below.

In many cases, it is observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Potential for mobilisation of specific constituents from IMG

Based on the tall column experiment, key potential constituents from soils amended with IMG include:

- Sulfate in leachates of Bassendean Joel and Spearwood sands;
- Phosphorus. Although IMG has been identified as an effective means of reducing phosphorus leaching from sandy soils, elevated concentrations were recorded in leachates from the tall column experiments. However, it is to be noted that the "subsoil" layer in the tall column experiment was actually topsoil containing elevated concentrations of labile phosphorus. In field situations, the natural subsoils would be expected to contain much lower concentrations of potentially labile phosphorus;
- Minor concentrations of trace metals present in fertilised soils; and

- Apart from mobilising trace amounts of molybdenum, application of IMG to Spearwood sand resulted in little change to leachate concentration. It is unlikely that IMG would be required as a soil amendment material for Spearwood sand.

An important finding was that manganese was not present in environmentally significant concentrations in any soil leachates, despite being a major constituent of IMG and found to be moderately soluble at under acidic conditions, including natural sandy soil pH values, from the LEAF tests (Section 5.3.2.1).

Table 12: Tall Column Leachate Analysis Summary.

Analyte	**IMG**			
	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩
TDS/EC	🟩	🟩	🟩	🟩
DOC	🟩	🟩	🟩	🟩
Al	🟧	🟩	🟩	🟧
As	🟩	🟩	🟩	🟩
B	🟧	🟧	🟩	🟧
Ba	🟩	🟩	🟩	🟩
Cd	🟩	🟩	🟩	🟩
Co	🟩	🟩	🟧	🟩
Cr	🟩	🟩	🟧	🟩
Cu	🟩	🟧	🟩	🟩
Mn	🟩	🟩	🟩	🟩
Mo	🟩	🟩	🟩	🟧
Ni	🟩	🟩	🟩	🟩
P	🟧	🟥	🟧	🟩
Pb	🟩	🟩	🟩	🟩
SO_4	🟩	🟧	🟩	🟧
Se	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩
Zn	🟧	🟧	🟧	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.3.5.2 Field Data

5.3.5.2.1 Ironman Gypsum® (IMG) Ellenbrook Trial

A trial was established in 2011 on Department of Defence land to assess the effectiveness of Ironman Gypsum® (IMG), together with Alkaloam and another Water Corporation material (Section 4.10.1.1). These amendments were applied to leaching sandy soils of the Ellenbrook catchment to assess their suitability for use to retain phosphorus (P) on cropping land. Note: these amendments were applied to the soil surface and were not incorporated into the soil profile. Three lysimeters were installed within nine 3 x 3 metre small plots to collect leachate from soil over different rain events during winter and spring from 2011 to 2017. Initially depth wise (0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm) soil sampling was conducted to assess the nutrient and metals movement down the profile and later only topsoil samples were analysed.

Results from analyses of lysimeter leachates sampled on 20 occasions between June 2012 and June 2017 are presented in Appendix A 14. A summary of key findings is presented as a risk profile table (Table 13) using the same analyte threshold concentration presented in Table 6 for the tall column experiment (Section 5.3.5.1). Risk profiles are presented for “short term” (end of 2012) and “long term” (2017) leachates.

Comparison of the risk profile of IMG from the Ellenbrook trial (Table 13) with that of the tall column laboratory trial (Table 12, Section 5.3.5.1) indicate that the “short term” potential risks are comparable. However, a short term and long-term risk for leachate acidification (pH) was recorded for the field trial on the basis of leachate pH values being below the adopted threshold value of 4.5.

Table 13: Ellenbrook Field Trial Summary for IMG.

Analyte	**IMG (NUA)**	
	"Short Term"	"Long Term"
pH	🟨	🟨
TDS/EC	🟨	🟩
TOC	🟩	🟩
Al	🟨	🟩
As	🟩	🟩
Ba	🟩	🟩
Cd	🟨	🟩
Co	🟨	🟨
Cr	🟨	🟩
Cu	🟨	🟨
Mn	🟩	🟩
Mo	🟩	🟩
Ni	🟩	🟩
P	🟩	🟩
Pb	🟩	🟩
SO_4	🟨	🟩
Se	🟩	🟩
U	🟩	🟩
V	🟩	🟩
Zn	🟨	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.3.5.2.2 Ironman Gypsum® (IMG) – Bullsbrook Turf Trial

Comparisons of results of LEAF test methods 1314 and 1316 (i.e. at the natural pH of IMG) with lysimeter (section 4.10.1.3) water sample analysis data are presented in Table 14.

Comparison of available data indicates general agreement of LEAF test results with field test results with the following exceptions:

- Concentrations of arsenic, barium, copper, iron, potassium, manganese, sodium, nickel, phosphorus, lead, selenium, thorium, titanium, chloride, vanadium and zinc were higher in the field samples. In each case, the differences were explained by either:
    - Contributions from irrigation water;
    - Contributions from applied fertiliser; and
    - Release from historical soil contamination or naturally elevated levels in soil, as indicated by similarity of results from amended and non-amended plots.

Concentrations of boron, chromium, magnesium and uranium were lower in the field samples. The decrease in boron, chromium and uranium concentrations may be attributed to interactions with soil organic matter in the amended soil plots.

Table 14: Comparison of LEAF Tests 1314 and 1316 Results with Bullsbrook Turf Field Trial Data.

Analyte	Units	LEAF Test	Field Data	Comments
pH	pH Units	7.6 to 7.8	6.9 to 8.0	Comparable
Conductivity	mS/m	232 to 370	<50 to 800	Comparable
Eh	mV	71 to 305	Not measured	
Dissolved Organic Carbon, DOC	mg/L	<1 to 2.8	Not measured	
Silver, Ag	mg/L	<0.0001 to 0.0005	Not measured	
Aluminium, Al	mg/L	<0.005 to 0.14	<0.1 to 1.0	Comparable
Arsenic, As	mg/L	<0.001	<0.001 to 0.006	Higher in field
Boron, B	mg/L	0.03 to 0.81	<0.01 to 0.2	Lower in field
Barium, Ba	mg/L	0.0019 to 0.016	0.05 to 0.23	Higher in field
Beryllium, Be	mg/L	<0.0001	Not measured	
Calcium, Ca	mg/L	353 to 606	50 to 1300	Comparable
Cadmium, Cd	mg/L	<0.0001 to 0.0003	<0.005	Comparable
Cobalt, Co	mg/L	<0.0001 to 0.0006	<0.005	Comparable

Analyte	Units	LEAF Test	Field Data	Comments
Chromium, Cr	mg/L	0.039 to 0.16	<0.01 to 0.05	Lower in field
Copper, Cu	mg/L	<0.0001 to 0.0031	<0.005 to 0.05	Higher in field
Iron, Fe	mg/L	<0.005 t0 0.042	<0.1 to 2.3	Higher in field
Mercury, Hg	mg/L	<0.0001	Not measured	
Potassium, K	mg/L	0.3 to 10.9	<10 to 260	Higher in field
Magnesium, Mg	mg/L	29 to 376	<10 to 130	Lower in field
Manganese, Mn	mg/L	<0.001 to 0.016	<0.05 to 0.15	Higher in field at natural pH
Molybdenum, Mo	mg/L	<0.001 to 0.006	Not measured	
Sodium, Na	mg/L	0.2 to 27.6	<20 to 680	Higher in field
Nickel, Ni	mg/L	<0.001 to 0.004	<0.01 to 0.05	Higher in field
Phosphorus, P	mg/L	<0.1	<0.1 to 0.8	Higher in field
Lead, Pb	mg/L	<0.0001	<0.001 to 0.008	Higher in field
Sulfur, S	mg/L	480 to 860	30 to 1100	Comparable
Antimony, Sb	mg/L	<0.0001	Not measured	
Selenium, Se	mg/L	<0.001	<0.0001 to 0.006	Higher in field
Tin, Sn	mg/L	<0.0001	Not measured	
Thorium, Th	mg/L	<0.0001	<0.0001 to 0.0018	Higher in field
Titanium, Ti	mg/L	<0.0005 to 0.0006	<0.005 to 0.05	Higher in field
Thallium, Tl	mg/L	<0.0001	Not measured	
Uranium, U	mg/L	0.001 to 0.0058	<0.00005 to 0.0009	Lower in field
Vanadium, V	mg/L	<0.0001	<0.005 to 0.05	Higher in field
Zinc, Zn	mg/L	<0.005 to 0.046	<0.005 to 0.51	Higher in field
Bromide, Br	mg/L	<0.1	Not measured	
Chloride, Cl	mg/L	0.5 to 26	<20 to 1250	Higher in field
Fluoride, F	mg/L	1.2 to 2.0	<0.1 to 1.8	Comparable
Sulfate, S	mg/L	1480 to 3350	100 to 3400	Comparable

5.3.6 LeachXS Solute Transport Modelling – Comparison with Field and Laboratory Column Leaching Data

5.3.6.1 Model Conditions

The predictive percolation column solute transport module of LeachXS was used to simulate leaching characteristics for the following scenarios:

- A blended layer of 10 cm of 5% IMG and Bassendean Ellenbrook sand overlying a 90 cm layer of Bassendean Ellenbrook sand.

These scenarios were designed to reflect the conditions of the tall column leaching experiment (Section 4.10.1.1) and in the case of IMG, the highest application rates of the Ellenbrook field trial (Section 4.10.2), noting that the materials were applied as a surface layer and not incorporated by mixing in the topsoil layer.

In addition to the chemical speciation fingerprints for each material, including the virtual materials representing the 5% blends of IMG with Bassendean Ellenbrook sand, LeachXS also requires model input parameters for:

- Column density;
- Column diameter;
- Number of “cells”;
- Column length;
- Column mobile fraction;
- Phase distance;
- Column porosity;
- Permeating solution; and
- Out of column flow rate.

Values for model input parameters for the three modelled scenarios are presented in Table 15. For several parameters relating to the hydraulic characteristics of the materials, nominal values were used rather than measured values. the nominal values adopted were considered to be indicative of free draining sandy materials on the Swan Coastal Plain. The addition of the by-products in the blended soil (IMG) was assumed not to alter the hydraulic characteristics of the soil (Bassendean Ellenbrook).

Table 15: Input Parameters for LeachXS Percolation Column Models.

Parameter	**IMG**
Number of Cells	20
Column Length	100 cm
Column Diameter	15 cm
Percolating fluid	Deionised water
Upper layer	5% blend
Upper layer cells	2
Upper Layer Chemical Speciation Fingerprint	Virtual Material (5% IMG)
Lower layer	Bassendean Ellenbrook soil
Lower layer cells	18
Column Mobile Fraction	70%
Effective Phase Distance	4.5 cm
Column Porosity	0.45
Column Density	1.5 x 10^3 kg/m^3
Out of column Flow Rate	4.49 x 10^3 mL/m^2/hr

5.3.6.2 Model Output Interpretation

LeachXS percolation output results were presented in four charts formats, from which bottom of column leachate concentrations could be calculated for each scenario and subsequently compared with field trial data and tall column laboratory leachate data (Section 5.3.5). Examples of these formats, using aluminium in the virtual column of 5% IMG blended with Bassendean Ellenbrook sand (2 cells, 10 cm depth) over Bassendean Ellenbrook sand (18 cells, 10 -100 cm) are presented in Figures 29 and 30. Interpretations of the predicted results are discussed thereafter.

Figure 29 presents the volumetric concentrations of specific solid and solid phases, on a whole column volumetric basis, for aluminium at an L/S = 0.404 as a function of column depth. Key points provided by presentation of modelled data in this format are:

- The volumetric concentration of “available content” aluminium in the first two cells is approximately 250 mg/L, some of which is associated with IMG in the blended soil layer.
- The volumetric concentration of “available content” aluminium in the underlying cells is lower, and approximately 150 mg/L, corresponding to the original concentration in Bassendean Ellenbrook sand. This indicates there has been very little mass transfer of aluminium from the amended soil layer to the underlying soil layer.
- The dominant form of aluminium in both layers was predicted by LeachXS to be amorphous aluminium hydroxide (from a cement materials database) ($Al(OH)_3$), rather than crystalline hydrous oxide minerals such as gibbsite or boehmite. The other major mineral form of aluminium in both layers is the sodium feldspar mineral albite ($NaAlSi_3O_8$).
- An important solid phase component of aluminium in Bassendean soil layers is that associated with particulate organic matter (POM).
- The concentration of solution phase aluminium (DOC-bound + free), but expressed on a column volumetric basis rather than a solution phase volumetric basis, decreases from approximately 0.2 mg/L within and immediately below the amended soil layer.
- The volumetric concentration of solution phase aluminium decreases to approximately 0.01 mg/L in the lower layers of the column.

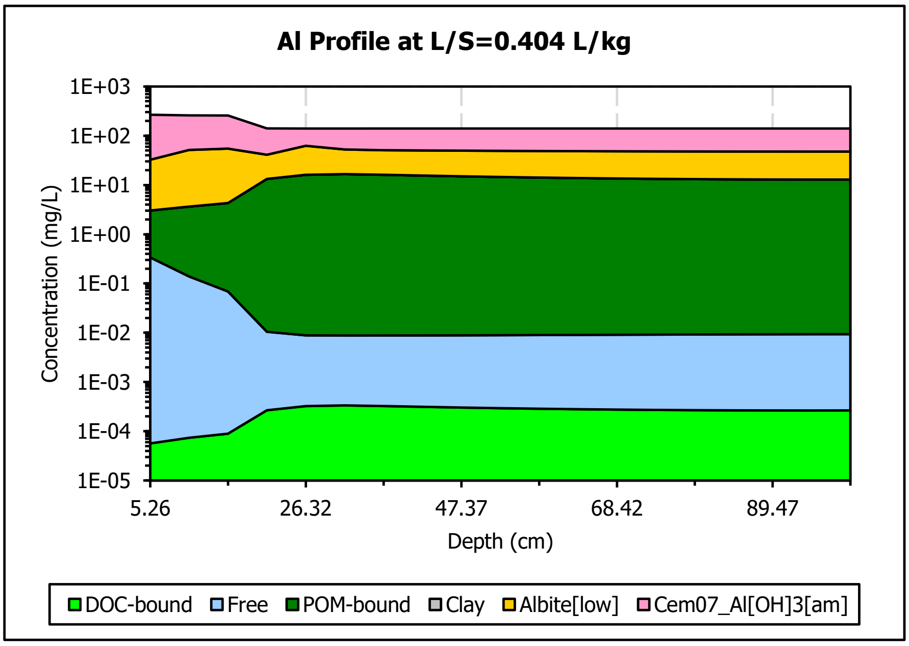


Figure 29: Aluminium profile by column depth at L/S = 0.397 L/kg.

Figure 30 presents the volumetric concentrations of specific solid and solid phases, on a whole column volumetric basis, for aluminium at the 100 cm layer (base of column) as a function of L/S, effectively providing predicted information relating to "out of column" leachate composition as function of leachate volume. Key points provided by presentation of modelled data in this format are:

- The model output mainly depends on the validity of mobile fraction and effective phase distance used in the model. The solution concentration will decrease with the increase in mobile fraction. The pH dependent data for Al shows the effect of pH change under changing "exposure" conditions in case of solubility control. The change in L/S ratio from 0.2 to 0.5 suggests an increase in pH values from 7.8 to 8 and the soluble Al concentration increased (Figure 30). This points at solubility control by the combination of phases controlling Al solubility. The model describes washout of DOC, however the model does not take into account generation of new DOC, which is likely under the long-term test conditions in the column study.
- The "first flush" leachate concentration of approximately 0.02 mg/L aluminium (allowing for conversion of column volume to solution phase volume), comprised of exclusively DOC-bound aluminium.
- As the solution phase ratio increases, the concentration of soluble aluminium is predicted to decrease and contain increasing proportion of free aluminium.
- The decrease in liquid phase aluminium is accompanied by proportional increases of POM-bound aluminium in the solid phase.

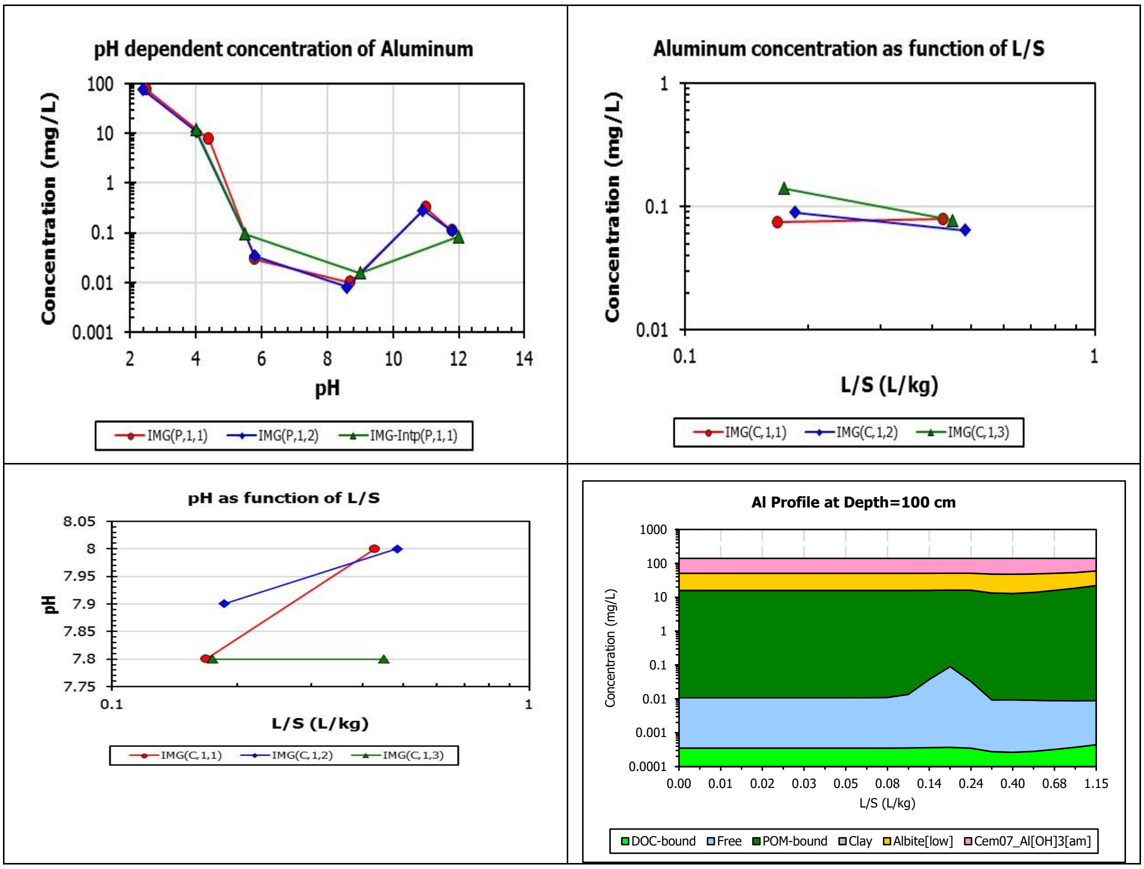


Figure 30: Aluminium Profile at depth = 100 cm (base of column) as a function of L/S.

5.3.6.3 Comparison of LeachXS Predictions with Field and Tall Column Results

5.3.6.3.1 Comparison Methodology

Predicted end of columbbn leachate concentrations from LeachXS modelling described in Section 5.3.6.2 were compared with results from field results (Ellenbrook trial for IMG) and laboratory tall column leachate data using the following methodology:

- Predicted end of column leachate concentration (sum of DOC-bond and free fractions) as a function of L/S, as calculated from LeachXS output data illustrated by Figure 31 (Section 5.3.6.2).
- Tall column bottom of column leachate concentrations for three sampling events (Leach Number 1, 2 and 3) discussed in Section 4.10.2.1.
- Lysimeter leachate concentrations from the first eight sampling events from the Ellenbrook Trial (Section 4.10.1.1) for IMG. When comparing LeachXS predictions with Ellenbrook lysimeter data, it is important to recognise that IMG was applied on top of the soil surface and was not blended with topsoil in the field trial.

Data from these three sources were plotted as a composite chart, as illustrated by Figure 31 presenting calcium concentrations for IMG applied to Bassendean Ellenbrook sand.

Information presented in Figure 31 for calcium is interpreted as follows:

- LeachXS predicts calcium concentrations in the initial leachates to be approximately 1,000 mg/L, which will increase to a maximum of approximately 1,000 mg/L as the "first flush" from dissolution of gypsum from IMG in the blended soil layer reaches the bottom of column. Concentrations thereafter are predicted to decrease until the L/S ratio reached 1.0, by which time most of the soluble column had been flushed from the column.
- Lysimeter data for the Ellenbrook field trail indicates calcium concentrations ranging from 500 to 700 mg/L, which aligns reasonably well with LeachXS predicted concentrations during the wash-out period. The field data reflects two years of leaching which, depending on frequency and intensity of rainfall events, correspond to L/S ratios greater than 1.0.
- Tall column leachate concentrations ranged from approximately 160 to 350 mg/L and showed an increasing trend with time. The results align reasonably well with the lower range of leachate concentrations predicted by LeachXS. While comparing LeachXS predictions with tall column leachate data, it is important to recognise that the tall columns were flushed with leaching fluid in a short period of time, but at intervals separated by four months.

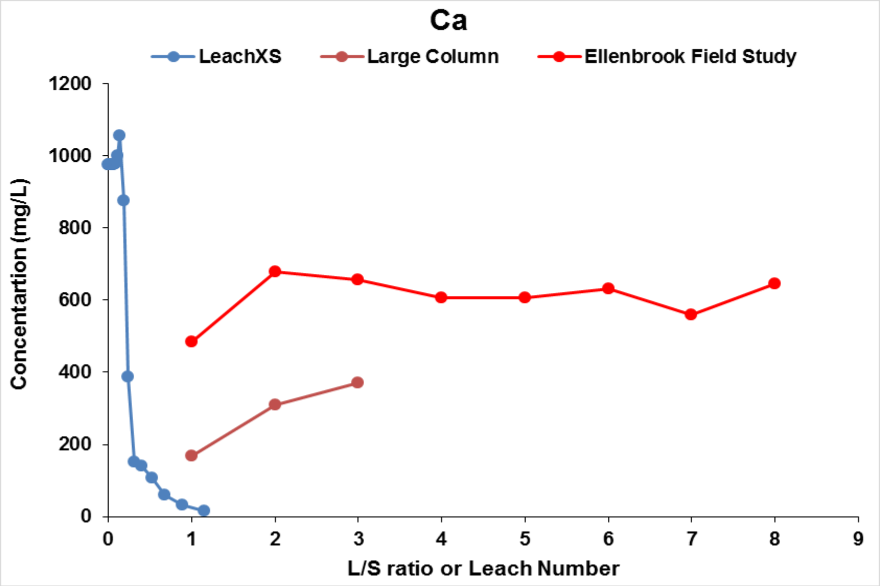


Figure 31: Comparison and Predicted, field and Laboratory Data for Calcium in Leachates of Bassendean Ellenbrook sand treated with IMG.

5.3.6.3.2 Ironman Gypsum® (IMG) Comparisons

Charts comparing predicted end of column leachate concentrations using LeachXS with Ellenbrook field trial leachate concentrations and tall column laboratory leachate concentrations for selected analytes are presented in Appendix A19.

The following discussion focuses on analytes that were identified as constituents of potential concern from assessment of the potential risk profiles derived from interpretation of LEAF tests (Table 9), tall column (Table 12) and field trial (Table 13) results:

- Sulfate;
- Manganese;
- Nickel;
- Cobalt;
- Cadmium (residual fertiliser cadmium from Ellenbrook field trial observations);
- Aluminium; and
- Barium.

Sulfate

Comparison data for sulfate leaching characteristics are presented in Figure 32. Comparison of LeachXS predicted concentrations with field and laboratory trial concentrations indicate predicted concentrations were approximately double the measured concentrations. The difference is considered acceptable given the inherent assumptions and differences between modelled and trial conditions. It was noted that LeachXS predicted end of column leachate concentrations greater than that of a saturated gypsum solution at low L/S, whereas the field and laboratory trial data suggest under-saturation with respect to gypsum.

It is noted that LeachXS does not predict extended concentrations of sulfate (and calcium) at elevated concentrations for relatively high L/S ratios, which would be expected for a material containing 60% gypsum. As discussed in Section 5.3.2.1, LeachXS has underestimated the available content of sulfur (and calcium) in IMG by a factor of 5.8, which would explain the “wash-out” leaching curve, rather than the gypsum equilibration curves indicated by the tall column and Ellenbrook trial (Figure 32).

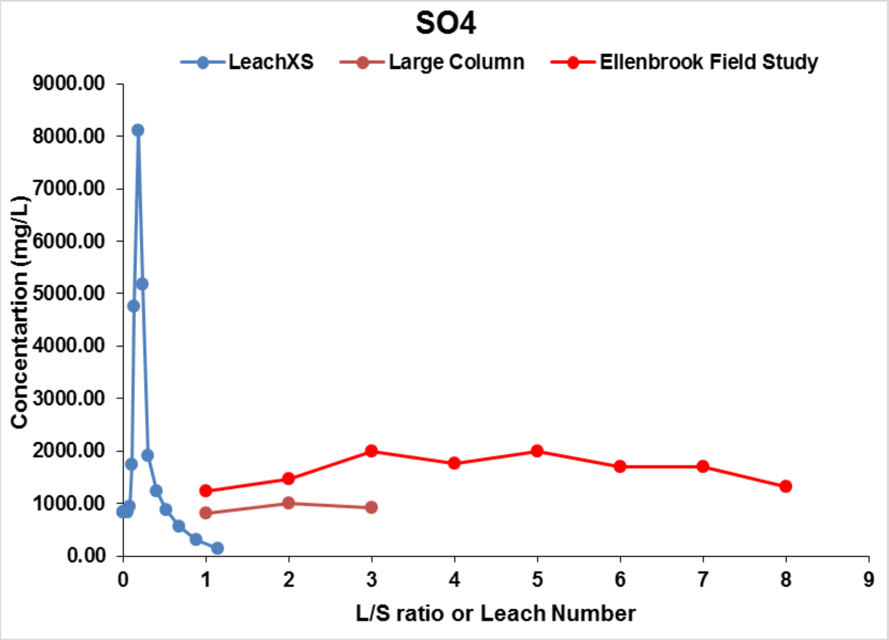


Figure 32: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Sulfate in IMG Leachates.

Manganese

Comparison data for manganese leaching characteristics are presented in Figure 33. Comparison of LeachXS predicted concentrations with field and laboratory trial concentrations comparable with field and laboratory measured concentrations at a nominal pE value of 8. Substantially higher concentrations were predicted by LeachXS when lower nominal pE values were used. The difference was pre-empted by discussion in previous Sections (Sections 5.3.3.1 and 4.10.1.2) which noted the sensitivity of manganese speciation to redox conditions.

Comparison of predicted and measured data for other elements (Fe, Cr and V) with two or more different valence states under different redox conditions variable predictive capacity of end of column leachate concentrations using LeachXS at pE = 8:

- LeachXS predicted very low concentrations of dissolved iron (<0.01 mg/L), which was consistent with Ellenbrook field trial data (maximum concentration approximately 0.15 mg/L). However, the tall column trial recorded of a maximum, first-flush, iron concentration of approximately 2 mg/L.

- LeachXS predicted extremely low concentrations of dissolved chromium (<0.0001 mg/L). Concentrations from the tall column trial (maximum 0.001 mg/L) and the Ellenbrook field trial (maximum 0.0015 mg/L) were several orders of magnitude higher, but do not indicate chromium to be a constituent of potential concern.
- LeachXS predicted slightly elevated, first-flush concentrations of soluble vanadium (maximum 0.5 mg/L), whereas tall column and Ellenbrook field trial data indicated consistently low vanadium concentrations (maximum 0.001 mg/L).

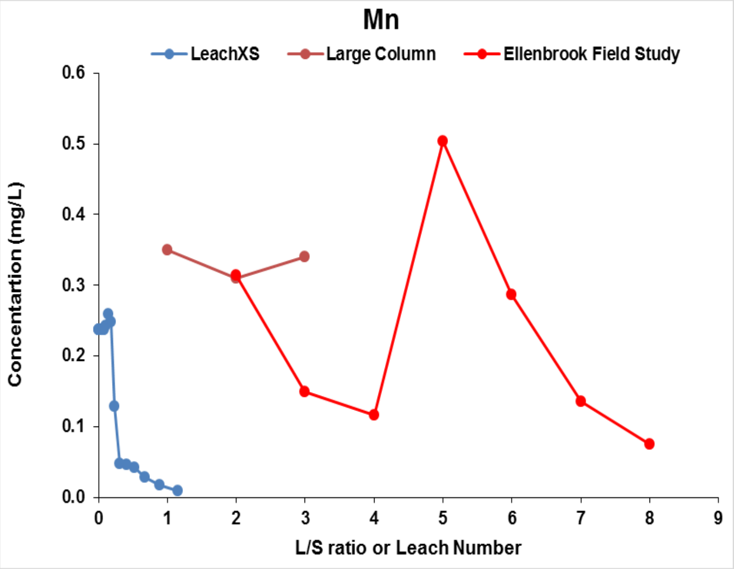


Figure 33: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Manganese in IMG Leachates.

Nickel

Comparison data for nickel leaching characteristics are presented in Figure 34. Comparison of LeachXS predicted concentrations with laboratory tall column trial concentrations indicated reasonably close agreement, with end of column concentrations predicted by LeachXS at L/S ratios of 1 or more to be extremely low (<0.0002 mg/L). These results indicate that nickel in IMG is not considered to be a constituent of potential concern.

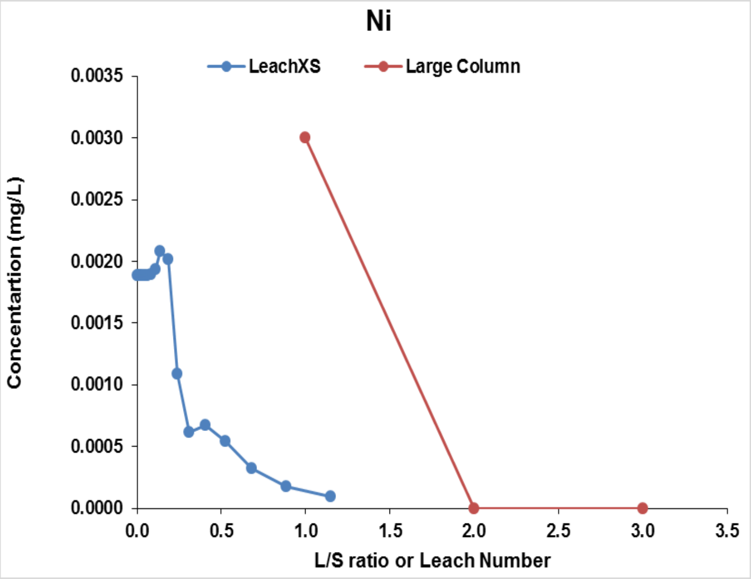


Figure 34: Comparison of LeachXS Predictions and Tall Column Laboratory Data for Nickel in IMG Leachates.

Cobalt

Comparison data for cobalt leaching characteristics are presented in Figure 35. Comparison of LeachXS predicted concentrations with laboratory tall column trial concentrations indicated reasonably close agreement, with end of column concentrations predicted by LeachXS at L/S ratios of 1 or more to be low (<0.002 mg/L) following a first-flush of cobalt with concentrations up to 0.01 mg/L. These results indicate that cobalt is not considered to be a constituent of potential concern in IMG.

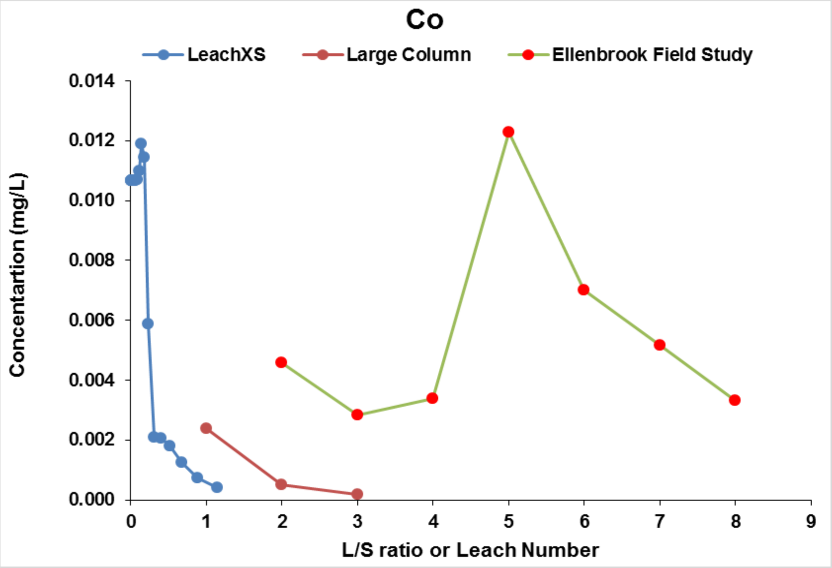


Figure 35: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Cobalt in IMG Leachates.

Cadmium

Comparison data for cadmium leaching characteristics are presented in Figure 36. LeachXS predicted generally low end of column cadmium concentrations, which was consistent with measured leachate concentrations from the tall column experiment. The relatively higher concentrations measured in the Ellenbrook field trial may be a consequence of different concentrations of cadmium from superphosphate residues in the field trial soil compared to the soil submitted for laboratory column experiments in this project.

These results indicate that cadmium is not considered to be a constituent of potential concern in IMG.

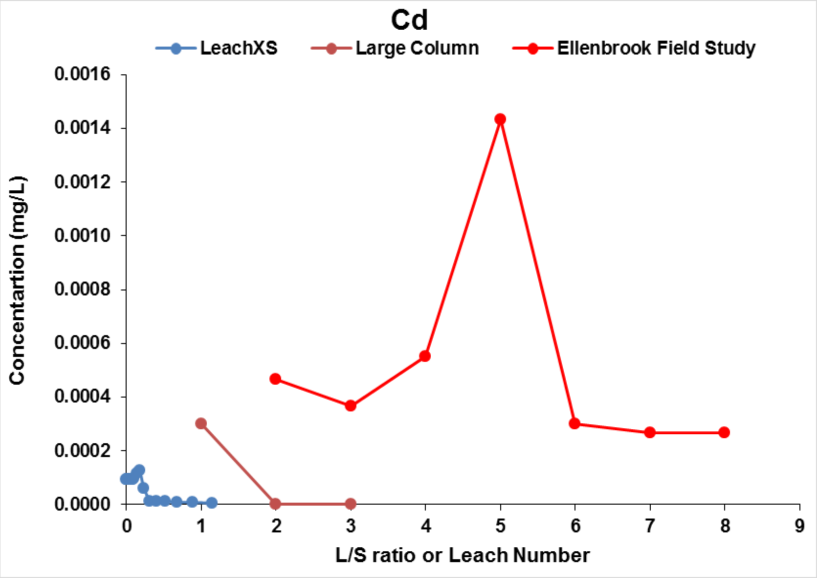


Figure 36: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Cadmium in IMG Leachates.

Aluminium

Comparison data for aluminium leaching characteristics are presented in Figure 37. LeachXS predicted generally low end of column cadmium concentrations following a first-flush of soluble aluminium at concentrations up to 0.2 mg/L. This observation is consistent with measured leachate concentrations from the tall column experiment. Elevated concentrations, up to 0.8 mg/L were measured in lysimeter leachates from the Ellenbrook field trial, which may be explained by the presence of very fine aluminium- particulate organic matter material forming in the lysimeters prior to subsequent standing.

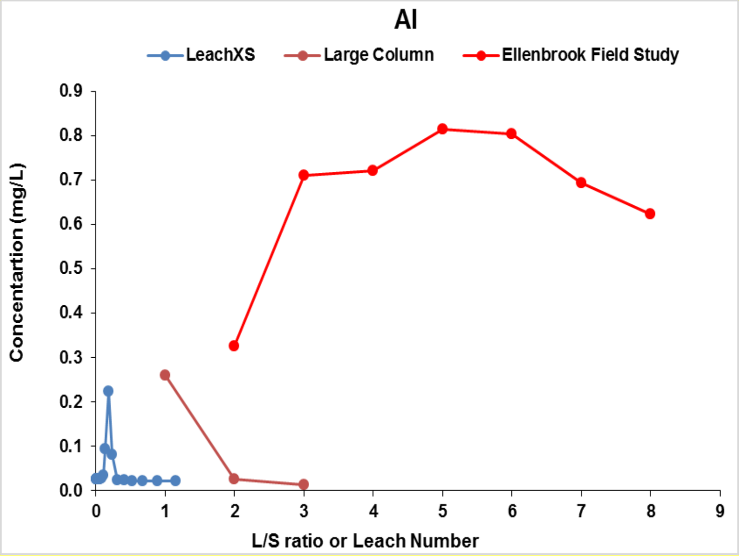


Figure 37: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Aluminium in IMG Leachates.

Barium

Although barium was not identified as a constituent of potential concern in IMG from high level assessment of LEAF Method 1313 results (Section 5.3.2.1, Table 8), LeachXS modelling predicted elevated barium concentrations (up to 8 mg/L, Figure 38) in a “first-flush” event, followed by much lower concentrations (below the adopted lower threshold value of 2 mg/L) as L/S increased above 0.3 L/kg. The tall column experiment indicated consistent leachate concentrations of approximately 0.2 mg/L, which were comparable with LeachXS predictions at L/S = 1.

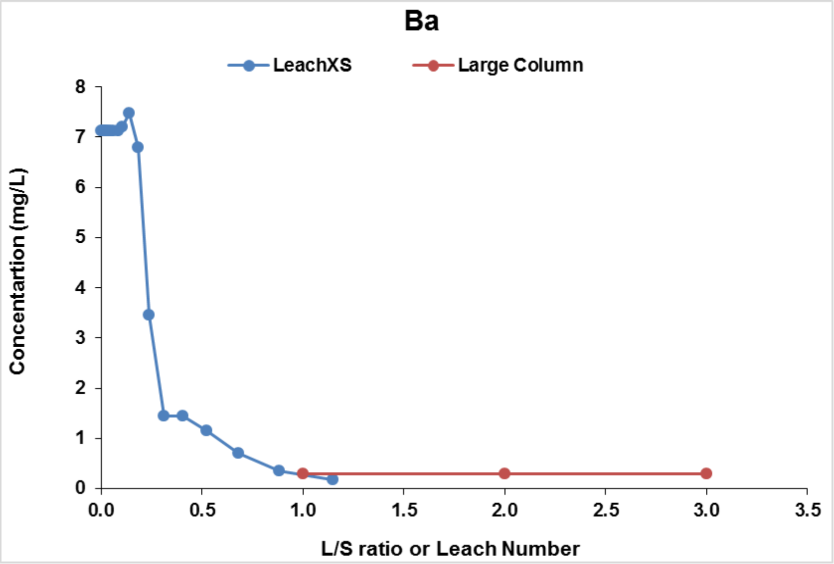


Figure 38: Comparison of LeachXS Predictions and Tall Column Laboratory Data for Barium in IMG Leachates.

5.3.7 Summary

Comparison for laboratory LEAF Method 1313 results, LeachXS solute transport modelling, tall column laboratory trials and the Ellenbrook field trial provides the following key points for consideration by WA regulators for approval of IMG as an amendment for Bassendean sands at application rates up to 50 t/ha:

- LEAF Method 1313 results identified aluminium, manganese, cobalt, nickel and (sulfate) salinity as constituents of potential concern in IMG, especially under acidic field conditions.

- LeachXS provided sensible chemical speciation fingerprints for these constituents of potential concern in IMG. The corresponding chemical speciation fingerprints of these elements, and others of general environmental interest, in Bassendean sand indicate major control of solubility by interaction with dissolved and particulate soil organic matter, rather than clay, hydrous ferric oxides or discrete mineral phases.

- LeachXS predicted "first-flush" washout characteristics for most elements, i.e. most of the leaching occurred at low L/S ratios (less than 0.3). This behaviour was also observed for several elements in the tall column and Ellenbrook field trials, although calcium, sulfate, barium and aluminium concentrations did not vary to the same degree at higher L/S values.

- LeachXS predicted substantial sensitivity of leachate concentrations for elements of more than one common redox state with adopted pE values. Under moderately oxic conditions, elements including manganese, vanadium and chromium are predicted to leach at concentrations presenting very low risk to the environment. However, concentrations of manganese in particular is predicted to increase under more reducing conditions (pE <6) and also at low pH (pH <5).

- LeachXS under-estimates the available contents of calcium and sulfur (as gypsum), mainly as a consequence of the L/S ratio of 10 L/kg used in the LEAF Method 1313 test. The available contents of calcium and sulfur were calculated as 19,000 mg/kg (1.9%) and 19,000 mg/kg (1.9%), respectively. In actual fact, almost all of the total concentrations of calcium (15.1%, Table 8) and sulfur (10.9%, Table 8) is present as gypsum, meaning the available contents may be under-estimated by more than 600%. This would have significant implication for LeachXS predictive modelling, particularly the leaching characteristics of calcium and sulfur, as well as other constituents with leaching characteristics dependent on alkalinity and ionic strength.

5.4 Bauxite Residue By-products

5.4.1 Example 2: How LEAF Can Be Used to Assess a By-product - Alkaloam

5.4.1.1 By-product Alkaloam Characterisation

Alcoa’s refineries process bauxite ore from several deposits in the darling range. Alumina, and other constituents of bauxite ore are extracted by the Bayer Process, which involves extraction of finely ground ore with sodium hydroxide solution at elevated temperature and pressure. The resulting fluid is filtered, with the solid residue referred to as “red mud” remaining to be potentially re-used or stored in residue drying beds. The filtrate, containing sodium aluminate and other soluble constituents is crystallised to produce aluminium hydroxide ($Al(OH)_3$), which is then calcined to form alumina (Al_2O_3). The Alkaloam sample provided by Alcoa contains less free alkalinity than freshly produced “red mud” as a consequence of partial neutralisation with carbon dioxide.

The principal constituents of Alkaloam are primarily iron oxides (goethite and hematite), residual and secondary aluminium oxides (gibbsite, boehmite), quartz and alkali insoluble oxides of titanium and vanadium. Several mixed $CaO\text{-}Al_2O_3$ phases, and zeolite minerals (such as sodalite) are formed as secondary minerals. Table 16 presents the results for elemental analysis of the sample of Alkaloam provided for this project. Note: the limit of reporting (LOR) values in Table 16 are for XRF and/or ICP/AES analysis (section 4.4).

Conditions of the Bayer Process also result in substantial alteration of organic materials present in ore. Organic forms of sulfur and phosphorus are converted to sulfate and phosphate respectively, will humic substances are degraded to lower molecular forms including fulvic acids and short-chain carboxylic acids (succinic, acetic and oxalate).

Table 16: Bauxite Residue By-product Alkaloam – Characterisation Data. Note: LOR values are for either XRF* or ICP/AES analysis.

Element	LOR	Units	Alkaloam
Ag	0.5	mg/kg	<0.5
Al	100*	mg/kg	114000
As	3	mg/kg	37.0
Ba	5	mg/kg	167
Be	0.5	mg/kg	<0.5
Ca	50*	mg/kg	33000
Cd	1	mg/kg	<1
Co	1	mg/kg	1.0
Cr	10	mg/kg	250
Cu	5	mg/kg	28.0
Fe	100*	mg/kg	211000
K	100	mg/kg	5870
Mg	20	mg/kg	2200
Mn	5	mg/kg	159
Mo	5	mg/kg	10.0
Na	50	mg/kg	29300
Ni	5	mg/kg	<5

Element	LOR	Units	Alkaloam
P	20	mg/kg	710
Pb	5	mg/kg	48.0
S	20	mg/kg	2190
Sb	2	mg/kg	<2
Se	10	mg/kg	<10
Sn	2	mg/kg	17.0
Ti	10	mg/kg	18700
Th	10	mg/kg	395
U	10	mg/kg	35.0
V	1	mg/kg	530
Zn	5	mg/kg	14.0
Tl	0.1	mg/kg	0.20
B	20	mg/kg	<20
Hg	0.1	mg/kg	<0.1
Cl	25	mg/kg	655
F	25	mg/kg	1070
LOI	-10	%	14.7
TOC	0.05	%	0.56
H20	0.1	%	8.80

Note; LOR-limit of reporting; LOI-loss of ignition; TOC-total organic carbon.

5.4.1.2 LEAF Tests 1313, 1314 and 1316

5.4.1.2.1 LEAF 1313 Test

Results for analysis of Alkaloam are presented as graphs in Appendix A5-1. Characteristics of the pH dependent leaching characteristics by analyte for this material are summarised as follows:

- Silver: Silver concentrations were extremely low (close to the LOR) and did not vary with pH.
- Aluminium: Indicated characteristic amphoteric behaviour for aluminium, with elevated concentrations at both very low and very high pH values. The pH value for minimum solubility was between pH 7 and 8. The maximum concentration available for leaching was at pH 2.
- Arsenic: Generally, the highest concentrations were recorded at the higher pH values, although solubility at low pH (2 and 4 units) was higher than those at circum-neutral values. The solubility minima were between pH 5 and 7.
- Boron: Boron concentrations indicated very little dependence with leachate pH.
- Barium: Leachate concentrations were typically <0.01 mg/L at pH values above 7. Highest concentration recorded of approximately 1 mg/L at pH 2.
- Beryllium: Concentrations of extractable beryllium were very low (0.0001 mg/L) at pH values above 6 but increasing with increasing acidity below pH 6 (Approximately 0.01 mg/L at pH 2).
- Calcium: Concentrations were elevated (1,000 to 5,000 mg/L) and consistent at pH values below 6 pH units, but then decreased with increasing pH to <1 mg/L at 13 pH units.

- Cadmium: Slightly elevated concentrations (approximately 0.001 mg/L) were record in strongly acidic leachates (pH 2 and 4), with much lower concentrations (including below method reporting limits) between pH 5 and 13.
- Cobalt: Cobalt concentrations were <0.02 mg/L at pH 2. Much lower concentrations (<0.0004 mg/L) were recorded in alkaline leachates (pH >8).
- Chromium: Elevated chromium concentrations (>0.1 mg/L) were recorded at both very low and very high pH values. Much lower concentrations (approximately 0.001 mg/L) were recorded for leachates with pH values between 6 and 8.
- DOC: Very high concentrations (approximately 100 mg/L) of DOC were recorded with very little pH dependence.
- Copper: Copper leachates indicated characteristic amphoteric behaviour, and the pH minimum for copper solubility was approximately at 6 pH units.
- Fluoride: Fluoride concentrations were low (approximately 0.001 mg/L) between 6 and 8 pH units but increasing significantly (to >10 mg/L) at both very low and very high pH values.
- Iron: High iron concentrations were evident between 2 and 4 pH units, but much lower concentrations between 6 and 9 pH units, before increasing again at very high pH (>12 pH units).
- Mercury: Apart from minor anomalous concentrations between 0.0001 and 0.001 mg/L, most mercury concentrations were <0.00001 mg/L across the pH range.
- Potassium: Potassium concentrations were consistent (approximately 1 – 2 mg/L) for pH values below 8. Higher concentrations at pH >8 were an analytical artefact arising from use of KOH to adjust leachate alkalinity.
- Magnesium: Magnesium leaching characteristics were similar to those described earlier for calcium, i.e. maximum solubility at low pH, with concentrations decreasing with increasing leachate alkalinity (to <0.01 mg/L at pH >10).
- Manganese: Leachate concentrations decreases with increasing pH. Concentrations in leachates were about 1mg/L at pH 2 and much lower at pH > 6.
- Molybdenum: Leachate concentrations were very low at low pH but increased with increasing pH at values greater than 6.
- Sodium: As expected for a conservative ion such as sodium, leachate concentrations did not vary with pH. Elevated concentrations (usually >1,000 mg/L) were recorded.
- Nickel: Low values (<0.1 mg/L) were recorded particularly in alkaline leachates.
- Phosphorus: Phosphorus concentrations were very low (>0.01 mg/L) in leachates between 6 and 9 pH units but increased at both very low and very high pH values.
- Lead: Elevated (>0.01 mg/L) concentrations of lead were recorded in pH 2 leachates. Concentrations in circum-neutral and alkaline leachates were below the reporting limit (<0.00001 mg/L).
- Sulfur: Sulfur concentrations were low.
- Antimony: Leachates contained dissolved antimony at concentrations between 0.0001 and 0.001 mg/L between pH values 8 and 11.
- Selenium: Selenium concentrations increased with increasing pH; from approximately 0.1 mg/L at pH 4 to 0.5 mg/L at pH 13.

- Silicon: Silicon concentrations in leachates were highly pH dependent, ranging from almost 1,000 mg/L at pH 2 to 1 mg/L at pH 9 to 11.
- Tin: Tin concentrations were at or below the method reporting limit.
- Titanium: The highest titanium concentrations (maximum 1 mg/L) were recorded in acid leachates. Solubility of titanium minerals were lowest (0.0001 to 0.001 mg/L) between pH7 and 9.
- Thallium: Thallium concentrations in all leachates were below the method reporting limit (0.0001 mg/L)
- Uranium: Uranium concentrations ranged from 0.1 to 0.2 mg/L in leachates between pH 4 and 11. Slightly higher concentrations were observed at very low pH, while lower concentrations were observed at high pH >11.
- Vanadium: Vanadium exhibited amphoteric behaviour, with elevated concentrations (up to 10 mg/L) in strongly acidic and strongly alkaline leachates.
- Zinc: Elevated concentration (0.1 to 0.3 mg/L) of zinc were noted in pH 2 leachates. Concentrations decreased with increasing pH.

Results from the LEAF Method 1313 were used to identify constituents of potential concern (CoPC) in Alkaloam based on methodology discussed in a document published by the US-EPA in October 2017. This methodology is based on LEAF test results for:

- The Available Content, defined as the maximum concentration available for leaching which is at end-point eluate pH values of 2, 9 and 13.
- The maximum eluate concentration over the defined “applicable scenario pH domain”. For hypothetical application of Alkaloam as a soil amendment of Swan Coastal Plain sandy soils, the applicable scenario pH domain was considered to be 5.5 to 9.0 pH units.

The adopted methodology is summarised as follows:

- Calculate the leachate concentrations based on:
  - Available Content (mg/kg) or;
  - Applicable scenario pH domain (mg/kg);
  - L/S ratio of 10 (for Method 1313);
  - Dilution and Attenuation Factor (DAF) of 10, which accounts for reduced concentrations between the leachate source (i.e leaching from Alkaloam) and the point of compliance in the receiving environment (which may be down-gradient groundwater or a surface waterbody, depending on location); and
  - Upper and lower threshold constituent values listed in Table 6, for assessment of soil leachate concentrations from the tall column study (Section 5.2.4)

Analytes where all concentrations were below the “lower threshold” values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 17), some of these are discussed below.

It is important to note that this approach to risk screening is based on that used in Europe and elsewhere mainly for materials stored as waste, and not for beneficial re-use as soil amendment products. Factors such as intended application rates (typically 20 to 50 t/ha) and interaction of product constituents with soil (both mobilisation and attenuation) have not been considered. In effect, this method provides a first pass, high level assessment of constituents of potential concern that require further evaluation, as discussed in subsequent sections.

Table 17: Risk Screening Profile Table for CoPCs from LEAF Test Data – Alkaloam.

Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟧	🟩
Ag	0.0001	🟩	🟩
Al	17,000	🟧	🟨
As	15	🟧	🟩
B	4	🟩	🟩
Ba	7.8	🟩	🟩
Cd	0.013	🟧	🟩
Co	0.14	🟧	🟩
Cr	5.8	🟧	🟨
Cu	2.5	🟧	🟨
F	680	🟧	🟩 (except high pH)
Mn	10	🟩	🟩
Mo	5.6	🟧	🟨
Ni	0.63	🟨	🟩
PO_4	98	🟧	🟩
Pb	0.46	🟧	🟩
SO_4	2600	🟩	🟩
Se	3.9	🟧	🟨
U	9.8	🟨	🟨
V	120	🟧	🟩
Zn	1.2	🟧	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Based on these results (Table 17), Alkaloam constituents of potential concern under typical soil pH conditions (5.5 to 9 pH units) are summarised as follows:

- Aluminium.
- Chromium.
- Copper, although potential risks are mitigated at DAF >10.
- Molybdenum, particularly under alkaline conditions.
- Selenium, particularly under alkaline conditions.
- Uranium.

Note that many constituents of potential concern identified on the basis of Available Content of Alkaloam were no longer of concern within the Applicable Scenario pH Domain Range (pH 5.5 to 9) as a consequence of reduced solubility and applicable to a DAF = 10. LEAF 1313 results for these constituents (aluminium, copper, chromium, fluoride (alkaline pH), molybdenum, selenium, uranium) are presented in Figures 39 and 40.

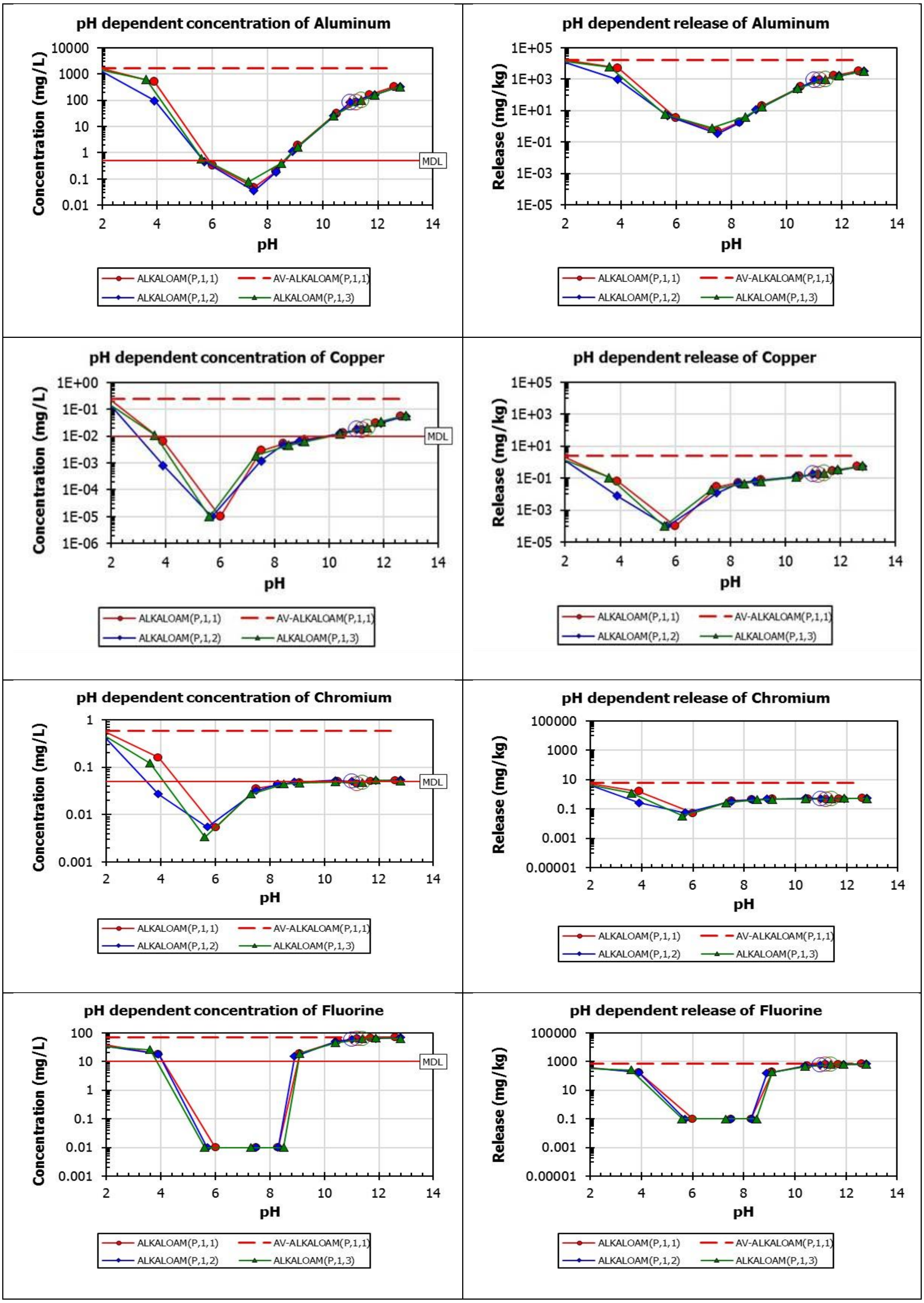


Figure 39: Graphical presentation LEAF 1313 of aluminium, copper, chromium, fluorine, for Alkaloam .

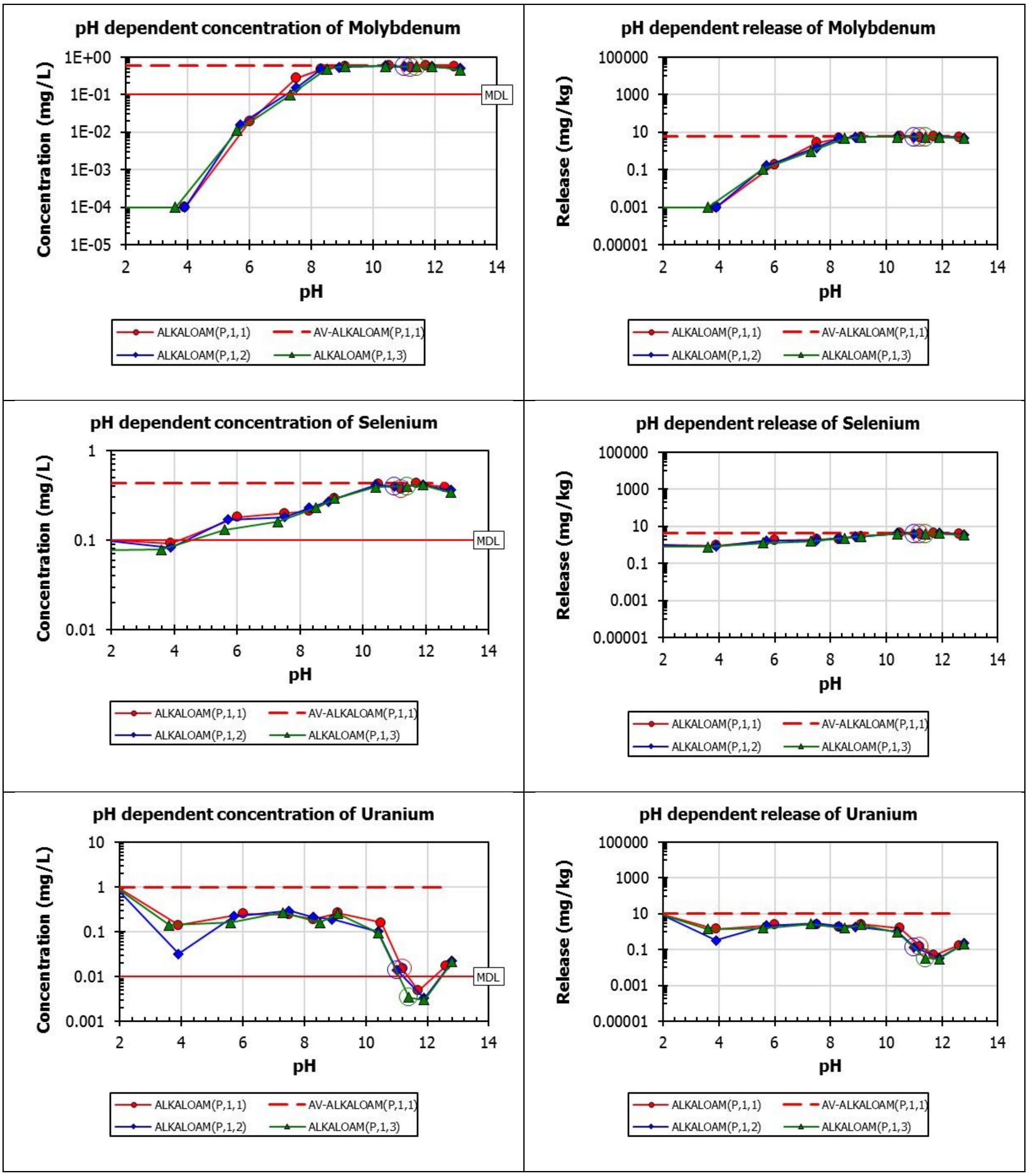


Figure 40: Graphical presentation LEAF 1313 of molybdenum, selenium and uranium for Alkaloam.

5.4.1.2.2 LEAF Test Results, Methods 1314 and 1316, L/S Dependence

Results for analysis of by-products (Alkaloam) using method 1314 (up-flow percolation) are presented as charts in Appendix A6-1. Corresponding results using method 1316 (batch equilibration) are presented in Appendix A7-1.

For most analytes present in measurable concentrations, leachate concentrations usually decrease with increasing L/S ratio.

The other type of leachate behaviour occurs in the presence of sparingly soluble mineral phases, which form saturated solutions containing comparable analyte concentrations at all L/S ratios.

Results presented in Appendix A6-1 indicate typically leachate concentrations between these two types of solute behaviour. Analytes indicating predominantly 'conservative ion' behaviour include bromide, chloride, sodium and potassium. Analytes indicating predominantly 'sparingly soluble mineral phase' behaviour include aluminium, barium, silicon, fluoride and calcium.

Many analytes demonstrate behaviour between these type extremes. This behaviour is likely to occur when other processes affect solute behaviour, such as:

- Ion exchange reactions, particularly with clay and humic phases.
- Surface adsorption to variably charged amorphous mineral phases such, especially hydrous ferric, aluminium and manganese oxides (collectively referred to as "hydrous ferric oxides – HFO").
- Changes in leachate pH in response to increasing L/S ratio.
- Changes in ionic strength (salinity) of leachate, which decreases with increasing L/S of materials containing significant amounts of soluble salts.
- Changes in leachate concentrations of solutes capable of forming stable complexes with metal ions as a function of L/S, especially dissolved organic carbon, and also ions including fluoride, sulfate and phosphate.

5.4.1.2 LeachXS Material Characterisation and Chemical Speciation Fingerprints

LeachXS is a computer software package that supports LEAF test data management by:

- Graphical and tabular presentation of data;
- Statistical analysis of data;
- Providing a tool for quality control;
- Chemical speciation analysis, i.e. identifying key mineral phases that control the dissolution/precipitation over the pH range of 2 to 13; and
- Scenario modelling, such a solute transfer from single stream by-products, blends of different by-product materials, or blends of by-products and soil.

This Section presents results obtained from LeachXS modelling to create geochemical speciation fingerprints for Alkaloam. LeachXS uses the following information to generate the geochemical “fingerprint”:

- pH dependence (Method 1313) leachate analysis data.
- The relationship between leachate pH and the amount of acid or alkali added, i.e. the material’s pH titration curve.
- Dissolved humic acid (DHA) content in each leachate, which is calculated as a fraction of dissolved organic carbon (typically 20% to 40%). DHA has the capacity to form soluble complexes with many transition metals, notably copper, cadmium, nickel and lead.
- Clay content (mg/kg). Clay minerals have a net negative charge, which results on solid phase interactions with cationic species. Clay content is not easily measured in materials such as Alkaloam using methods developed for characterisation of soils because of a tendency for some particles, including secondary minerals such as zeolites, to flocculate during the measurement step. The value used for LeachXS (presented in Table 18) was that used in earlier assessments of bauxite residues by Alcoa.
- Hydrous ferric oxide (HFO). These materials, which include hydrous aluminium and manganese oxides, have very high surface areas and variable surface charge (which is pH dependent). They can therefore retain anionic species by surface adsorption at low pH and cationic species by surface adsorption at high pH. The value used for LeachXS (presented in Table 18) was that used in earlier assessments of bauxite residues by Alcoa.
- Solid Humic Acid. The value used for LeachXS (presented in Table 18) was that used in earlier assessments of bauxite residues by Alcoa. As discussed in Section 5.4.1.1, the conditions of the Bayer Process extraction step results in substantial alternation of soil organic matter present in bauxite ore.
- A thermodynamic database containing data for oxide, carbonate, silicate, sulfide and DHA mineral phases of potentially environmentally significant metals and metalloids. Minteq version 4 was used as the thermodynamic database for this study.
- Initial pH and pE (redox potential) values. The pE values were estimated from a “rule of thumb” relationship (Equation 1)[20] applied for LeachXS modelling in the absence of reliable experimental data.

Equation 1 $pH + pE \sim 14$

Table 18 shows the nominal values applied for fingerprinting of each test material and Table 19 lists some of the key mineral phases adopted for the chemical speciation fingerprint models using LeachXS.

Table 18: Input Parameters for LeachXS Geochemical Speciation Modeling for Alkaloam and Bassendean Sand. Note: "nominal" means estimated, not measured.

Material	pH	pE	Solid HA	Clay	HFO
Alkaloam	11.2 (natural pH)	4 (nominal)	1240 (supplied by Alcoa)	72070 (supplied by Alcoa)	9000 (supplied by Alcoa)
Bassendean sand	6.1 (natural pH)	8 (nominal)	1250 (nominal)	10000 (measured)	120 (measured)

Table 19: Mineral Phases Adopted for Chemical Speciation Fingerprint Models of Alkaloam Using LeachXS.

Mineral Phase	Formula	Function
Calcite	$CaCO_3$	pH buffering, calcium dissolution
Dolomite	$CaMg(CO_3)_2$	pH buffering, calcium and magnesium dissolution
Magnesite	$MgCO_3$	pH buffering, magnesium dissolution
Brucite	MgO	Magnesium dissolution
Gypsum	$CaSO_4.2H_2O$	Calcium and sulfur (sulfate) dissolution
Gibbsite	$Al(OH)_3$	Aluminium dissolution
Boehmite	$AlO(OH)$	Aluminium dissolution
Kaolinite	$Al_2Si_2O_5(OH)_4$	Aluminium and silicon dissolution
Ferrihydrite	"$Fe(OH)_3$"	Iron dissolution
Goethite	$FeOOH$	Iron dissolution
Hematite	Fe_2O_3	Iron dissolution
Siderite	$FeCO_3$	Iron dissolution
Strengite	$FePO_4$	Iron and phosphorus dissolution

Mineral Phase	Formula	Function
Fluorite	CaF_2	Calcium and fluoride dissolution
Albite	$NaAlSi_3O_8$	Aluminium, sodium and silicon dissolution
Ettringite	$Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$	Calcium, aluminium and sulfate dissolution
Barite	$BaSO_4$	Barium and sulfate dissolution
Witherite	$BaCO_3$	Barium dissolution
Strontianite	$SrCO_3$	Strontium dissolution
Celestite	$SrSO_4$	Strontium dissolution
Manganite	$MnO(OH)$	Manganese dissolution, redox potential
Rhodocrosite	$MnCO_3$	Manganese dissolution, redox potential
Hausmannite	$Mn^{2+}Mn^{3+}{}_2O_4$	Manganese dissolution, redox potential
Quartz	SiO_2	Silicon dissolution
Chalcedony	SiO_2	Silicon dissolution
Halloysite	SiO_2	Silicon dissolution
Wulfenite	$PbMoO_4$	Lead and molybdenum dissolution
Tenorite	CuO	Copper dissolution
Smithsonite	$ZnCO_3$	Zinc dissolution
Zinc hydroxide	$Zn (OH)2$	Zinc dissolution
Nickel hydroxide	$Ni (OH)2$	Nickel dissolution
Bunsenite	NiO	Nickel dissolution
Tricalcium phosphate	$Ca_3(PO4)_2$	Calcium and phosphorus dissolution
Carnotite	$K_2(UO_2)_2(VO_4)_2\cdot 3H_2O$	Uranium dissolution

The LeachXS chemical speciation fingerprint for aluminium is presented in Figure 41. These results are used to describe the key components of LeachXS predictions, and overview of the mineral phases that have been identified by the model to explain the experimental pH and L/S dependence of aluminium solubility.

The first chart in Figure 41 (left) comprises:

Experimental data for the pH dependent dissolution of aluminium using Method 1313, shown as red dots.

- Predicted leachate concentrations in leachate with L/S = 0.4 (noting that the "red dots" represent L/S = 10 leachates). This predicted relationship is indicated by a green dashed curve. These values may be considered as indicative of "porewater" or "first flush" leachate adjusted for different pH values.

- Predicted leachate concentrations in leachate with L/S = 10. This predicted relationship is indicated by a red dashed curve. These values may be considered as indicative of long-term neat seepage (adjusted for different pH values) or diluted first flush seepage leachate in the receiving environment. Coincidence of the L/S = 0.4 and L/S = 10 curve is indicative of concentration control by sparingly soluble mineral phases, while significant deviation is indicative of conservative ion behaviour. For analyte behaviour exclusively as a conservative species, the two curves will be displaced by a common factor of 25.

The accuracy of LeachXS chemical speciation fingerprints was found to be highly variable. A "good fit" is indicated by near coincidence of the experimental data (red dots) and the predicted curve fitted to L/S =10. The fit for aluminium in Figure 39 is considered a reasonable fit, particularly for acidic and circum-neutral pH values, although predicted concentrations in the alkaline pH range may be an order of magnitude lower than experiment values.

In general, the accuracy of chemical speciation fingerprints for a specific analyte depends on:

- The abundance of the element in the material. Predictions for major component elements such as aluminium, silicon, calcium, magnesium and iron (which are typically present in percent levels) are generally much more accurate than those for elements predicted as trace components (mg/kg or less);
- The number of mineral phases in the database. Common elements such as aluminium, silicon, calcium, magnesium, copper, manganese and zinc are covered by at least six mineral phases in the Minteq database;
- Whether or not the minerals in the database cover the assemblage of minerals stable across the full pH range of Method 1313 (2 to 13 pH units). Some elements include mineral oxide and hydroxide phases that are only stable in alkaline solution with a paucity of phases stable under acidic conditions;
- The availability and quality of thermodynamic data for each mineral phase in the database; and
- The limitations of LeachXS in accounting for the competitive adsorption effects of cations and organics.

The second chart in Figure 41 (on the right) presents the predicted concentrations, on a volumetric basis at L/S = 10, of various mineral and solution phases. The concentrations (y-axis) are usually presented with a logarithmic scale, which requires careful interpretation of the predicted results.

Liquid phases components comprise:

- "Free" or dissolved inorganic ions. Note that LeachXS does not indicate relative proportions of these ions in different oxidation states (e.g. Fe^{2+} and Fe^{3+}), or those present as coordination complexes or ion pairs (e.g. AlF^{2+}, $CaSO_4$, $MgHCO_3^+$); and
- "DOC bound", which refers to ions covalently complexed with dissolved organic carbon compounds.

Solid phases components comprise:

- Analytes associated with particulate organic matter (POM);
- Analytes bound to clay minerals as by ion-exchange reactions;
- Analytes bound to amorphous hydrous ferric, aluminium and manganese oxide surface, designated as the "FeOxide" phase; and
- Crystalline mineral phases included in the mineral database used in LeachXS modelling

Note that the total mass of analyte presented in each LeachXS chart corresponds to the maximum amount of leachable analyte (referred to as the "Available Content") from the pH dependence test (Method 1313), typically that present in pH 2 or pH 13 leachates. Thus, substantial amounts of major elements present as insoluble primary minerals are not accounted for in LeachXS modelling i.e. there is no relationship between "Available Content" and results from "total" elemental composition analyses. The amount of constituent remaining in the soil post leaching (i.e. total concentration minus "available content") is of no environmental concern as it is not bio-available within the pH range of 2 to 13. In effect, it may be considered as contributing to the "ambient background concentration" under NEPM/DWER Contaminated Site assessment guidelines.

Conclusions provided by assessment of the phase apportionment diagram presented as the second chart in Figure 41 indicates the following characteristics of "Available" aluminium in Alkaloam:

- All of the "available" aluminium at pH values less than 3.5 is present as "free aluminium". Although not available from LeachXS output data, the most likely ions include $[Al(H_2O)_6]^{3+}$ and $[Al(H_2O)_5OH]^{2+}$;
- The concentration of free aluminium decreases as pH increases from 3.5 to 7 pH units, mainly as a result of precipitation of the hydroxide mineral gibbsite, $Al(OH)_3$;
- The lowest concentration of "free" aluminium, approximately 0.001 mg/L in L/S = 10 leachate, occurs at pH 7.0;
- The lowest concentration of "dissolved" aluminium is observed within the pH range of 5.5 to 8 at a concentration of approximately 0.01 mg/L, comprising DOC-bound (major) and "free" (minor) forms;
- The solid phase includes a small proportion of POM-bound aluminium, but only within a pH range of 5.5 to 9.5;

- Gibbsite is the dominant solid phase component present at pH values above 9.5 pH units; and
- The proportion of aluminium reporting to the solution phase increases with increasing pH above 8 pH units. At pH 15, approximately 10% of “available” aluminium partitions to the solution phase (at L/S = 10). Although not predicted by LeachXS, the dominant form of soluble aluminium at high pH is likely to be the anionic form, $[Al(OH)_4]^-$.

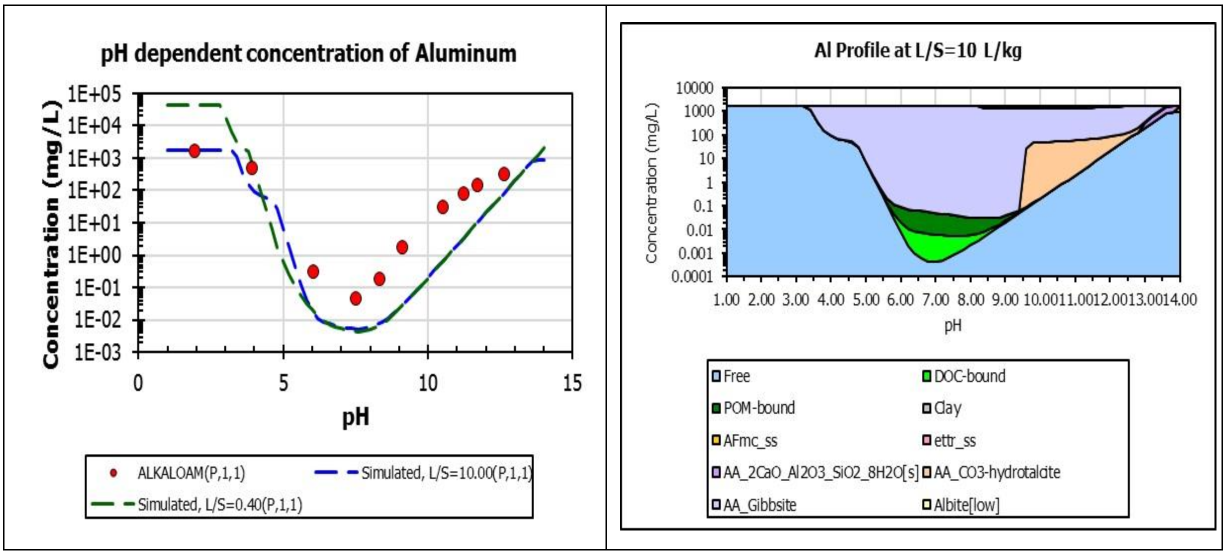


Figure 41: LeachXS Model Output for the Geochemical Speciation Fingerprint of Aluminium in Alkaloam.

5.4.1.3 LeachXS Predictive Modelling- Virtual Material and Column Simulation

LeachXS includes a flexible set of laboratory test and field simulation model scenarios that can be used for parameter estimation (laboratory test simulations) and evaluating leaching under a variety of field conditions (prediction scenarios). In general, the user can adjust the material characteristics, initial conditions and boundary conditions for within each scenario.

The predicted chemical speciation fingerprints of soils and by-product amendment materials, and percolation parameters may be used to evaluate the results of percolation column tests using a conceptual model comprising mobile and immobile zones. The conceptual model (Figure 17) consists of two zones segmented along the flow path, with one zone containing a mobile fluid phase in local equilibrium with the solid phase and the second zone containing an immobile fluid phase in local equilibrium with the solid phase. Within each column segment, each of the mobile and immobile zones are well mixed (i.e. uniform distribution of constituents within each of the solid phase and liquid phase orthogonal to the flow direction), and the mobile and immobile zones exchange dissolved constituents based on mass transfer coefficients that can be considered an effective diffusion distance. This model is insensitive to percolation flow rate because homogeneity within the immobile zone is assumed. This model can be used for a first-order approximation of the effects of preferential flow in a percolation system, as well as the impacts of changes in redo potential and influent solution chemistry on the leaching of constituents.

In order for LeachXS to predict leaching characteristics of amended soils, the concept of a “virtual material” was developed. For the purpose of this project, a “virtual material” may be considered as a representation of a blend of a by-product with a sandy soil in a ratio equivalent to typical field application rates. Typically, this is 5% by mass which is approximately equivalent to 30 to 50 tonnes per hectare of dry material applied to soil and mixed by incorporating to a depth of 100 mm.

LeachXS has a capability for generating chemical speciation fingerprints of a virtual material (amended soil layer) by combining the chemical speciation fingerprints of each component at the assigned mixing ratio. While there is sufficient LEAF test data and LeachXS chemical special fingerprints available to generate virtual materials for all combinations of by-products and the four soil types selected for this study, the following discussion relates to the following combinations:

- Alkaloam blended with Bassendean Ellenbrook soil (5% by weight).

5.4.1.3.1 Alkaloam and Bassendean Ellenbrook Soil Blend

Predicted chemical speciation fingerprints for the virtual material comprising a blend of Alkaloam (5% by weight) with Bassendean Ellenbrook sand are presented in Appendix A10-1. For many analytes, the chemical speciation fingerprints are mainly influenced by the Bassendean Ellenbrook sand component. Exceptions arise in the case of analytes that are a major component of Alkaloam and a minor component of the soil – as indicated in Figure 42 for iron and Figure 43 for aluminium. Ferrihydrite is predicted to be a major solid phase component in Alkaloam and a minor component in Bassendean Ellenbrook sand (where POM-bound is dominant, which is typical of podzol soil types). Ferrihydrite is the dominant solid phase component in the blended soil.

Similarly, gibbsite (Al $(OH)_3$) was predicted to be the dominant solid phase form of aluminium in Alkaloam at pH values greater than 4, but was not predicted to be present in Bassendean Ellenbrook sand – in which POM-bound aluminium was the dominant solid phase component at the soil's natural pH (acidic pH). Gibbsite with minor POM-bound aluminium were the main solid phase components predicted by LeachXS for the soil blend.

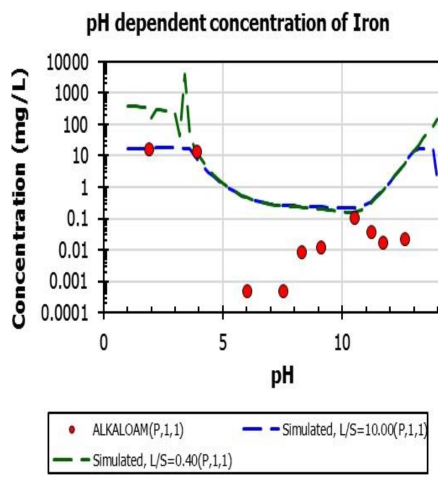
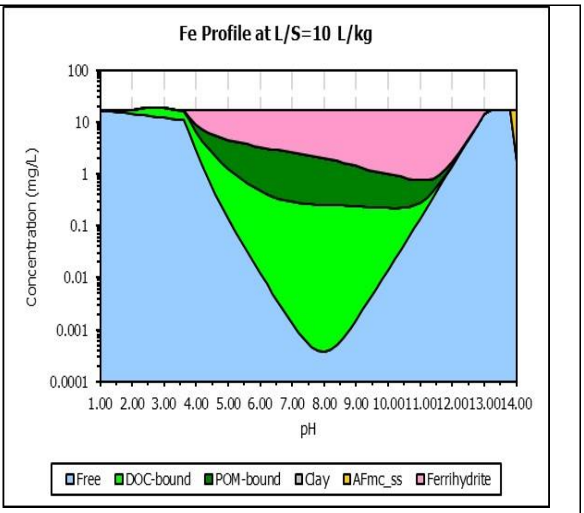
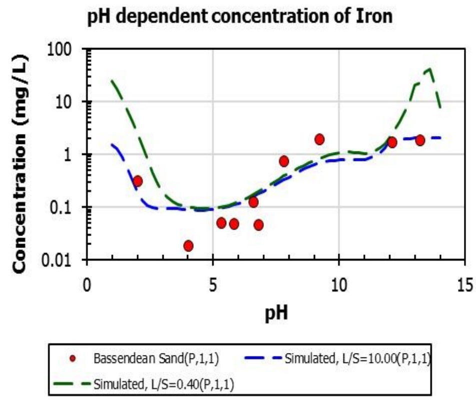
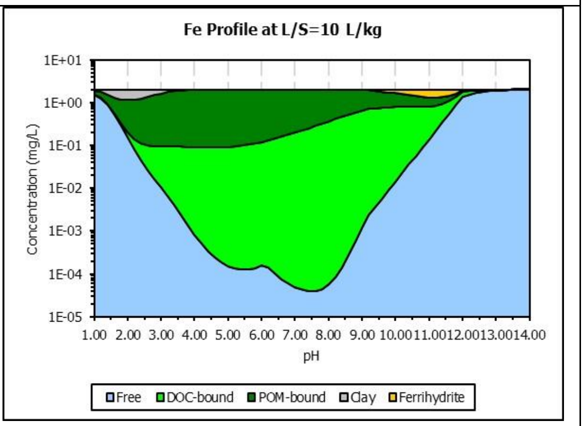
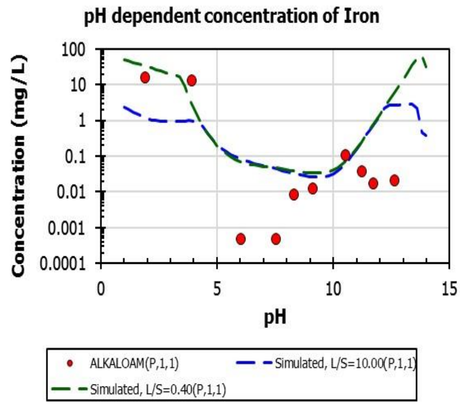
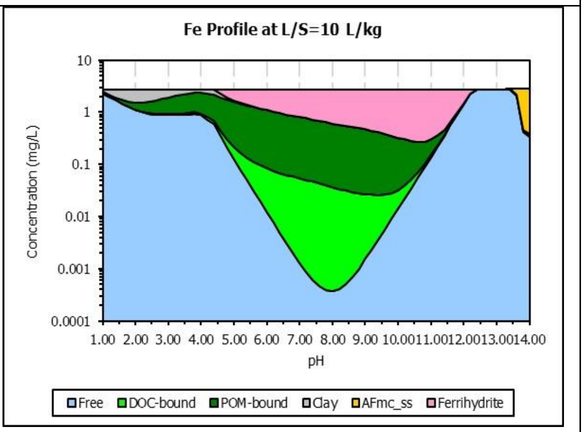
Alkaloam		
Soil		
Blended soil		

Figure 42: Chemical Speciation Fingerprints for iron in a virtual material relating to a blend of Alkaloam and Bassendean Ellenbrook sand.

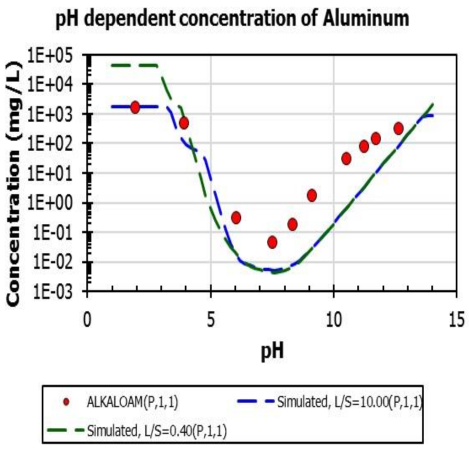
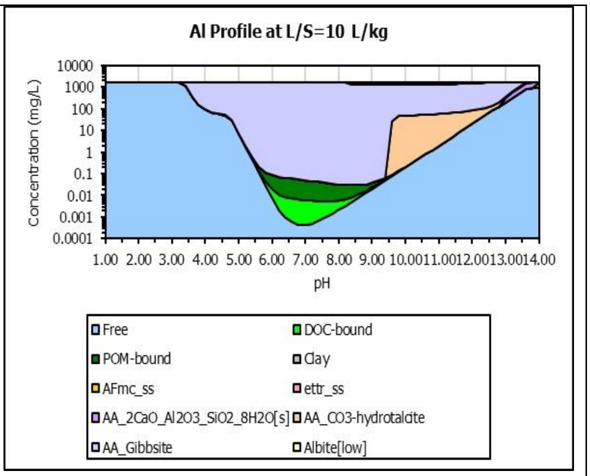
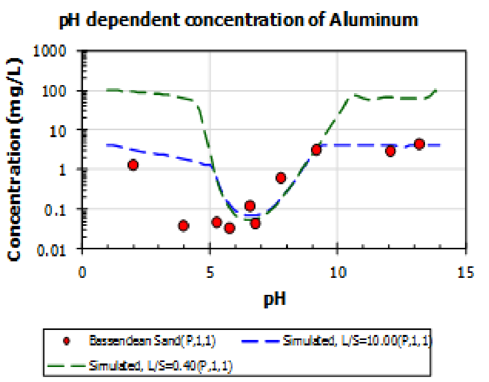
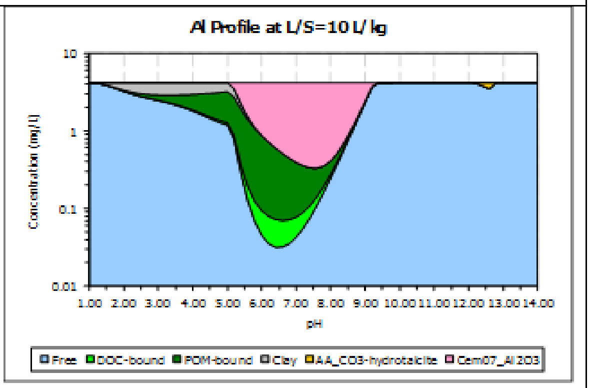
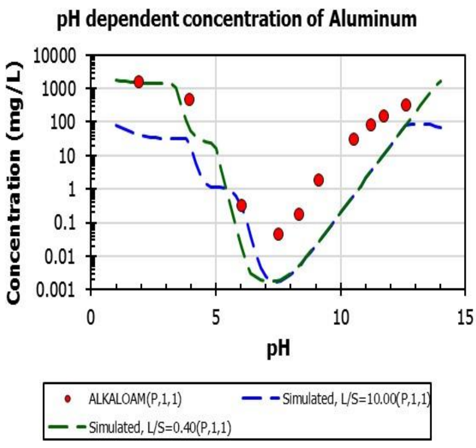
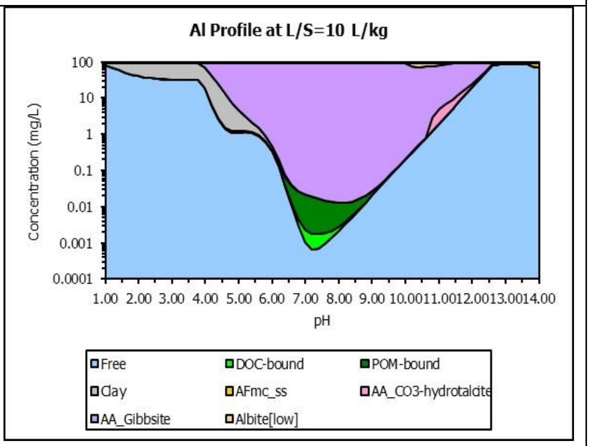
Alkaloam		
Soil		
Blended soil		

Figure 43: Chemical Speciation Fingerprints for aluminium in a virtual material relating to a blend of Alkaloam and Bassendean Ellenbrook sand.

5.4.1.4 Laboratory and Field data

5.4.1.4.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A surface layer of either amended soil (using Alkaloam as amendment) was applied at the application rate equivalents to 50 t/ha/10 cm layer for the soil amendment materials.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the amended soil/material layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A1-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the "control" columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 20), some of these are discussed below.

In many cases, it is observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Potential for mobilisation of specific constituents from Alkaloam

Based on the tall column experiment, key potential constituents from soils amended with Alkaloam include:

- Aluminium, noting that a substantial proportion of leachable aluminium is predicted to be in low toxicity forms associated with DOC and other constituents;
- Copper, zinc and chromium, which includes substantial contributions from the soil rather than Alkaloam; and
- Phosphorus. Although Alkaloam has been identified as a potentially effective means of reducing phosphorus leaching from sandy soils, elevated concentrations were recorded in leachates from the tall column experiments. However, it is to be noted that the "subsoil" layer in the tall column experiment was actually topsoil containing elevated concentrations of labile phosphorus. In field situations, the natural subsoils would be expected to contain much lower concentrations of potentially labile phosphorus.

Table 20: Tall Column Leachate Analysis Summary.

Analyte	Alkaloam			
	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩
TDS/EC	🟩	🟩	🟩	🟩
DOC	🟩	🟩	🟩	🟩
Al	🟥	🟥	🟥	🟧
As	🟩	🟩	🟩	🟩
B	🟧	🟧	🟩	🟧
Ba	🟩	🟩	🟩	🟩
Cd	🟩	🟩	🟩	🟩
Co	🟩	🟩	🟧	🟩
Cr	🟧	🟧	🟧	🟧
Cu	🟧	🟥	🟧	🟩
Mn	🟩	🟩	🟩	🟩
Mo	🟩	🟩	🟩	🟩
Ni	🟩	🟩	🟩	🟩
P	🟥	🟥	🟥	🟩
Pb	🟧	🟩	🟩	🟩
SO_4	🟩	🟩	🟩	🟩
Se	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩
Zn	🟧	🟧	🟧	🟧

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.4.1.4.2 Field Data

5.4.1.4.2.1 Alkaloam Ellenbrook Trial

A trial was established in 2011 on Department of Defence land to assess the effectiveness Alkaloam. Alkaloam was applied to leaching sandy soils of the Ellenbrook catchment to assess their suitability for use to retain phosphorus (P) on cropping land. Three lysimeters were installed within nine 3 x 3 metre small plots to collect leachate from soil over different rain events during winter and spring from 2011 to 2017. Initially depth wise (0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm) soil sampling was conducted to assess the nutrient and metals movement down the profile and later only topsoil samples were analysed.

Results from analyses of lysimeter leachates sampled on 20 occasions between June 2012 and June 2017 are presented in Appendix A 14. A summary of key findings is presented as a risk profile table (Table 21) using the same analyte threshold concentration presented in Table 6 for the tall column experiment. Risk profiles are presented for “short term” (end of 2012) and “long term” (2017) leachates.

Comparison of the risk profile of Alkaloam from the Ellenbrook trial (Table 19) with that of the tall column laboratory trial (Table 20, Section 5.4.1.4.1) indicate that the “short term” potential risks are comparable (noting that zinc did not present as a potential risk from the Ellenbrook trial). With the exceptions of minor potential risks from chromium and copper (some of which is present in Ellenbrook soil), the potential risk associated with the remaining elements decrease to very low.

Table 21: Ellenbrook Field Trial Summary for Alkaloam.

Analyte	**Alkaloam**	
	"Short Term"	"Long Term"
pH	🟩	🟩
TDS/EC	🟩	🟩
TOC	🟩	🟩
Al	🟧	🟩
As	🟨	🟩
Ba	🟩	🟩
Cd	🟨	🟩
Co	🟨	🟩
Cr	🟨	🟨
Cu	🟧	🟨
Mn	🟩	🟩
Mo	🟨	🟩
Ni	🟩	🟩
P	🟨	🟩
Pb	🟨	🟩
SO_4	🟩	🟩
Se	🟧	🟩
U	🟨	🟩
V	🟩	🟩
Zn	🟩	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.4.1.5 LeachXS Solute Transport Modelling – Comparison with Field and Laboratory Column Leaching Data

5.4.1.5.1 Model Conditions

The predictive percolation column solute transport module of LeachXS was used to simulate leaching characteristics for the following scenarios:

- A blended layer of 10 cm of 5% Alkaloam and Bassendean Ellenbrook sand overlying a 90 cm layer of Bassendean Ellenbrook sand.

These scenarios were designed to reflect the conditions of the tall column leaching experiment (Section 4.10.1.1) and in the case of Alkaloam, the highest application rates of the Ellenbrook field trial (Section 4.10.2), noting that the materials were applied as a surface layer and not incorporated by mixing in the topsoil layer.

Note that the field rainfall records cannot be used to relate the lysimeters leachate concentrations at Ellenbrook to a specific L/S ratio. Although an estimate of the cumulative volume of incident rainfall can be derived from Bureau of Meteorology records, there is no information on the percentage of that rainwater reporting to the lysimeter – known as the Net Percolation (NP). NP will vary with each rainfall event as a consequence of the variable amount of incident rainfall returned to the atmosphere via evapotranspiration (or less likely, surface run-off). For a very intense event, NP may be very high (>90%). For a very light shower, or extended drizzle, NP may be very low (<20%).

In addition to the chemical speciation fingerprints for each material, including the virtual materials representing the 5% blends of Alkaloam with Bassendean Ellenbrook sand, LeachXS also requires model input parameters for:

- Column density;
- Column diameter;
- Number of “cells”;
- Column length;
- Column mobile fraction;
- Phase distance;
- Column porosity;
- Permeating solution; and
- Out of column flow rate.

Values for model input parameters for the three modelled scenarios are presented in Table 22. For several parameters relating to the hydraulic characteristics of the materials, nominal values were used rather than measured values. the nominal values adopted were considered to be indicative of free draining sandy materials on the Swan Coastal Plain. The addition of the by-products in the blended soil (IMG) was assumed not to alter the hydraulic characteristics of the soil (Bassendean Ellenbrook).

Table 22: Input Parameters for LeachXS Percolation Column Models.

Parameter	**Alkaloam**
Number of Cells	20
Column Length	100 cm
Column Diameter	15 cm
Percolating fluid	Deionised water
Upper layer	5% blend
Upper layer cells	2
Upper Layer Chemical Speciation Fingerprint	Virtual Material
Lower layer	Bassendean Ellenbrook soil
Lower layer cells	18
Column Mobile Fraction	70%
Effective Phase Distance	4.5 cm
Column Porosity	0.45
Column Density	1.5×10^3 kg/m^3
Out of column Flow Rate	4.49×10^3 mL/m^2/hr

5.4.1.5.2 Model Output Interpretation

LeachXS percolation output results were presented in four charts formats, from which bottom of column leachate concentrations could be calculated for each scenario and subsequently compared with field trial data and tall column laboratory leachate data (Section 5.4.1.4). Examples of these formats, using aluminium in the virtual column of 5% Alkaloam blended with Bassendean Ellenbrook sand (2 cells, 10 cm depth) over Bassendean Ellenbrook sand (18 cells, 10 -100 cm) are presented in Figures 44 and 45. Interpretations of the predicted results are discussed thereafter.

Figure 44 presents the volumetric concentrations of specific liquid and solid phases, on a whole column volumetric basis, for aluminium at an L/S = 0.397 as a function of column depth. Key points provided by presentation of modelled data in this format are:

- The volumetric concentration of “available content” aluminium in the first two cells is approximately 50,000 mg/L, most of which is associated with Alkaloam in the blended soil layer.
- The volumetric concentration of “available content” aluminium in the underlying cells is approximately 150 mg/L, corresponding to the original concentration in Bassendean Ellenbrook sand. This indicates there has been very little mass transfer of aluminium from the amended soil layer to the underlying soil layer.
- The dominant form of aluminium in both layers is predicted to be the feldspar mineral albite, with additional aluminium hydroxide in the amended soil layer. Both layers, but particularly the amended soil layer, were also predicted to contain a hydrotalcite phase ($Mg_6Al_2CO_3(OH)_{16}\cdot 4(H_2O)$).
- The concentration of solution phase aluminium (DOC-bound + free), but expressed on a column volumetric basis rather than a solution phase volumetric basis, increases slightly below the amended soil layer.

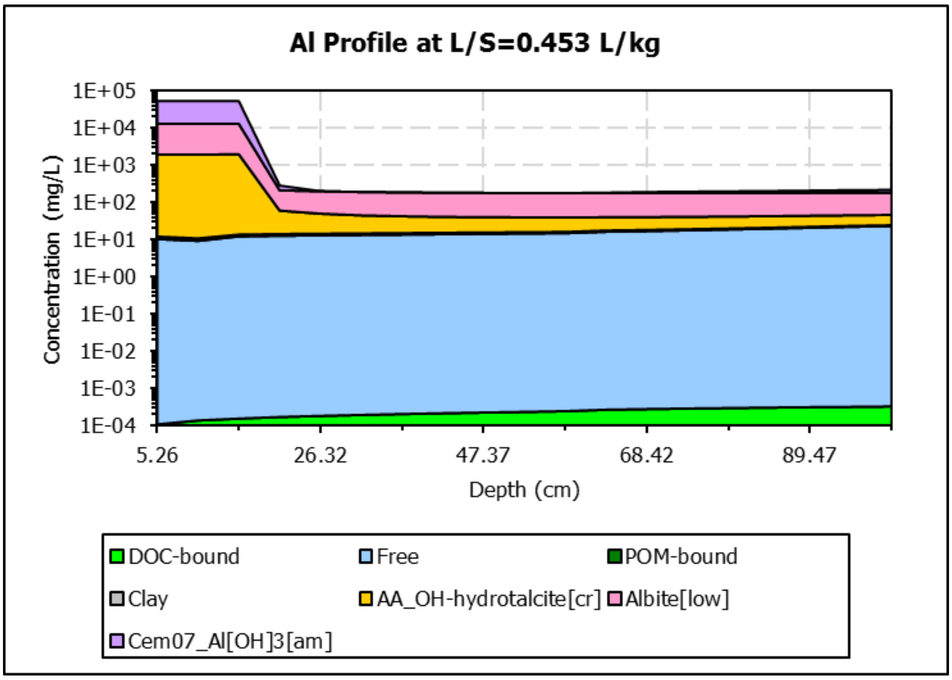


Figure 44: Aluminium profile by column depth at L/S = 0.45 L/kg.

Figure 45 presents the volumetric concentrations of specific soluble and solid phases, on a whole column volumetric basis, for aluminium at the 100 cm layer (base of column) as a function of L/S, effectively providing predicted information relating to "out of column" leachate composition as function of leachate volume. Key points provided by presentation of modelled data in this format are:

- The model output mainly depends on the validity of mobile fraction and effective phase distance used in the model. The solution concentration will decrease with the increase in mobile fraction. The pH dependent data for Al shows the effect of pH change under changing "exposure" conditions in case of solubility control. The change in L/S ratio from 0.2 to 0.5 suggests an increase in pH values from 7.8 to 8 and the soluble Al concentration increased (Figure 45). This points at solubility control by the combination of phases controlling Al solubility. The model describes washout of DOC, however the model does not take into account generation of new DOC, which is likely under the long-term test conditions in the column study.
- The "first flush" leachate concentration of approximately 0.02 mg/L aluminium (allowing for conversion of column volume to solution phase volume), comprised of exclusively DOC-bound aluminium.

  As the solution phase ratio increases, the concentration of soluble aluminium is predicted to decrease and contain increasing proportion of free aluminium.

The decrease in liquid phase aluminium is accompanied by proportional increases of both kaolinite and POM-bound aluminium in the solid phase.

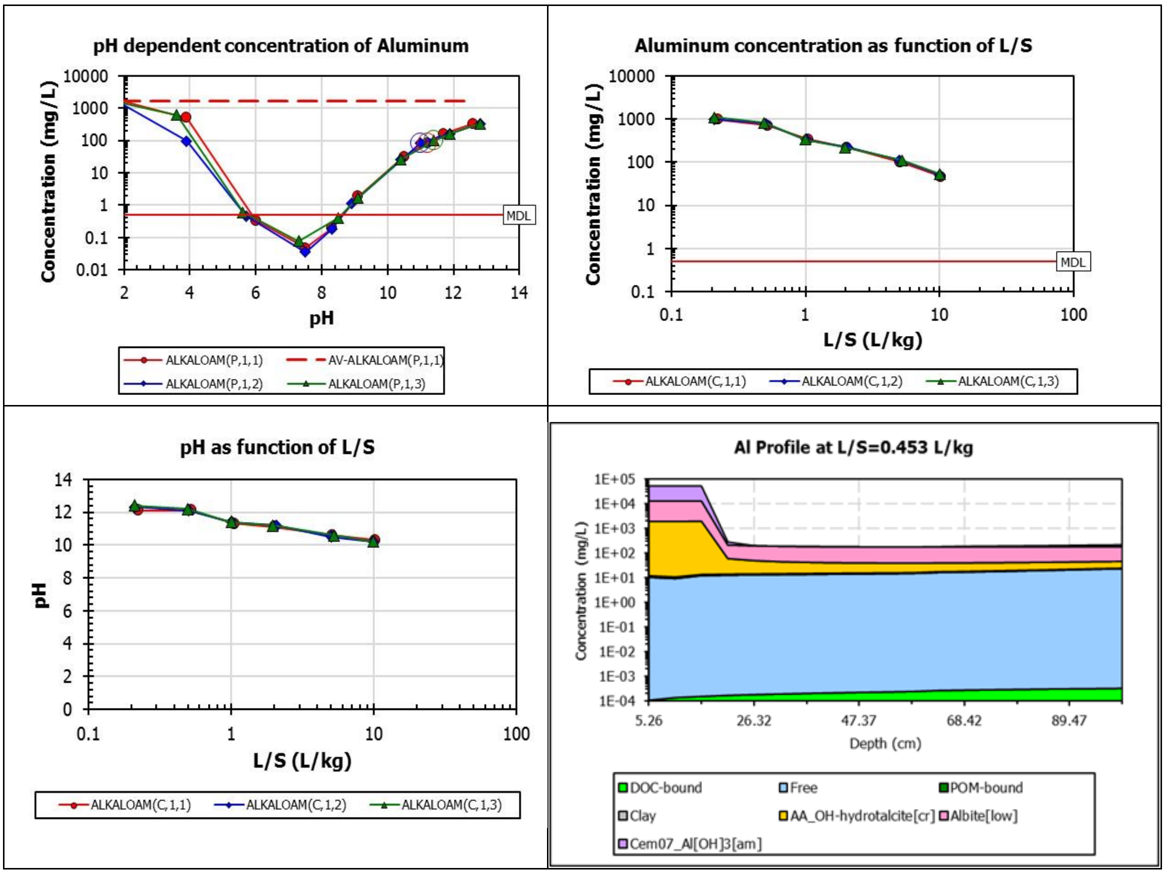


Figure 45: Aluminium Profile at depth = 100 cm (base of column) as a function of L/S.

5.4.1.5.3 Comparison of LeachXS Predictions with Field and Tall Column Results

5.4.1.5.4 Comparison Methodology

Predicted end of column leachate concentrations from LeachXS modelling described in Section 5.4.1.5.1 were compared with results from field results (Ellenbrook trial for Alkaloam) and laboratory tall column leachate data using the following methodology:

- Predicted end of column leachate concentration (sum of DOC-bond and free fractions) as a function of L/S, as calculated from LeachXS output data illustrated by Figure 44 (Section 5.4.1.5.2).
- Tall column bottom of column leachate concentrations for three sampling events (Leach Number 1, 2 and 3) discussed in Section 4.10.2.1.
- Lysimeter leachate concentrations from the first eight sampling events from the Ellenbrook Trial (Section 4.10.1.1) for Alkaloam.

5.4.1.5.5 Alkaloam Comparisons

Charts comparing predicted end of column leachate concentrations using LeachXS with Ellenbrook field trial leachate concentrations and tall column laboratory leachate concentrations for selected analytes are presented in Appendix A18.

The following discussion focuses on the following analytes which were identified as constituents of interest from assessment of the potential risk profiles derived from interpretation of LEAF test, tall column and field trial results:

- Aluminium;
- Chromium;
- Copper;
- Phosphorus;
- Selenium; and
- Zinc.

Aluminium

Comparison data for aluminium leaching characteristics are presented in Figure 46. In the LeachXS prediction no change in aluminium concentration was noted below L/S ratio 0.1 (0.15 mg/L) but elevated aluminium concentration occurred from L/S ratio 0.1 to 0.35 to a maximum of 107 mg/L. A decreasing trend was noticed for higher L/S ratios followed by generally low end of tall column aluminium concentrations, the latter being consistent with lower level of measured leachate concentrations from the tall column experiment. Elevated aluminium concentration was observed in the field trial and tall column experiment but decreased to lower levels over leaching events. Noting that a substantial proportion of leachable aluminium is predicted to be in low toxicity forms associated with DOC and other constituents.

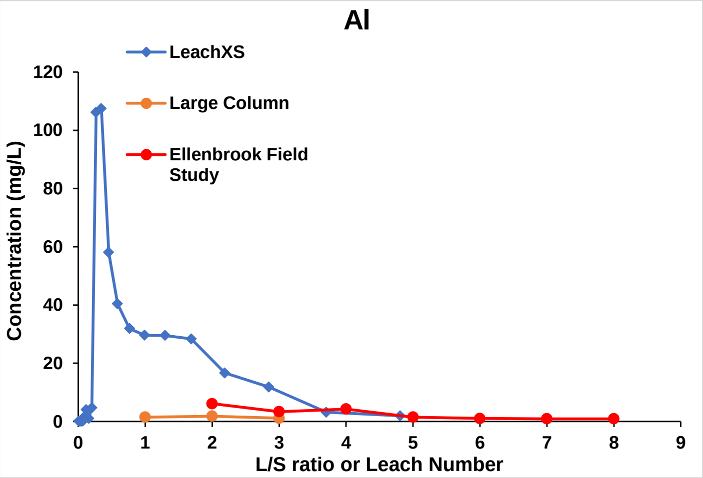


Figure 46: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for aluminium in Alkaloam Leachates.

Chromium

Comparison data for chromium leaching characteristics are presented in Figure 47. LeachXS predicted a "first-flush" event of elevated chromium, followed by generally low end of column chromium concentrations, the latter being consistent with lower level of measured leachate concentrations from the tall column experiment. Elevated concentrations measured in the Ellenbrook field trail, which indicated a minor potential risk which could be due to a substantial contribution from soil rather than Alkaloam. This potential risk would be considered as very low if speciation analysis indicated the chromium to be present in trivalent, rather than hexavalent, forms. LeachXS has the capability to apportion soluble chromium between trivalent and hexavalent forms (but was not undertaken for this study).

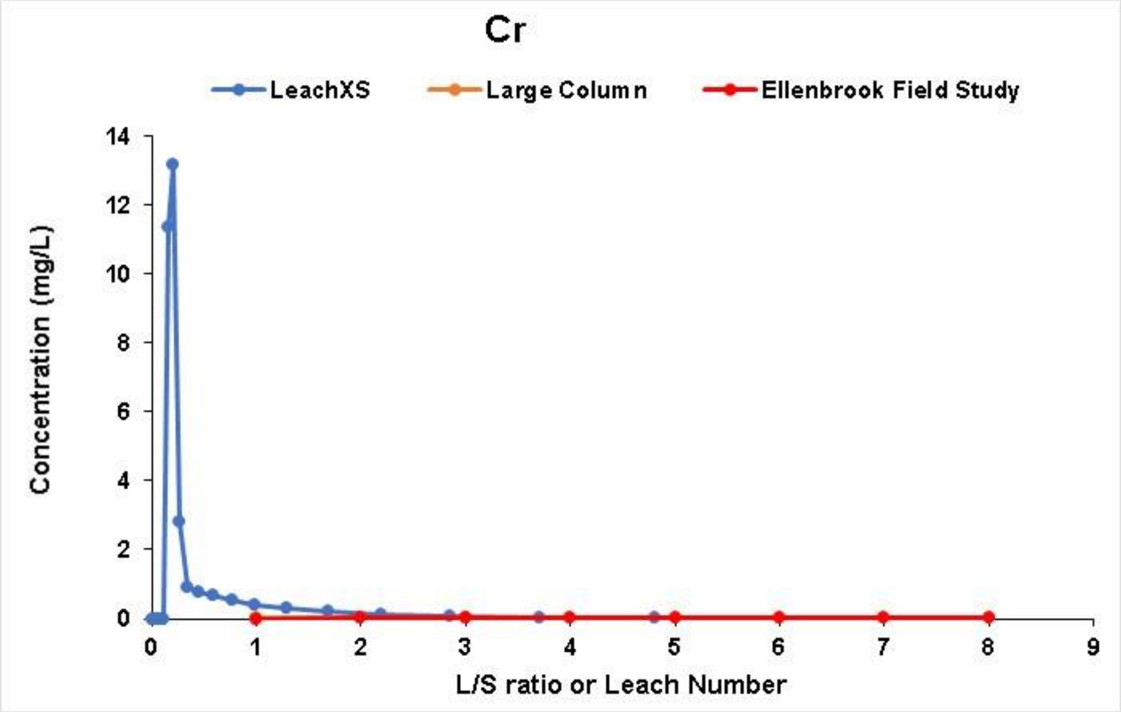


Figure 47: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Chromium in Alkaloam Leachates.

Copper

Comparison data for copper leaching characteristics are presented in Figure 48. No free copper was observed in the LeachXS prediction which was mainly suggesting DOC association of copper. Field trial indicated higher copper concentration initially and decrease to very low levels which is similar to the tall column laboratory trial. Both Ellenbrook field trial and laboratory tall column experiment provided leachates with significantly higher concentrations of copper than those predicted by LeachXS. Nevertheless, both LeachXS and laboratory trial results predict minor potential risk from copper leaching (by comparison with irrigation and livestock drinking water quality, Table 1, which is in agreement with the field trial over a longer period.

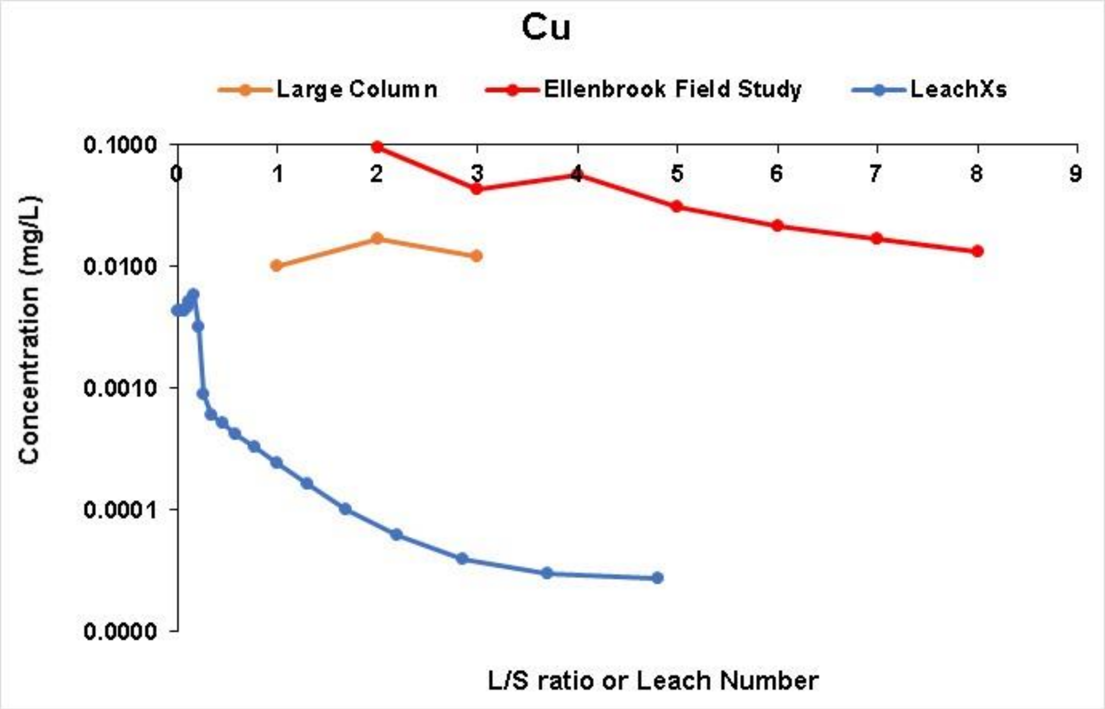


Figure 48: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Copper in Alkaloam Leachates. Y-axis in Log scale.

Phosphorus

Comparison data for phosphorus leaching characteristics are presented in Figure 49. Although Alkaloam has been identified as a potentially effective means of reducing phosphorus leaching from sandy soils, elevated concentrations were recorded in leachates from the tall column and field trial. However, it is to be noted that the “subsoil” layer in the tall column experiment was actually topsoil contain elevated concentrations of labile phosphorus. In field situations, the natural subsoils would be expected to contain much lower concentrations of potentially labile phosphorus.

LeachXS predicted an initial flush of leachate with very high phosphorus concentrations, which subsequently decreased after L/S = 1 L/kg to concentrations consistent with those from the laboratory tall column and Ellenbrook field trials.

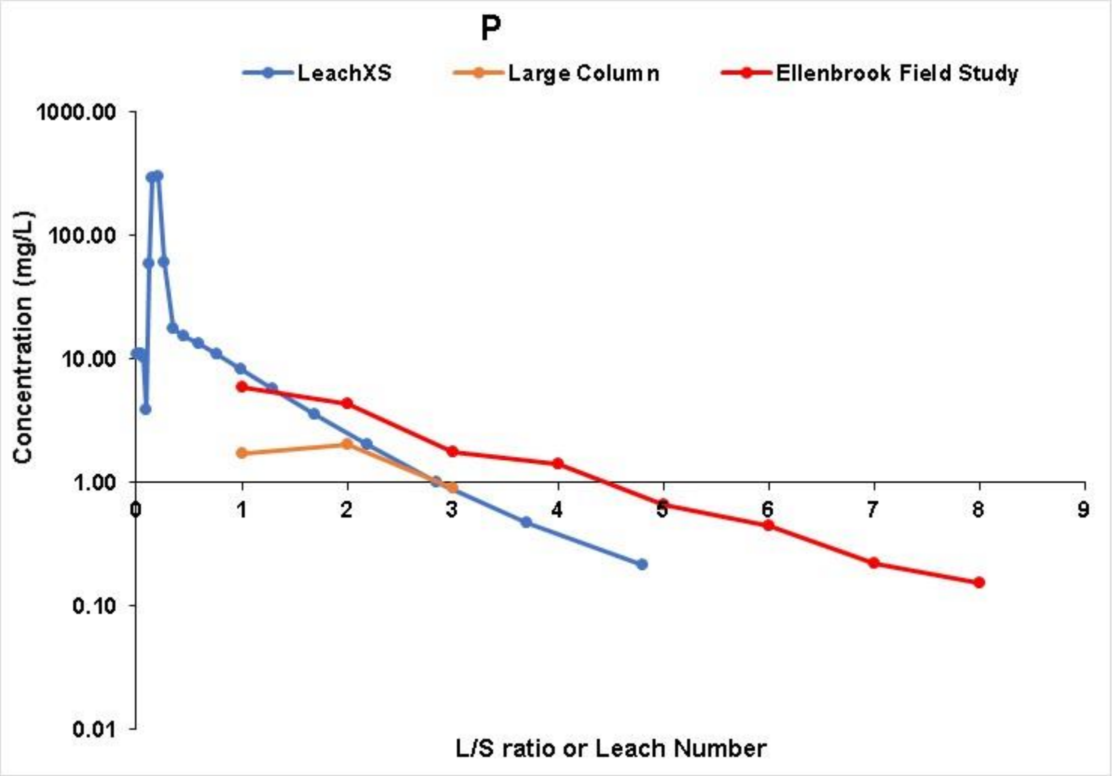


Figure 49: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Phosphorus in Alkaloam Leachates. Y-axis in Log scale.

Selenium

Comparison data for selenium leaching characteristics are presented in Figure 50. The selenium concentration predicted by LeachXS at L/S ratio 1 L/kg or more is consistent with both field and experimental trial. As with several other constituents of potential concern, LeachXS predicted elevated concentrations of selenium in first-flush (low L/S) leachates. Given the volume of leachate expected by leaching at these low L/S values (approximately 0.3 L/kg), the predicted first-flush concentrations predicted by LeachXS could not be verified by the laboratory and field trial data.

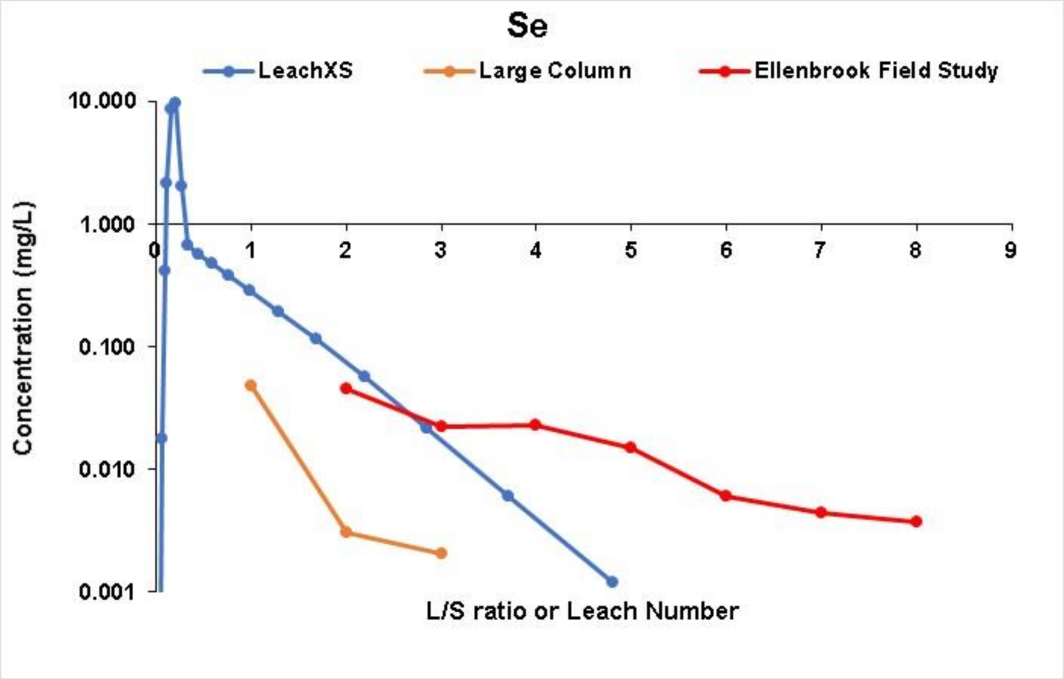


Figure 50: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Selenium in Alkaloam Leachates. Y-axis in Log scale.

Zinc

Comparison data for zinc leaching characteristics are presented in Figure 51. LeachXS predicted generally very low end of column zinc concentration which is consistent with measured leachate concentration from field trial. LeachXS prediction suggests that zinc is mostly DOC bound zinc. Elevated concentration of zinc measured in the tall column experiment decreased with respect to leaching events. Note that this elevated zinc concentration could be a substantial contribution from the soil used in the tall column trial.

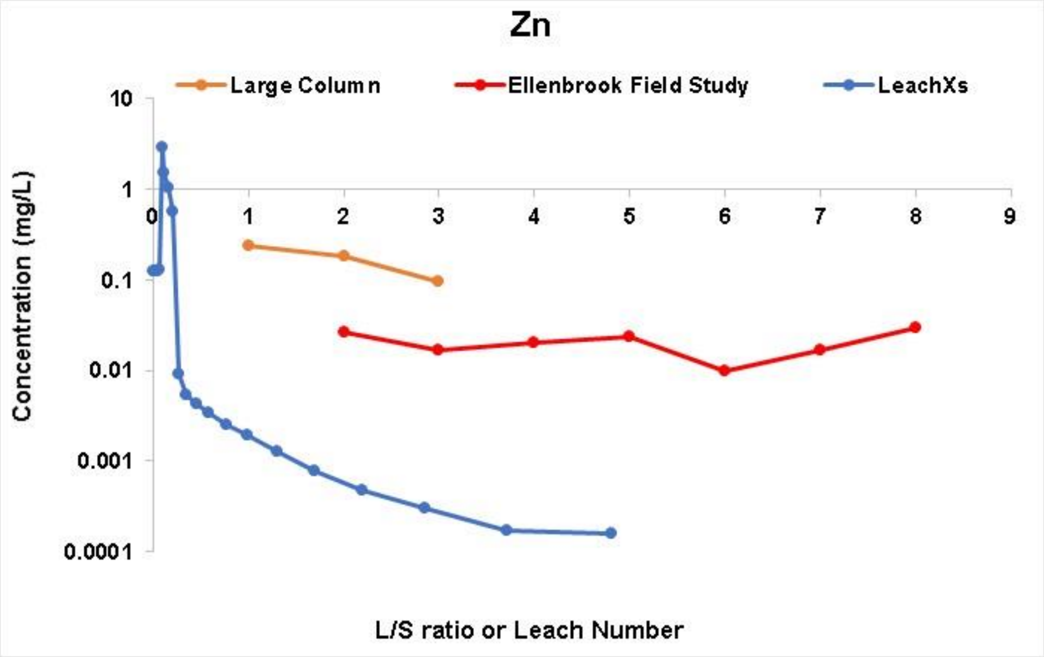


Figure 51: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Zinc in Alkaloam Leachates. Y-axis in Log scale.

Molybdenum

Comparison data for molybdenum leaching characteristics are presented in Figure 52. As with other constituents of potential concern, LeachXS predicted generally very low end of column molybdenum concentration which is consistent with measured leachate concentrations from the field trial. LeachXS also predicted a significant "first-flush" event, with most of the labile molybdenum leaching from the column after L/S increased to >1 L/kg.

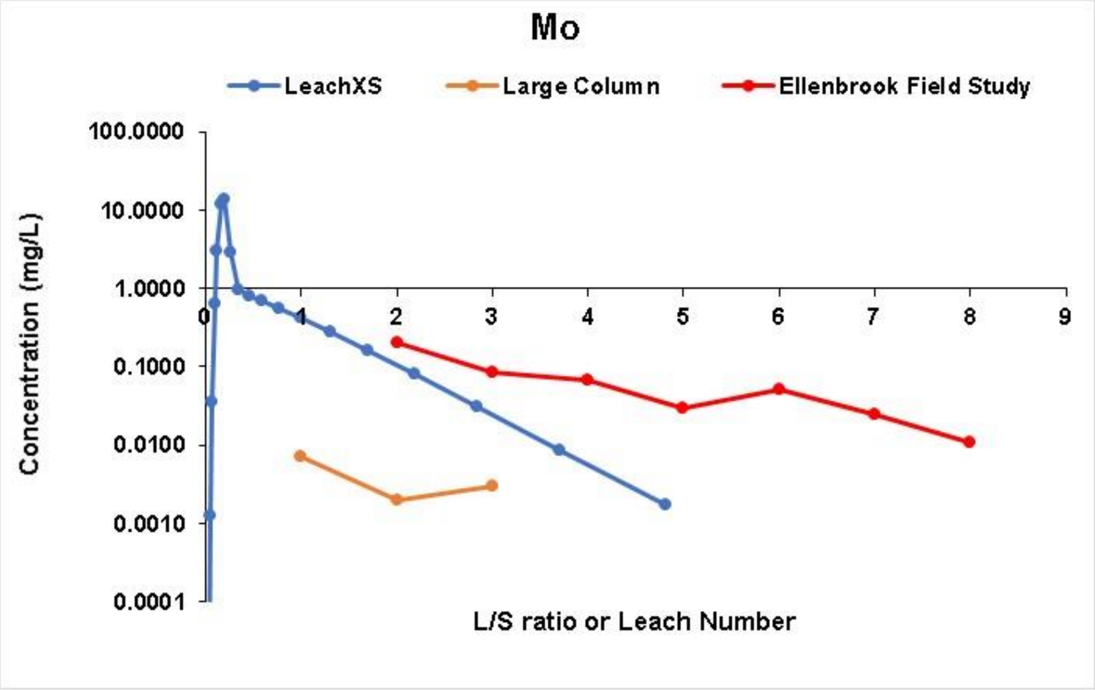


Figure 52: Comparison of LeachXS Predictions, Ellenbrook Field Trial and Tall Column Laboratory Data for Molybdenum in Alkaloam Leachates. Y-axis in Log scale.

5.4.1.6 Summary

Comparison of laboratory LEAF Method 1313 results, LeachXS solute transport modelling, tall column laboratory trials and the Ellenbrook field trial provides the following key points with respect to Alkaloam by-product as a potential soil amendment:

- LEAF Method 1313 results identified aluminium, chromium, copper, molybdenum, selenium and uranium as constituents of potential concern in Alkaloam and would need further investigation when assessing its application in this scenario pH domain. Fluoride was also indicated as a constituent of potential concern at pH values at the higher end of the applicable scenario pH domain, corresponding to instability of the mineral fluorite (CaF_2) under strongly alkaline conditions.

- With exception of copper, the identified constituents of potential concern are capable of forming stable oxy-anions, including $Al(OH)_4^-$, $CrO_4^{2-,}$ SeO_4^{2-}, MoO_4^{2-} and UO_3^{2-}. Several oxy-anions, notably those of chromium and uranium are only stable under strongly oxic (high pE) condition.

- LeachXS provided sensible chemical speciation fingerprints for these constituents of potential concern in Alkaloam. The corresponding chemical speciation fingerprints of these elements, particularly the oxy-anion elements, in Alkaloam indicate major control of solubility by interaction with hydrous ferric oxides, rather than organic matter and discrete mineral phases. Bassendean sand contain very little HFO, and so provide very low potential for attenuation of these elements should they leach from the amended soil layer.

- LeachXS predicted “first-flush” washout characteristics for most elements, i.e. most of the leaching occurred at low L/S ratios (less than 0.3). This behaviour was also observed for some elements in the tall column and Ellenbrook field trials, but not for the oxy-anion constituents of potential concern.

- The elevated concentrations predicted in first-flush events in LeachXS are partly explained by:

    - The high permeability conditions adopted for the column, which is consistent with the exceptional drainage properties of Swan Coastal Plain soil types.
    - The inability of Bassendean sand to attenuate soluble oxy-anions as a consequence of very low HFO (and clay) contents.
    - A lack of thermodynamic data for key mineral phases for these elements non-represented in the mineral database used by LeachXS.
    - Mobilisation of constituents of the lower, unamended soil layer – either by mobilisation under the soil’s “natural” pH/EC conditions, or changes in porewater composition (especially pH, pE and DOC) by interaction with leachate from the amended soil layer.

5.4.2 NRP

5.4.2.1 By-product NRP Characterisation

The NRP sample was a sample of filtered, air dried red-mud combined with some additional material (Section 4.1), supplied by Alcoa.

Results for elemental composition of the sample of NRP provided for this study are presented in Table 23.

Table 23: Bauxite Residue By-products Characterisation - NRP

Element	LOR	Units	NRP
Ag	0.5	mg/kg	<0.5
Al	100	mg/kg	79100
As	3	mg/kg	18.0
Ba	5	mg/kg	57.0
Be	0.5	mg/kg	<0.5
Ca	50	mg/kg	22700
Cd	1	mg/kg	<1
Co	1	mg/kg	4.0
Cr	10	mg/kg	170
Cu	5	mg/kg	20.0
Fe	100	mg/kg	191000
K	100	mg/kg	1850
Mg	20	mg/kg	540
Mn	5	mg/kg	119
Mo	5	mg/kg	5.00
Na	50	mg/kg	8030
Ni	5	mg/kg	<5
P	20	mg/kg	260
Pb	5	mg/kg	28.0
S	20	mg/kg	13200
Sb	2	mg/kg	<2
Se	10	mg/kg	<10
Sn	2	mg/kg	4.00
Ti	10	mg/kg	8200
Th	10	mg/kg	200
U	10	mg/kg	10.0
V	1	mg/kg	415
Zn	5	mg/kg	26.0
Tl	0.1	mg/kg	<0.1
B	20	mg/kg	<20
Hg	0.1	mg/kg	<0.1
Cl	25	mg/kg	110
F	25	mg/kg	580
LOI	-10	%	9.22
TOC	0.05	%	0.21
H20	0.1	%	4.20

Note; LOR-limit of reporting; LOI-loss of ignition; TOC-total organic carbon.

5.4.2.2 LEAF Tests 1313, 1314 and 1316

5.4.2.2.1 LEAF 1313 Test

Results for analysis of by-product NRP are presented as graphs in Appendix A5-2. Characteristics of the pH dependent leaching characteristics by analyte for NRP are summarised as follows:

- Silver: Silver concentrations were extremely low (typically <0.0001 mg/L) and did not vary with pH.
- Aluminium: Characteristic amphoteric behaviour was observed for aluminium, with elevated concentrations at both very low and very high pH values. The pH value for minimum solubility was between 7 and 8 pH units. Maximum concentrations were approximately 500 mg/L at pH 2, and 200 mg/L at pH 13.
- Arsenic: In generally, the highest concentrations were recorded at the higher pH values, although solubility at low pH (2 and 4 units) was higher than those at circum-neutral values. The solubility minima were between 6 and 7 pH units. The maximum concentration was approximately 0.3 mg/L at pH 13.
- Boron: Leachate boron concentrations were very low (maximum 0.08 mg/L) and decreased (to <0.001 mg/L) with increasing pH.
- Barium: Leachate concentrations were typically <0.02 mg/L at leachate pH values above 8. The leachates showed increasing barium concentrations with decreasing pH.
- Beryllium: Concentrations of extractable beryllium were very low (0.0001 mg/L) at pH values above 6 but increasing with increasing acidity below pH 6 (Approximately 0.01 mg/L at pH 2).
- Calcium: Highest concentrations were noted at pH 2 (1,800 mg/L) and were constant between pH 4-6 and pH 8-10 (at approximately 500 mg/L) but then decreased further with increasing pH. This behaviour is consistent with most of the calcium being associated with a mixture of calcium carbonate (or aluminates) and gypsum.
- Cadmium: With exception of the pH 2 leachates, concentrations of cadmium in leachate were very low (<0.0005 mg/L, particularly at circum-neutral pH. The maximum concentration (in pH 2 leachates) was approximately 0.003 mg/L.
- Cobalt: concentrations of cobalt were below the method reporting limit (<0.0001 mg/L) under circum-neutral and slightly alkaline conditions. Slightly elevated concentrations (maximum 0.006 mg/L) were recorded in low pH (pH 2) leachates. One of three replicate samples also recorded slightly elevated (0.004 mg/L) concentrations at very high pH (pH 13).
- Chromium: Elevated chromium concentrations (>0.1 mg/L) were recorded at both very low and very high pH values. Much lower concentrations were recorded for leachates with pH values between 6 and 8, with the lowest value of approximately 0.0002 mg/L recorded for NRP at approximately pH 7.
- DOC: Leachates contained relatively low concentrations (10 to 15 mg/L) of DOC.
- Copper: Copper leachates indicated characteristic amphoteric behaviour. The pH minimum for copper solubility (<0.01 mg/L) was measured at 6 pH units. The maximum concentrations were approximately 0.08 mg/L in pH 2 leachates.

- Fluoride: Fluoride concentrations were relatively low (below the method reporting limit of 10 mg/L) between 6 and 8 pH units but increasing significantly (to approximately 40 mg/L) at both very low and very high pH values.
- Iron: Iron concentration were elevated between 2 and 4 pH units (>10 mg/L), but much lower concentrations between 6 and 9 pH units, before increasing again at very high pH (>12 pH units).
- Mercury: Apart from minor anomalous concentrations between 0.0001 and 0.001 mg/L, most mercury concentrations were <0.0001 mg/L across the pH range.
- Potassium: Potassium concentrations were similar and consistent (approximately 5 – 10 mg/L) for pH values below 8. Higher concentrations at pH >8 were an analytical artefact arising from use of KOH to adjust leachate alkalinity (Section 4.6).
- Magnesium: Magnesium leaching characteristics were similar to those described earlier for calcium, i.e. maximum solubility at low pH (30 mg/L), with concentrations decreasing with increasing leachate alkalinity (to <0.2 mg/L at pH >10).
- Manganese: Leachate concentrations decreases with increasing pH.
- Molybdenum: Leachate concentrations were very low at low pH, but increased with increasing pH at values greater than 6. Maximum concentrations of approximately 0.1 mg/L were recorded in pH 13 leachates.
- Sodium: As expected for a conservative ion such as sodium, leachate concentrations did not vary with pH. Elevated concentrations (usually >700 mg/L) were recorded.
- Nickel: Very low values (<0.001 mg/L) were recorded in alkaline leachates (pH >8). Concentrations increased with decreasing pH to a maximum value of 0.02 mg/L at pH 2.
- Phosphorus: Phosphorus concentrations were very low (< 0.01 mg/L) in leachates at pH>6, but elevated phosphorus concentration noted (0.5 mg/L) at pH value 2.
- Lead: Elevated (>0.01 mg/L) concentrations of lead were only recorded in pH 2 leachates. Concentrations in circum-neutral and alkaline leachates were below the reporting limit (<0.0001 mg/L).
- Sulfur: Sulfur concentrations were approximately 700-800 mg/L between 4 and 10 pH units, and slightly higher concentrations at pH 2 and pH >10.
- Antimony: Concentrations of antimony in leachates were at or below the limit of detection (<0.0001 mg/L) at all pH values.
- Selenium: Selenium concentrations in leachates were slightly elevated (approximately 0.05 mg/L) and not pH dependent.
- Silicon: Silicon concentrations in leachates were highly pH dependent, ranging from almost 250 mg/L at pH 2 to 1 mg/L at pH 9 to 10. Concentrations in leachates increased at higher pH values about 25-35 mg/L.
- Tin: Tin concentrations were at or below the method reporting limit at all pH values.
- Titanium: The highest titanium concentrations (maximum 3.3 mg/L) were recorded in acid leachates. Solubility of titanium minerals were lowest (0.0001 to 0.001 mg/L) between pH 7 and 9.
- Thallium: Thallium concentrations in all leachates were below the method reporting limit (0.0001 mg/L)

- Uranium: Slightly elevated concentrations were observed at very low pH and they ranged from 0.05 to 0.4 mg/L between pH 2 and 4, while lower concentrations (<0.01 mg/L) were observed at high pH (>8).
- Vanadium: Vanadium exhibited amphoteric behaviour, with elevated concentrations (up to 2.5 mg/L) in strongly acidic and strongly alkaline leachates. Concentrations in leachate with pH values between 5 and 10 were very low (typically <0.01 mg/L),
- Zinc: Elevated concentration (0.08 mg/L) of zinc were measured in pH 2 and above pH 12 leachates. Concentrations decreased with increasing pH from 4 to 12, with the solubility minima (typically <0.01 mg/L) being between pH 8 and 10.

Results from the LEAF Method 1313 were used to identify constituents of potential concern (CoPC) in NRP based on methodology discussed in a document published by the US-EPA in October 2017. This methodology is based on LEAF test results for:

- The Available Content, defined as the maximum concentration at end-point eluate pH values of 2, 9 and 13.
- The maximum eluate concentration over the defined “applicable scenario pH domain”. For hypothetical application of NRP as a soil amendment of Swan Coastal Plain sandy soils, the applicable scenario pH domain was considered to be 5.5 to 9.0 pH units.

The adopted methodology is summarised as follows:

- Calculate the leachate concentrations based on:
    - Available Content (mg/kg) or;
    - Applicable scenario pH domain (mg/kg);
    - L/S ratio of 10 (for Method 1313);
    - Dilution and Attenuation Factor (DAF) of 10, which accounts for reduced concentrations between the leachate source (i.e leaching from NRP) and the point of compliance in the receiving environment (which may be down-gradient groundwater or a surface waterbody, depending on location); and
    - Upper and lower threshold constituent values listed in Table 6, for assessment of soil leachate concentrations from the tall column study (Section 5.2.4)

Analytes where all concentrations were below the “lower threshold” values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 24), some of these are discussed below.

It is important to note that this approach to risk screening is based on that used in Europe and elsewhere mainly for materials stored as waste, and not for beneficial re-use as soil amendment products. Factors such as intended application rates (typically 20 to 50 t/ha) and interaction of product constituents with soil (both mobilisation and attenuation) have not been considered. In effect, this method provides a first pass, high level assessment of constituents of potential concern that require further evaluation, as discussed in subsequent sections.

Table 24: Risk Screening Profile Table for CoPCs from LEAF Test Data – NRP.

Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟧	🟩
Ag	0.0001	🟩	🟩
Al	5,200	🟧	🟨
As	3.4	🟧	🟩
B	0.7	🟩	🟩
Ba	2.3	🟩	🟩
Cd	0.028	🟧	🟩
Co	0.06	🟧	🟩
Cr	3.9	🟧	🟩
Cu	0.91	🟧	🟩
F	430	🟧	🟩
Mn	2.1	🟩	🟩
Mo	1.2	🟧	🟨
Ni	0.27	🟨	🟩
PO_4	18	🟩	🟩
Pb	1.2	🟧	🟩
SO_4	3,900	🟨	🟩
Se	0.7	🟨	🟩
U	4.7	🟧	🟩
V	30	🟧	🟩
Zn	0.73	🟨	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Based on these results, NRP constituents of potential concern under typical soil pH conditions (5.5 to 9 pH units) are summarised as follows:

- Aluminium.
- Molybdenum, particularly under alkaline conditions.

Note that many constituents of potential concern identified on the basis of Available Content of NRP were no longer considered to be of concern within the Applicable Scenario pH Domain Range as a consequence of reduced solubility and applicable to a DAF = 10. LEAF 1313 results for these constituents (aluminium and molybdenum) are presented in Figure 53.

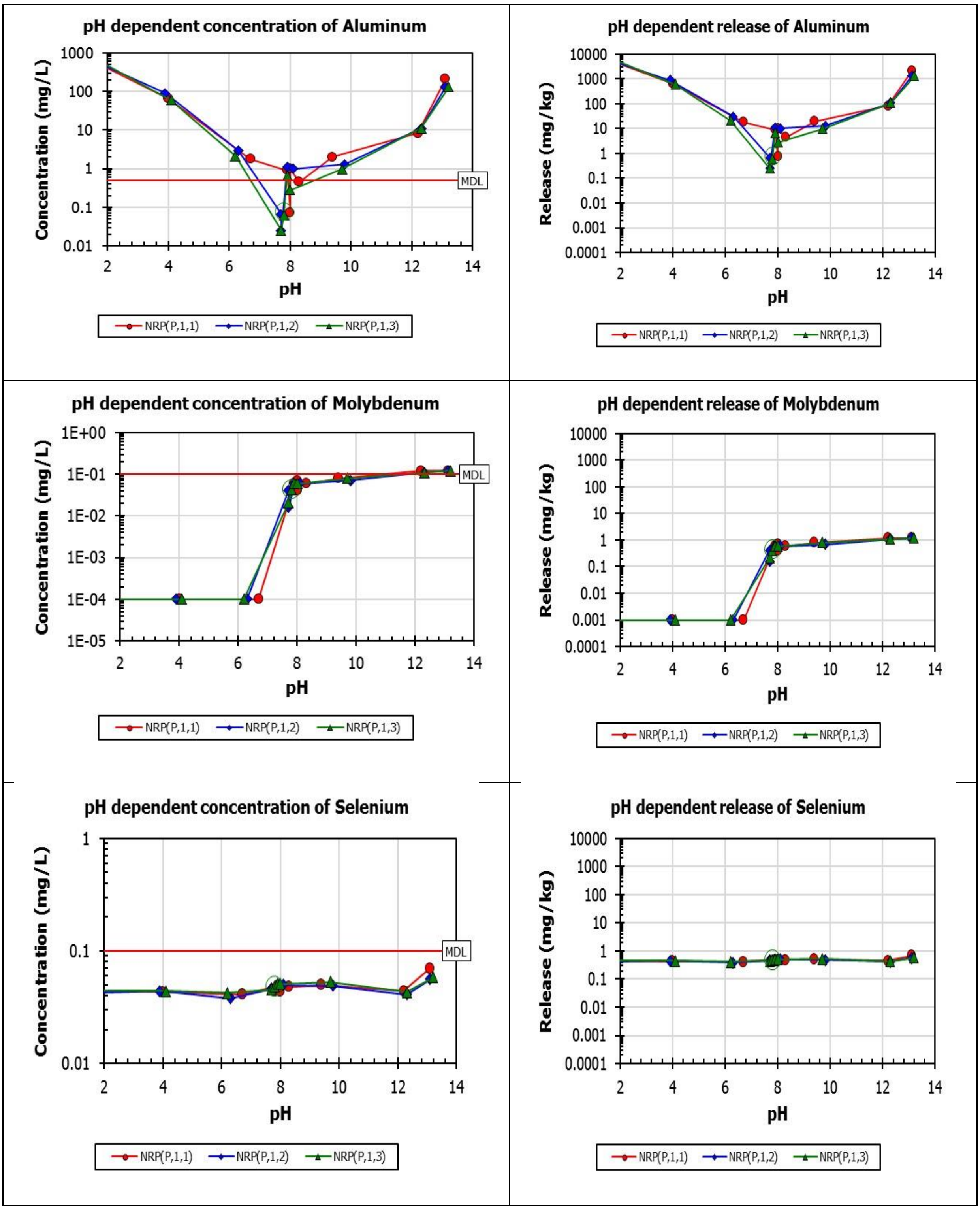


Figure 53: Graphical presentation LEAF 1313 of aluminium, molybdenum, selenium for NRP.

5.4.2.2.2 LEAF Test Results, Methods 1314 and 1316, L/S Dependence

Results for analysis of by-products (NRP) using method 1314 (up-flow percolation) are presented as charts in Appendix A6-2. Corresponding results using method 1316 (batch equilibration) are presented in Appendix A7-2. Note: the charts show good consistency between triplicate testing, hence showing good test reproducibility.

5.4.2.2 LeachXS material characterisation and Chemical Speciation Fingerprints

5.4.2.2.1 NRP

Table 25 shows the values applied for generating the chemical speciation fingerprint models for constituents of NRP using LeachXS. The same mineral phases used for modelling Alkaloam (Table 19) were used for NRP.

Table 25: Input Parameters for LeachXS Geochemical Speciation Modeling for NRP.
Note: "nominal" means estimated, not measured.

Material	pH	pE	Solid HA	Clay	HFO
NRP	8.03 (Natural pH)	7	460 (nominal)	45000 (based on LOI and Al ratio of Alkaloam)	11300 (same ratio to total Fe as Alkaloam)

Chemical speciation fingerprints for NRP constituents are presented in Appendix A8.1. For most constituents, the chemical speciation fingerprints were similar to Alkaloam. Notable differences were:

- NRP included gypsum as a dominant solid phase for both calcium and sulfate over the pH range 2 to 8.
- Hematite was predicted to be the dominant solid phase for iron in NRP across the complete pH range.

5.4.2.3 Laboratory and Field data

5.4.2.4.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A surface layer of either amended soil (using NRP materials as amendment) was applied at the application rate equivalents to 50 t/ha/10 cm layer for the soil amendment materials.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the amended soil/material layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A11-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the "control" columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 26), some of these are discussed below.

For most constituents of both materials, it was observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Potential for mobilisation of specific constituents from NRP

The elemental risk profile for NRP amended soil is shown below.

Table 26: Tall Column Leachate Analysis Summary.

Analyte	**NRP**			
	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩
TDS/EC	🟩	🟩	🟩	🟩
DOC	🟩	🟩	🟩	🟩
Al	🟧	🟩	🟧	🟩
As	🟩	🟩	🟩	🟩
B	🟧	🟧	🟩	🟧
Ba	🟩	🟩	🟩	🟩
Cd	🟩	🟩	🟩	🟩
Co	🟩	🟩	🟧	🟩
Cr	🟧	🟩	🟧	🟩
Cu	🟧	🟥	🟩	🟩
Mn	🟩	🟩	🟩	🟩
Mo	🟩	🟧	🟩	🟧
Ni	🟩	🟩	🟩	🟩
P	🟥	🟥	🟥	🟩
Pb	🟩	🟩	🟩	🟩
SO_4	🟩	🟩	🟩	🟩
Se	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩
Zn	🟧	🟧	🟧	🟧

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.4.2.6 Summary

No solute transport modelling was undertaken for blends of NRP and Bassendean Ellenbrook, although this project has generated sufficient LEAF test data and LeachXS chemical speciation fingerprints to undertake this work.

5.5 Aroona By-products

5.5.1 Example 3: How LEAF can be used to Assess a By-product – Groundwater Treatment Residues

5.5.1.1 Groundwater Residues (Jandakot and Wanneroo) Characterisation

Much of the potable water produced by the Water Corporation for distribution to consumers on the Swan Coastal Plain is source from shallow groundwater aquifers, notably the Gnangara and Jandakot Mounds. Groundwater requires treatment, mainly by aeration and flocculation/filtration to remove constituents such as iron and dissolved humic substances to render it suitable for potable use. This process produces large volumes of fine, solid materials that currently require disposal to landfill. Aroona is investigating the potential for these materials to be used as an alternative to clean fill (and potentially soil amendment, subject to demonstrating benefits).

Aroona supplied two samples of groundwater treatment residues for this project; one from a groundwater treatment plant at Wanneroo, and the other from a second plant at Jandakot. Results for elemental composition of both materials (reported on an air-dry basis) are presented in Table 27.

The results indicate the major inorganic constituents are aluminium (particularly Jandakot) and iron (particularly Wanneroo), most likely as hydrous oxides, with substantial concentrations of calcium, phosphorus, sulfur and both chloride and sodium in the Jandakot sample. Barium is slightly elevated in the Wanneroo sample, while the Jandakot material is comparatively enriched in fluoride.

Both materials contain substantial amounts of humic substances, as indicated by values of 8.55% and 5.73% for the Jandakot and Wanneroo materials, respectively. The humic substances are anticipated to be present as complexes with hydrous iron and aluminium oxide materials, which is consistent with the podzolic character of aquifer regolith materials in this region.

Both samples contain low samples of heavy metals and metalloids.

Table 27. Groundwater Residue (Jandakot and Wanneroo) Characterisation.

Element	LOR	Units	Jandakot	Wanneroo
Ag	0.5	mg/kg	<0.5	<0.5
Al	100	mg/kg	156000	128000
As	3	mg/kg	8.00	6.00
Ba	5	mg/kg	69	635
Be	0.5	mg/kg	0.90	<0.5
Ca	50	mg/kg	2680	2790
Cd	1	mg/kg	<1	<1
Co	1	mg/kg	3.00	17.0
Cr	10	mg/kg	35.0	15.0
Cu	5	mg/kg	<5	<5
Fe	100	mg/kg	40300	115000
K	100	mg/kg	230	130
Mg	20	mg/kg	345	200
Mn	5	mg/kg	150	379
Mo	5	mg/kg	<5	<5

Element	LOR	Units	Jandakot	Wanneroo
Na	50	mg/kg	1920	225
Ni	5	mg/kg	<5	<5
P	20	mg/kg	2920	5100
Pb	5	mg/kg	<5	<5
S	20	mg/kg	6800	2560
Sb	2	mg/kg	<2	<2
Se	10	mg/kg	<10	<10
Sn	2	mg/kg	<2	<2
Ti	10	mg/kg	140	90
Th	10	mg/kg	<10	<10
U	10	mg/kg	<10	<10
V	1	mg/kg	33.0	15.0
Zn	5	mg/kg	10.0	21.0
Tl	0.1	mg/kg	<0.1	<0.1
B	20	mg/kg	<20	<20
Hg	0.1	mg/kg	<0.1	<0.1
Cl	25	mg/kg	3220	185
F	25	mg/kg	2200	690
LOI	-10	%	46.0	33.6
TOC	0.05	%	8.55	5.73
H20	0.1	%	31.5	38.5
Si	0.01	%	ND	ND

Note; LOR-limit of reporting; LOI-loss of ignition; TOC-total organic carbon.

5.5.1.2 LEAF Tests 1313, 1314 and 1316

5.5.1.2.1 LEAF 1313 Test

Results for analysis of ground water residue (Jandakot and Wanneroo) are presented as graphs in Appendix A5-4. Characteristics of the pH dependent leaching characteristics by analyte for these materials are summarised as follows:

- Silver: All leachates recorded silver concentrations below the method reporting limit.

- Aluminium: Both ground water residues indicated characteristic amphoteric behaviour for aluminium, with elevated concentrations at both very low and very high pH values. Lowest solubility of groundwater residue noted between pH value 4.5 and 8. At pH 7, higher aluminium concentration noted in Jandakot compared to Wanneroo residue.

- Arsenic: Highest concentrations were recorded at the higher pH values about 12, although solubility at low pH (2) was higher than those at circum-neutral values. The lowest solubility for Jandakot was between pH 8 and 10 whereas for Wanneroo residue was at pH 4. Concentrations within the pH range associated within typical soil environments (4.5 to 9 pH units) were less than 0.01 mg/L and therefore unlikely to present an environmental risk.

- Both groundwater residues released soluble boron, with concentrations at both low pH (pH 2) and high pH (pH 12 to 13) exceeding 1 mg/L. The Jandakot residue contained higher concentrations of soluble boron than did the Wanneroo residue.

- Elevated concentrations of barium, greater than 50 mg/L, were present in acidic leachates of groundwater residues, especially the Wanneroo material. Minimum concentrations of approximately 0.01 mg/L were recorded at alkaline pH values (9 to 12 pH units), followed by a slight increase at pH 13.

- Significant concentrations of beryllium (greater than 0.001 mg/L) where only recorded at very low pH (<4 pH units) and very high pH (>13 pH units), which is consistent with the amphoteric properties of boron compounds.

- Elevated concentrations of calcium were recorded from both materials at acidic pH values (<6 pH units). The solubility characteristics were consistent of carbonate minerals such as calcite and aragonite. Slightly higher concentrations (up to 10 mg/L) were recorded at circum-neutral to moderately alkaline conditions (7.5 to 12 pH units) for the Jandakot residue.

- Concentrations of soluble cadmium were less than 0.001 mg/L for both materials between pH 4 and 11 but increased with increasing pH to a maximum of approximately 0.005 mg/L at very high pH. The pH dependent solubility curves were similar for both materials.

- Chloride concentrations indicated relatively little pH dependence. Significantly higher concentrations (approximately 300 mg/L vs approximately 50 mg/L) were associated with the Jandakot material (i.e. higher salinity).

- Cobalt indicated amphoteric characteristics, with the highest concentrations associated with low pH (approximately 0.01 mg/L) and similar concentrations for the Jandakot residue at pH 12. Concentrations within the pH range associated within typical soil environments (4.5 to 9 pH units) were less than 0.001 mg/L and therefore unlikely to present an environmental risk.

- Chromium: Elevated concentrations (up to 1 mg/L) were recorded for both materials at both very low and very high pH values. Much lower concentrations were recorded for leachates with pH values between 4 and 8, although concentrations from the Jandakot material (approximately 0.01 mg/L) were much higher than those from the Wanneroo material (0.001 to 0.002 mg/L).

- Copper: Both materials recorded near identical pH dependent curves. Maximum concentrations of approximately 0.2 mg/L were recorded at low and less than 0.1 mg/L at very high pH values, indicating amphoteric behaviour. Concentrations in the pH range associated within typical soil environments (4.5 to 9 pH units) were within a range of 0.1 to 0.001 mg/L, presenting a potential environmental risk.

- Dissolved organic carbon concentrations were highly variable, with minimum concentrations of 1 to 10 mg/L aligning with circum-neutral pH conditions. Maximum concentrations of approximately 10,000 mg/L were recorded for the Jandakot material at pH 13. The Jandakot material released higher concentrations (typically 2x to 5x) of organic carbon than did the Wanneroo material at all pH values.

- Fluoride concentrations were elevated for both materials at very low pH (2 pH units) and high (>10 pH units), with the minimum solubility at slightly acidic and circum-neutral pH. The Jandakot material contained more soluble fluoride than the Wanneroo material.

- Magnesium: Magnesium leaching characteristics were similar to those described earlier for calcium, i.e. maximum solubility at low pH (Jandakot > Wanneroo), with concentrations decreasing with increasing leachate alkalinity (to <1 mg/L for all products at pH >8).

- Manganese: The pH dependence solubility curves for both materials were similar at circum-neutral to strongly alkaline pH conditions, with concentrations generally less than 0.1 mg/L. Elevated concentration (>10 mg/L) were recorded for both materials under acidic conditions, with the Wanneroo material releasing higher concentrations than the Jandakot material at all pH values between 2 and 6.

- Molybdenum was only present in reportable concentrations in leachates with pH >7 pH units. Alkaline leachates were similar for both materials and increased with increasing pH to maximum of approximately 0.06 mg/L.

- Sodium concentrations reflected those of chloride, indicating that sodium chloride was the principal soluble salt in both materials, particularly in the Jandakot residue.

- Nickel concentrations within typical soil environments (4.5 to 9 pH units) were within a range of 0.1 to 0.01 mg/L, presently minimal environmental risk. Higher concentrations (up to approximately 0.05 mg/L) were recorded at low pH (both materials) and high pH (Jandakot).

- Phosphorus concentrations were highly variable, ranging from approximately 1 mg/L to several hundred mg/L. Solubility maxima were associated with very low and very high pH values. The Wanneroo material contained slightly higher concentrations of soluble phosphorus at all pH values than the Jandakot material.

- Lead concentrations were below the method reporting limit (0.0001 mg/L) for both materials at pH values greater than 6. Solubility increased with decreasing acidic pH values, with concentrations of approximately 0.01 and 0.05 at pH 2 for the Jandakot and Wanneroo materials, respectively.

- Sulfur (mainly as sulfate) concentrations were variable, with the Jandakot material containing more soluble sulfur than the Wanneroo material. Solubility minima of approximately 1 mg/L were observed at slightly acidic pH values (4 to 6 pH units), with corresponding maximum at both pH 2 and alkaline pH values between 10 and 14.

- Selenium was only present in leachates of both materials at moderately to highly alkaline pH values (>9 pH units). Concentrations at lower pH units were <0.001 mg/L and therefore unlikely to present an environmental risk.

- Tin concentrations were of no environmental concern, with concentrations greater than 0.001 mg/L only recorded in leachates with pH >12 pH units.

- Titanium concentrations in leachates of both materials indicated similar amphoteric characteristics. Concentrations >0.1 mg/L very only recorded at very low (2 pH units) and high (>11 pH units).

- Uranium also indicated amphoteric characteristics, with maximum concentrations (>0.01 mg/L) recorded at very low (2 pH units) and high (>12 pH units). Concentrations in the pH range associated within typical soil environments (4.5 to 9 pH units) were within a range of 0.001 to 0.0001 mg/L, presenting low environmental risk.

- Vanadium concentrations were highly variable, ranging from 0.0001 mg/L at circum-neutral to slightly alkaline conditions, and solubility maxima of greater than 1 mg/L at very low (2 pH units) and high (>10 pH units).

- Zinc concentrations were also highly variable, ranging from approximately 0.001 mg/L at circum-neutral to slightly alkaline conditions, and solubility maxima of slightly less than 1 mg/L at very low (2 pH units) and high pH (>12 pH units). Concentrations in the pH range associated within typical soil environments (4.5 to 9 pH units) were within a range of 0.001 to 0.01 mg/L, presenting low environmental risk.

Results from the LEAF Method 1313 were used to identify constituents of potential concern (CoPC) in Jandakot and Wanneroo groundwater residues based on methodology discussed in a document published by the US-EPA in October 2017. This methodology is based on LEAF test results for:

- The Available Content, defined as the maximum concentration at end-point eluate pH values of 2, 9 and 13.
- The maximum eluate concentration over the defined "applicable scenario pH domain". For application of Jandakot and Wanneroo groundwater residues as fill in Swan Coastal Plain sandy soils, the applicable scenario pH domain was considered to be 5.5 to 9.0 pH units.

The adopted methodology is summarised as follows:

- Calculate the leachate concentrations based on:
  - Available Content (mg/kg) or;
  - Applicable scenario pH domain (mg/kg);
  - L/S ratio of 10 (for Method 1313);
  - Dilution and Attenuation Factor (DAF) of 10, which accounts for reduced concentrations between the leachate source (i.e leaching from Jandakot and Wanneroo groundwater residues) and the point of compliance in the receiving environment (which may be down-gradient groundwater or a surface waterbody, depending on location); and
  - Upper and lower threshold constituent values listed in Table 6, for assessment of soil leachate concentrations from the tall column study (Section 5.2.4)

Analytes where all concentrations were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Tables 28 and 29), some of these are discussed below.

It is important to note that this approach to risk screening is based on that used in Europe and elsewhere mainly for materials stored as waste, and not for beneficial re-use as soil amendment products. Factors such as intended application rates (typically 20 to 50 t/ha) and interaction of product constituents with soil (both mobilisation and attenuation) have not been considered. In effect, this method provides a first pass, high level assessment of constituents of potential concern that require further evaluation, as discussed in subsequent sections.

Tables 28 and 29 indicate that both materials contain numerous constituents that present considerable environmental risk based on Available Content, despite relatively low total concentrations of these elements (Table 27); this is not surprising given that these elements were originally present as dissolved or colloidal species in groundwater prior to treatment. However, very much lower potential risks are evident when the assessment in based on the Applicable Scenario pH Domain Range and a DAF of 10. The only constituents identified as being of potential concern using this approach are:

- Chromium in the Jandakot sample (possibly as hexavalent chromium at elevated pE)
- Aluminium in the Wanneroo sample.
- Copper in the Wanneroo sample, but only at the alkaline end of the Applicable Scenario pH Domain.

Examples of LEAF 1313 data for selected constituents (Ba, Cr, Cu, Mn, V and Zn) indicating elevated risk based on Available Content are present in Figure 54.

Table 28: Risk Screening Profile Table for CoPCs from LEAF Test Data – Jandakot Groundwater Residue.

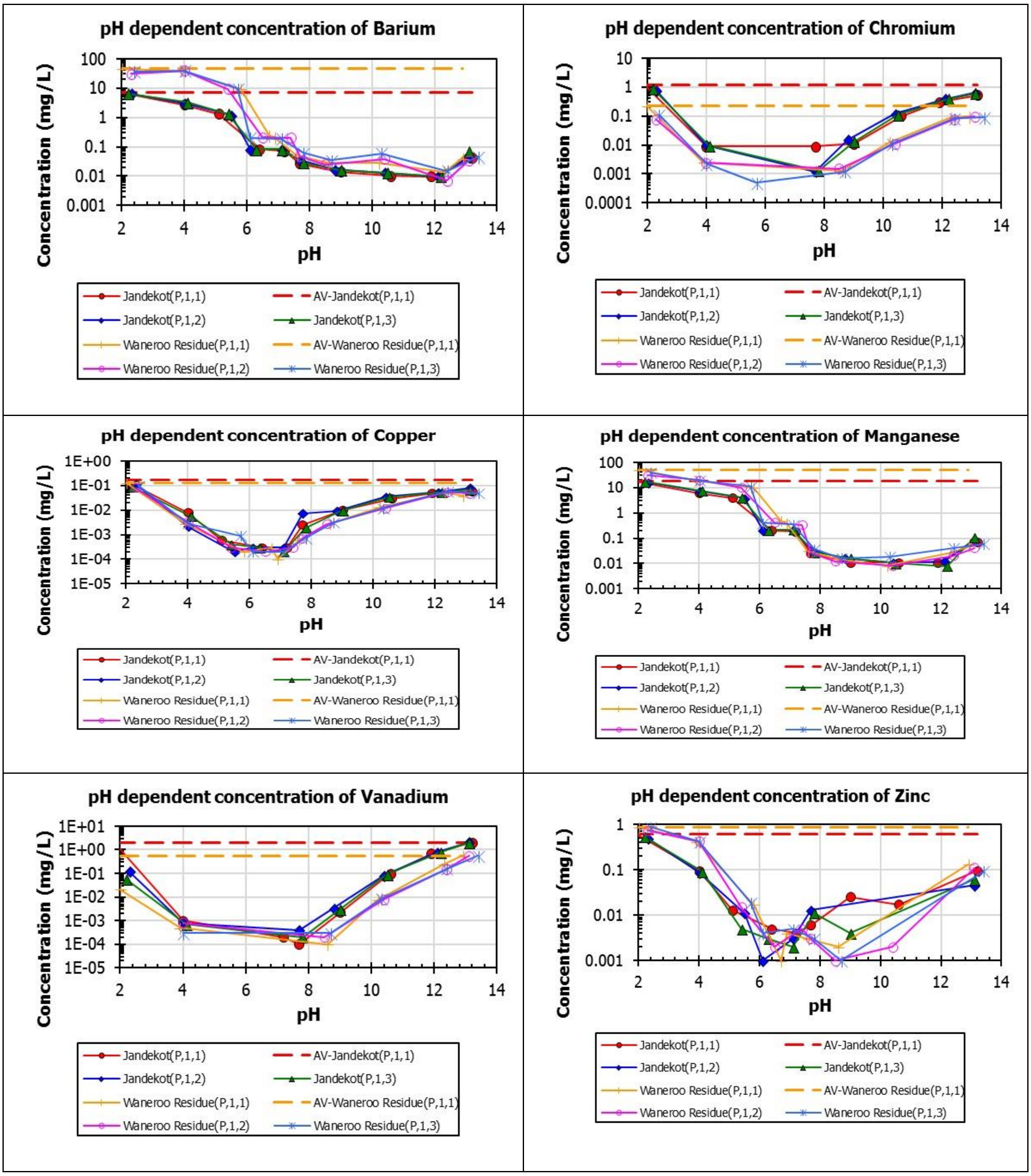
Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟧	🟩
Ag	<0.0001	🟩	🟩
Al	21,000	🟧	🟩
As	1.8	🟧	🟩
B	27	🟨	🟩
Ba	73	🟨	🟩
Cd	0.05	🟧	🟩
Co	0.14	🟨	🟩
Cr	12	🟧	🟨
Cu	1.7	🟧	🟩
F	2,800	🟧	🟩
Mn	180	🟧	🟩
Mo	0.5	🟧	🟩
Ni	0.57	🟧	🟩
PO_4	7,050	🟧	🟩
Pb	0.48	🟧	🟩
SO_4	20,700	🟨	🟩
Se	0.28	🟨	🟩
U	0.25	🟨	🟩
V	20	🟧	🟩
Zn	6.1	🟨	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Table 29: Risk Screening Profile Table for CoPCs from LEAF Test Data – Wanneroo Groundwater Residue.

Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟩	🟩
Ag	<0.0001	🟩	🟩
Al	14,000	🟧	🟨
As	0.83	🟧	🟩
B	6.6	🟧	🟩
Ba	450	🟧	🟩
Cd	0.05	🟨	🟩
Co	0.08	🟨	🟩
Cr	2.2	🟧	🟩
Cu	1.3	🟧	🟨 (alkaline pH only)
F	1,000	🟧	🟩
Mn	500	🟧	🟩
Mo	0.45	🟨	🟩
Ni	0.4	🟧	🟩
PO_4	11,000	🟧	🟩
Pb	0.13	🟧	🟩
SO_4	8,400	🟩	🟩
Se	<0.001	🟨	🟩
U	0.17	🟩	🟩
V	5.4	🟧	🟩
Zn	8.7	🟨	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.



pH dependent concentration of Barium

pH dependent concentration of Chromium

pH dependent concentration of Copper

pH dependent concentration of Manganese

pH dependent concentration of Vanadium

pH dependent concentration of Zinc

Figure 54: Graphical presentation LEAF 1313 of barium, chromium, copper, manganese, vanadium and zinc for Jandakot and Wanneroo residues.

5.5.1.2.2 LEAF Test Results, Methods 1314 and 1316, L/S Dependence

Results for analysis of Jandakot and Wanneroo groundwater treatment residues using LEAF Methods 1314 (up-flow percolation column, section 3.1.2) and 1316 (L/S parallel batch extraction, section 3.1.4) are presented in Appendices A6-4 and A6-5.

Most constituents present in measurable concentrations, but especially calcium, chloride, sodium, potassium, sulfate, bromide and zinc demonstrated "wash-out" behaviours.

Aluminium (and also iron) demonstrated mineral phase equilibria control on solubility at natural pH. Figure 55 shows results for aluminium in Jandakot and Wanneroo groundwater treatment residues measured by Method 1316.

Somewhat surprisingly, boron in Jandakot residue did not vary significantly with L/S and therefore likely to be under solid phase equilibria control. On average, concentrations in Jandakot residue leachates were slightly higher than those in leachates of the Wanneroo material.

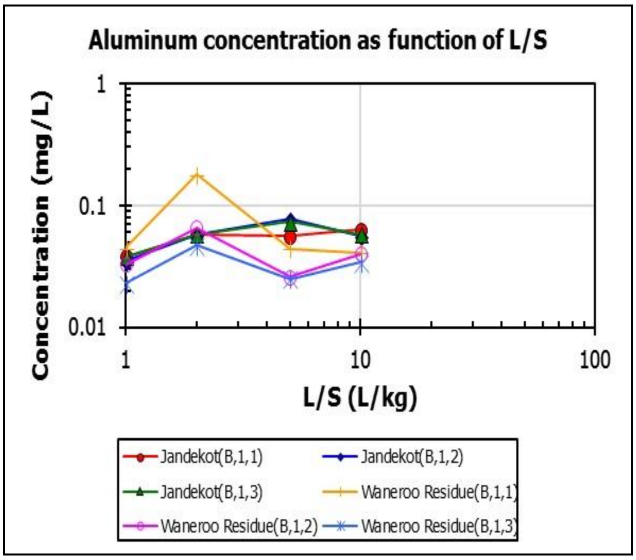


Figure 55: Aluminium Concentrations in Leachates of Jandakot and Wanneroo Groundwater Residues as a Function of L/S (Method 1316).

5.5.1.3 LeachXS Material Characterisation and Chemical Speciation Fingerprints

Table 30 shows the nominal values applied for fingerprinting of each test material and Table 27 lists the mineral phases Adopted for the chemical speciation fingerprint models using LeachXS.

Table 30: Input Parameters for LeachXS Geochemical Speciation Modeling for Jandakot and Wanneroo groundwater treatment residues and for Bassendean Sand.
Note: “nominal” means estimated, not measured.

Material	pH	pE	Solid HA	Clay	HFO
Jandakot Residue	6.3 (Natural pH)	8	19000 (nominal)	2000 (nominal)	2400 (nominal)
Wanneroo Residue	6.4 (Natural pH)	8	11800 (nominal)	3000 (nominal)	6800 (nominal)
Bassendean Ellenbrook	6.1 (natural pH)	8	1500 (nominal)	10000 (measured)	100 (measured)

5.5.1.3.1 Jandakot

Discussion in this section focuses on three of the elements present in the Jandakot groundwater treatment residue that were identified in Section 5.5.1.2.1 with potential for environmental impacts; chromium, copper and manganese.

The chemical speciation fingerprint charts for chromium are presented in Figure 56. Key predictions presented in these charts indicate the following:

- LeachXS modelling provides a reasonable description of the solubility of chromium in this material across the full pH range. Predicted leachate concentrations at L/S = 10 are generally within one order of magnitude higher than experimental results.
- Within the pH range of 2 to 10 pH, units, LeachXS predicts similar chromium concentrations at L/S ratios of 10 and 0.4, indicating mineral phase control.
- While the predictions very low concentrations (<0.000001 mg/L) for free chromium between 4 and 9 pH units is consistent with expectations, predicted concentrations of DOC-bound ions (up to 0.001 mg/L) within this pH range are much higher; and
- The dominant solid phase component is POM bound between 2 and 10 pH units.

LeachXS has capacity to predict relative contributions from both trivalent and hexavalent forms of chromium, with proportions expected to be dependent on adopted pE values (hexavalent chromium favoured at high pE)

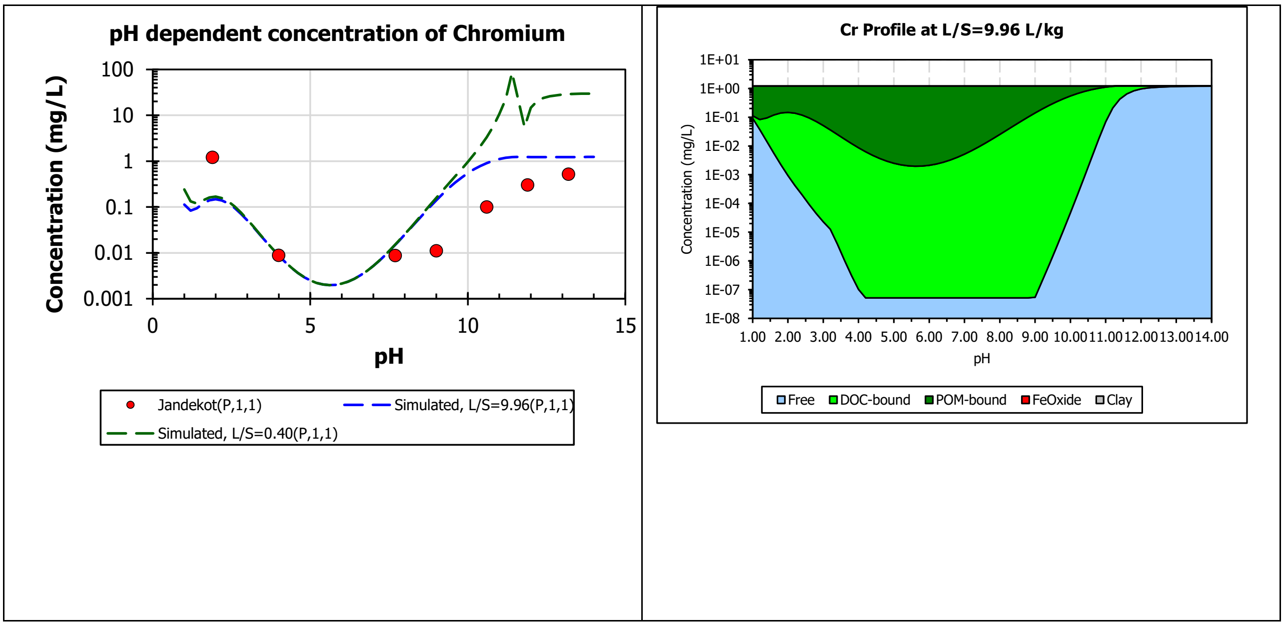


Figure 56: LeachXS Model Output for the Chemical Speciation Fingerprint of Chromium in Jandakot Groundwater Residue.

The chemical speciation fingerprint charts for copper are presented in Figure 57. Key predictions presented in these charts indicate the following:

- As was observed for chromium, LeachXS modelling provides a reasonable description of the solubility of copper in this material across the full pH range;
- Unlike chromium, LeachXS predicts substantially lower concentration (typically one tenth) at L/S = 0.4 compared to L/S = 10;
- The sum of predicted copper fractions exceeds the Available Content at very high pH (>13 pH units). This effect is understood to be a consequence of LeachXS modelling arising when the (extrapolated) dissolved humic acid component exceeds the solid humic acid content in the solid.
- The dominant form of soluble copper at very low pH (<4) is free copper, with increasing contributions from DOC bound copper with increasing pH; and
- The dominant solid phase form containing copper is the POM-bound fraction.

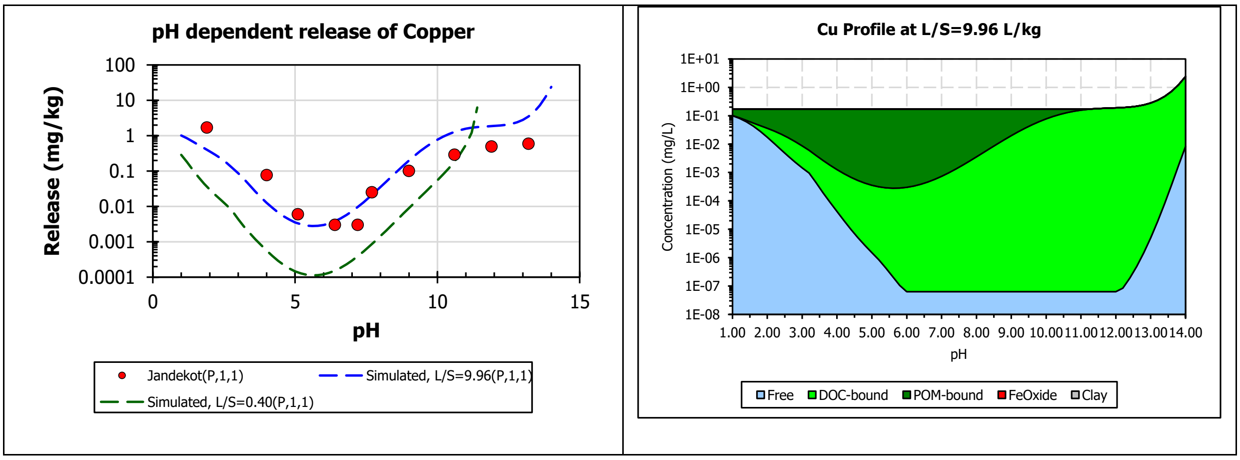


Figure 57: LeachXS Model Output for the Chemical Speciation Fingerprint of Copper in Jandakot Groundwater Residue.

The chemical speciation fingerprint charts for manganese at two pH values (pE = 8, denoting slightly oxic conditions, and p E = 10, denoting moderately oxic conditions) are presented in Figure 58. Key predictions presented in these charts indicate the following:

- As was observed for chromium and copper, LeachXS modelling provides a poor description of the solubility of manganese in this material across the full pH range with a nominal pE value of 8. Predicted leachate concentrations at L/S = 10 are generally more the one order of magnitude higher than experimental results, especially within the alkaline pH range. Increasing the nominal pE value to 10 resulted in a much improved alignment between experimental and predicted concentrations at L/S = 10;
- There is better agreement between predicted and experimental values at higher pE (pE = 10).
- Very high concentrations of free manganese, up to 20 mg/L, are predicted for acidic pH values, regardless of adopted pE values. Predicted concentrations of free manganese at higher pH values decrease, although DOC-bound concentrations are predicted to be high (up to 1 mg/L); and
- The major solid phases containing manganese are the FeOxide-bound fraction between 7.5 and 10 pH units, and the trivalent manganite mineral manganite at higher pH values. The abundance of manganite is predicted to increase considerably under more oxic conditions (pE = 10).

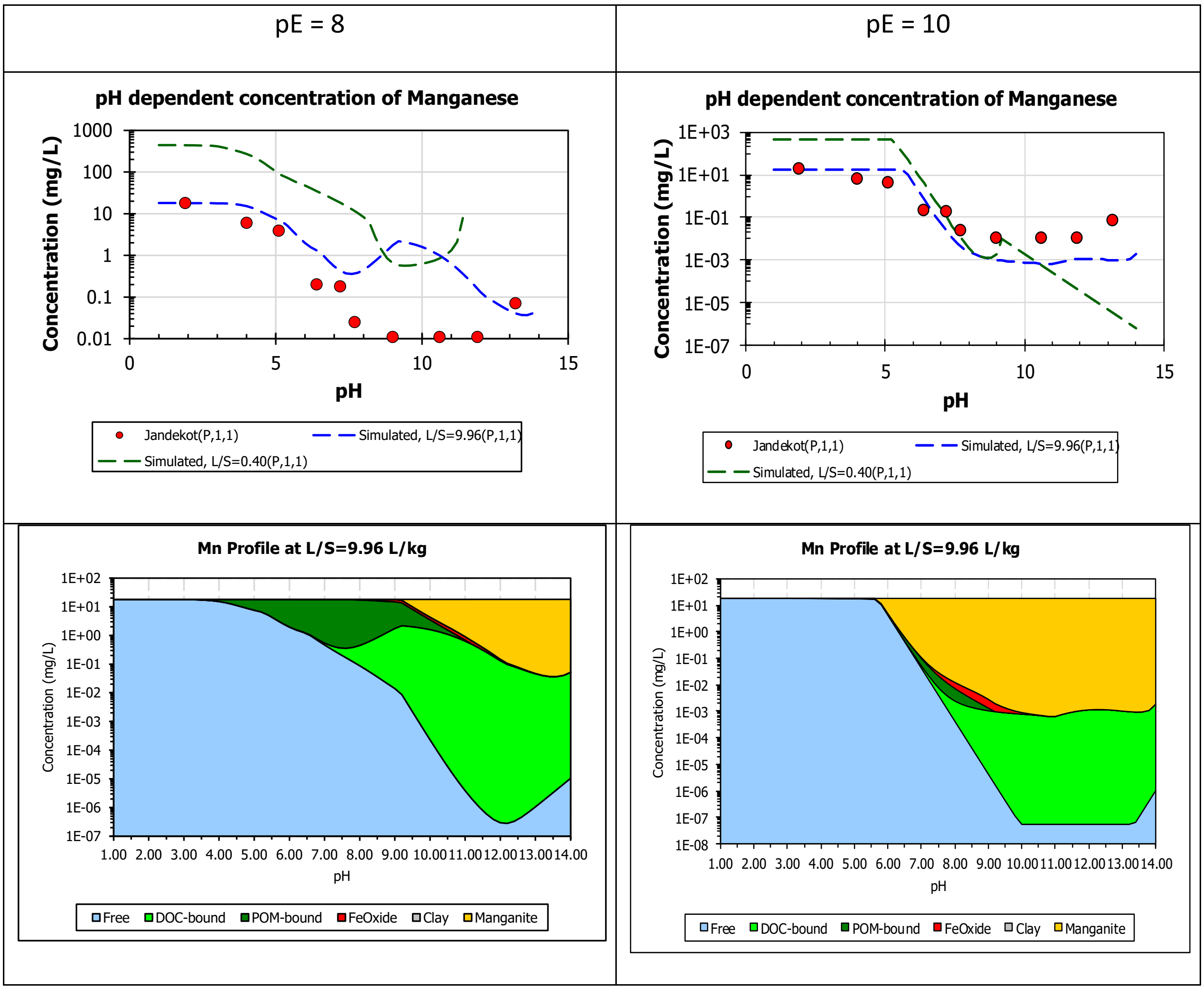


Figure 58: LeachXS Model Output for the Chemical Speciation Fingerprint of Manganese in Jandakot Groundwater Residue (pE = 8 and 10).

5.5.1.3.2 Wanneroo

The leaching characteristics of the Wanneroo groundwater treatment residue were notably different to that of the Jandakot residue in several respects, notably higher concentrations of barium and lower salinity.

The chemical speciation fingerprint charts for barium are presented in Figure 59. Key predictions presented in these charts indicate the following:

- As was observed for several metals in the Jandakot residue, LeachXS modelling provides a poor description of the solubility of barium in this material across the full pH range. Predicted leachate concentrations at L/S = 10 were several orders of magnitude higher than experimental results under acidic conditions (pH <7), and several orders of magnitude lower under strongly alkaline conditions (pH >10). Unexpectedly, the predicted concentrations at L/S = 0.4 are lower than those predicted for L/s = 10 at certain pH ranges;
- Most of the barium is predicted to be present as the sparingly soluble mineral barite ($BaSO_4$) at pH values between 2 and 12 pH units, with increasing proportions of particulate organic matter bound material at pH >6. Proportions of the soluble DOC-bound form increase with increasing pH at pH values greater than 9 pH units; and
- LeachXS predicts concentrations of soluble barium, mainly as the free ion, to be relatively constant at approximately 0.02 mg/L between pH 4 and 9.

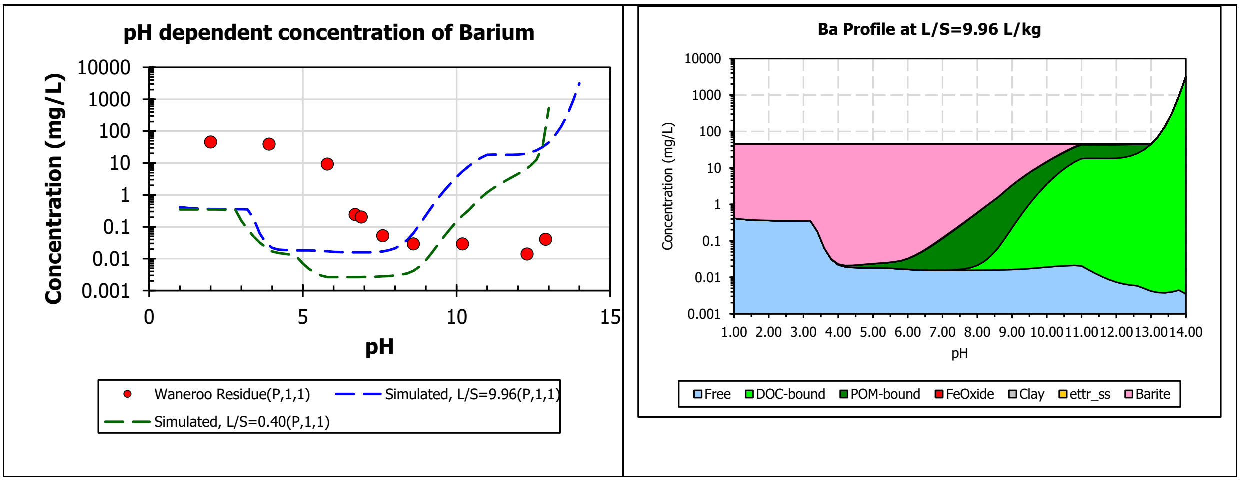


Figure 59: LeachXS Model Output for the Chemical Speciation Fingerprint of Barium in Wanneroo Groundwater Residue.

The chemical speciation fingerprint charts for manganese are presented in Figure 60 at a nominal pE value of 6. Key predictions presented in these charts indicate the following:

- As was observed for manganese in the Jandakot residue, LeachXS modelling provides a poor description of the solubility of manganese in this material at pH values greater than 6 under oxic conditions (pE = 8). Predicted leachate concentrations at L/S = 10 were elevated (approximately 60 mg/L) and comparable with experimental results under strongly acidic conditions (pH <5), and several orders of magnitude lower under strongly alkaline conditions (pH >10);

- Unlike the Jandakot material, manganese was predicted to behave at a soluble solute under strongly acidic condition (pH <5), with the predicted L/S = 0.4 concentrations approximately 20 times those predicted for L/S = 10. This is consistent with the phase diagram indicating most of the manganese is present in the free form under these pH and pE conditions; and
- The dominant forms of solid phase manganese under alkaline conditions were particulate organic matter-bound and manganite phases, with the latter increasing in concentration with increasing pH.

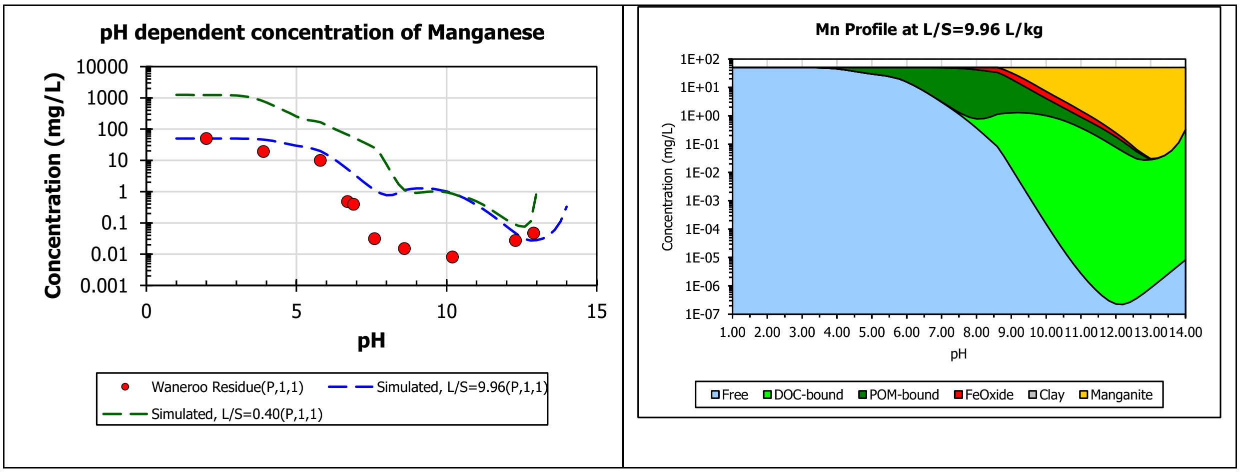


Figure 60: LeachXS Model Output for the Chemical Speciation Fingerprint of Manganese in Wanneroo Groundwater Residue.

The chemical speciation fingerprint charts for zinc are presented in Figure 61, as the available content of zinc in this material was notably higher than that of the Jandakot residue. Key predictions presented in these charts indicate the following:

- As with other divalent metals with both Jankakot and Wanneroo residue, LeachXS predicted soluble zinc concentrations in reasonable agreement with experimental concentrations. Predicted concentrations of free zinc were approximately 1 mg/L at pH values below 4, but were much lower (approximately 0.001 mg/L) under circum-neutral and ; and
- The major solid phases predicted to be stable according to LeachXS predictions was the POM-bound fractions between 7 and 9 pH units. Despite the very high concentrations of hydrous ferric and aluminium oxide phases in this material (as well as the Jandakot sample), none of the zinc (and several other metals) were not predicted by LeachXS to reside in this fraction. This prediction is consistent with current understanding of these materials whereby the surface sorption sites on the HFO phase are “blocked’ by competitive adsorption by humic substances and phosphate.

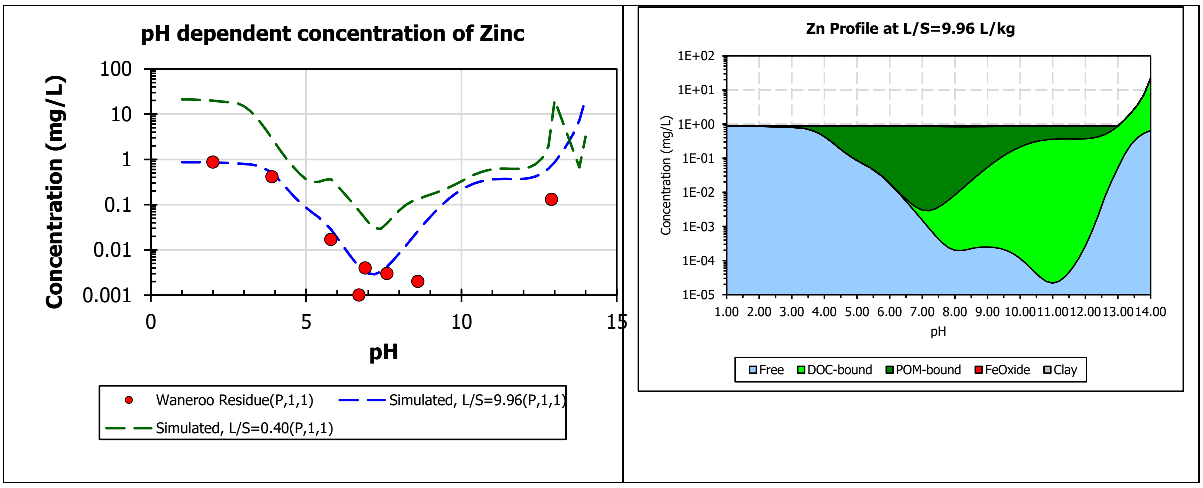


Figure 61: LeachXS Model Output for the Chemical Speciation Fingerprint of Zinc in Wanneroo Groundwater Residue.

5.5.1.4 Laboratory and Field data

5.5.1.4.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A layer of 20 cm of groundwater treatment residue overlying an 80 cm layer of Bassendean Ellenbrook sand.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the amended soil/material layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A1-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the "control" columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 31), some of these are discussed below.

In many cases, it is observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Table 31: Tall Column Leachate Analysis Summary for Groundwater Residues (Jandakot and Wanneroo).

Analyte	**Jandakot Residue**				**Wanneroo Residue**			
	Bass/E	Bass/J	Duplex	S'wood	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
TDS/EC	🟨	🟨	🟨	🟨	🟩	🟩	🟩	🟩
DOC	🟨	🟨	🟧	🟩	🟩	🟩	🟨	🟩
Al	🟨	🟨	🟧	🟨	🟨	🟨	🟧	🟨
As	🟩	🟨	🟩	🟩	🟩	🟩	🟩	🟩
B	🟨	🟨	🟩	🟨	🟩	🟨	🟩	🟨
Ba	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Cd	🟨	🟨	🟨	🟩	🟩	🟩	🟨	🟩
Co	🟨	🟩	🟨	🟩	🟨	🟩	🟨	🟩
Cr	🟨	🟨	🟨	🟩	🟩	🟩	🟨	🟩
Cu	🟨	🟧	🟨	🟨	🟩	🟧	🟨	🟨
Mn	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Mo	🟩	🟨	🟨	🟨	🟩	🟨	🟨	🟨
Ni	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
P	🟧	🟥	🟩	🟩	🟥	🟥	🟩	🟩
Pb	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
SO_4	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Se	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Zn	🟨	🟨	🟨	🟩	🟨	🟨	🟨	🟩

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Potential for mobilisation of specific constituents from the Jandakot Material

Application of Jandakot groundwater residue as a soil cover material resulted in brackish leachates from the Bassendean sands and the duplex soil containing slightly elevated concentrations of various metals (notably copper and zinc, but not manganese). Leachates were found to contain lower concentrations of phosphorus, with only leachate from Bassendean Joel sand remaining as a relatively high risk (noting that the material was not intended for use as a soil amendment).

The risk profile for use as a cover material for Spearwood sand was significant, with only aluminium, boron, copper and molybdenum identified as low-level potential risks.

Potential for mobilisation of specific constituents from the Wanneroo Material

The Wanneroo groundwater residue was less saline than the Jandakot material. Overall, the risk profile for leaching metals and metalloids was similar to that of the Jandakot material.

5.5.1.4.2 Field Trial Groundwater Treatment Residues (Jandakot and Wanneroo)

Results from lysimeter field trials managed by Aroona for the Jandakot and Wanneroo groundwater treatment residues, described in Section 4.10.1.2, are presented in Appendix A13. The results were summarised as potential risk profiles using the same criteria adopted for the tall column leaching trials (Section 5.5.1.4.1) and the field trail (Section 5.5.1.4.2) using the threshold values presented in Table 6. The risk profiles for the water treatment residues are presented in Table 32.

Comparison of the risk profile for these materials from the field lysimeter trials with those from the tall column trial (Section 5.5.1.4.1) is not appropriate because the soils at Wanneroo and Jandakot sites were not included in the tall column trial. Of the four soils used in the column trial, the soil that most closely resembles the Jandakot and Wanneroo soils is Spearwood sand, based on alkaline pH values, low salinity and no fertiliser history.

Table 32: Groundwater Treatment Residues Field Trial Summary.

Analyte	Wanneroo	Jandakot
pH	🟩	🟩
TDS/EC	🟩	🟨
DOC	🟩	🟩
Al	🟩	🟩
As	🟩	🟩
B	🟩	🟩
Ba	🟩	🟩
Cd	🟨	🟩
Co	🟨	🟨
Cr	🟩	🟩
Cu	🟧	🟧
Mn	🟩	🟩
Mo	🟩	🟩
Ni	🟥	🟥
P	🟩	🟩
Pb	🟨	🟥
SO_4	🟩	🟩
Se	🟩	🟩
U	🟩	🟩
V	🟩	🟩
Zn	🟨	🟨

Note: Level of potential environment risk, based on threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

The most significant findings from the field experiments were the elevated concentrations of nickel and lead, neither of which were assessed as significant risks with combinations of these two materials and the four soil types used in the tall column experiment (Table 31, Section 5.5.1.4.1).

The source of these metals appears to be the residues based on generally lower, but variable, concentrations in the “control” plots.

The field trial results confirm a flush of saline leachate, mainly sodium and chloride.

5.5.1.5 LeachXS Solute Transport Modelling – Comparison with Field and Laboratory Column Leaching Data

5.5.1.5.1 Model Conditions

The predictive percolation column solute transport module of LeachXS was used to simulate leaching characteristics for the following scenarios:

- A layer of 20 cm of Jandakot groundwater treatment residue overlying an 80 cm layer of Bassendean Ellenbrook sand.

These scenarios were designed to reflect the conditions of the tall column leaching experiment (Section 4.10.1.1).

In addition to the chemical speciation fingerprints for groundwater residues, LeachXS also requires model input parameters for:

- Column density;
- Column diameter;
- Number of “cells”;
- Column length;
- Column mobile fraction;
- Phase distance;
- Column porosity;
- Permeating solution; and
- Out of column flow rate.

Values for model input parameters for the three modelled scenarios are presented in Table 33. For several parameters relating to the hydraulic characteristics of the materials, nominal values were used rather than measured values. The nominal values adopted were considered to be indicative of free draining sandy materials on the Swan Coastal Plain. The addition of the groundwater residues was assumed not to alter the hydraulic characteristics of the soil (Bassendean Ellenbrook).

Table 33: Input Parameters for LeachXS Percolation Column Models.

Parameter	**Jandakot Residue**
Number of Cells	20
Column Length	100 cm
Column Diameter	15 cm
Percolating fluid	Deionised water
Upper layer	100% residue
Upper layer cells	4
Upper Layer Chemical Speciation Fingerprint	Jandakot residue
Lower layer	Bassendean Ellenbrook soil
Lower layer cells	16
Column Mobile Fraction	70%
Effective Phase Distance	4.5 cm
Column Porosity	0.45
Column Density	1.5×10^3 kg/m^3
Out of column Flow Rate	4.49×10^3 mL/m^2/hr

5.5.1.5.2 Model Output Interpretation

The following discussion covers two constituents of potential concern identified as presenting the greatest potential risk based on LEAF Method 1313 data over the applicable scenario pH domain for (Section 5.5.1.2.1) use as a fill material:

- Chromium in the Jandakot residue.

Figure 62 presents the LeachXS modelling output for chromium speciation phases as:

- A function of L/S at 100 cm at the base of a column of Jandakot Residue fill over Bassendean Ellenbrook sand.
- The corresponding profiles of chromium phases as a function of column depth at L/S 0.494 L/kg.

The key findings are that the leachate from the base of the virtual column is predicted to very low concentrations of dissolved chromium (<0.001 mg/L), almost exclusively in association with dissolved organic carbon (and therefore most likely to be trivalent chromium). Chromium concentrations are much higher in the upper groundwater residue layer than the underlaying soil layer. POM-bound chromium is the dominant form in both layers.

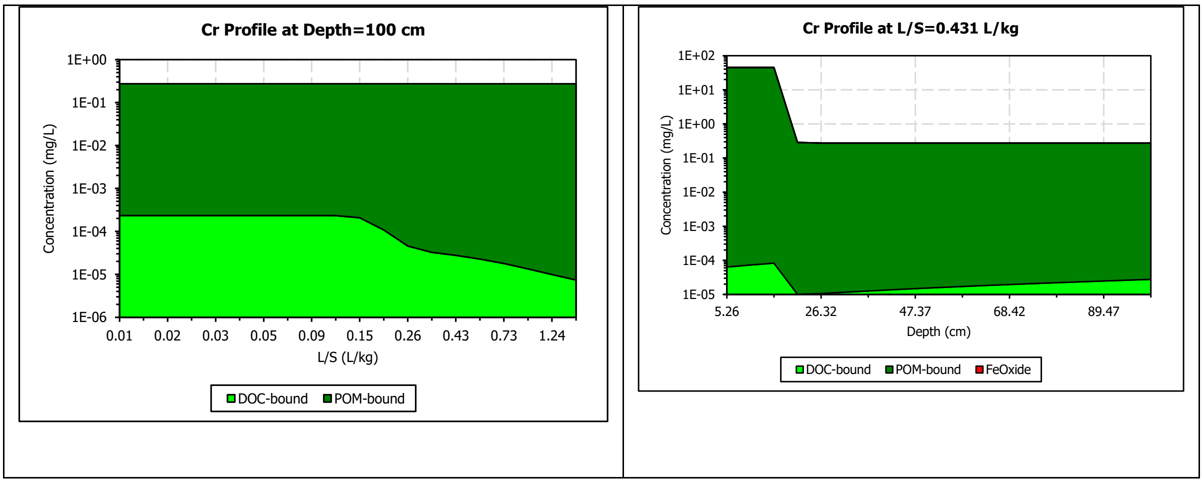


Figure 62: LeachXS Model Output for Solute Transport Modelling of Chromium in Jandakot Groundwater Residue and Bassendean Sand.

5.5.1.6 Comparison of LeachXS Predictions with Field and Tall Column Results

5.5.1.6.1 Comparison Methodology

Predicted end of column leachate concentrations from LeachXS modelling described in Section 5.5.1.5.1 were compared with results from field results (Aroona field trial for Jandakot residue) and laboratory tall column leachate data using the following methodology:

- Predicted end of column leachate concentration (sum of DOC-bond and free fractions) as a function of L/S, as calculated from LeachXS output data illustrated by Figure 63 (Section 5.5.1.5.2).
- Tall column bottom of column leachate concentrations for three sampling events (Leach Number 1, 2 and 3) discussed in Section 4.10.2.1.
- Lysimeter leachate concentrations from the three sampling events from the Aroona field trial (Section 4.10.1.2) for the Jandakot groundwater treatment residue.

5.5.1.6.2 Jandakot Comparisons

Charts comparing predicted end of column leachate concentrations using LeachXS with Jandakot field lysimeter trial leachate concentrations and tall column laboratory leachate concentrations for selected analytes are presented in Appendix A20.

The following discussion focuses on the following analytes which we identified as constituents of interest from assessment of the potential risk profiles derived from interpretation of LEAF test, tall column and field trial results:

- Sodium (as an indicator of brackish seepage quality);
- Copper;
- Zinc; and
- Nickel (from Aroona field trial observations).

Sodium

Comparison data for sodium leaching characteristics are presented in Figure 63 (noting concentrations are expressed against a logarithmic y-axis). LeachXS predicted a rapid flush of sodium from the simulated column, based on the high proportion of free sodium in the material (and soil) chemical speciation fingerprint (Appendix A8-3). The tall column and field lysimeter leachate data are generally in reasonable agreement with LeachXS predictions for sodium.

Assessment of data for other soluble ions (chloride, boron, potassium etc) for other modelled combinations of by-products and soil indicated generally close agreement between LeachXS leachate composition predictions and measured values in field/laboratory experiment leachates.

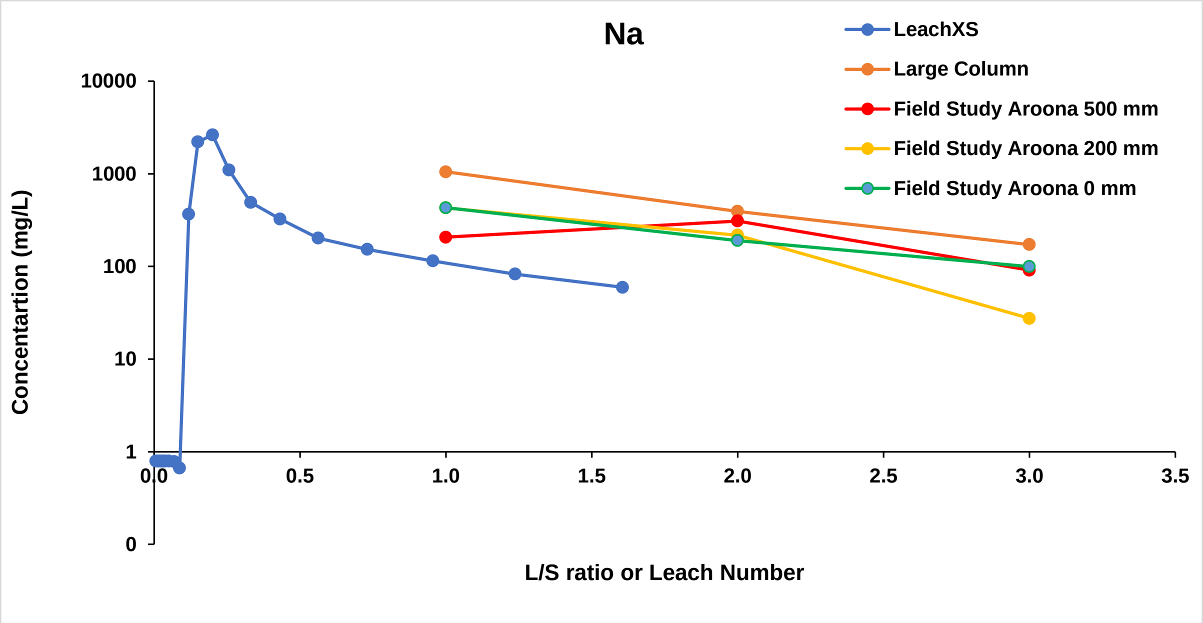


Figure 63: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Sodium in Jandakot Residue Leachates.

Copper

Comparison data for copper leaching characteristics are presented in Figure 64 (using a logarithmic y-axis). Unlike sodium, there was no evident predicted initial first flush of copper. An initial first-flush event, LeachXS predicted very low (<0.01 mg/L) end of column leachate concentrations for copper, which was consistent with findings from the tall column experiment. The elevated concentrations of copper in samples of lysimeter leachates, especially the third sampling, were not predicted by LeachXS modelling.

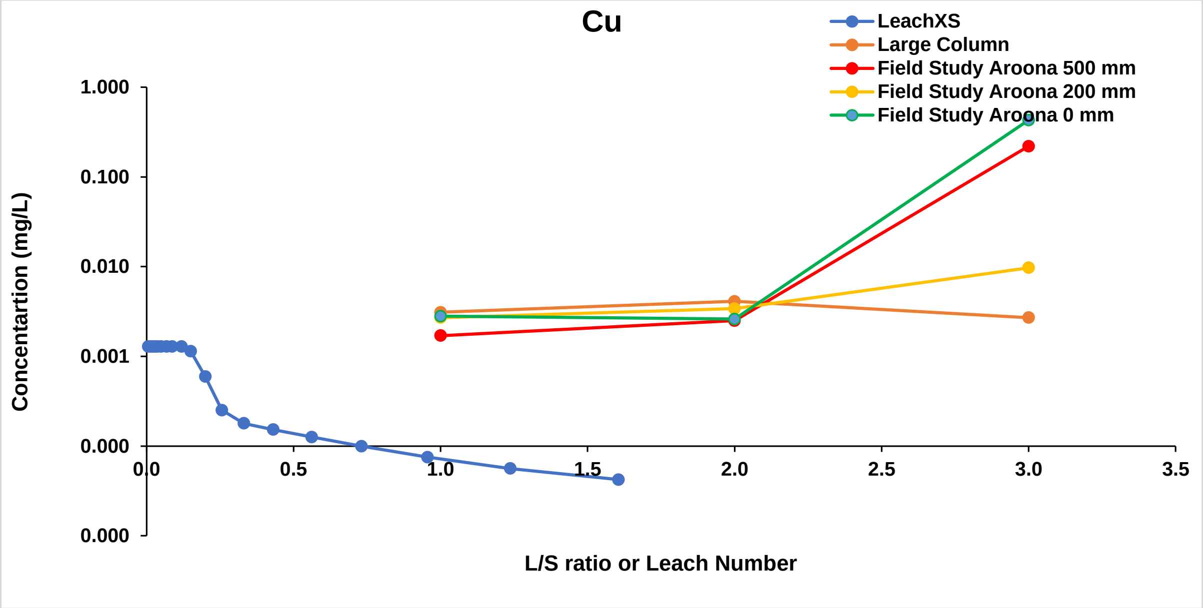


Figure 64: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Copper in Jandakot Residue Leachates.

Zinc

Comparison data for zinc leaching characteristics are presented in Figure 65. LeachXS predicted an initial flush of soluble zinc at very low L/S, with much lower concentrations as L/S increases (typically 0.5 mg/L, mainly as free zinc). These predictions align reasonably well with low measured concentrations in leachates from the tall column experiment. As with copper (and nickel), anomalously high concentrations of zinc were recorded in lysimeter leachates from the field trial.

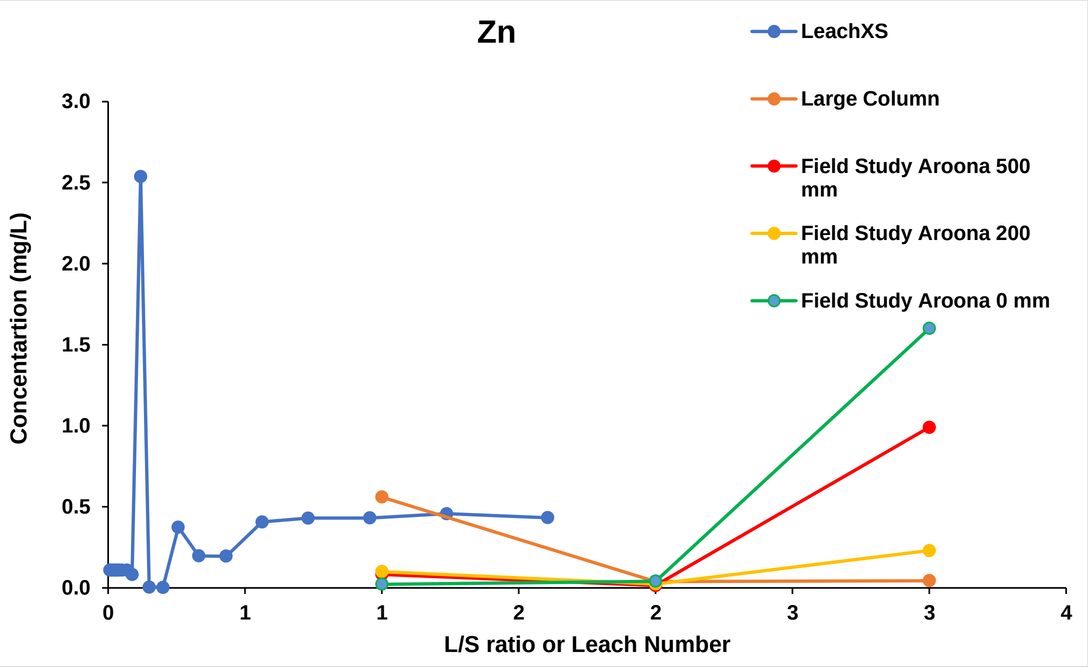


Figure 65: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Zinc in Jandakot Residue Leachates.

Nickel

Comparison data for nickel leaching characteristics are presented in Figure 66. As was the case for zinc, LeachXS predicted an initial flush of soluble nickel at very low L/S, with much lower concentrations as L/S increases. These predictions align reasonably well with low measured concentrations in leachates from the tall column experiment. As with copper and zinc (and also lead, Appendix A20), anomalously high concentrations of nickel were recorded in lysimeter leachates from the field trial.

The presence of elevated copper, nickel and zinc in Aroona field trial lysimeter leachates is not consistent with LeachXS modelling of the source material, or the tall column laboratory experiment, which used Bassendean Ellenbrook soil and not local Jandakot sand. It is considered unlikely that the metals are leached from the Jandakot sand as very low concentrations were recorded in all leachates from the control plot lysimeters. Further investigation of the source of these metals will be required if Aroona wishes to continue with the assessment of these groundwater residues as substitute clean fill materials.

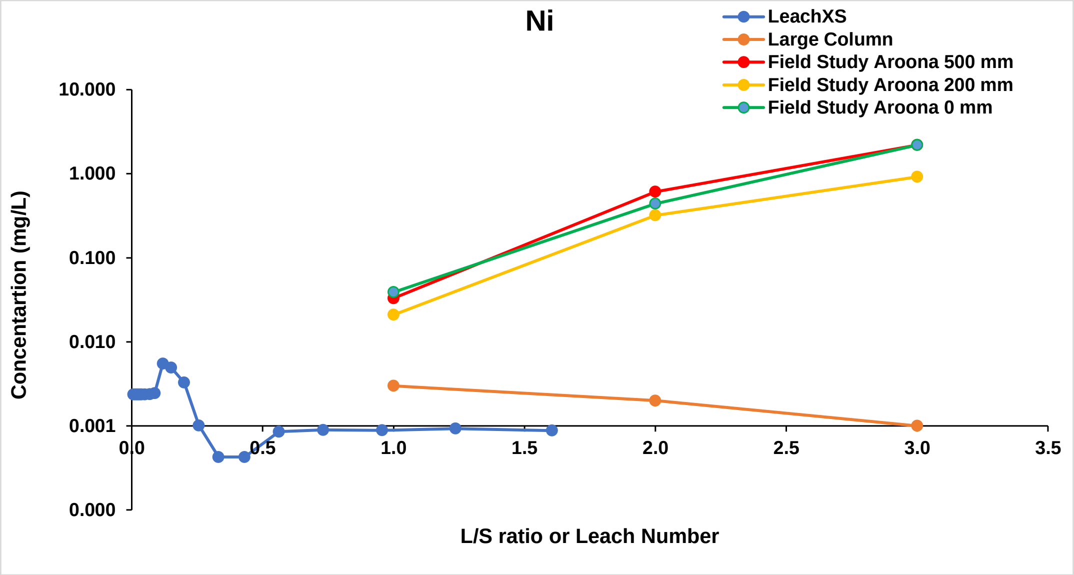


Figure 66: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Nickel in Jandakot Residue Leachates.

Chromium

Chromium was identified as the constituent with the highest potential risk based on LEAF 1313 leachate concentrations within the applicable scenario pH domain (Table 28). Slightly elevated concentrations (maximum 0.003 mg/L) were recorded in the second sampling from the tall column experiment (Figure 67). Very low (<0.0005 mg/L) were recorded in all samples from the lysimeters field trial (Figure 67). LeachXS modelling predicted very low concentration (approximately 0.0006 mg/L) up to L/S = 0.2 L/kg, followed by even lower concentrations as L/S increased. The predictions and experimental results indicate the chromium is not considered to be a constituent of potential concern in the Jandakot residue.

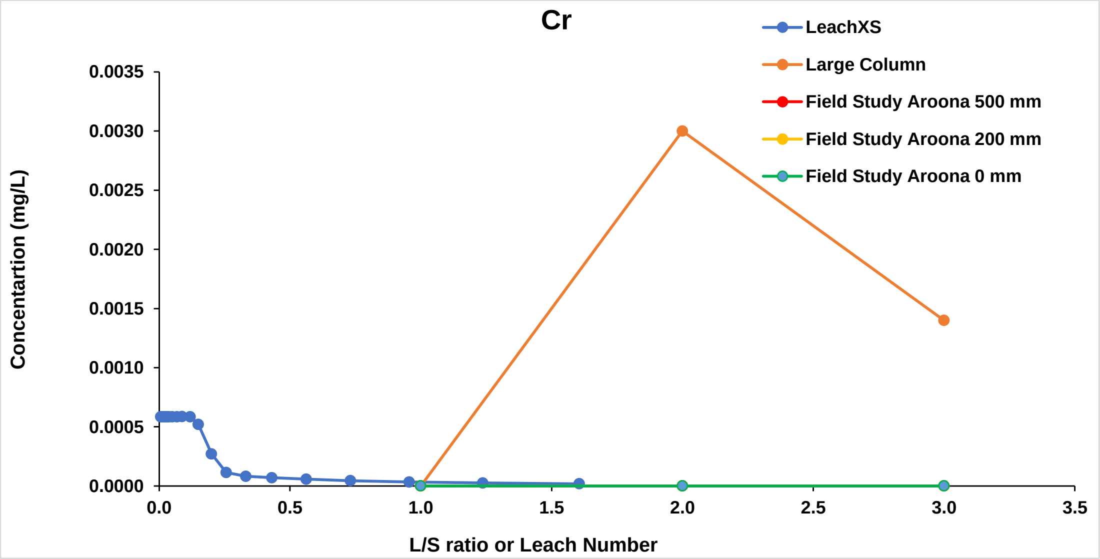


Figure 67: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Chromium in Jandakot Residue Leachates.

Fluoride

Although fluoride was not identified as a constituent of potential concern based on LEAF Method 1313 results under the applicable scenario pH domain (Table 28), its leaching behaviour is discussed in this section as the leaching characteristics predicted by LeachXS solute modelling differ to those of other elements discussed in this report. As shown in Figure 68, fluoride concentrations were predicted to be very low at low L/S, followed by a rapid increase to a maximum of approximately 500 mg/L at L/S = 0.4 L/kg, and then followed by a decrease to relatively stable concentrations of approximately 250 mg/L (considered very high) between L/S = 0.5 to 1.5 L/kg. However, neither the tall column leaching experiment nor the Aroona lysimeters field trial recorded fluoride concentrations above 0.2 mg/L.

The fluoride phase speciation diagram (shown as Figure 69) for L/S = 0.431 indicates equilibrium with the mineral phase fluorite in the upper layers, but most of the column fluoride in the lower layers is present as free (leachable) fluoride. DOC-associated fluoride accounts for a very small component of soluble fluoride. These predicted indicate elevated concentrations of fluorite are present in the groundwater residue layer (consistent with an available content of 2,800 mg/kg (Table 26), which dissolves in permeating water (despite a natural pH of 6.3, at which fluorite is only sparingly soluble). The underlying soil layer effectively has zero capacity to attenuate fluoride in the percolating leachate.

LeachXS also predicted leaching behaviour contrary to experimental data for the following constituents of Jandakot residue:

- Barium, with “first flush” concentrations up to 50 mg/L. Concentrations measured in tall column and field lysimeter leachates were <0.1 mg/L, and of no environmental significance.
- Arsenic, with “first flush” concentrations up to 5 mg/L. Concentrations measured in tall column and field lysimeter leachates were <0.01 mg/L, and of no environmental significance.
- Manganese, with low concentrations predicted to L/S of 0.8 mg/L, followed by a significant increase to 7 mg/L at L/S = 1.5 L/kg. All experimental values were <1 mg/L.
- Selenium, with “first flush” concentrations up to 0.8 mg/L. Concentrations measured in tall column and field lysimeter leachates were <0.001 mg/L, and of no environmental significance.

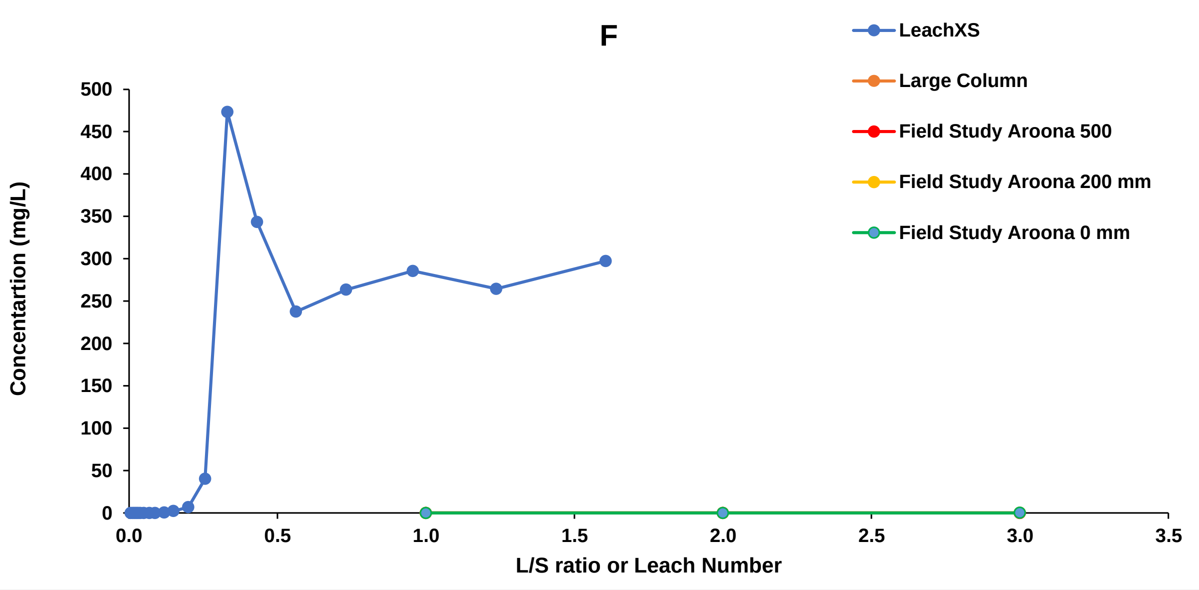


Figure 68: Comparison of LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Fluoride in Jandakot Residue Leachates.

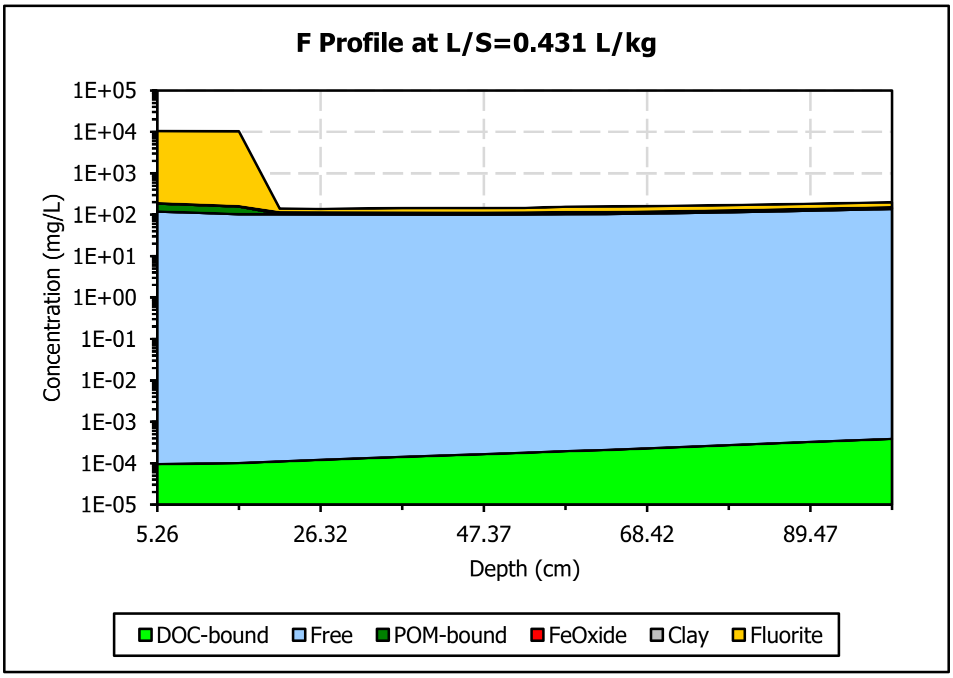


Figure 69: LeachXS Predictions, Aroona Field Trial and Tall Column Laboratory Data for Fluoride in Jandakot Residue Leachates.

5.5.1.7 Summary

Laboratory test results for analysis of these groundwater treatment residues indicate generally low concentrations of constituents of potential concern. The tall column laboratory leaching trial indicated generally low potential for leaching constituents of potential concern, with substantial contributions of several elements being sourced from the underlying Bassendean soil layer, and not the groundwater residues layer.

Of the two materials assessed, the Wanneroo material has the lower concentrations of constituents of potential concern, both in the material itself and leachates from the column experiment. The Jandakot material is saline, and a first flush of saline leachate may be expected when used as fill material.

Results from lysimeter field trials set up and managed by Aroona at the Jandakot and Wanneroo groundwater treatment plants were generally consistent with those of the tall column experiment, apart from elevated concentrations of nickel and (to lesser degrees) copper, lead and zinc. The source of these constituents is not known, as the available contents and concentrations measured in leachates from the LEAF 1313 test are not particularly high. It is likely that the elevated concentrations are a consequence of contamination of either the experimental site or collected leachates (the highest values were recorded for the third and final set of leachates).

The results from this study generally support the use of groundwater treatment residues as fill for low lying areas on the Swan Coastal Plain, provided that:

- Samples of material intended for use as clean fill are tested before application to ensure consistency of supply. Samples should be tested for pH and EC, as well as water soluble metals, metalloids and fluoride.

- The fill material should not be exposed to low redox conditions. Both materials contain elevated concentrations of iron and, to a lesser degree, manganese. These elements may be converted to soluble divalent ions under strongly reducing conditions.

- Both materials are enriched in phosphorus. Most of the phosphorus is predicted to be tightly bound to hydrous iron or aluminium oxide minerals, or present as the insoluble iron phosphate mineral strengite. Under reducing conditions, phosphorus bound to hydrous iron oxides may be released as soluble phosphorus following reduction of ferric iron to ferrous iron.

- As with other materials assessed in this study, the highest risk for release of constituents of potential concern by leaching is predicted to arise under “first-flush” conditions. Potential for long term impacts are considered to be of much lower risk.

5.5.2 Biosolids Cake and Lime Amended Biosolids (LAB)

5.5.2.1 Biosolids Cake and LAB By-product Characterisation

Water Corporation treats 80% of WA's waste water at three large wastewater treatment plants in the Perth metropolitan area – Woodman Point, Beenyup and Subiaco.

The liquid and solids in waste water (sewage) are separated during the wastewater treatment process. After treatment, the liquid is released via ocean outfalls, allowed to infiltrate back into the ground, or recycled for industrial or other uses. The sludge undergoes extensive stabilisation by addition of lime (Subiaco) or anaerobic digestion (Woodman Point, Beenyup). This process stabilises the organic matter while reducing the quantity of solids and the level of pathogens.

Two types of biosolids are produced:

- Biosolids cake – produced at both the Beenyup and Woodman Point wastewater treatment plants.
- Lime-amended biosolids (LAB) – produced at the Subiaco Wastewater Treatment Plant.

Results for elemental composition of samples of Biosolids Cake and LAB provided by Aroona for this project are presented in Table 34.

The elemental composition of both materials largely reflect the nutritional composition of food products consumed by residents (notably phosphorus), use of laundry products (sodium, sulfur and boron) and water reticulation corrosion products, notably copper, zinc, lead and cadmium. With the exception of calcium, most elements are present in lower concentrations in LAB than Biosolids Cake (as a consequence of dilution by lime) – the increased calcium content in LAB (110,000 mg/kg, 11%) is indicative of the mass of lime used in the stabilisation process at Subiaco.

Elevated concentrations of metals such as copper and zinc (mainly from corrosion of copper pipes and brass fittings) have contributed to limited scale adoption of biosolids materials as fertilisers and soil amendments for commercial agriculture throughout Australia

Table 34. Biosolids Cake and LAB Characterisation Data.

Element	LOR	Units	Biosolids Cake	LAB
Ag	0.5	mg/kg	6.40	2.80
Al	100	mg/kg	10045	2700
As	3	mg/kg	<3	<100
Ba	5	mg/kg	427.5	100
Be	0.5	mg/kg	<0.5	<0.5
Ca	50	mg/kg	24750	110000
Cd	1	mg/kg	2	<1
Co	1	mg/kg	6	<100
Cr	10	mg/kg	110	<100
Cu	5	mg/kg	614	300
Fe	100	mg/kg	10900	4300
K	100	mg/kg	2370	2100

Element	LOR	Units	Biosolids Cake	LAB
Mg	20	mg/kg	7700	7300
Mn	5	mg/kg	118.5	<100
Mo	5	mg/kg	21.5	<100
Na	50	mg/kg	1580	1500
Ni	5	mg/kg	37.0	<100
P	20	mg/kg	23400	11800
Pb	5	mg/kg	28.5	<100
S	20	mg/kg	13000	5350
Sb	2	mg/kg	3	<100
Se	10	mg/kg	<10	<10
Sn	2	mg/kg	49.5	<100
Ti	10	mg/kg	1925	500
Th	10	mg/kg	<10	<50
U	10	mg/kg	<10	<50
V	1	mg/kg	14.5	<100
Zn	5	mg/kg	985.5	300
Tl	0.1	mg/kg	0.10	<0.1
B	20	mg/kg	70.0	35
Hg	0.1	mg/kg	2.30	ND
Cl	25	mg/kg	1830	335
F	25	mg/kg	325	305
LOI	-10	%	15.6	ND
TOC	0.05	%	31.6	26.9
H20	0.1	%	10.1	69.3
Si	0.01	%	5.70	1.5

Note; LOR-limit of reporting; LOI-loss of ignition; TOC-total organic carbon.

5.5.2.2 LEAF Tests 1313, 1314 and 1316

5.5.2.2.1 LEAF 1313 Test

Results for analysis of the biosolids cake and LAB samples are presented as graphs in Appendix A5-6. Characteristics of the pH dependent leaching characteristics by analyte for these materials are summarised as follows:

- Silver concentration for LAB were less than 0.001mg/L and no variation was noticed over pH. Elevated concentration was noted for biosolids cake between 0.005 to 0.01 mg/L at pH 9 to 12.
- Aluminium concentrations were much lower than those of the other materials, probably as a consequence of very low concentrations in the human diet. Elevated concentrations were noted for biosolids cake at both low and high pH values, whereas LAB has higher aluminium concentration at pH values 2 and 4.
- Arsenic: In generally higher concentration (0.2 mg/L) was noted between pH values 9 and 12 for biosolids cake and for LAB concentration were higher at low pH values between 2 and 4. No variation in arsenic concentration noted at circum neutral pH for both biosolids cake and LAB.

- Barium: Leachate concentrations were typically <0.1 mg/L for biosolids cake at leachate pH values above 4 whereas for elevated concentrations (10 mg/L) were present in the pH 2 leachate of LAB, probably derived from trace barium carbonate minerals in lime.

- Beryllium, mercury and uranium concentrations were below or slightly above the method reporting limit at all pH values and therefore present very low environmental risk.

- Boron: higher concentration was noted for both biosolids cake (5 mg/L) and LAB (2.5 mg/L) at lower pH and it decreases with the increase in pH.

- Concentrations of soluble cadmium were less than 0.01 mg/L for both materials between pH 4 and 13 but higher concentrations were noted at low pH 2 for biosolids cake (0.1 mg/L). The pH dependent solubility curves were similar for both materials.

- Calcium: not surprisingly, concentrations of calcium in LAB leachates were typically two orders of magnitude higher than those of biosolids cake. Maximum concentrations recorded in pH 2 leachates.

- Cobalt concentrations were generally less than 0.1 mg/L for both materials and indicated no clear pH dependency. The maximum concentration for the biosolids cake sample (approximately 0.09 mg/L) was higher than that of the LAB sample (approximately 0.05 mg/L).

- Chromium concentrations in the biosolids cake sample leachates were generally less than 0.1 mg/L between pH 4 and 12 for both materials. Slightly elevated concentrations (approximately 0.5 mg/L) were recorded in acidic (pH 2) leachates of the LAB sample and are likely to be derived from traces of chromium minerals present in lime.

- Copper concentrations were highly variable and depended on both material type and pH. Maximum concentrations for LAB leachate were approximately 15 mg/L recorded at both very low (pH 2) and very high (pH 14) leachates. Maximum concentrations for biosolids cake leachates were much lower, approximately 12 mg/L, and less dependent on pH. These results suggest that addition of lime in production of LAB has increased to potential solubility of copper, possibly as a consequence of forming metastable copper hydroxide mineral phases from mainly copper-organic matter phases in biosolids cake.

- Fluoride concentrations were low (approximately 0.01 mg/L) and comparable for both materials in leachates between 4 and 13 pH units. Slightly higher concentrations (approximately 40 mg/L) were recorded in pH 2 leachates of LAB, suggesting dissolution of trace fluoride minerals present in lime.

- Iron concentrations were generally low and variable in leachates of both materials. The maximum concentration recorded for LAB leachates (approximately 130 mg/L at pH 2) was significantly higher than the maximum concentration for biosolids cake (approximately 60 mg/L and 20 mg/L at pH 2 and pH 12). The acid solution iron present in LAB may be derived for trace iron mineral impurities in lime.

- Manganese concentrations in leachates of both materials were low (less than 0.1 mg/L). Maximum concentrations were recorded for acidic leachates (pH 2 for biosolids cake) and pH 2 and pH 4 for LAB.

- Molybdenum concentrations were less than 1 mg/L for both materials, with the biosolids cake leachates containing slightly higher concentrations than LAB cake leachates in alkaline leachates.

- Nickel concentrations were less than 1.0 mg/L for both samples, with the biosolids cake leachates containing slightly higher concentrations across the full pH range.

- Phosphorus concentrations ranged from 120 to 2,100 mg/L, with both materials recording maximum concentrations of 2,100 mg/L for biosolid and 840 mg/L for LAB at low (pH 2). Concentrations in biosolids cake leachate within the circum-neutral to slightly alkaline range (180 to 600 mg/L) were significantly higher than those of LAB (16 to 56 mg/L). This observation is consistent with formation of sparingly soluble calcium phosphate phases (such as $CaHPO_4$) by reaction with lime with biosolids cake, but effectively completed dissolution of all calcium phosphate phases at low pH.

- Lead concentrations were less than 0.1 mg/L in all biosolids cake leachates. Slightly higher concentrations (approximately 0.3 mg/L) were recorded in the pH 2 leachate of LAB.

- Sulfur (sulfate) concentrations in LAB leachates were approximately ranged from 250 to 450 mg/L across the pH range. Biosolids cake leachates were more variable, with concentrations ranging from 330 to 480 mg/L, but with not consistent trend with leachate pH.

- Zinc concentrations were variable, ranging from 0.75 mg/L for both samples at circum-neutral pH to more than 80 mg/L for biosolids cake and more than 25 mg/L for LAB at low pH. The maximum concentration (110 mg/L) for biosolids cake was higher than for LAB (29 mg/L).

These results indicate that the elements with potential to leach from LAB and biosolids cake applied to soils are copper, phosphorus and zinc (Figure 70). Addition of lime to form LAB reduces leaching potential at circum-neutral pH 2 conditions but may increase leaching potential of sample constituents at very low pH (<4).

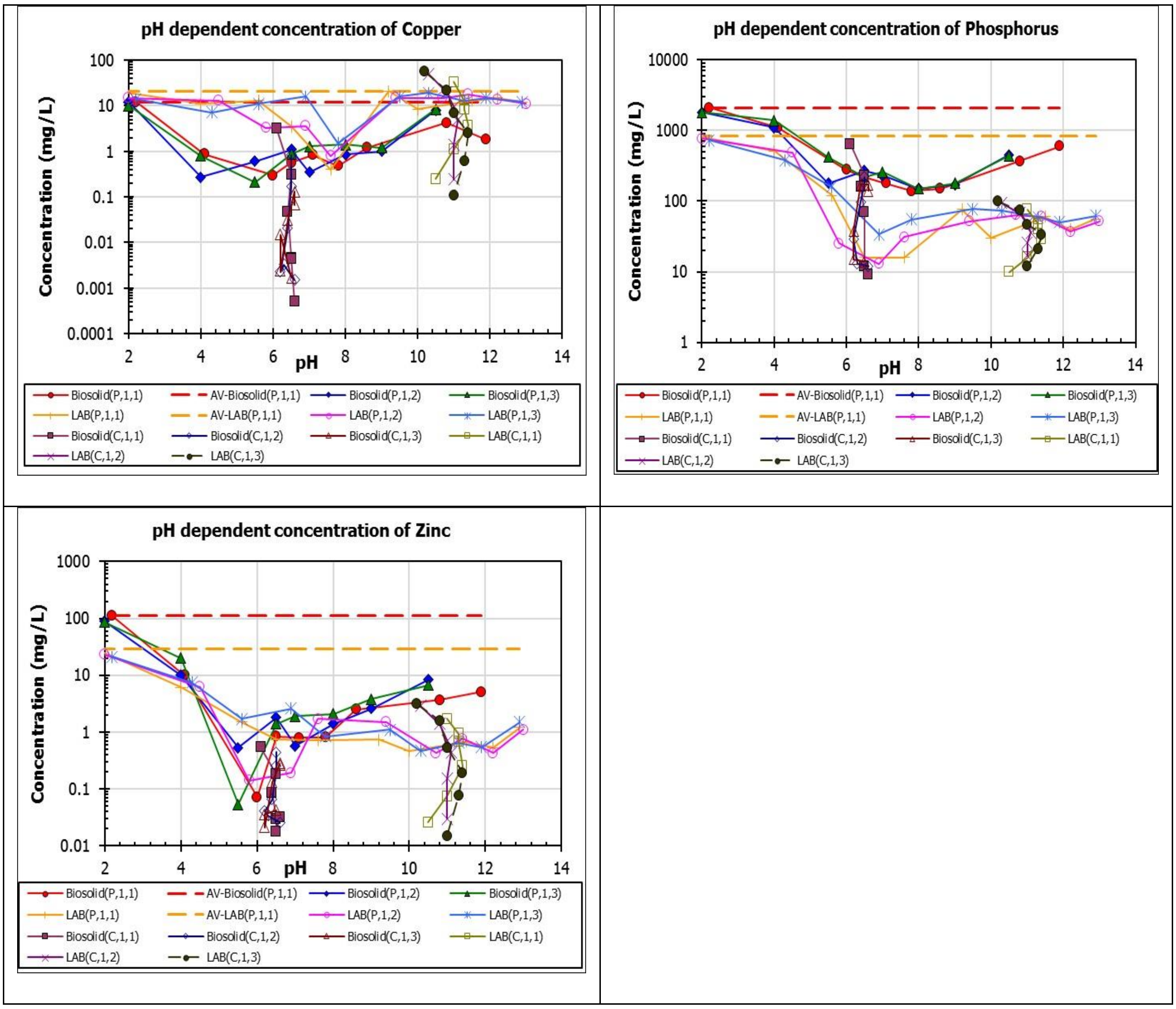


Figure 70: Graphical presentation LEAF 1313 and 1314 of copper, phosphorus and zinc for biosolids cake and LAB.

As was undertaken for other product samples (section 5.5.1.2.1), a high-level constituent risk profile for biosolids cake and LAB was undertaken using LEAF Method 1313 data based on:

- Available content (L/S = 10) as an indication of “worst case” conditions.
- Measured leachate (L/S = 10) concentrations within the applicable scenario pH domain and a DAF =- 10.

The constituent risk profiles for biosolids cake and LAB are presented in Tables 35 and 36, respectively. These results indicate that the risk profiles of both materials include numerous constituents of potential concern when the profile assessment is based on available content. However, the number of constituents of potential concern is substantially reduced when the applicable scenario pH domain and DAF factors are considered. On the basis, major constituent of potential concern in both materials is phosphorus, with other metals (cadmium, cobalt, chromium, copper, molybdenum and zinc) and metalloids (arsenic in biosolids cake, but not selenium) requiring further evaluation.

Table 35: Risk Screening Profile Table for CoPCs from LEAF Test Data – Biosolids Cake.

Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟩	🟩
TDS/EC		🟧	🟩
Ag	0.05	🟩	🟩
Al	2,200	🟧	🟨
As	1.2	🟧	🟧
B	52	🟧	🟩
Ba	7.8	🟧	🟩
Cd	0.94	🟧	🟨
Co	0.94	🟧	🟧
Cr	6.4	🟧	🟨
Cu	120	🟧	🟧
F	200	🟧	🟩
Hg	0.013	🟧	🟨
Mn	130	🟧	🟩
Mo	11	🟧	🟨
Ni	21	🟧	🟧
PO_4	64,000	🟧	🟧
Pb	0.33	🟧	🟩
SO_4	13,800	🟨	🟩
Se	0.35	🟧	🟩
U	0.13	🟩	🟩
V	1.8	🟨	🟩
Zn	1,100	🟧	🟨

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

Table 36: Risk Screening Profile Table for CoPCs from LEAF Test Data – LAB.

Constituent of Potential	Available Content (mg/kg)	Available Content Basis	Applicable Scenario pH Domain Basis (pH 5.5 to 9)
pH		🟧	🟩
TDS/EC		🟧	🟩
Ag	0.014	🟩	🟩
Al	890	🟧	🟩
As	1.5	🟧	🟩
B	27	🟨	🟩
Ba	100	🟨	🟩
Cd	0.33	🟧	🟨
Co	0.5	🟨	🟨
Cr	5.4	🟧	🟨
Cu	210	🟧	🟨
F	310	🟧	🟩
Hg	<0.0001	🟩	🟩
Mn	57	🟧	🟩
Mo	4.5	🟧	🟨
Ni	2.6	🟧	🟨
PO_4	25,800	🟧	🟧
Pb	3.2	🟧	🟩
SO_4	12,600	🟧	🟩
Se	0.39	🟧	🟩
U	0.09	🟩	🟩
V	0.8	🟩	🟩
Zn	290	🟧	🟨

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

5.5.2.2.2 LEAF Test Results, Methods 1314 and 1316, L/S Dependence

Results for analysis of biosolids cake and LAB using method 1314 (up-flow percolation) are presented as charts in Appendix A6-6. Corresponding results using method 1316 (batch equilibration) are presented in Appendix A7-5.

The results for each element were generally consistent with those present in other materials. Elements such as sodium, potassium, chloride, bromide and sulfate indicate predominantly "wash-out" behaviour. Elements including magnesium, manganese, aluminium, barium and copper indicate relatively little dependence on L/S and therefore more slightly to be controlled by equilibria with discrete solid phases.

Iron in biosolids cake indicated anomalous behaviour in that biosolids cake leachate concentrations increased with increasing L/S (while those in leachates of LAB decreased with increasing L/S).

Molybdenum concentrations in biosolids cake leachates indicated only minor variation with L/S, while concentrations in LAB leachates were one to two orders of magnitude higher and decreased with increasing L/S. This is interpreted as molybdenum in lime used to prepare LAB exists in different mineral forms to those naturally present in sewage and biosolids.

5.5.2.3 LeachXS Material Characterisation and Chemical Speciation Fingerprints

LeachXS was used to generate the chemical speciation fingerprints for both materials. Table 37 shows the nominal values applied for fingerprinting of each test material. Being organic materials, the concept of characterising these materials for parameters used for soil characterisation presented issues for LeachXS modelling. The following considerations were addressed when selecting nominal value for LeachXs modelling:

- Solid humic acid - biosolids cake and LAB contain complex polymeric organic compounds, mainly cellulose, lignin and resistant starches present in food, but their properties (notably in relation to interaction with dissolved metals) bear little resemblance to those of humic soil materials. Lignin, which contains aromatic carboxylic and phenolic groups, is considered to have some similar metal interaction characteristics to solid humic acid. A nominal value of 10,000 mg/kg used as the estimate of "solid humic acid equivalents" in these materials. Use of lower values (e.g. 2,000 mg/kg) resulted in unrealistic chemical speciation fingerprints for some metals as the dissolved humic acid fraction (based on dissolved organic carbon in Method 1313 leachates) exceeded the solid humic acid content.

- Clay - a nominal value of 1,000 mg/kg for clay content was adopted for LeachXS modelling. This was based approximately on the aluminium content, much of which would be expected by traces of soil present in food.

- Hydrous ferric oxides - a nominal value of 1,000 mg/kg for hydrous ferric oxide content was adopted for LeachXS modelling. This was based approximately on the iron content, which is expected to be distributed in various phases including corrosion products of water services infrastructure and insoluble dietary iron (such as phytic acid derivatives).

- pE - a nominal value of 7 for both materials was adopted for LeachXS modelling, based on the relationship pH + pH ~14 for biosolids. As the biosolids cake was produced by anaerobic digestion, it is expected that lower pE values may be appropriate.

Table 37: Input Parameters for LeachXS Geochemical Speciation Modeling for Biosolids Cake and LAB. Note: "nominal" means estimated, not measured.

Material	**pH**	**pE**	**Solid HA**	**Clay**	**HFO**
Biosolids Cake	6.5 (natural pH)	7	100,000 (nominal)	1000 (based on Al%)	1000 (based on Fe%)
LAB	11.1 (natural pH)	7	100,000 (nominal)	1000 (based on Al%)	1000 (based on Fe%)

5.5.2.3.1 Biosolids Cake and LAB

LeachXS was also used to provide chemical speciation fingerprints for all elements in samples of biosolids cake and LAB. Predictions are presented in Appendix A8-6 and A8-7.

In this Section, predicted chemical speciation fingerprints are presented for those elements presenting the greatest potential for (site specific) environmental impacts when these materials are used as amendments for sandy soils – copper (Figure 71), zinc (Figure 72) and phosphorus (Figure 73).

Comparison of the chemical speciation fingerprints for copper in samples of biosolids cake and LAB, presented in Figure 71, indicate:

- Experimental (Method 1313) leachate concentrations indicated only minor pH dependence in both materials, but with LAB leachates containing substantially higher concentration (approximately 10 mg/L) than biosolids cake leachates (approximately 1 mg/L). LeachXS provided a satisfactory prediction curve to describe copper solubility in biosolids cake, indicating mainly solid phase dissolution equilibria controlled by particulate organic matter phases. There was poor agreement between measured and LeachXS predictions highly alkaline (pH >10) leachates of LAB, as a consequence of LeachXs predicting the presence of tenorite (CuO) as a stable solid phase over this pH range.
- Similar concentrations of free copper in both samples, with a predicted minimum concentration of approximately 0.0002 mg/L at pH 9. However, the total dissolved concentration of copper in biosolids cake leachates under strongly alkaline conditions is predicted to be higher than those of LAB as a result of greater contributions from the DOC-bound fraction;

- LeachXS leachate concentration predictions are substantially better for biosolids cake than for LAB, especially within the alkaline pH range (in which LeachXS substantially under-estimate leachate concentrations);

- Tenorite, with minor POM-bound copper, is predicted to be the dominant copper phase under alkaline conditions, more in LAB. Similarly, LeachXS also predicted greater concentration of POM-bound copper in LAB compared to biosolids cake; and
- LeachXS predicted formation of an ettringite copper-containing fraction at very high pH (most likely as a consequence of higher contents of calcium and aluminium present in lime.

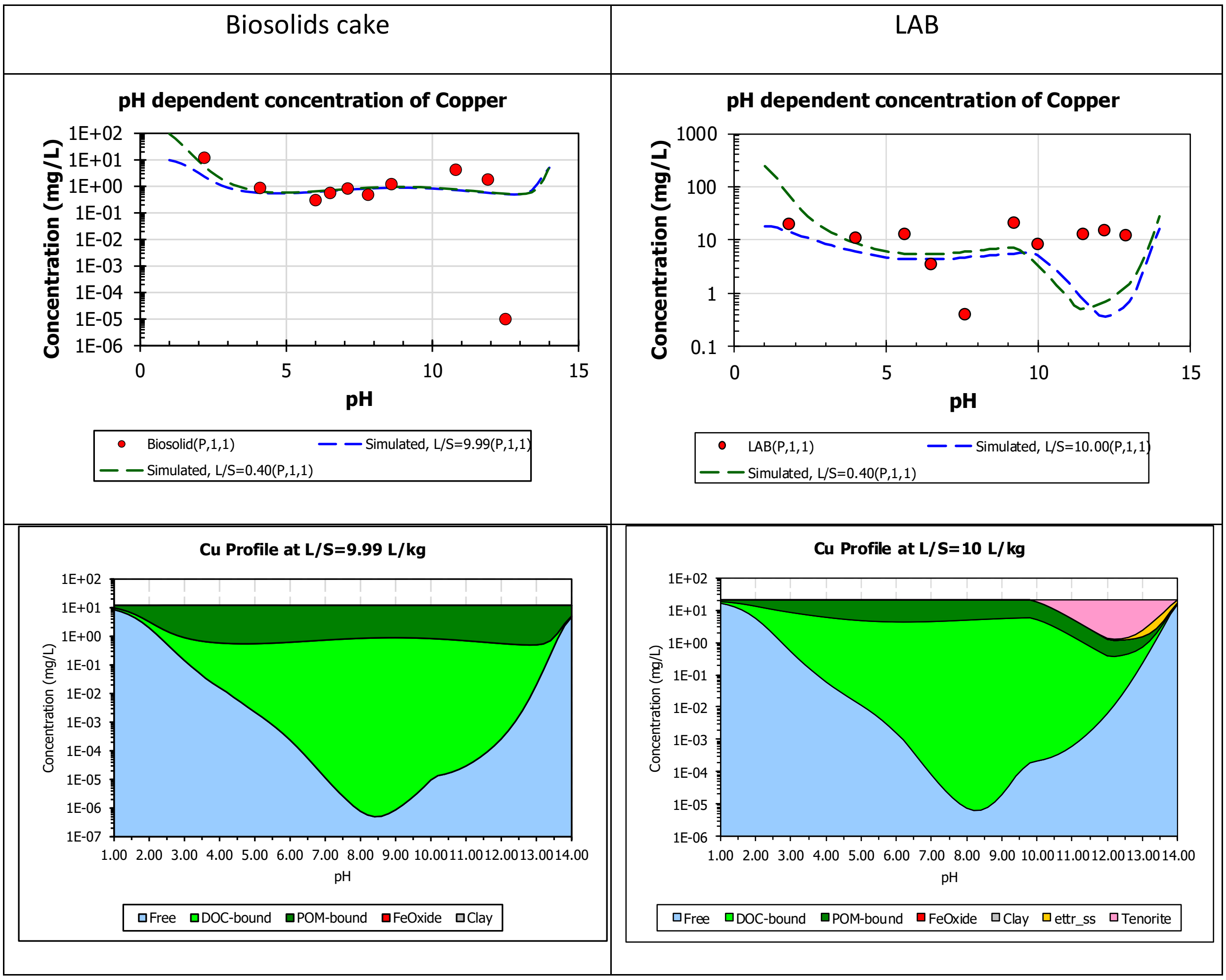


Figure 71: LeachXS Model Output for the Chemical Speciation Fingerprints of Copper in Biosolids Cake and LAB.

Comparison of the chemical speciation fingerprints for zinc in samples of biosolids cake and LAB, presented in Figure 72, indicate:

- LeachXS leachate concentration predictions for zinc are similar for both materials (noting the different y-axis scales in Figure 71), but show poor agreement with experimental data – notably over-estimating concentrations circum-neutral and alkaline leachates of LAB;
- Minimum leachate concentrations of free zinc of approximately 0.1 mg/L are predicted within the pH range of 9 to 11 for both materials. Free zinc is predicted to be the dominant form in in leachates of both materials under acidic leachate conditions (pH <5), while the DOC-bound fraction is predicted to be the dominant form at higher leachate pH values; and

- LeachXS predicts similar solid phases under alkaline conditions for both materials. Willemite ($ZnSiO_4$) is predicted to be the dominant phase in alkaline conditions, while POM-bound phases is predicted to be the dominant solid phase under circum-neutral conditions. As observed for copper, LeachXS also predicts formation of an ettringinite phase containing zinc at very high pH values in LAB (but not biosolids cake).

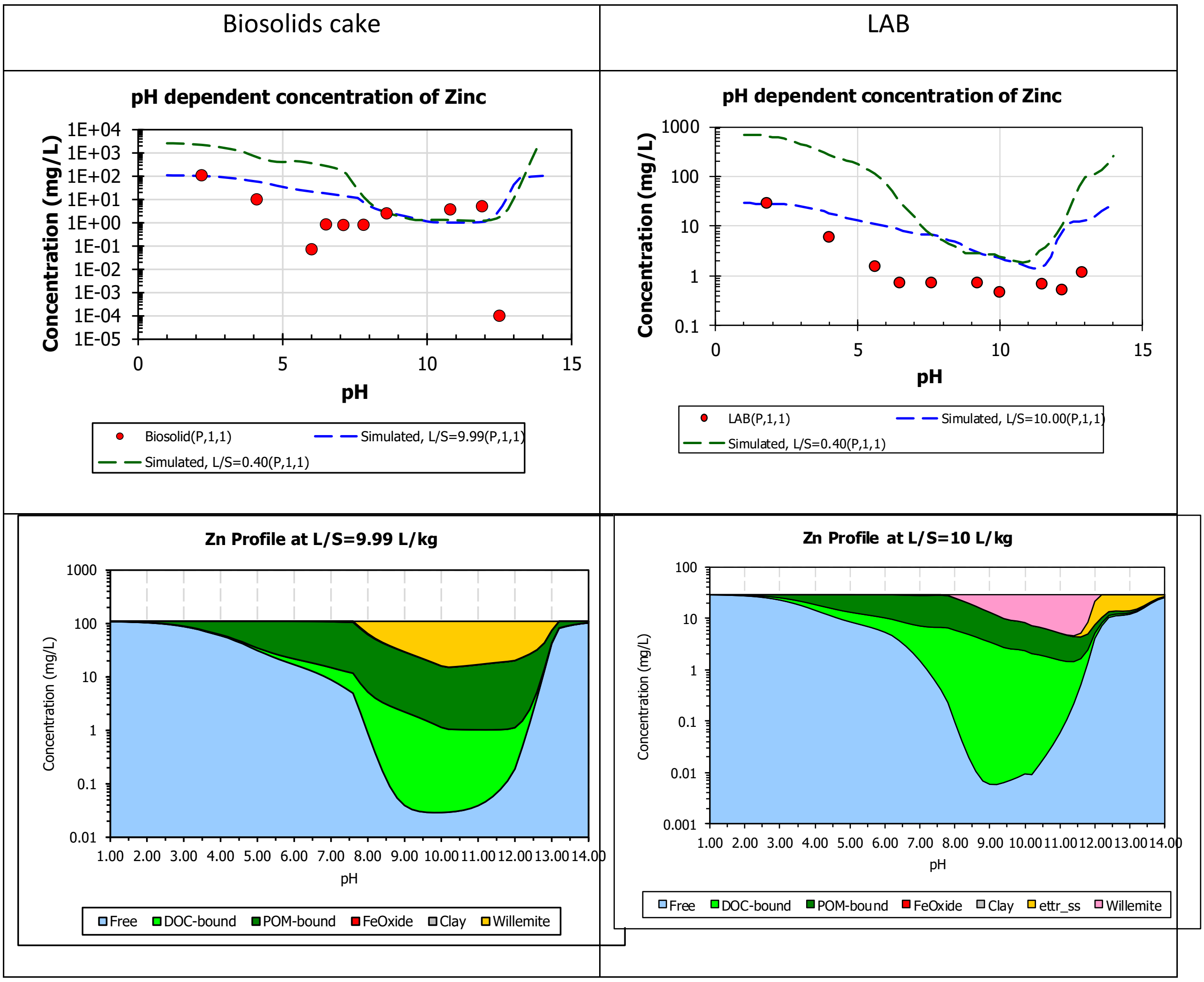


Figure 72: LeachXS Model Output for the Chemical Speciation Fingerprints of Zinc in Biosolids Cake and LAB.

Comparison of the chemical speciation fingerprints for phosphorus in samples of biosolids cake and LAB, presented in Figure 73, indicate:

- Both samples provided experimental conditions that indicated only minor dependence with pH. Typical phosphorus concentration in biosolids cake leachates (100 to 1,000 mg/L) were similar to LAB leachates in acidic (pH <5 leachates), but an order of magnitude higher than LAB leachates (10 to 100 mg/L) in circum-neutral and alkaline leachates;

- LeachXS predicts much lower concentrations of phosphorus in alkaline LAB leachates than the experimental results. The low solubility of phosphorus under these conditions is predicted to be a consequence of the formation of tricalcium phosphate (TCP) minerals, which is the principle of reducing the solubility of phosphorus by adding lime to biosolids to form LAB (together with conditions that kill pathogens and reduce odour).

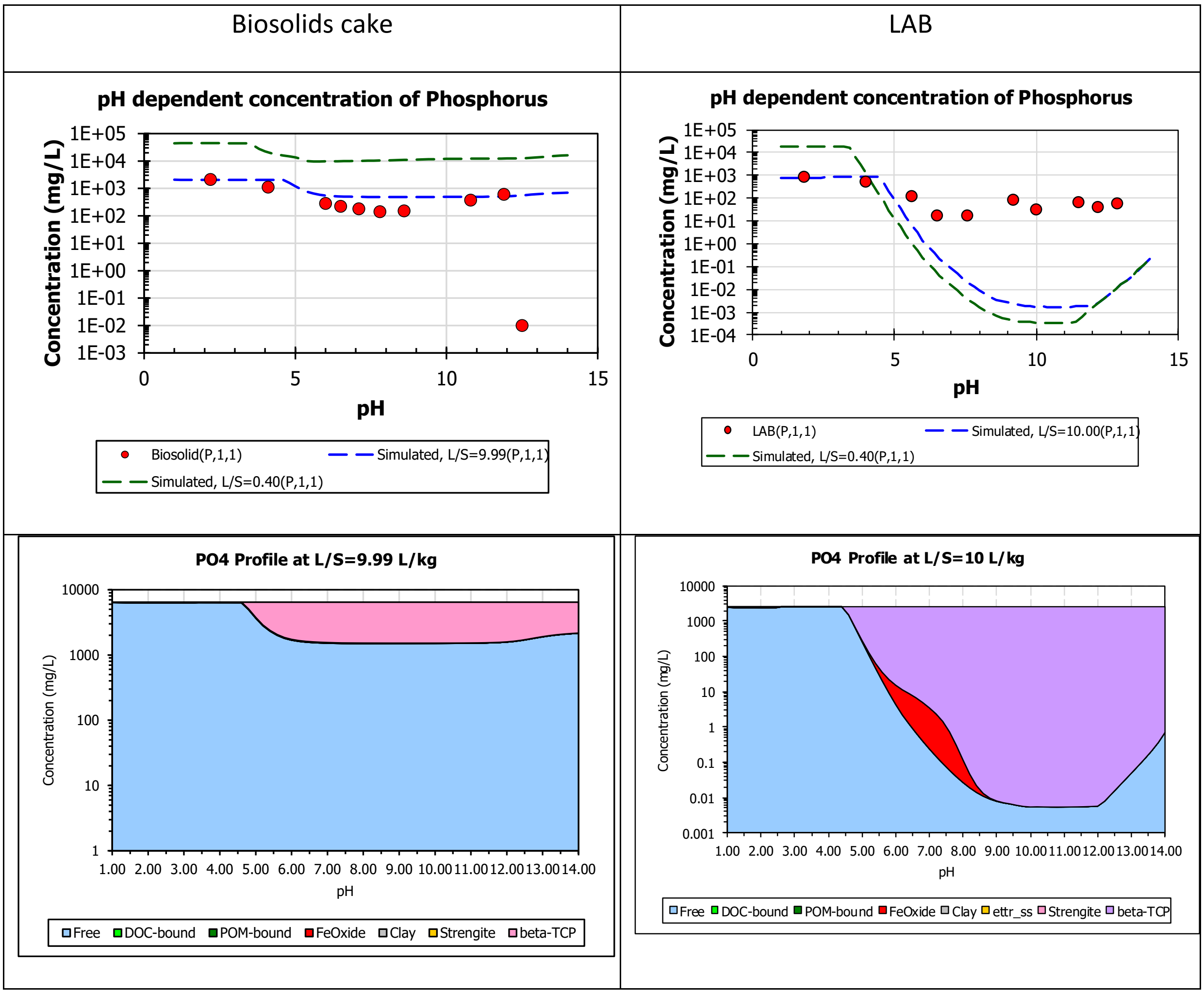


Figure 73: LeachXS Model Output for the Chemical Speciation Fingerprints of Phosphorus in Biosolids Cake and LAB.

5.5.2.4 Laboratory and Field Data

5.5.2.4.1 Tall Column Experiment

As discussed in Section 4.10.2, a large column experiment was set up as follows:

A surface layer of either amended soil (using biosolids materials as amendment). The application rate equivalents for the soil amendment materials were:

- 7.5 t/ha/10 cm layer for (dry) biosolids cake.
- 15 t/ha/10 cm layer for (dry) LAB.

Leachates were collected on three occasions, as summarised in Section 4.10.2.1 (designated as Time 1, 2 and 3).

At each sampling event, leachates were collected from:

- Immediately below the amended soil/material layer;
- Draining the tap at the base of the column prior to flushing, i.e. sampling interstitial water from soil voids from the initial setting up of the column and subsequent leaching events; and
- Collecting leachate from the base of the column after the flushing event described in Section 4.10.2.1.

Results for analysis of the leachates are tabulated in Table A1-1 of Appendix A11. In addition, results for all analytes are plotted as charts presented in Appendix 12. Each chart shows the concentrations for the specific analyte and soil type from the three leachate sampling points collected on three occasions (coloured lines and markers), with the corresponding results from the "control" columns (i.e. no amended soil and residue material cover layer) as black dashed lines (no markers).

Analytes where all concentrations were below the "lower threshold" values listed in Table 6 have very low potential for environmental impact. All other analytes may warrant further investigation (Table 38) some of these are discussed below.

Table 38 Tall Column Leachate Analysis Summary for Biosolids Cake and LAB.

Analyte	**Biosolids Cake**				**LAB**			
	Bass/E	Bass/J	Duplex	S'wood	Bass/E	Bass/J	Duplex	S'wood
pH	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
TDS/EC	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
DOC	🟨	🟨	🟨	🟩	🟨	🟨	🟧	🟩
Al	🟨	🟨	🟨	🟩	🟨	🟨	🟨	🟩
As	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
B	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Ba	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Cd	🟩	🟩	🟨	🟩	🟩	🟩	🟨	🟩
Co	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟩
Cr	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Cu	🟨	🟧	🟧	🟨	🟧	🟧	🟨	🟨
Mn	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Mo	🟩	🟨	🟨	🟨	🟩	🟨	🟨	🟨
Ni	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
P	🟥	🟥	🟧	🟨	🟥	🟥	🟧	🟩
Pb	🟩	🟨	🟩	🟧	🟩	🟨	🟨	🟧
SO_4	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Se	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
U	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
V	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Zn	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨

Note: Level of potential environment risk, based on conservative threshold criteria (Table 6), shown as; (i) below the lower threshold values (green) and (ii) above the lower threshold values with relative exceedances in the increasing order yellow<orange<red.

In many cases, it is observed that the leachate concentrations from the flushing of the column are controlled mainly by the soil material rather than the amendment material. Exceptions to this general observation are discussed in greater detail in the following sections.

Potential for mobilisation of specific constituents from Biosolids Cake and LAB

The tall column experiment indicated that the risk profile associated with use of Biosolids cake and LAB as soil amendments were similar to those of other amendment materials, with slightly higher risks associated with phosphorus, copper and zinc.

Lead was identified as a potential risk arising from LAB applied to Spearwood sand, noting this classification was based on a single elevated ("first flush") bottom column leachate concentration of 0.018 mg/L. This result may be an anomaly as no other elevated leach concentrations were recorded for leachates from the control soils, leachates from biosolids-amended soils, or subsequent leachates from the LAB amended Spearwood sand. However, LAB would not be recommended for use an alkaline Spearwood sands because of potential for phytotoxity or deficiency of critical plant nutrient under highly alkaline conditions.

Predictive solute transport modelling for soils amended with either biosolids cake or LAB was not conducted as it was outside the project scope. However, the LEAF test data and associated chemical speciation fingerprints generated by LeachXS would enable this work to be done at a later date.

5.5.2.6 Summary

The results from this study generally support the use of biosolids cake and LAB as “soil conditioners” for sandy soils on the Swan Coastal Plain, provided that:

- Consideration is given to the hazards associated with pathogens present in biosolids cake. This is beyond the scope of this study. Previous work has indicated the pathogen risk associated with LAB is very much lower.

- The potential for leaching of phosphorus from both materials is rated as high, particularly for biosolids cake. Consideration by regulators should include limiting application rates for biosolids cake to sandy soils as an alternative to water-soluble fertilisers (such as superphosphate). Maximum application rates should initially be based on phosphorus content; a limit of 10 kg P/ha/yr may be appropriate. LeachXS may be used to predict leachate quality at application rates lower than that used in the tall column study.

- As LAB contains typically lower concentrations of constituents of potential concern and has potential to increase alkalinity of acidic sandy soils (and thereby potentially reducing leaching rates of metals), higher application rates of LAB may be considered for improving agronomic performance with minimal risk to the environment. Application rates up to a maximum of 3 to 4 t/ha every three or four years may be appropriate for LAB usage. Again, LeachXS may prove useful for predicting leachate quality under these scenarios.

It is important to note that using dried biosolids in testing has certain limitations as the DOC is higher and the redox state is different. It takes longer for the material in a column to exert the same redox behaviour as the undried material (microbial activity needs to be restored). In using dried material (which was required to work with in this study) a number of aspects can be addressed, but the translation to actual conditions in the field is harder.

7 SUMMARY AND CONCLUSION

7.1 LEAF Test Methodology

Through ChemCentre, completing the method development and validation component of this project, Western Australian industry, researchers and government regulatory agencies now have access to the following LEAF tests accredited by the National Association of Testing Authorities (NATA):

- Test Method 1313, which determines how liquid-solid partitioning varies with the pH of the leaching solution (from 2 to 13 pH units) using a parallel batch extraction method.
- Test Method 1314, which determines how liquid-solid partitioning (LSP) varies with L/S using an up-flow percolation column procedure.
- Test Method 1316, which determines how liquid-solid partitioning varies with the L/S using a parallel batch extraction procedure.

Note: Test Method 1315 (for monoliths) is also accredited by NATA.

ChemCentre demonstrated the robustness of the test methodology by providing both repeatable and reproducible data compared with an independent laboratory (ECN).

The methods were well suited for analysis of samples of by-products with the potential for beneficial re-use in Western Australia, comprising Alkaloam, Ironman Gypsum® (IMG), NRP, two groundwater treatment residues (Jandakot and Wanneroo), biosolids cake and lime amended biosolids (LAB). Test Method 1313 was also found to be useful for providing useful leachate composition data for geochemical characterisation of typical sandy soils occurring on the Swan Coastal Plain.

Leachate data provided by Test Method 1313 (pH dependence) is superior to that provided by the ASLP method, the latter which has been widely adopted throughout Australia for classification of waste materials to landfill and extended to assessment of mining wastes (waste rock, tailings and leach residues) and contaminated soils. The LEAF test provides two additional useful parameters;

- Available content, defined as the maximum concentration (by weight in solids) available for leaching at pH 2, 9 or 13. Available content is a superior metric to “total” concentrations or concentrations measured in single pH leachates, such as provided by the ASLP or TLCP tests (Section 3); and
- Leachable concentrations within the “applicable scenario pH domain”, which has been proposed by researchers in Europe and the US to be 5.5 to 9.0 pH units. Although WA has a number of very acidic soil types, this pH range is considered suitable for Swan Coastal Plain soil types.

Test Methods 1314 and 1316 provide useful information on the behaviour of ions as “soluble” or controlled by dissolution/precipitation of sparingly soluble mineral phases, or other processes including interaction with soil constituents including clay minerals, hydrous iron/aluminium oxide surfaces or organic matter. Most observations were consistent with published geochemical properties of well-studied potentially environmentally significant metals and metalloids. The LEAF test methods provide a sound empirical basis for the behaviour of these elements in the LeachXS chemical speciation fingerprint and percolation column mass transport modules.

While the LEAF test methods were used in this project for materials of inorganic origin, two samples of organic materials (biosolids cake and LAB) produced by urban waste water treatment plants were assessed as part of this project. The high moisture content, presence of pathogens and low permeability of these materials presented challenges for reproducible and meaningful analysis of these types of samples. ChemCentre recommends the following procedures for preparation and analysis of these types of materials:

- Removing most of the free water by fan-forced air drying at slightly elevated temperatures (40°C) to a residual moisture content that is amenable to sample mixing and homogenisation by crushing and grinding.
- Recording the residual moisture content by oven drying at 105°C to enable correction of measured concentrations to a standard oven-dry basis.
- Use the homogenised air-dry material directly for preparation of leachates using LEAF Method 1313.
- Preparing blends of the homogenised air-dry material with a coarse, inert, acid-leached inorganic substrate (such as quartz sand) to provide suitable samples for testing by LEAF Method 1314 (up-flow column percolation).

The large column study of the four soil types studied as controls (with no by-products) in this project showed potential for mobilization of specific constituents from soils that included aluminium, copper, zinc, chromium and/or phosphorus for some of the soil types. These findings suggest that for some constituents the natural soils (as opposed to the by-products) may significantly contribute to overall leaching characteristics of the by-product/soil mixture.

7.2 Chemical Speciation Fingerprint Assessment

The ChemCentre research team was trained on the use of LeachXS to provide chemical speciation fingerprints of by-products, local soils and blends of the two material types (as "virtual materials") using LeachXS modelling.

Generally, the chemical speciation fingerprints of key analytes in the by-products are consistent with current understanding on the geochemistry of these analytes and the mineralogy of materials, viz:

- Alkali metals, boron and halogen ions (and nitrate ions) were mainly present in the "free" form.
- Metalloid elements such as arsenic, selenium and antimony, fluoride ions and transition metals capable of forming stable oxyanions at environmental pH and pE conditions (molybdenum, vanadium and chromium) were found to be predominantly present in hydrous iron oxide fractions. It is important to recognise that this fraction also encompasses hydrous aluminium and manganese oxide phases, and not exclusively (ferric) iron oxides.
- Many transition metal ions, notably trivalent chromium, copper, lead and zinc, were associated with particulate and dissolved organic carbon (DOC) fractions, although these

phases were generally minor components of mineral processing by-products (but major components of biosolids cake and LAB).

- The number of mineral phases available in the thermodynamic mineral database (Minteq) for each element used by LeachXS is highly variable. Common lithophilic elements, such as calcium, magnesium, aluminium, iron and manganese are well represented, while less common elements (such as antimony, cadmium, cobalt, uranium and thallium) are represented by very small numbers of mineral phases. Constituents commonly included in environmental impact considerations such as copper and zinc are reasonably well represented.

The chemical speciation fingerprints of elements in the four soil types were found to be of variable quality. This is not surprising as these soils were characterised by very low hydrous iron oxide and clay contents (compared to European and US soil types) and very low concentrations of many trace metals, metalloids and some lithophilic elements (such as calcium and magnesium in the acid sandy soil types).

LeachXS software requires training, a degree of expertise and judgement to correctly select input parameters required by the model including:

- Redox potential (pE);
- Clay content;
- Hydrous iron oxide;
- Solid humic acid; and
- The dissolved humic acid percentage of DOC as a function of pH.

With exceptions of pE (which cannot be measured directly in any material) and dissolved humic acid (a water composition parameter), these parameters are important for characterisation of soils, but may not have direct counterparts in by-products, particularly those of organic origin.

The ChemCentre recommends adoption of standardised methods for measuring clay content, hydrous iron (aluminium and manganese) and solid humic acid concentrations in both soils and by-products. Further development or refinement of procedures applicable for WA soils may be required for some by-products.

In the absence of some measured concentrations, nominal values were used and adjusted as required to improve the relationship between predicted and measured concentrations of specific analytes (notably arsenic, sulfur, copper, chromium, aluminium and iron). In some cases, very good “curve fits” were determined using clay, hydrous iron oxide and solid humic acid concentrations that were inconsistent with the analytical data. This re-affirms that correct application of the LeachXS models requires both training and a degree of expertise and judgement.

LeachXS chemical speciation fingerprints for elements such as phosphorus and sulfur were found to correlate poorly with experimental data for Bassendean sands (Ellenbrook and Joel samples) and the sandy duplex soil (Fairbridge). These soils belong to the soil group known as Podsols, which are characterised by elevated contents of soil organic matter associated with iron and aluminium oxide minerals. Much of the phosphorus and sulfur in these soils, particularly topsoils with a long history of fertiliser applications required for productive agriculture, is associated with biological microorganisms and detritus (dead particulate organic matter), which is very difficult to model by geochemical methods.

The predictive value of LeachXS modelling could be improved for application in Western Australia with the addition of applicable thermodynamic data to the LeachXS minerals database.

7.3 LeachXS Percolation Column Mass Transport Model Predictions

Comparison of predicted leachate concentrations provided by LeachXS percolation column mass transport modelling with measured leachate concentrations of field trial lysimeter and laboratory tall column experiments were variable. Generally, reasonable agreement was obtained for species that were:

- Present at “high” concentrations (greater than 1,000 mg/kg “available content” for lithophilic elements and greater than 10 mg/kg for heavy metals and metalloids;
- Well represented by common mineral phases in the Minteq thermodynamic mineral database; and
- Characterised by chemical speciation fingerprints that aligned reasonably well with LEAF test experimental results.

LeachXS predictive modelling provided poor agreement with experimental data for elements likely to be present in more than one valence state under pH and pE conditions likely to be encountered in soil and aquatic conditions in the southwest of WA. Of particular interest were comparisons of predicted and experimental values for materials containing elevated concentrations of manganese, such as IMG and Wanneroo groundwater treatment residues. Reasonable predictions were only obtained when very high nominal pE values (>9) were assumed. Further research will be required to develop methods for determining parameters, such as pE values, that are more appropriate to use for LeachXS modelling for Western Australian conditions.

7.4 By-product Assessment

All by-products assessed in this study have the potential for use as either soil amendments or clean fill substitutes.

Results from this study of Ironman Gypsum® and Alkaloam, including the use of predictive solute transport modelling, may provide useful information toward future land application assessments for site-specific, restricted use applications.

Groundwater treatment residues produced by Aroona have potential for use as fill materials. Approval for use however would require consideration of some constituents of potential concern to be mobilised under conditions of low redox potential, such as inundation by rising groundwater tables.

Biosolids cake and LAB contain several constituents of potential concern, as indicated by available contents for LEAF 1313 testing and results from column leach testing (from both the materials themselves and the soils). There is however potential for both materials to be used as alternative fertilisers (instead of water-soluble fertilisers including superphosphate). However, further studies are required to define maximum permissible application rates for soils on the Swan Coastal Plain. As LAB presents a decreased risk profile in terms of constituents of potential concern identified in biosolids (and a considerably reduced pathogens risk), there is potential for use of LAB as an alternative to lime materials currently used to counter solid acidity of naturally acidic soil types on the Swan Coastal Plain.

It is important to note that using dried biosolids in testing has certain limitations as the DOC is higher and the redox state is different. It takes longer for the material in a column to exert the same redox behaviour as the undried material (microbial activity needs to be restored). In using dried material (which was required to work with in this study) a number of aspects can be addressed, but the translation to actual conditions in the field is harder.

7.5 Concluding Remarks

ChemCentre has demonstrated that it can perform LEAF laboratory test methods in a robust and accredited manner.

Chemical speciation and solute transport modelling through LeachXS requires both training and skilled execution to obtain useful results. ChemCentre and other WA scientists have gained considerable experience and expertise with the use of LeachXS and have access to global experts in the field (including those responsible for development of the LEAF methodology) to further develop this expertise.

Understanding the geochemical characteristics of both local by-products and local soils is a prerequisite for accurate modelled predictions. WA researchers have an extensive knowledge in this regard. The collaborative relationships developed with overseas experts during this project will be useful in adopting and adapting of LEAF methodology to Western Australian applications.

This project established a LeachXS database of Western Australian local soils and by-products, which can be augmented as other soil types and materials are tested in the future. Such an improved LeachXS database will have the potential to be utilised to provide predictions for various potential by-product applications.

The LEAF tools and approach can provide more certainty regarding the characteristics of potential soil amendment materials and the long-term environmental impact of their potential use for specific applications in Western Australia. For example, LEAF is likely to effectively assess by-products as potential soil amendment materials to ameliorate phosphate leaching from the Swan Coastal Plain sandy soils.

LeachXS would be a useful tool for optimising application rates, assessing blends of by-products as soil amendments (e.g. IMG + Lime Amended Biosolid), and predicting leaching potential for other soil types not included in this study.

8 RECOMMENDATIONS FOR FUTURE WORK

1. Develop suitable LEAF certified reference materials and inter-laboratory control samples applicable to Western Australian conditions.

   Currently there in no certified reference material (CRM) for LEAF testing in Australia. There is a need to develop suitable certified reference materials for LEAF testing and to ensure an ongoing source of such CRMs. A mildly contaminated soil may be a good choice in view of long-term stability. This is more complicated for an alkaline material such as Municipal solid waste incinerator ash used as in-house standard by ECN due to ongoing carbonation and associated changes in release behaviour of specific elements in the long term.

2. ChemCentre to engage in regular inter-laboratory comparisons with other LEAF accredited laboratories.

3. Reduce reliance on nominal values for LeachXS and improve the accuracy of LeachXS modelling by:

   a. Developing or improving methods for the determination of clay content, hydrous iron oxide (aluminium and manganese) content in Western Australian by-products and solid humic acid (SHA) concentrations in Western Australian soils and by-products; and

   b. Augmenting the existing LeachXS thermodynamic database with additional mineral phases applicable to Western Australia.

4. Using LeachXS for the 1313 model description for virtual material mixes in a downflow column model (including preferential flow) allows to compare the samples taken and analysed from the top of the column (Amendment) at three-time steps with model output. In a next step, the full tall column description can be run using a 40-cell column model with 5 cells for the amendment layer.

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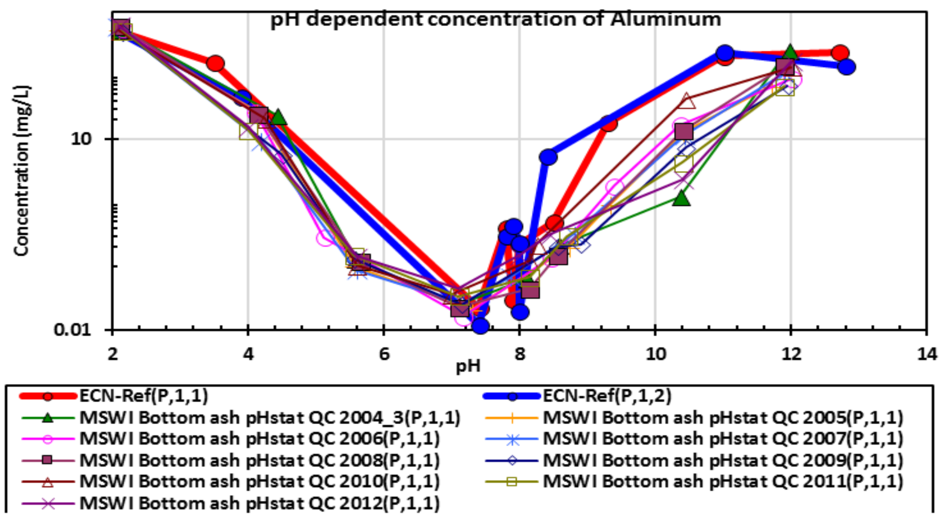
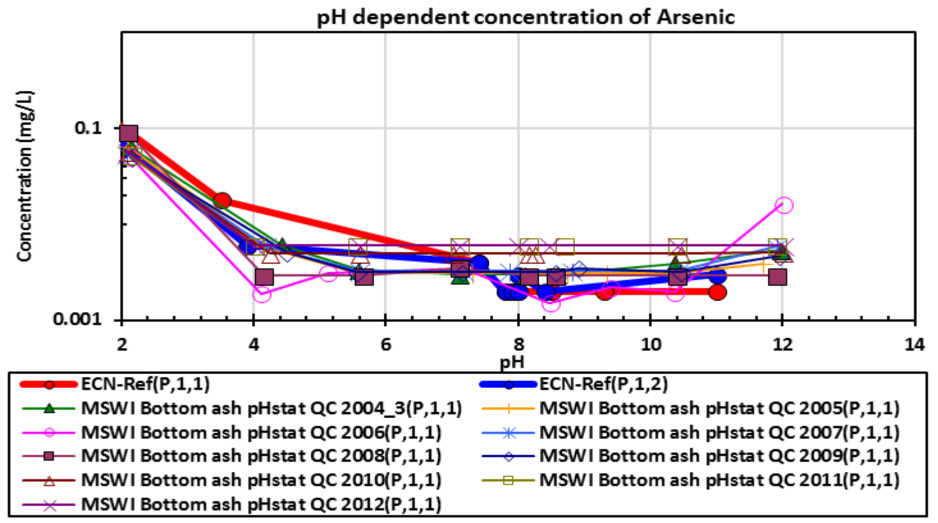
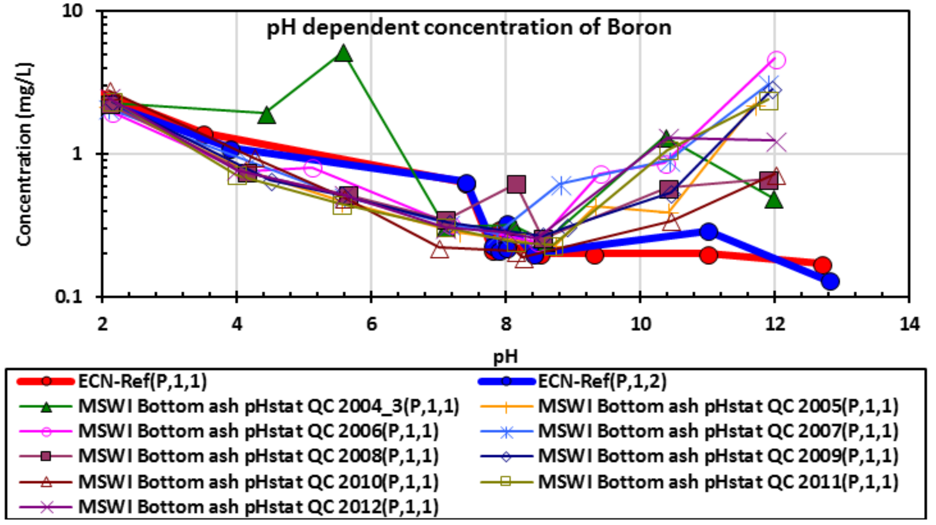
10 APPENDICES

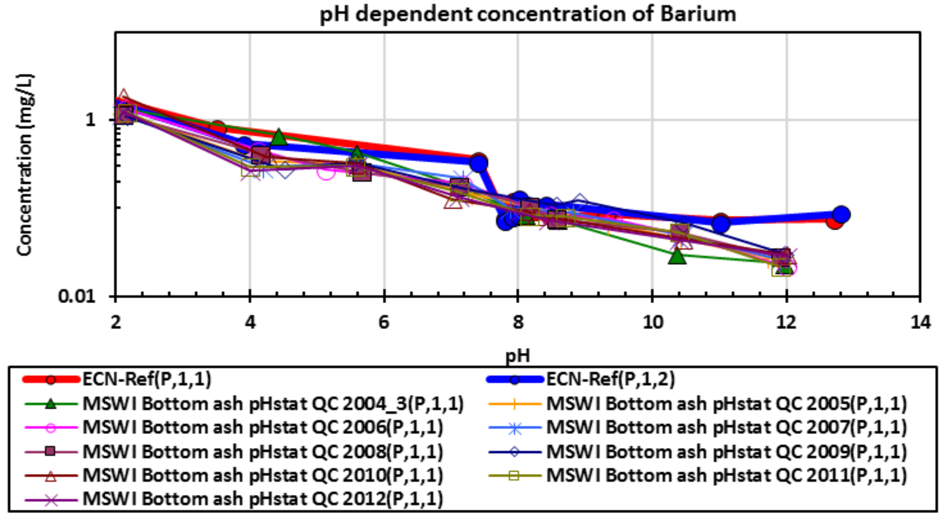
10 APPENDICES Graphical Presentation of Analytical and Field Data

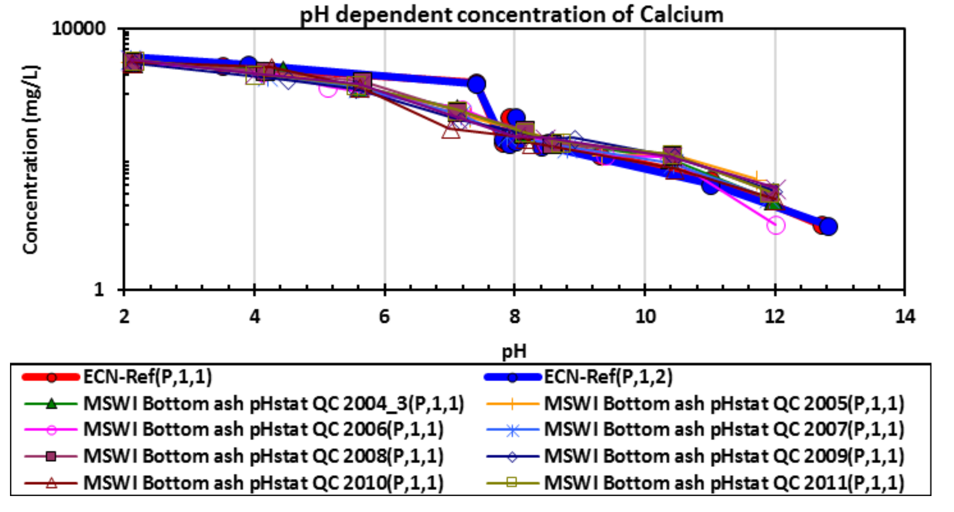
Appendix A1: pH dependent 1313 leaching results for ECN reference material performed by ECN and ChemCentre.

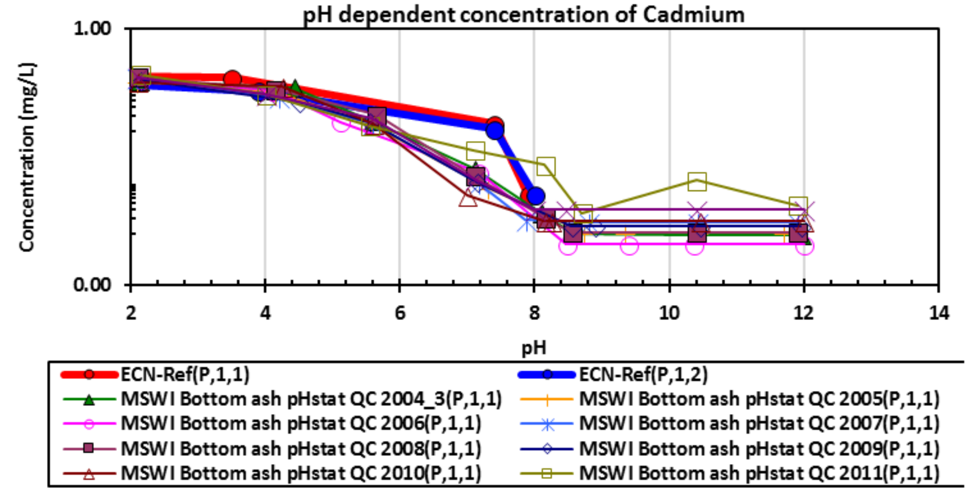


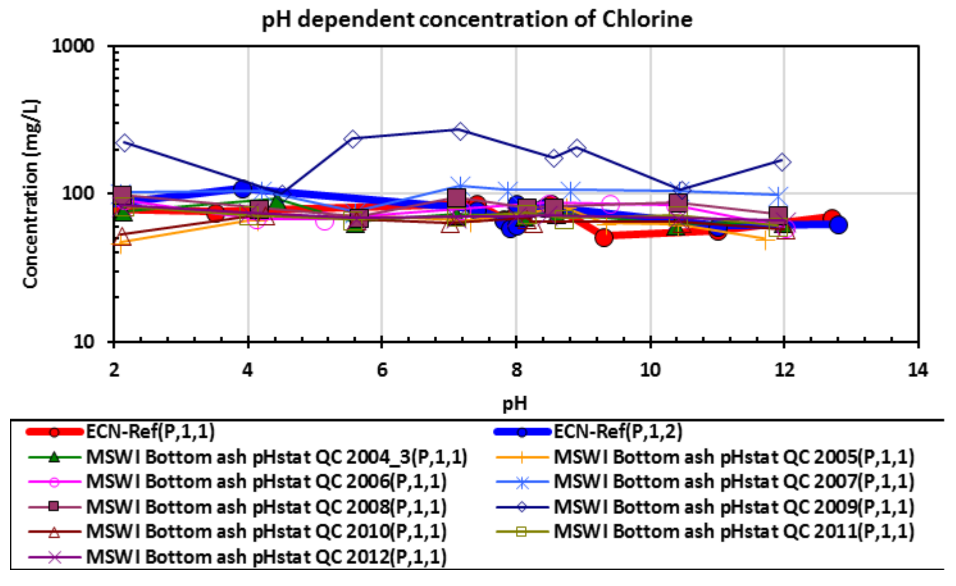


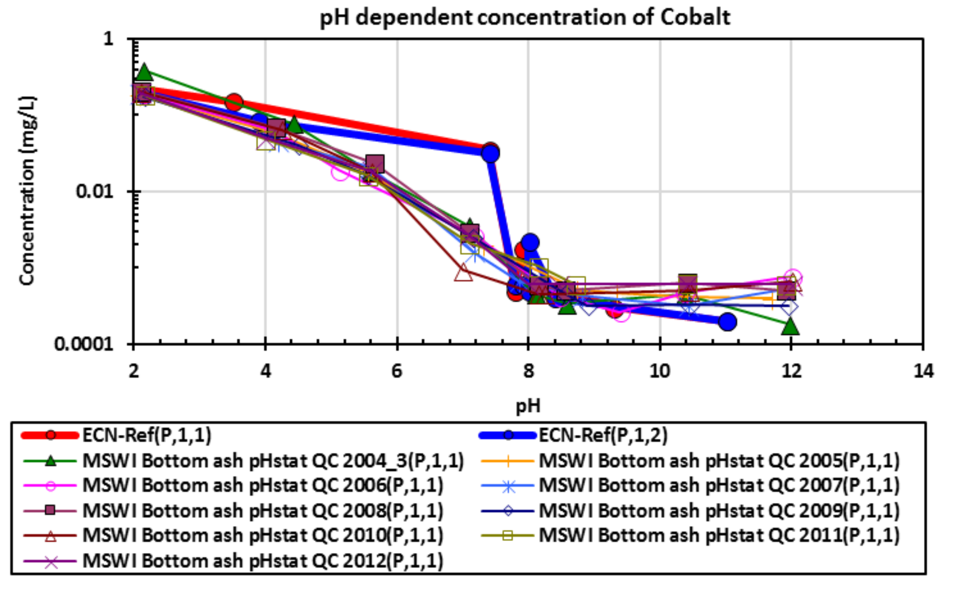


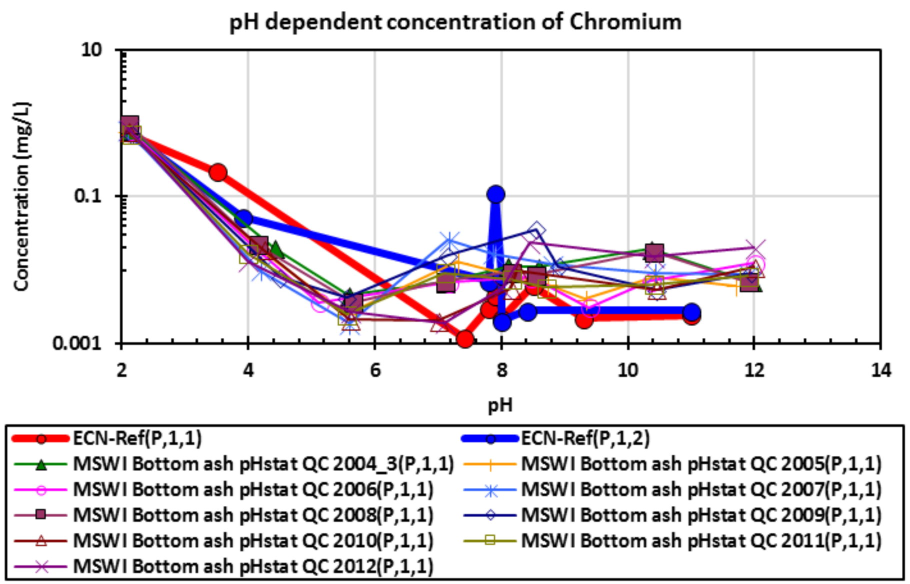


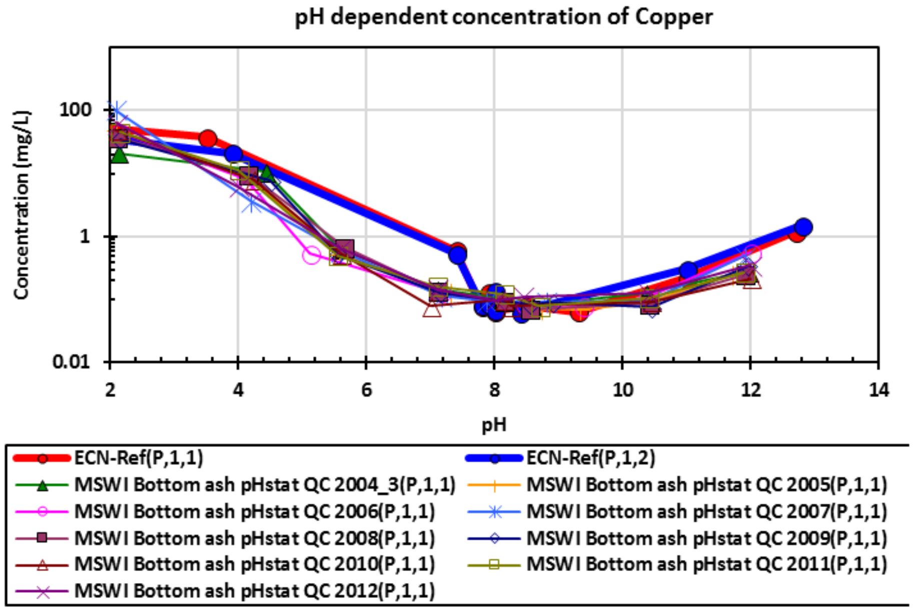

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)

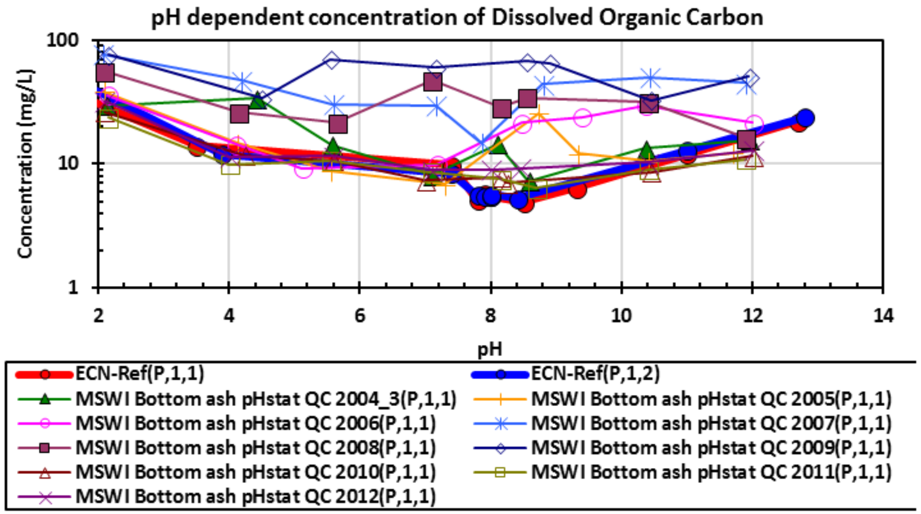

pH dependent concentration of Cadmium
Concentration (mg/L)
1.00
0.00
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)

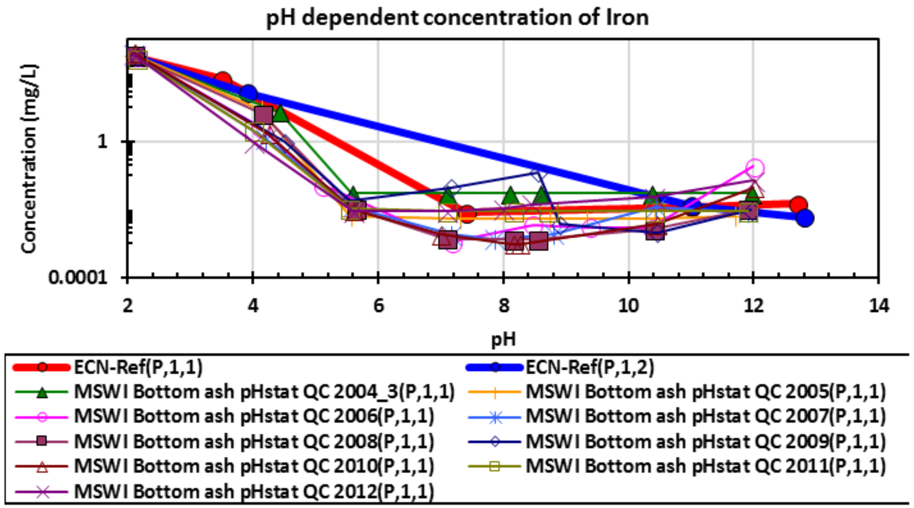

pH dependent concentration of Chlorine
Concentration (mg/L)
1000
100
10
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

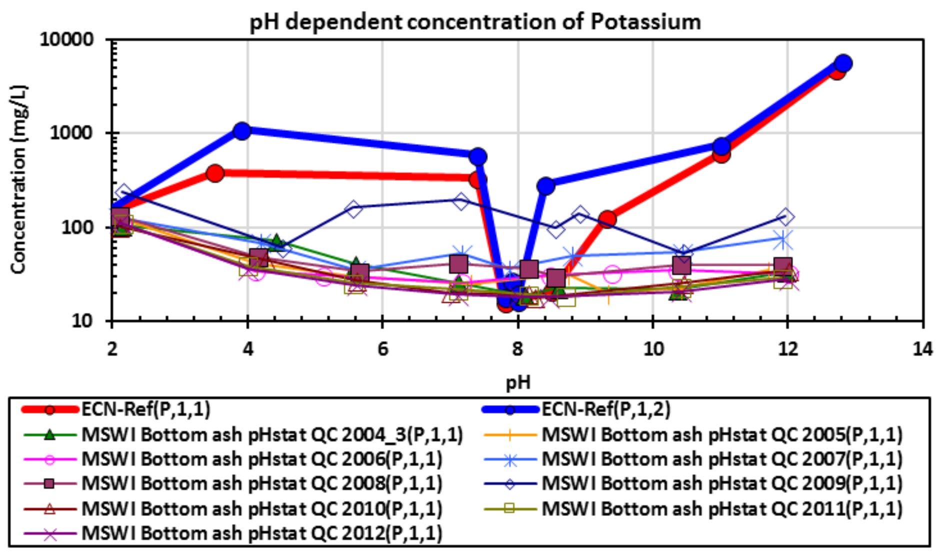

pH dependent concentration of Cobalt
Concentration (mg/L)
1
0.01
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

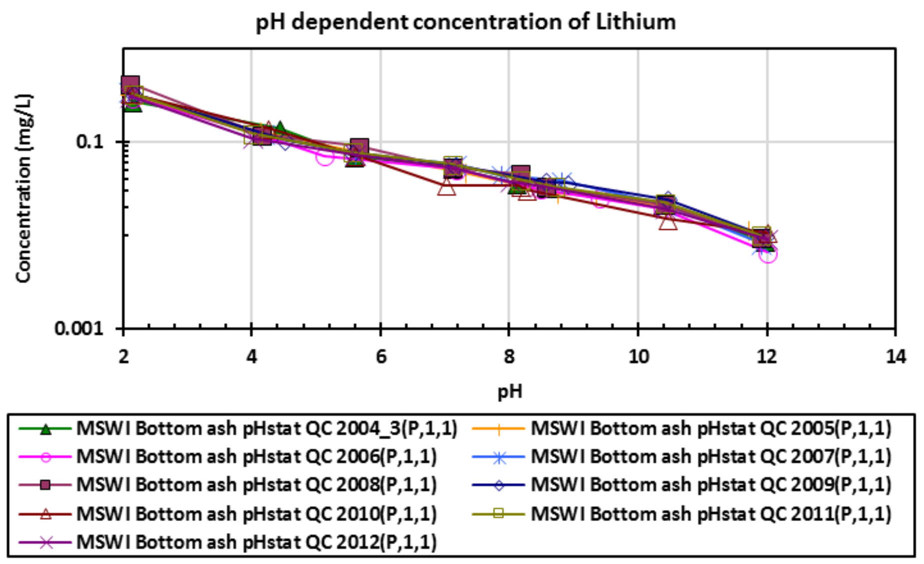

pH dependent concentration of Chromium
Concentration (mg/L)
10
0.1
0.001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

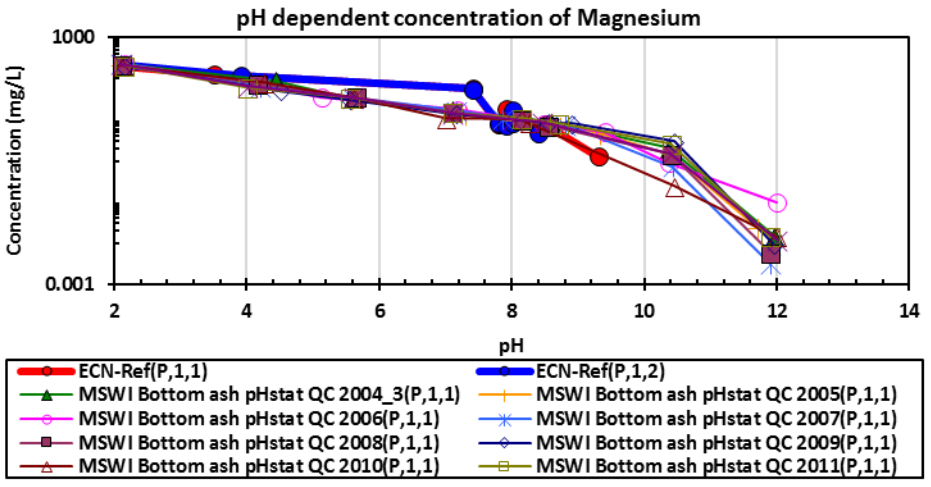

pH dependent concentration of Copper
Concentration (mg/L)
100
1
0.01
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

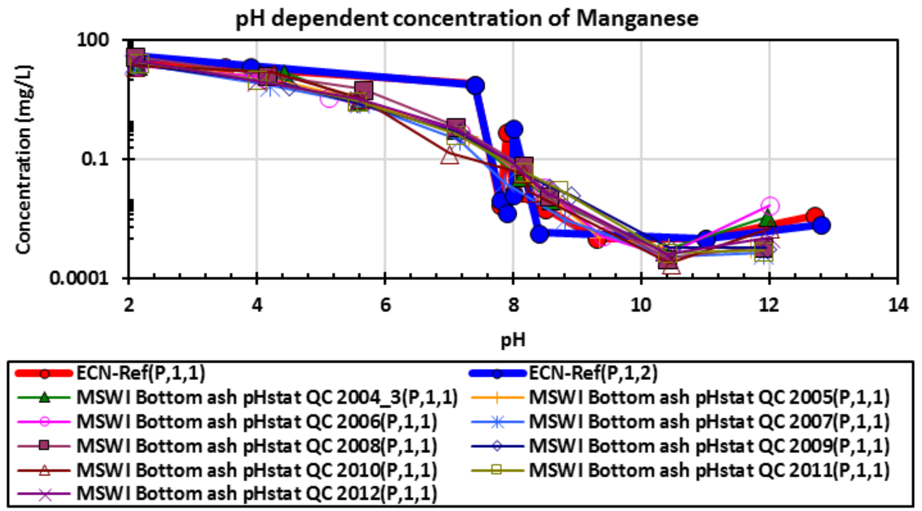

pH dependent concentration of Dissolved Organic Carbon
Concentration (mg/L)
100
10
1
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Iron
Concentration (mg/L)
1
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Potassium
Concentration (mg/L)
10000
1000
100
10
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Lithium
Concentration (mg/L)
0.1
0.001
2
4
6
8
10
12
14
pH
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Magnesium
Concentration (mg/L)
1000
0.001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)


pH dependent concentration of Manganese
Concentration (mg/L)
100
0.1
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
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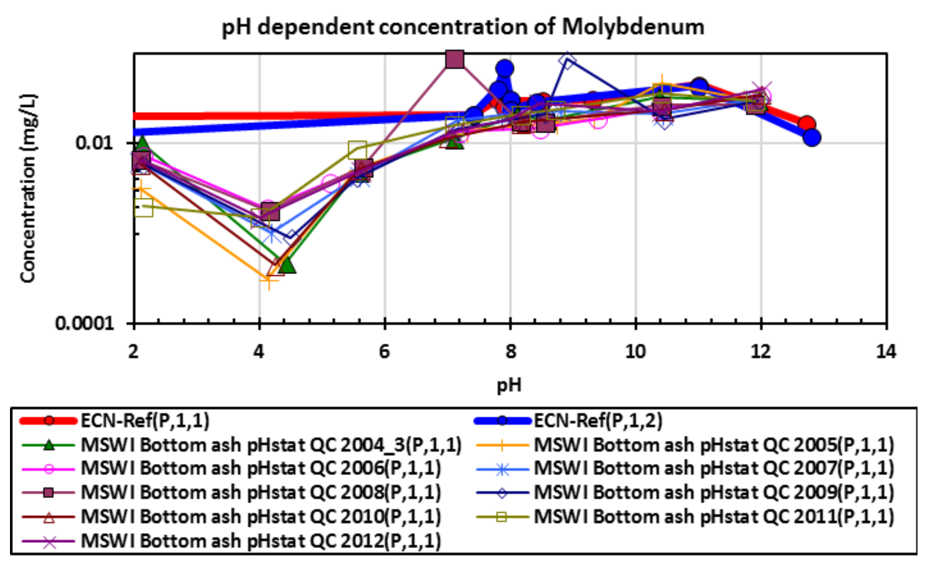
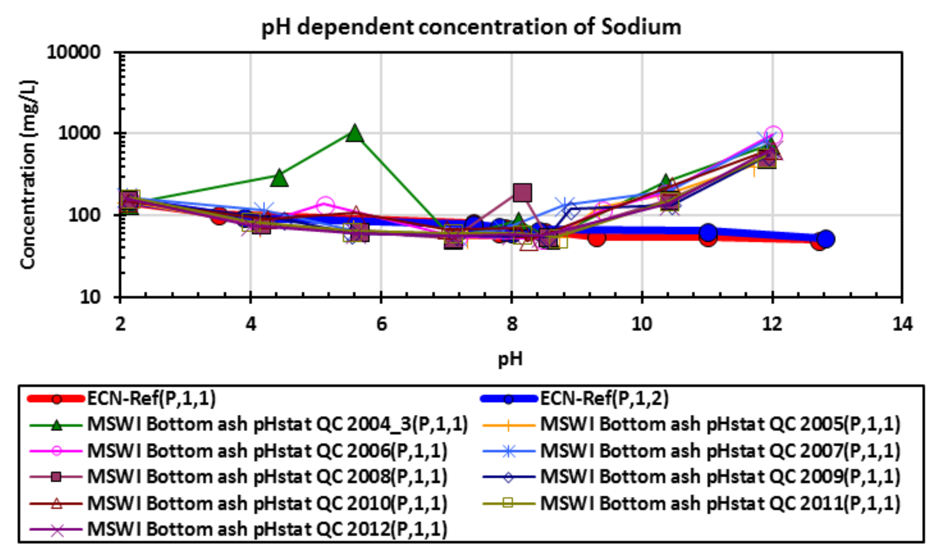
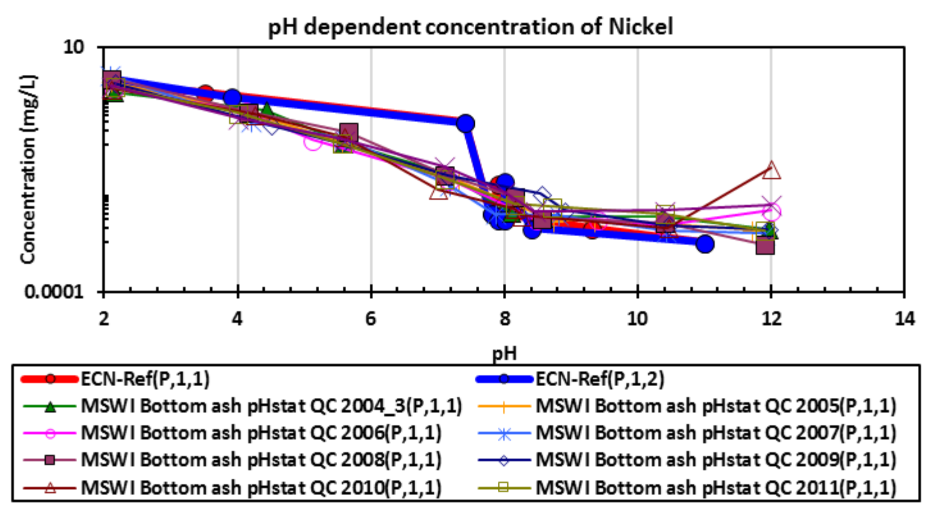
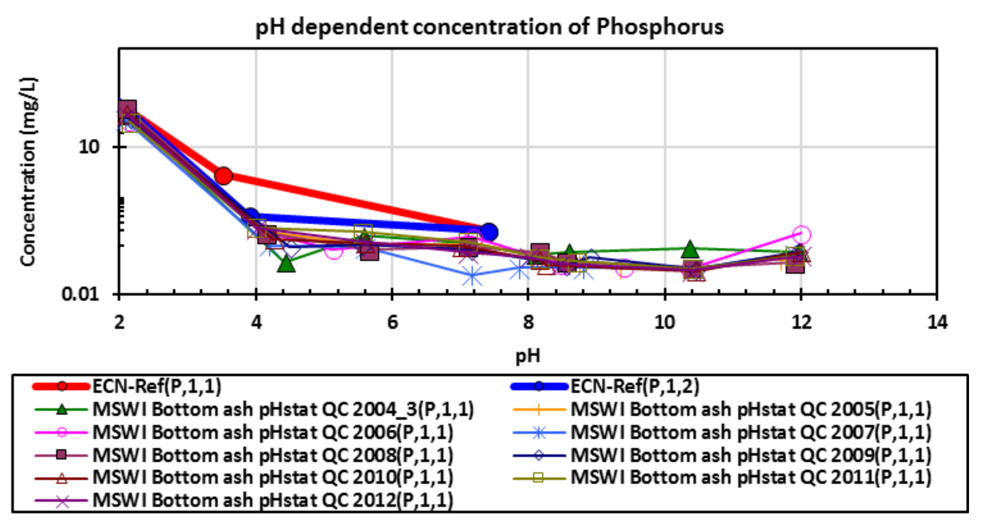
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

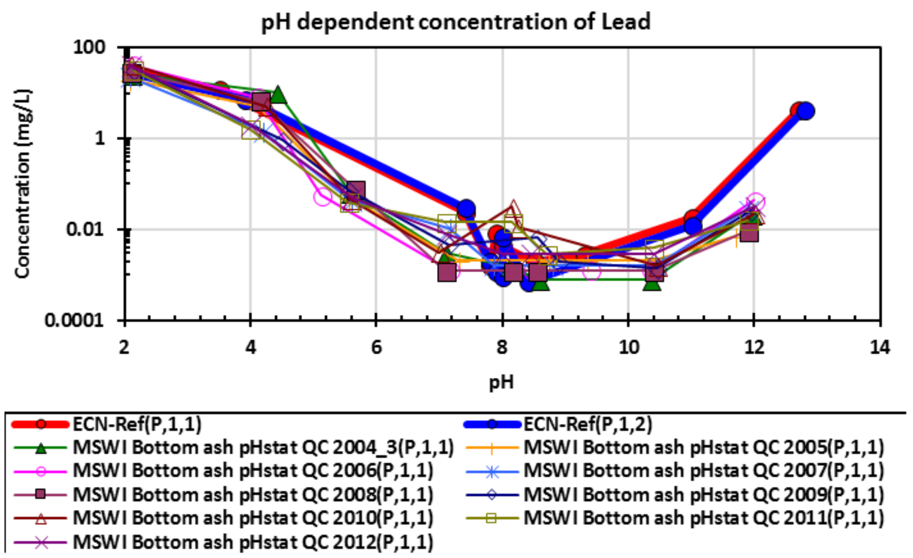

pH dependent concentration of Molybdenum
Concentration (mg/L)
0.01
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

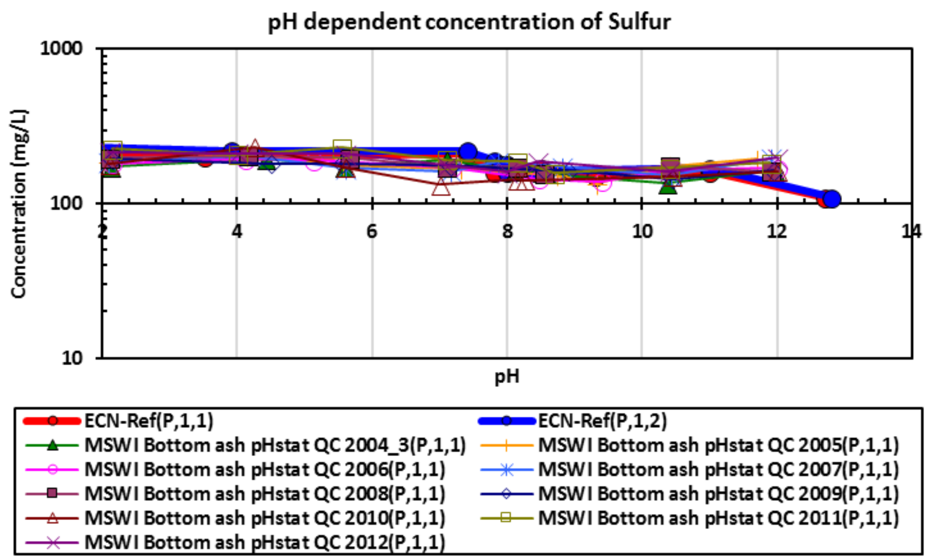

pH dependent concentration of Sodium
Concentration (mg/L)
10000
1000
100
10
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

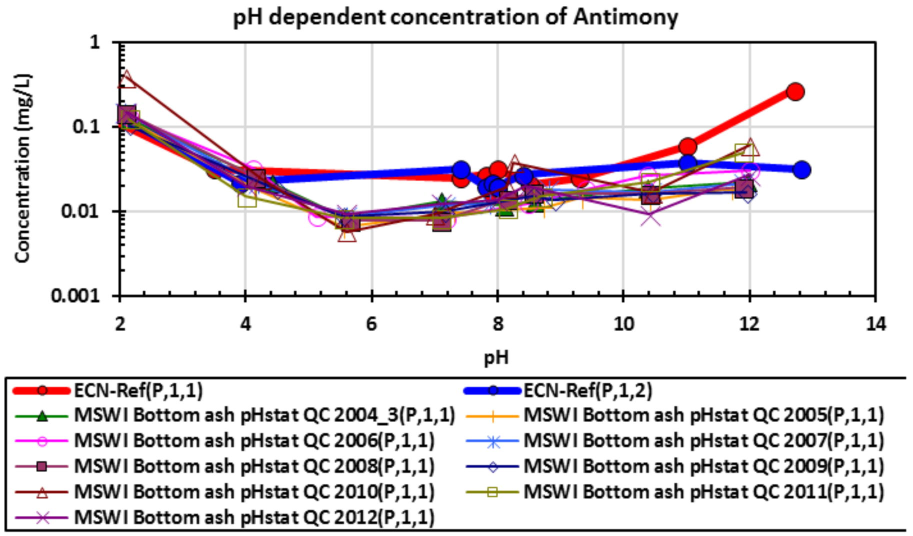

pH dependent concentration of Nickel
Concentration (mg/L)
10
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)

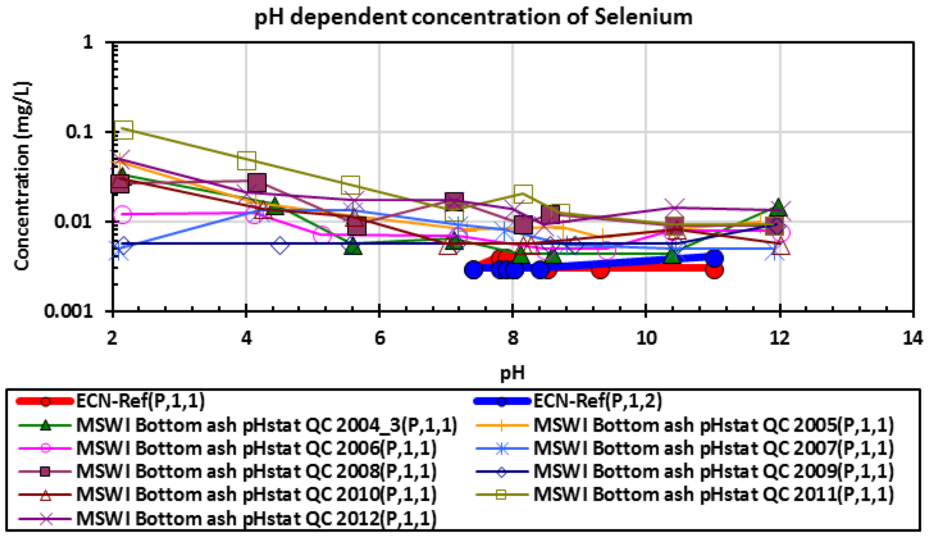

pH dependent concentration of Phosphorus
Concentration (mg/L)
10
0.01
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

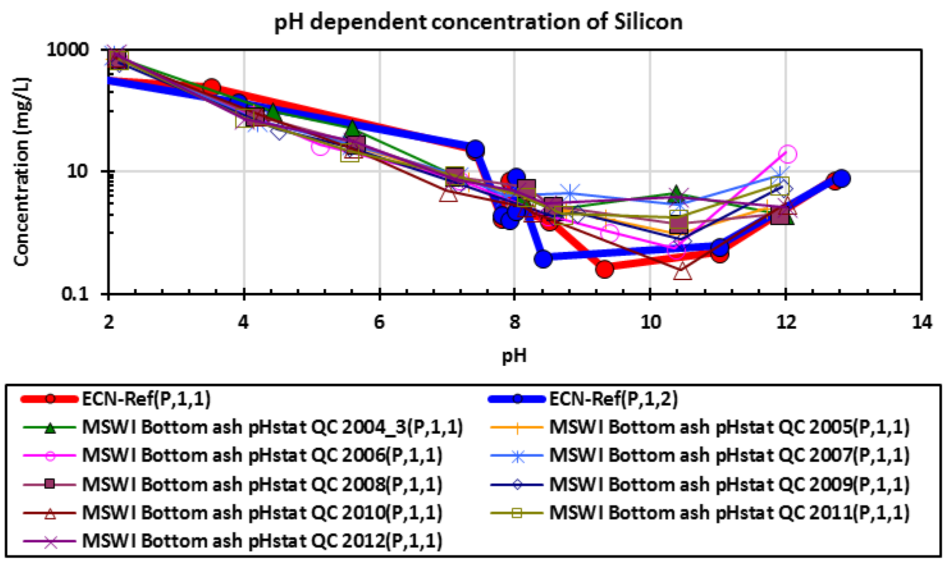
0-1

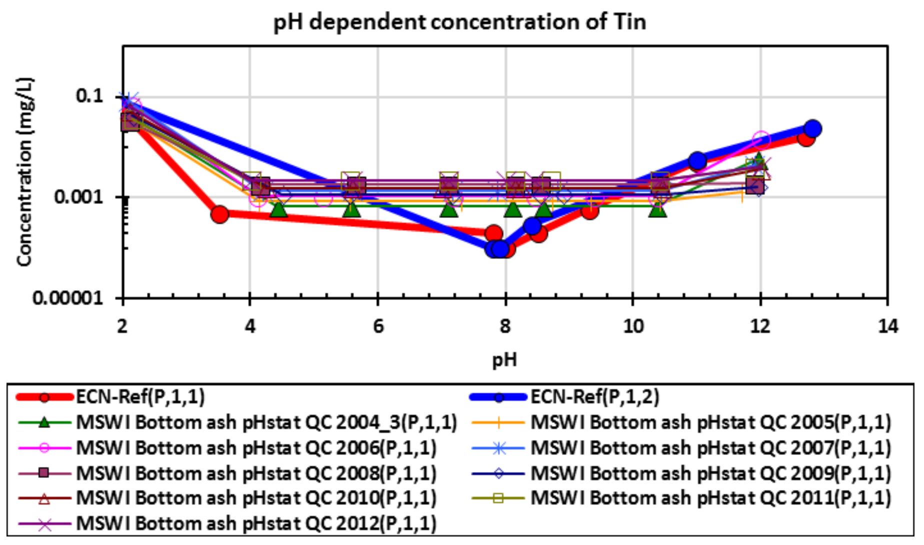

pH dependent concentration of Lead
Concentration (mg/L)
100
1
0.01
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

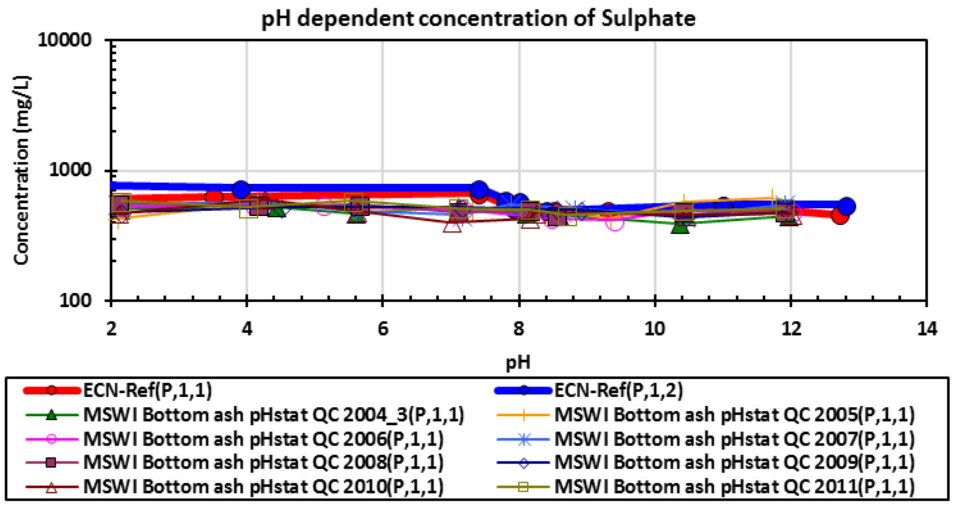

pH dependent concentration of Sulfur
Concentration (mg/L)
1000
100
10
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

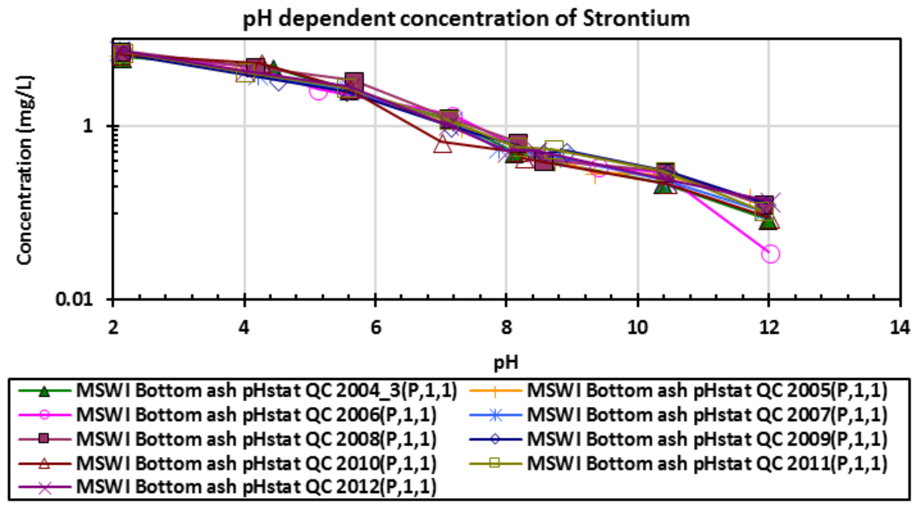

pH dependent concentration of Antimony
Concentration (mg/L)
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

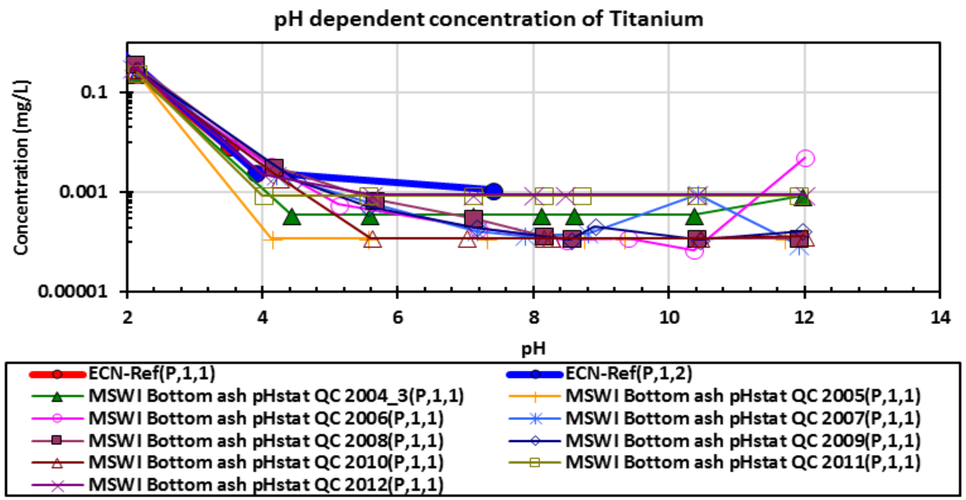

pH dependent concentration of Selenium
Concentration (mg/L)
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

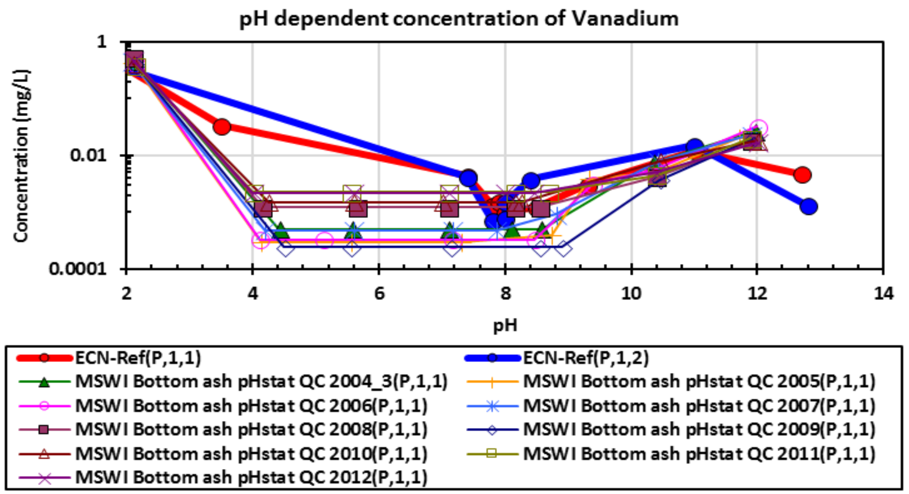

pH dependent concentration of Silicon
Concentration (mg/L)
1000
10
0.1
pH
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

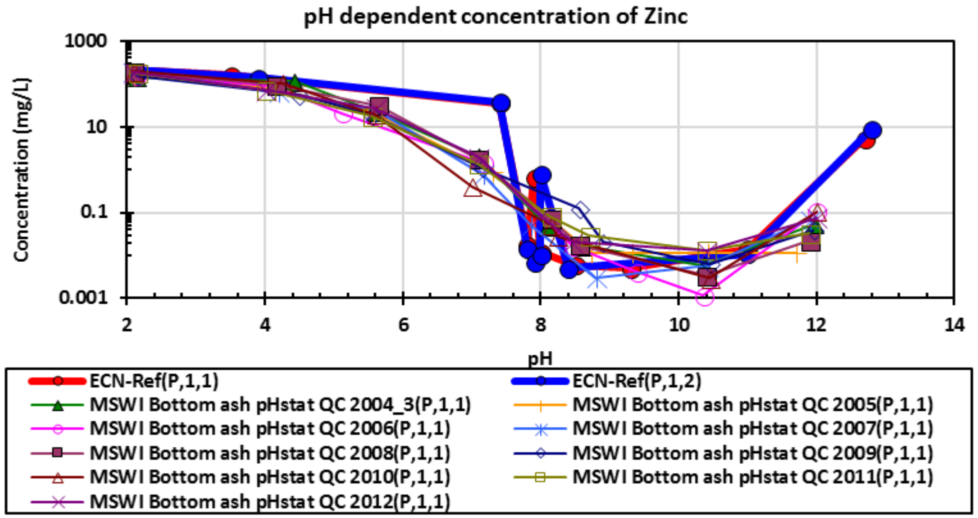

pH dependent concentration of Tin
Concentration (mg/L)
0.1
0.001
0.00001
pH
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
pH
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)


pH dependent concentration of Strontium
Concentration (mg/L)
1
0.01
pH
2
4
6
8
10
12
14
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Titanium
Concentration (mg/L)
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Vanadium
Concentration (mg/L)
1
0.01
0.0001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)


pH dependent concentration of Zinc
Concentration (mg/L)
1000
10
0.1
0.001
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)

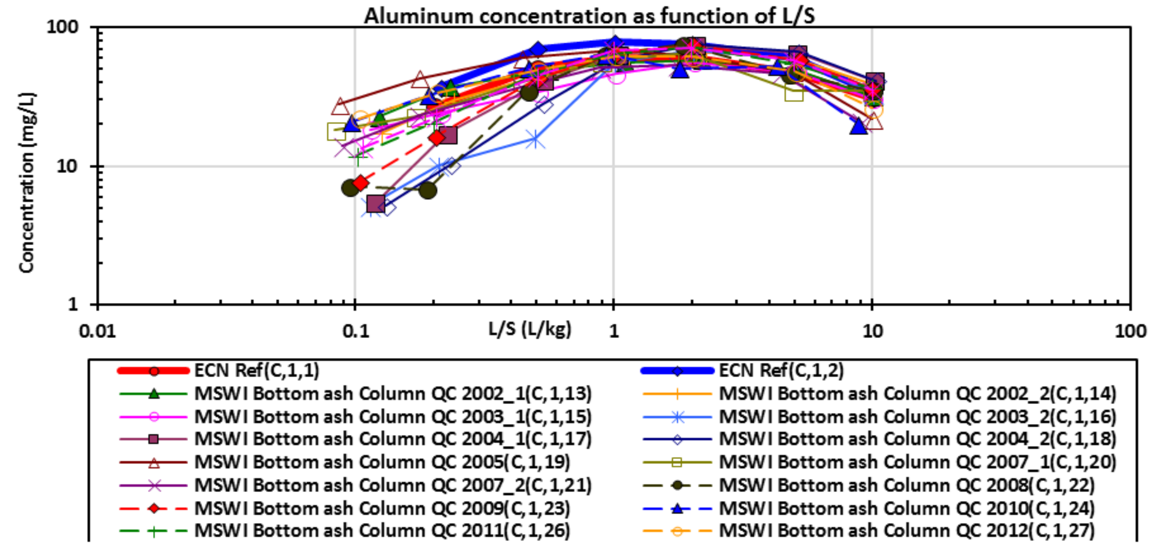
Appendix A1.1: pH dependence LEAF 1313 method performed by ChemCentre in duplicate on ECN reference material.

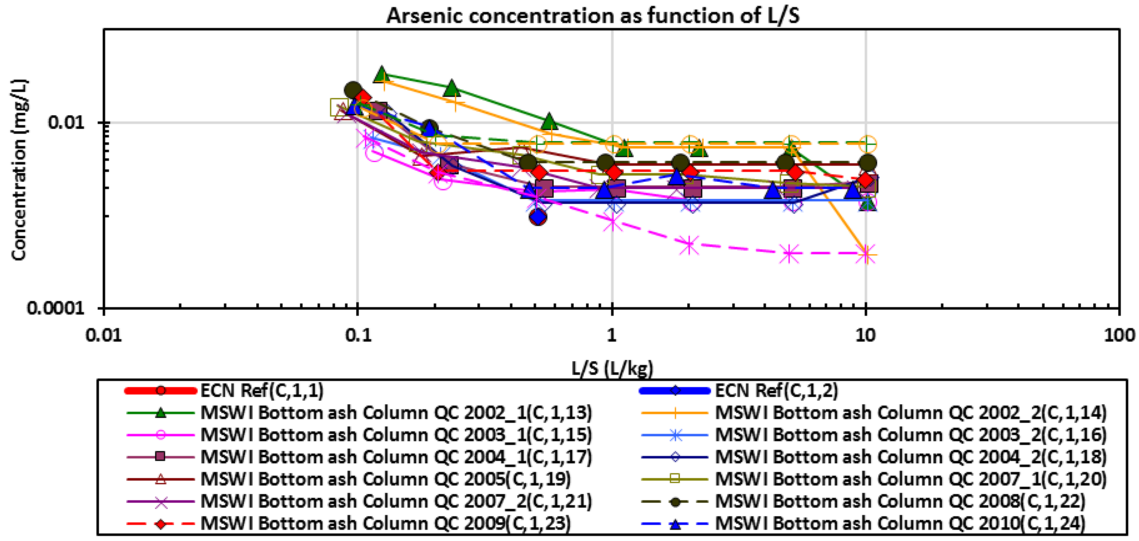
		pH 2	pH 4	pH 5.5	pH 7	pH 8	pH 9	pH 10.5	pH 12	pH 13
pH	Mean	1.75	3.70	7.40	7.95	8.00	8.20	8.85	11.0	12.8
	SE	0.05	0.20	0.00	0.05	0.00	0.30	0.45	0.00	0.05
EC	Mean	3035	1785	907	244	134	125	163	262	2835
	SE	65.0	15.0	0.50	3.50	3.00	1.50	37.0	18.5	255
Eh (mV)	Mean	593	544	408	378	363	367	320	210	122
	SE	0.50	4.00	18.0	9.50	16.0	23.0	39.0	7.50	21.0
DOC (mg/L)	Mean	39.5	13.0	9.10	5.75	5.50	5.20	5.85	12.5	23.0
	SE	3.50	1.00	0.70	0.05	0.00	0.30	0.55	0.50	1.00
Al (mg/L)	Mean	695	103	0.02	0.03	0.23	0.46	11.8	215	185
	SE	25.0	57.5	0.01	0.00	0.01	0.03	6.25	15.0	45.0
As (mg/L)	Mean	0.12	0.012	0.004	0.003	0.002	0.002	0.002	0.003	ND
	SE	0.03	0.006	0.000	0.001	0.000	0.000	0.000	0.001	ND
B (mg/L)	Mean	2.75	1.25	0.64	0.32	0.23	0.21	0.20	0.25	0.15
	SE	0.25	0.15	0.01	0.02	0.01	0.00	0.00	0.05	0.02
Ba (mg/L)	Mean	1.80	0.68	0.34	0.13	0.08	0.08	0.10	0.07	0.08
	SE	0.10	0.14	0.01	0.01	0.00	0.00	0.01	0.00	0.01
Ca (mg/L)	Mean	3800	2835	1500	453	206	183	142	46.5	10.0
	SE	120	55.0	40.0	2.00	14.0	1.50	23.0	4.10	0.10
Cd (mg/L)	Mean	0.10	0.09	0.01	0.001	ND	ND	ND	ND	ND
	SE	0.02	0.02	0.00	0.000	ND	ND	ND	ND	ND
Co (mg/L)	Mean	0.24	0.12	0.03	0.0020	0.0006	0.0006	0.0004	0.0002	ND
	SE	0.01	0.03	0.00	0.0002	0.0001	0.0001	0.0001	0.0000	ND
Cr (mg/L)	Mean	1.10	0.14	0.0012	0.0032	0.01	0.06	0.00	0.00	ND
	SE	0.10	0.08	0.0000	0.0012	0.00	0.05	0.00	0.00	ND
Cu (mg/L)	Mean	47.5	29.5	0.57	0.14	0.07	0.08	0.06	0.27	1.35
	SE	8.50	8.50	0.03	0.01	0.00	0.00	0.00	0.05	0.15
Fe (mg/L)	Mean	480	48.5	0.01	ND	ND	ND	ND	0.01	0.01
	SE	10.0	20.5	ND	ND	ND	ND	ND	0.00	0.00
K (mg/L)	Mean	126	737	458	19.6	16.6	23.9	206	685	5240
	SE	4.00	354	124	0.00	0.30	2.85	81.0	66.5	480
Mg (mg/L)	Mean	230	124	57.9	18.4	9.30	7.65	3.10	ND	ND
	SE	5.00	5.00	1.60	0.15	0.50	0.15	1.80	ND	ND
Mn (mg/L)	Mean	41.0	22.5	7.75	0.56	0.014	0.005	0.001	0.000	0.003
	SE	4.00	0.50	0.15	0.07	0.001	0.001	0.001	0.000	0.001
Mo (mg/L)	Mean	0.02	ND	0.02	0.03	0.03	0.05	0.03	0.04	0.01
	SE	0.00	ND	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Na (mg/L)	Mean	163	98.7	80.2	69.4	64.9	64.5	60.9	59.7	51.6
	SE	1.00	4.30	1.40	2.20	3.15	0.30	6.35	4.65	1.55
Ni (mg/L)	Mean	2.25	1.08	0.30	0.017	0.004	0.003	0.002	0.001	ND
	SE	0.35	0.12	0.01	0.001	0.001	0.000	0.000	0.000	ND
P (mg/L)	Mean	140	1.60	0.20	ND	ND	ND	ND	ND	ND
	SE	0.00	1.20	0.00	ND	ND	ND	ND	ND	ND
Pb (mg/L)	Mean	37.0	9.65	0.03	0.008	0.003	0.002	0.002	0.02	4.30
	SE	4.00	2.35	0.00	0.001	0.002	0.000	0.001	0.00	0.10
S (mg/L)	Mean	215	210	215	180	170	175	155	165	110
	SE	15.0	10.0	5.00	0.00	10.0	5.00	5.00	5.00	0.00
Sb (mg/L)	Mean	0.15	0.03	0.03	0.02	0.03	0.02	0.03	0.05	0.15
	SE	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.12
Se (mg/L)	Mean	ND	ND	0.003	0.004	0.003	0.003	0.003	0.004	ND
	SE	ND	ND	0.000	0.001	0.000	0.000	0.000	0.001	ND
U (mg/L)	Mean	0.0205	0.0012	0.0018	0.0006	0.0002	0.0001	ND	ND	ND
	SE	0.0005	0.0004	0.0001	0.0000	0.0000	0.0000	ND	ND	ND
V (mg/L)	Mean	0.46	0.03	0.0043	0.0015	0.0009	0.0012	0.0034	0.014	0.003
	SE	0.08	ND	0.0001	0.0000	0.0001	ND	0.0004	0.002	0.002
Zn (mg/L)	Mean	220	150	36.5	0.74	0.01	0.01	0.00	0.01	7.10
	SE	0.00	10.0	1.50	0.07	0.00	0.00	0.00	0.00	1.80
F (mg/L)	Mean	14.0	ND	ND	ND	ND	ND	ND	ND	ND
	SE	1.00	ND	ND	ND	ND	ND	ND	ND	ND
SO4 (mg/L)	Mean	691	681	700	567	548	505	493	540	502
	SE	83.5	50.0	29.0	8.00	21.0	8.50	1.00	3.00	41.0

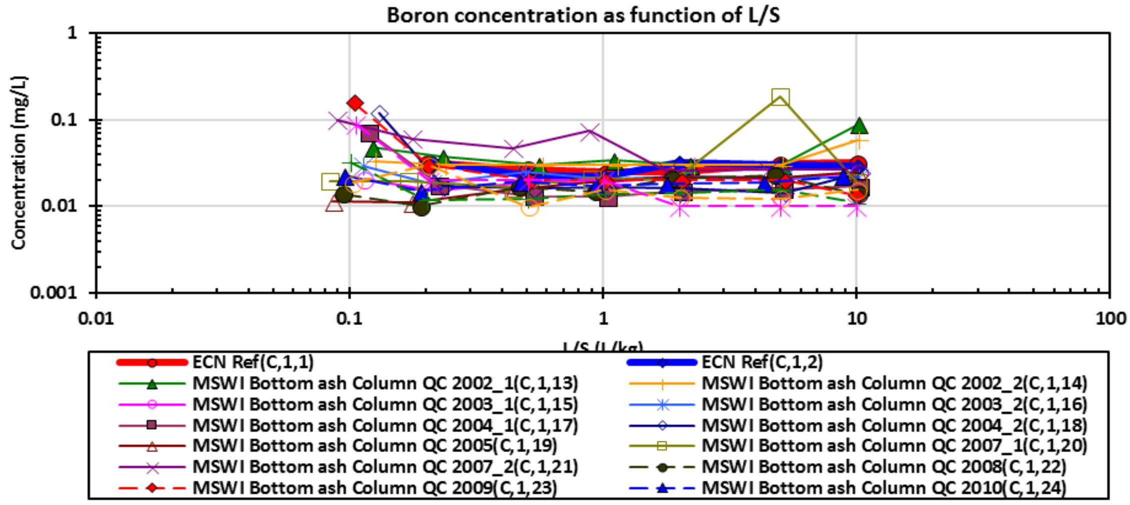
Appendix A1.2: Inter-lab LEAF 1313 method comparison between ECN and ChemCentre for Bottom Ash Reference Material.

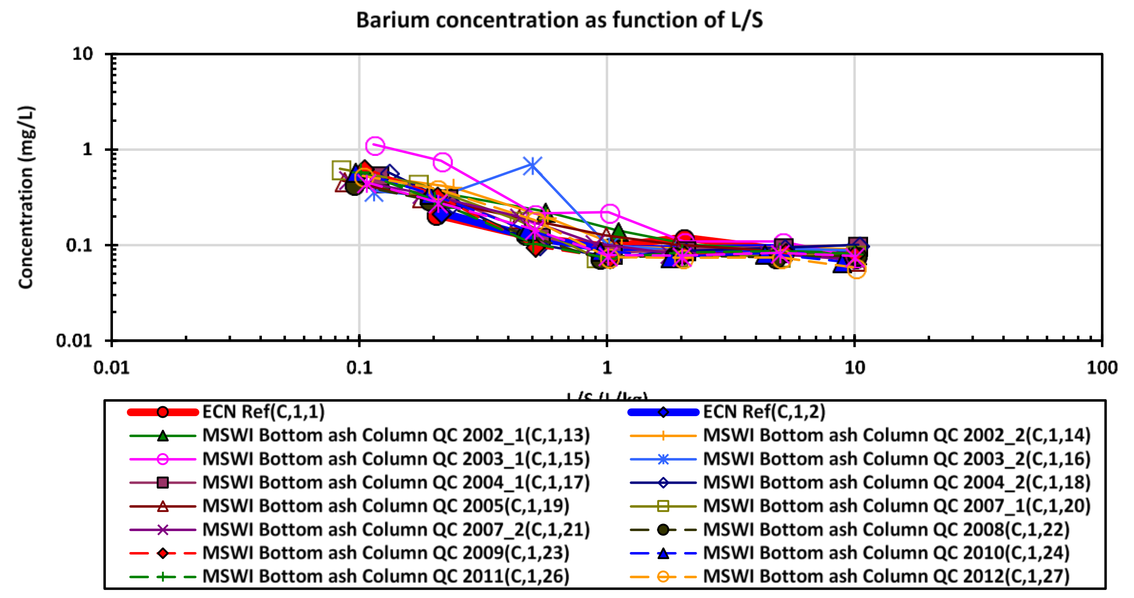
Extractions		8	7	6	5	4	3	2	1
pH	ECN	2.12	4.19	5.53	7.13	8.24	8.77	10.4	11.9
	ChemCentre	1.75	3.70	7.40	7.95	8.20	8.85	11.0	12.8
Al (mg/L)	ECN	540	18.5	0.14	0.03	0.12	0.50	12.4	121
	ChemCentre	695	103	0.02	0.03	0.46	11.8	215	185
As (mg/L)	ECN	0.06	0.005	0.004	0.004	0.004	0.004	0.004	0.01
	ChemCentre	0.12	0.01	0.004	0.003	0.002	0.002	0.003	ND
B (mg/L)	ECN	2.30	0.91	1.05	0.31	0.30	0.36	0.81	2.04
	ChemCentre	2.75	1.25	0.64	0.32	0.21	0.20	0.25	0.15
Ba (mg/L)	ECN	1.29	0.38	0.32	0.17	0.09	0.08	0.05	0.03
	ChemCentre	1.80	0.68	0.34	0.13	0.08	0.10	0.07	0.08
Ca (mg/L)	ECN	3206	2203	1372	496	229	173	107	29.9
	ChemCentre	3800	2835	1500	453	183	142	46.5	10.0
Cd(mg/L)	ECN	0.10	0.06	0.02	0.002	0.0004	0.0002	0.0003	0.0002
	ChemCentre	0.10	0.09	0.01	0.001	ND	ND	ND	ND
Cl (mg/L)	ECN	95.7	81.7	88.0	100	90.9	91.7	79.5	77.6
	ChemCentre	82.0	93.0	82.5	65.5	73.0	67.0	59.0	66.5
Co (mg/L)	ECN	0.21	0.06	0.02	0.002	0.001	0.0004	0.0005	0.0005
	ChemCentre	0.24	0.12	0.03	0.002	0.001	0.0004	0.0002	ND
Cr (mg/L)	ECN	0.80	0.017	0.0031	0.010	0.012	0.0099	0.0103	0.01
	ChemCentre	1.10	0.137	0.0012	0.003	0.058	0.0025	0.0026	ND
Cu (mg/L)	ECN	50.0	8.36	0.58	0.13	0.10	0.08	0.10	0.34
	ChemCentre	47.5	29.5	0.57	0.14	0.08	0.06	0.27	1.35
Fe (mg/L)	ECN	346	3.66	0.018	0.01	0.02	0.01	0.01	0.04
	ChemCentre	480	48.5	0.008	ND	ND	ND	0.013	0.011
K (mg/L)	ECN	130	49.6	45.5	47.5	34.4	39.0	32.9	49.0
	ChemCentre	126	737	458	19.6	23.9	206	685	5240
Mg (mg/L)	ECN	221	71.0	34.1	15.0	9.72	7.46	1.56	0.02
	ChemCentre	230	124	57.9	18.4	7.65	3.10	ND	ND
Mn (mg/L)	ECN	27.3	11.4	3.47	0.47	0.040	0.010	0.000	0.002
	ChemCentre	41.0	22.5	7.75	0.56	0.005	0.001	0.000	0.003
Mo (mg/L)	ECN	0.01	0.00	0.01	0.02	0.02	0.03	0.03	0.03
	ChemCentre	0.02	ND	0.02	0.025	0.05	0.03	0.04	0.015
Na (mg/L)	ECN	154	110	187	56.9	78.2	84.4	183	646
	ChemCentre	163	98.7	80.2	69.4	64.5	60.9	59.7	51.6
Ni (mg/L)	ECN	1.79	0.42	0.13	0.02	0.006	0.004	0.003	0.01
	ChemCentre	2.25	1.08	0.30	0.02	0.003	0.002	0.001	ND
P (mg/L)	ECN	44.0	0.15	0.12	0.10	0.05	0.05	0.04	0.08
	ChemCentre	140	1.60	0.20	ND	ND	ND	ND	ND
Pb (mg/L)	ECN	31.6	4.58	0.06	0.005	0.007	0.003	0.002	0.02
	ChemCentre	37.0	9.65	0.03	0.008	0.002	0.002	0.015	4.30
S (mg/L)	ECN	194	204	189	172	164	157	159	177
	ChemCentre	215	210	215	180	175	155	165	110
SO4 (mg/L)	ECN	513	551	519	489	482	462	471	505
	ChemCentre	691	681	700	567	505	493	540	502
Zn (mg/L)	ECN	172	82.1	22.7	1.29	0.060	0.017	0.007	0.06
	ChemCentre	220	150	36.5	0.74	0.007	0.004	0.013	7.10

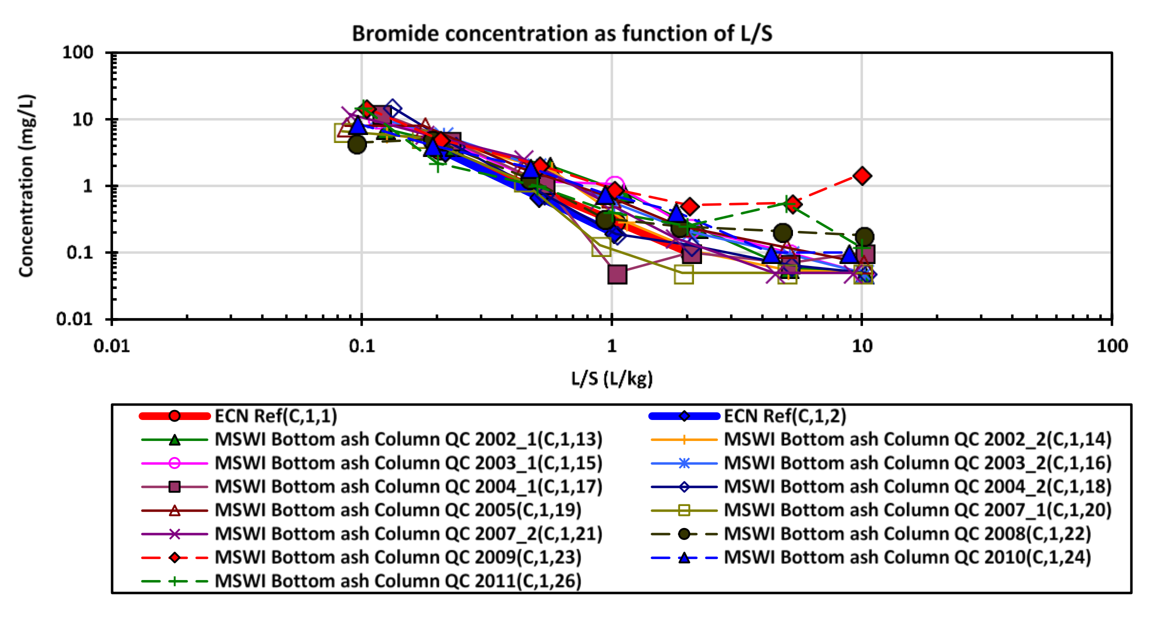
Appendix A2: Graphical Presentation of Analytical Data for Percolation 1314 leaching results for ECN reference material performed by ECN and ChemCentre.

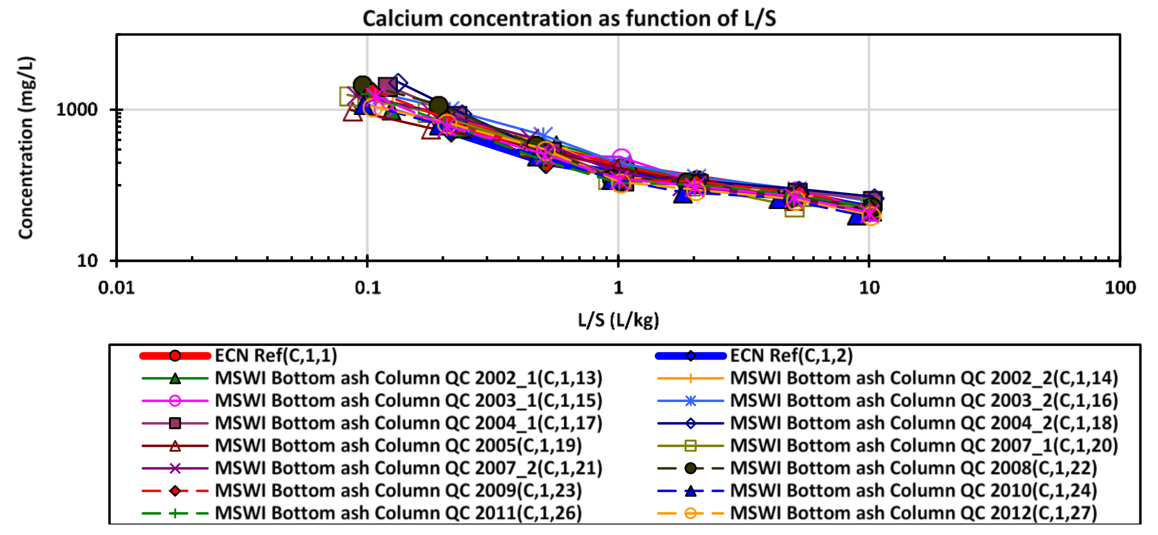

Aluminum concentration as function of L/S
Concentration (mg/L)
100
10
1
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)

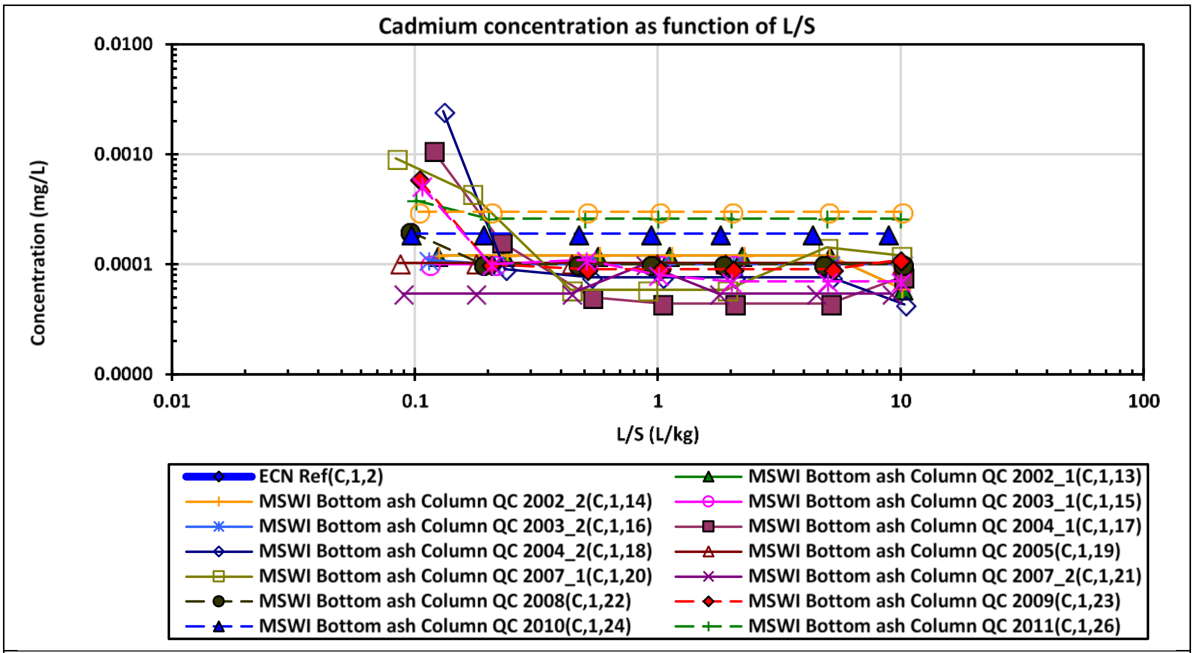

Arsenic concentration as function of L/S
Concentration (mg/L)
0.01
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)

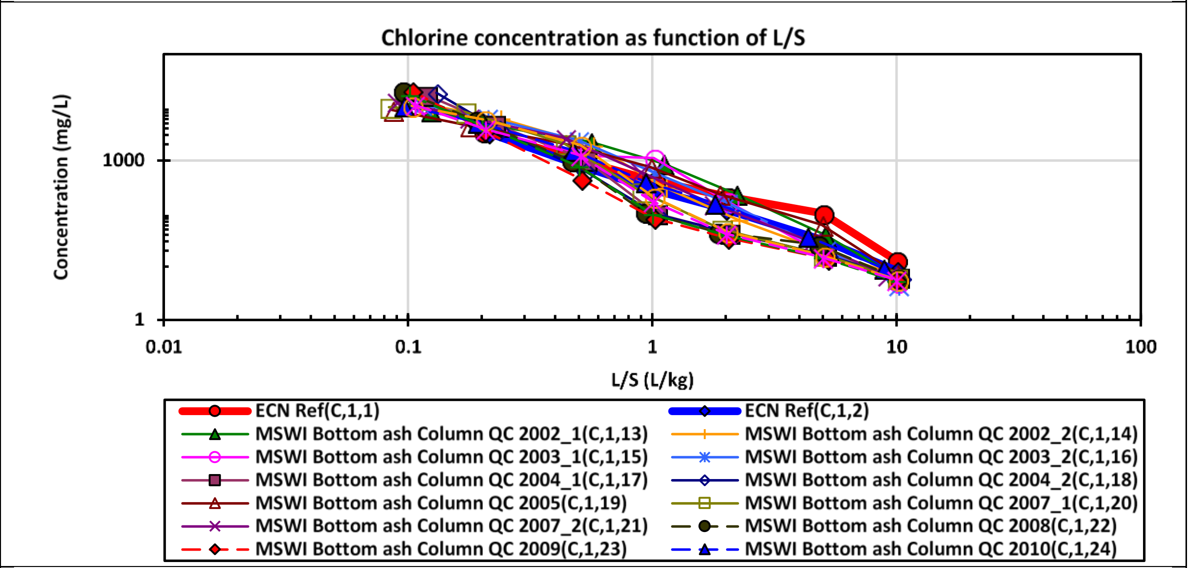

Boron concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)

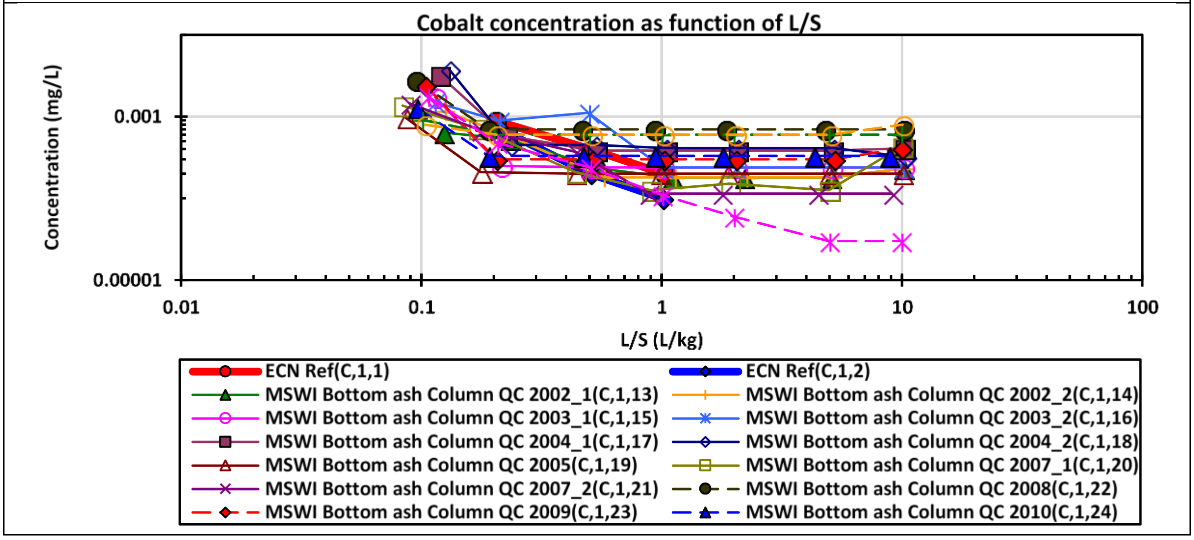

Barium concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.01
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)

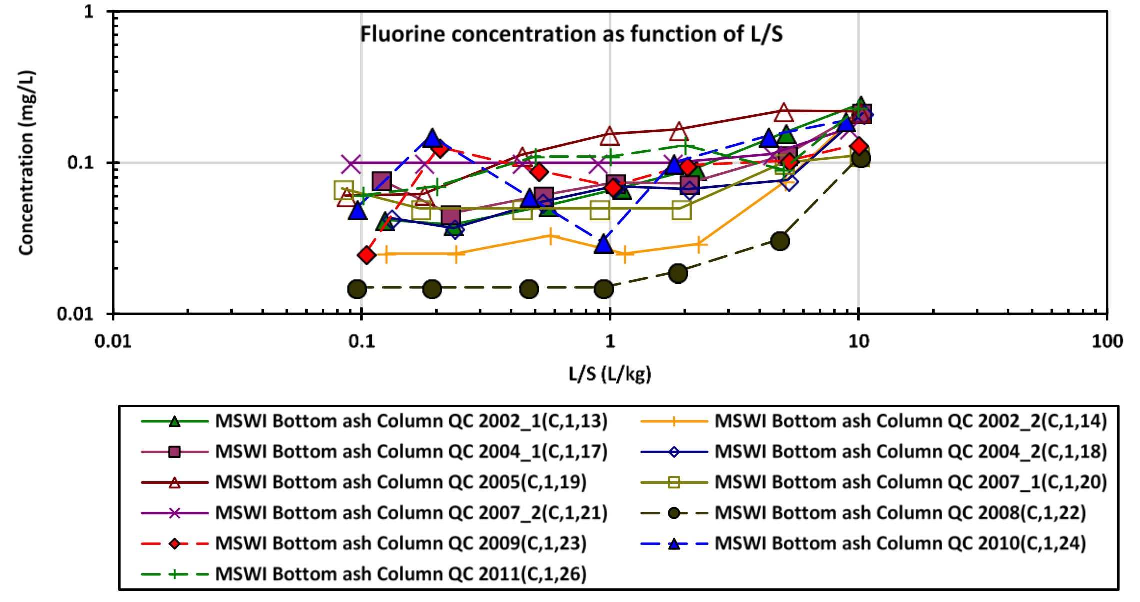

Bromide concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)

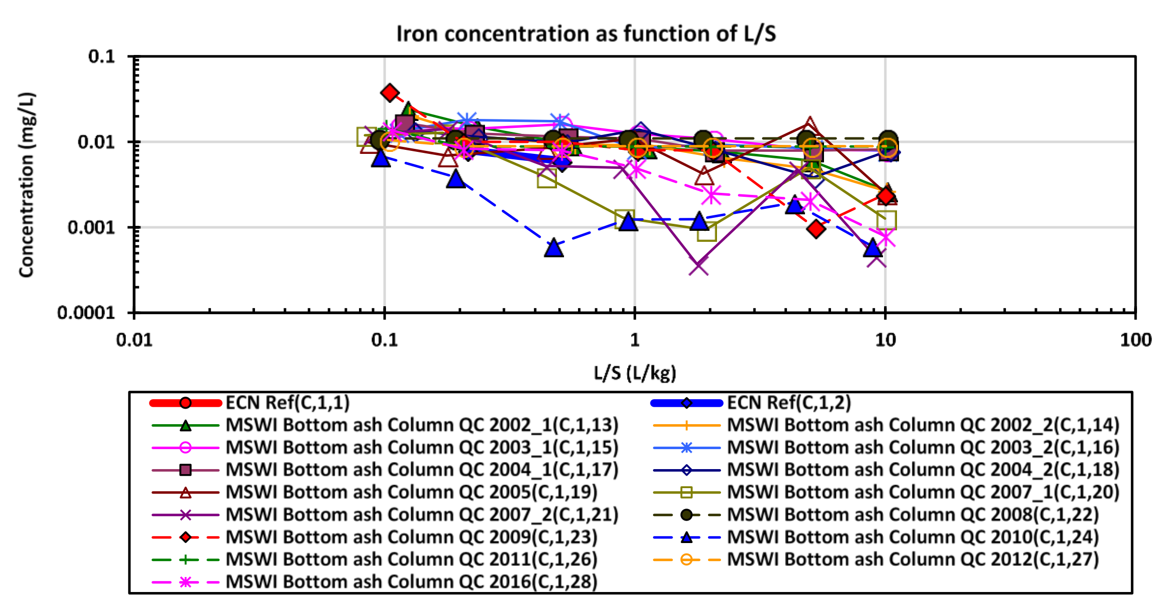

Calcium concentration as function of L/S
Concentration (mg/L)
1000
10
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)

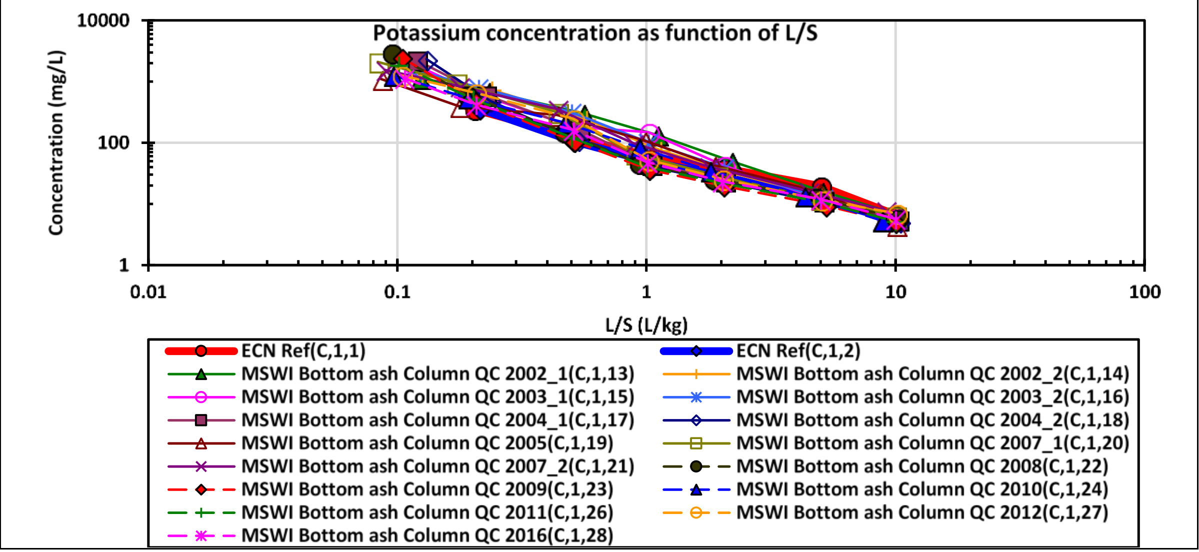

Cadmium concentration as function of L/S
Concentration (mg/L)
0.0100
0.0010
0.0001
0.0000
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)

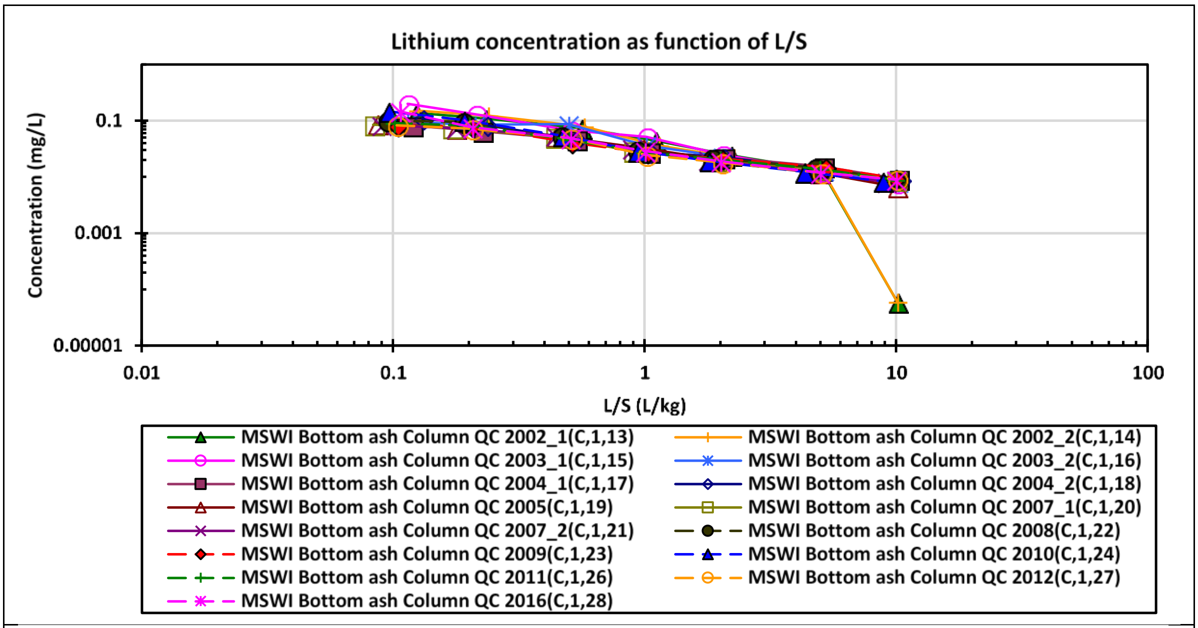

Chlorine concentration as function of L/S
Concentration (mg/L)
1000
1
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)

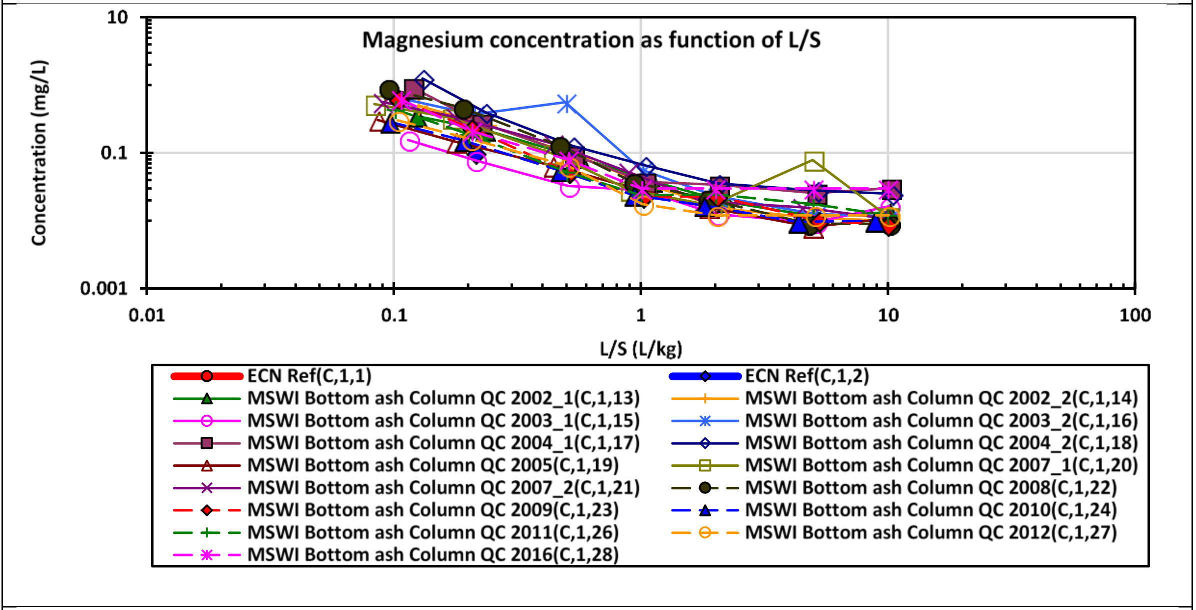

Cobalt concentration as function of L/S
Concentration (mg/L)
0.001
0.00001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)

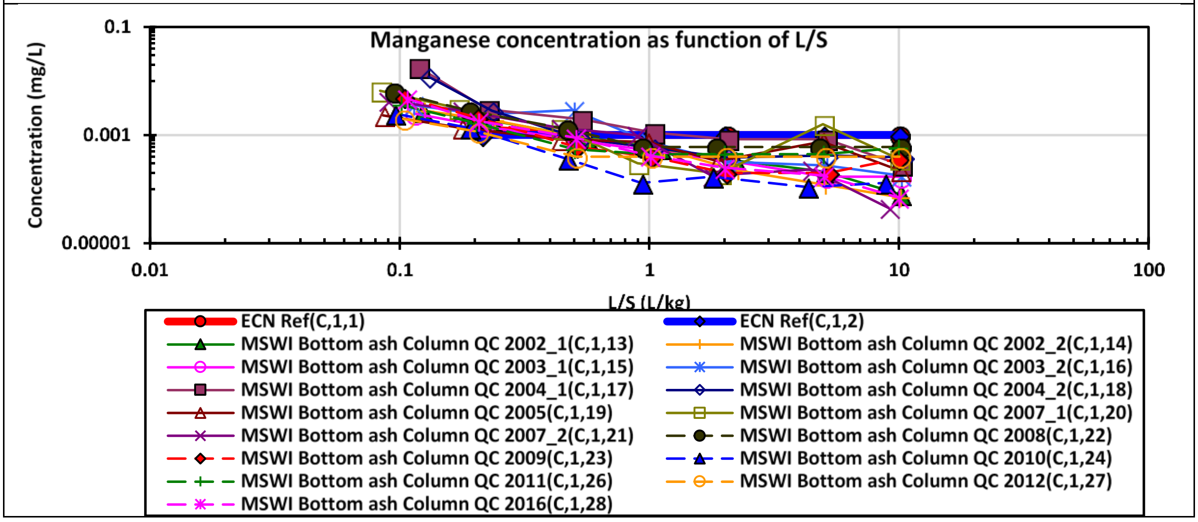

Fluorine concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.01
0.1
1
10
100
L/S (L/kg)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)

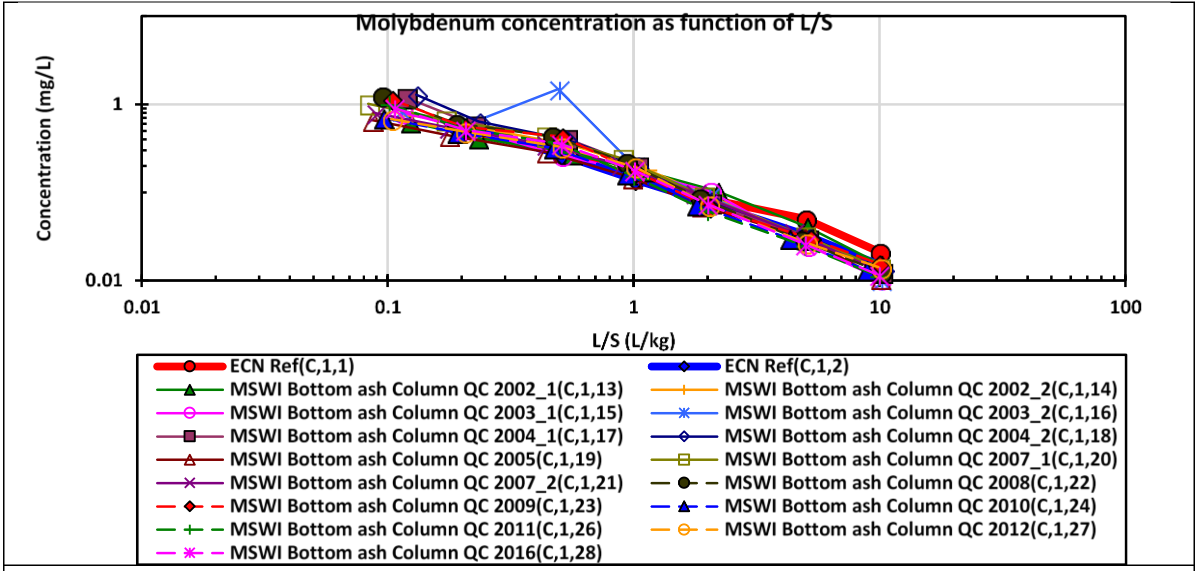

Iron concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

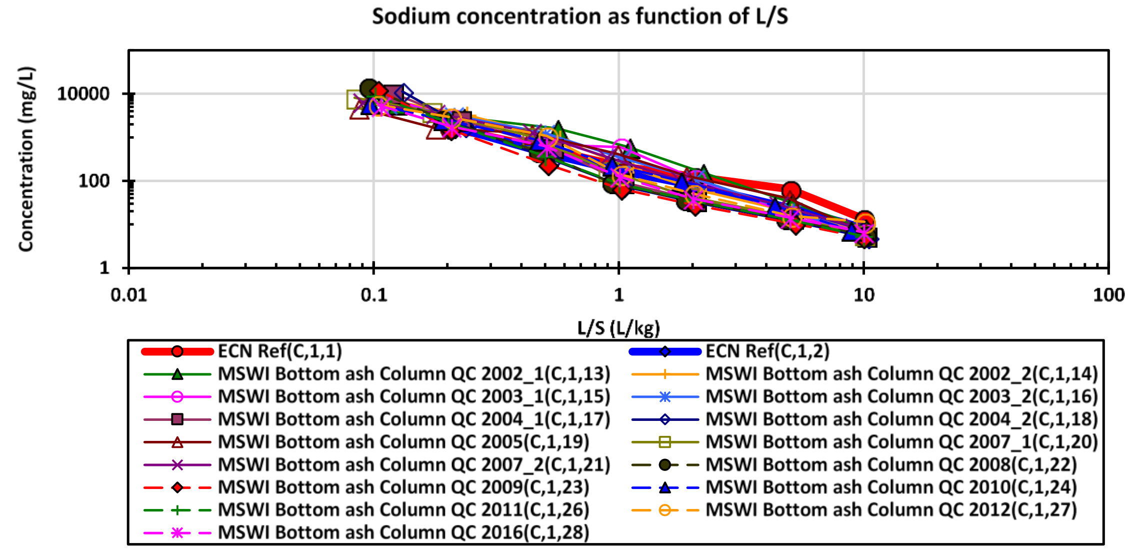

Potassium concentration as function of L/S
Concentration (mg/L)
10000
100
1
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

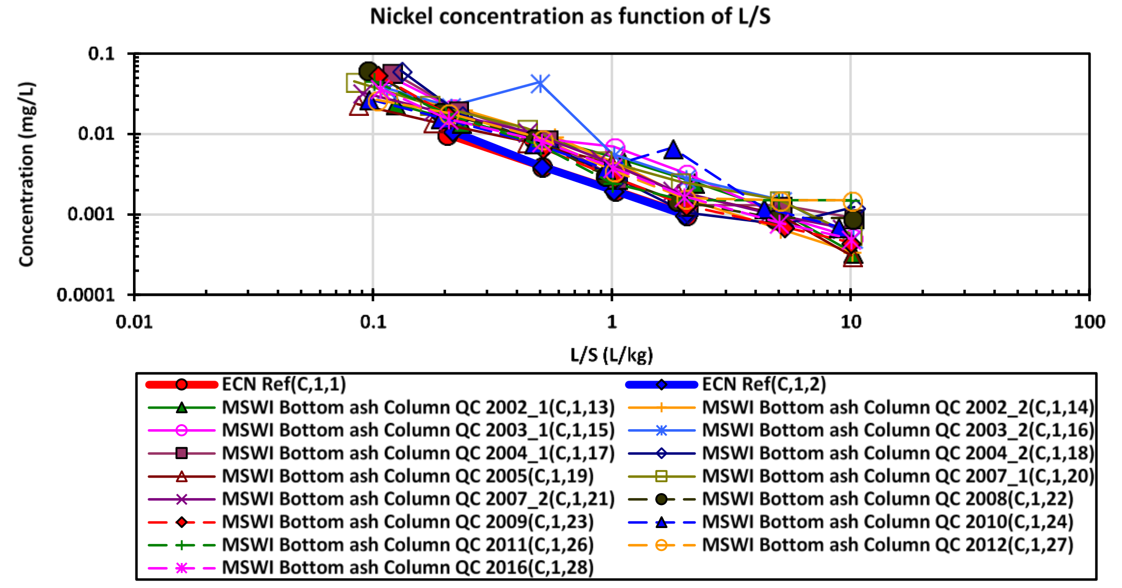

Lithium concentration as function of L/S
Concentration (mg/L)
0.1
0.001
0.00001
0.01
0.1
1
10
100
L/S (L/kg)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

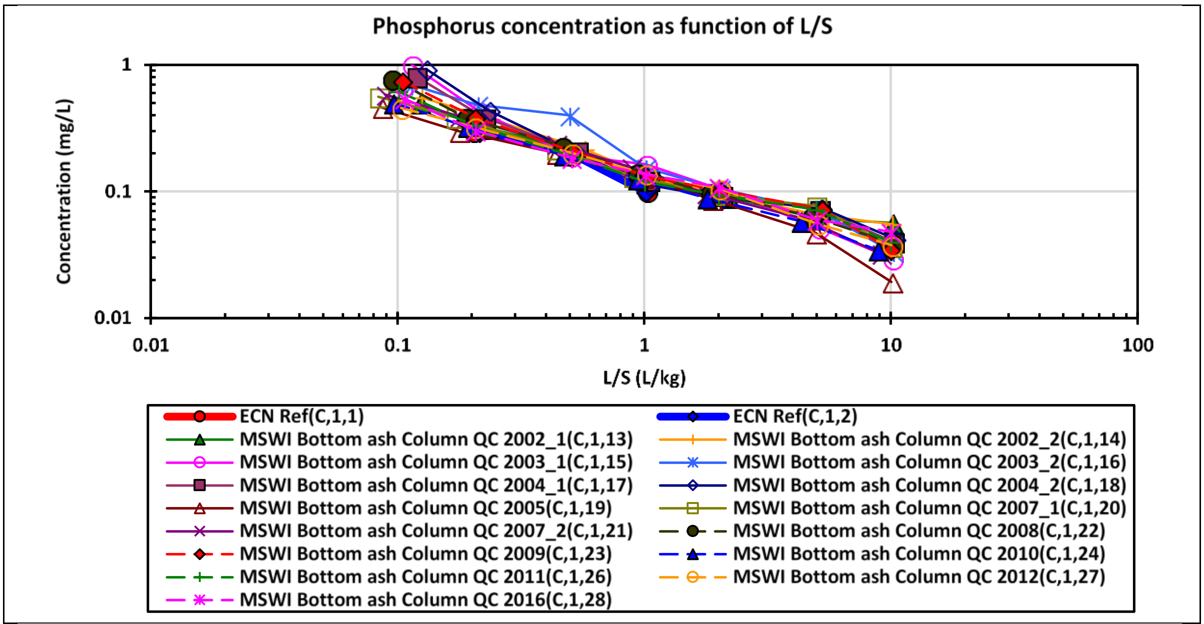

Magnesium concentration as function of L/S
Concentration (mg/L)
10
0.1
0.001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

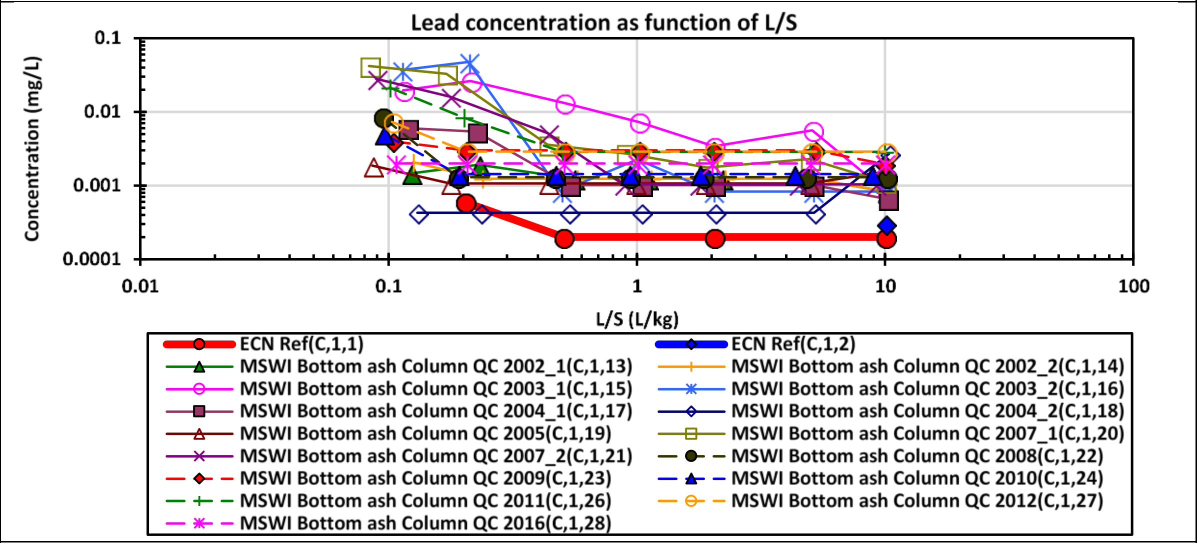

Manganese concentration as function of L/S
Concentration (mg/L)
0.1
0.001
0.00001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

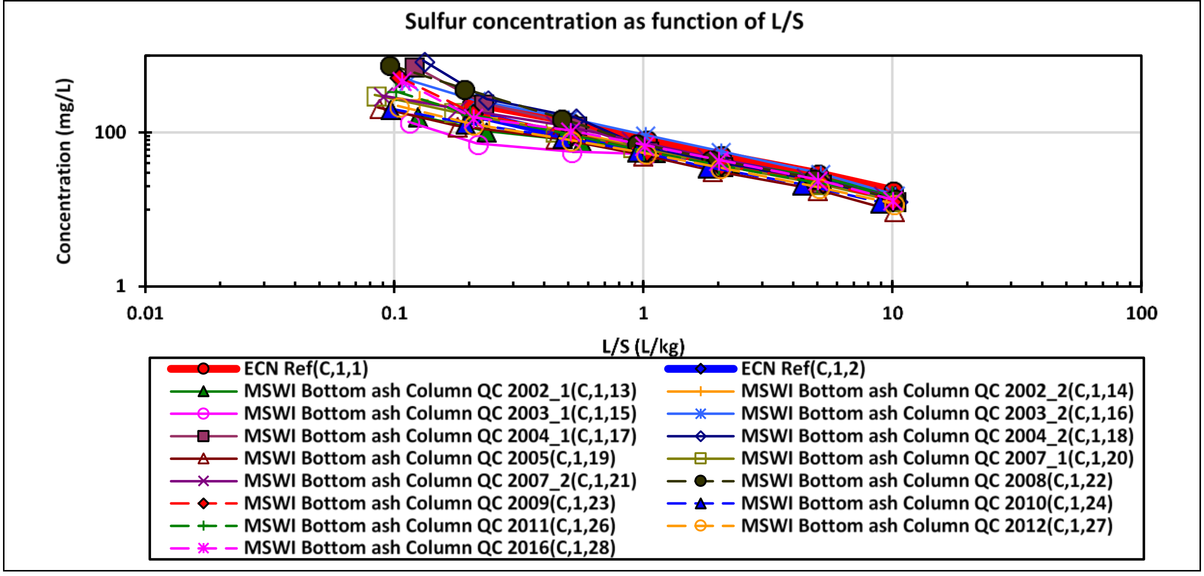

Molybdenum concentration as function of L/S
Concentration (mg/L)
1
0.01
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

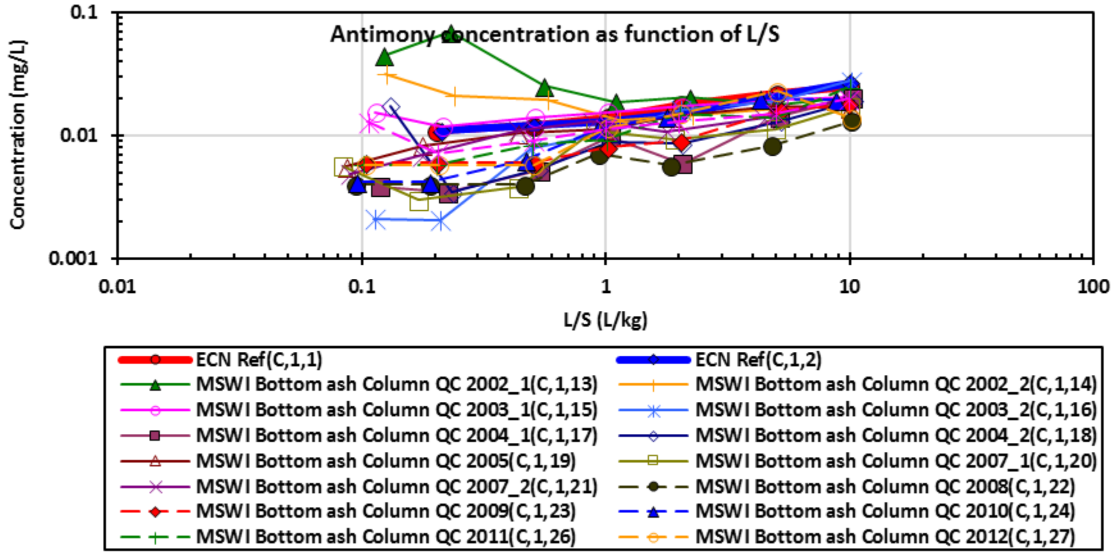

Sodium concentration as function of L/S
Concentration (mg/L)
10000
100
1
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

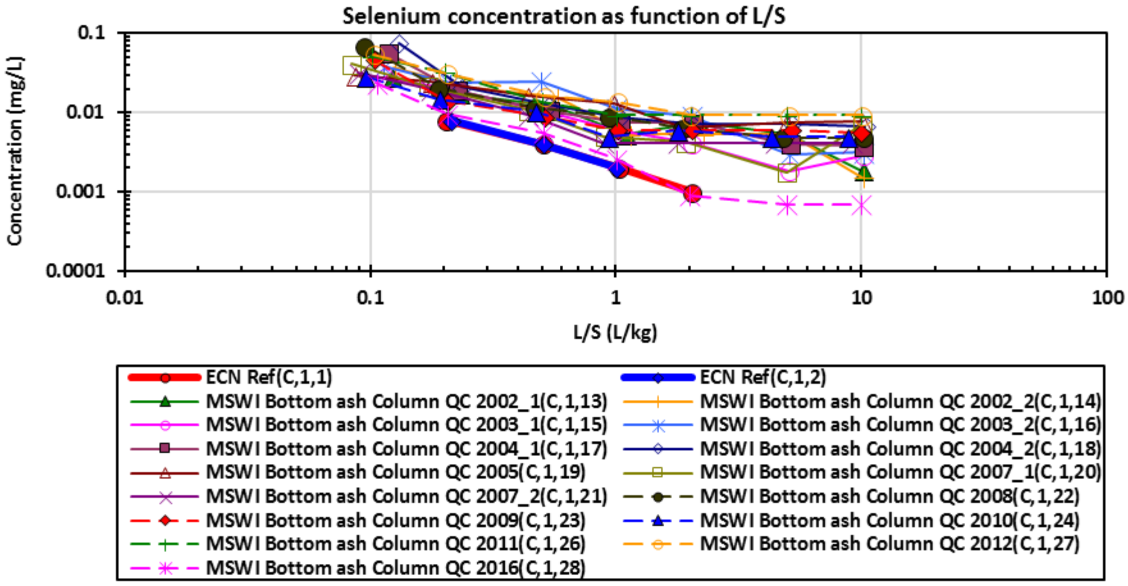

Nickel concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

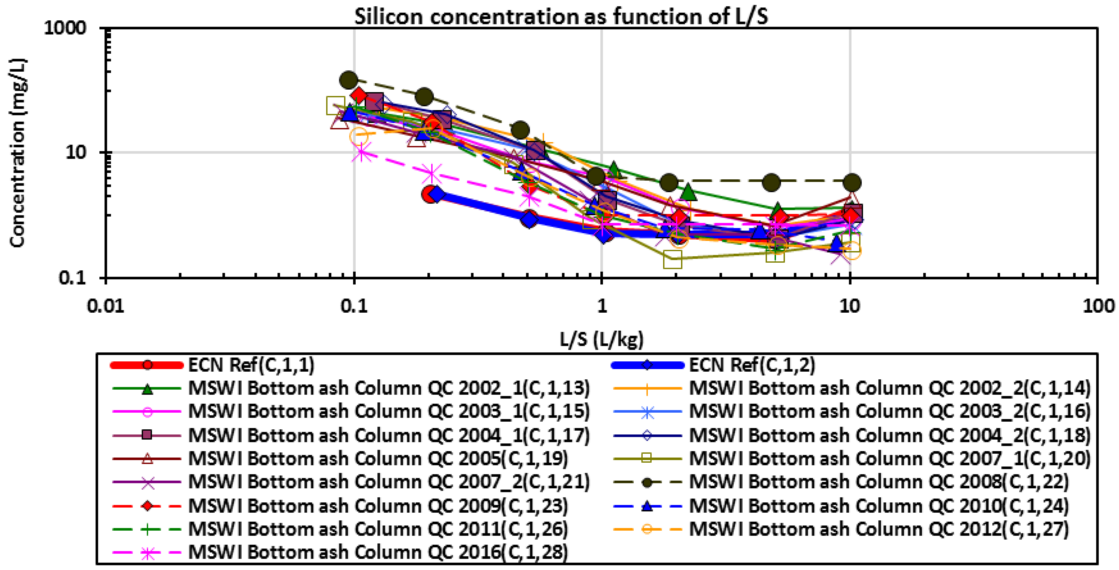

Phosphorus concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

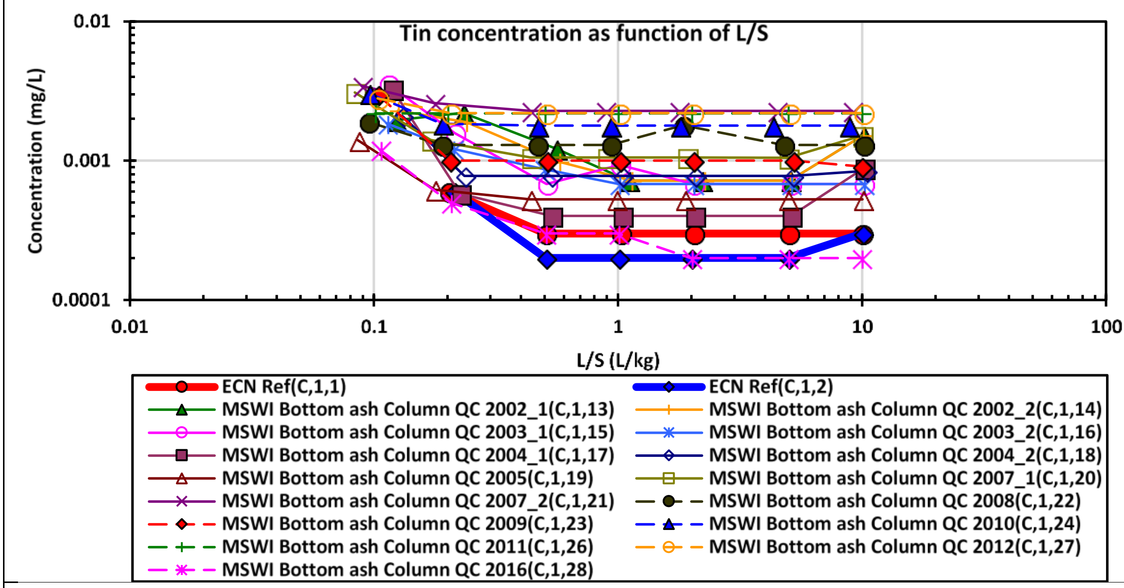

Lead concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

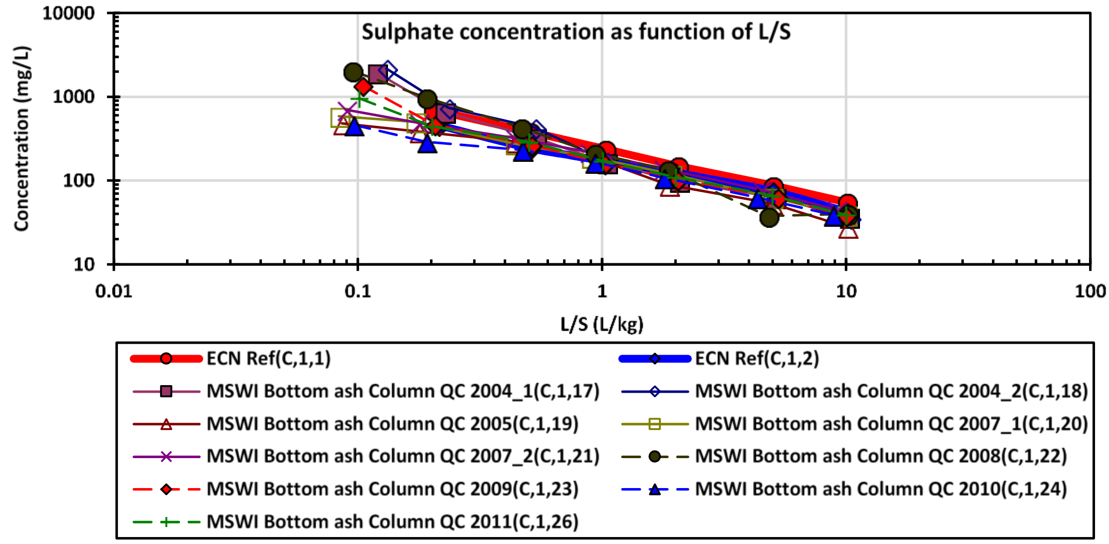

Sulfur concentration as function of L/S
Concentration (mg/L)
100
1
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

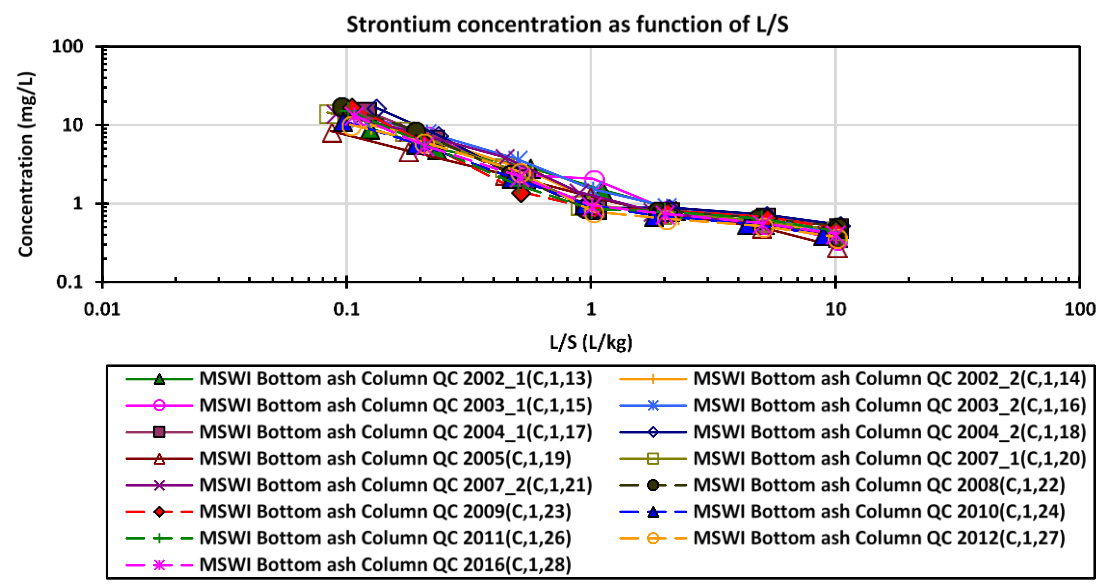

Antimony concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)

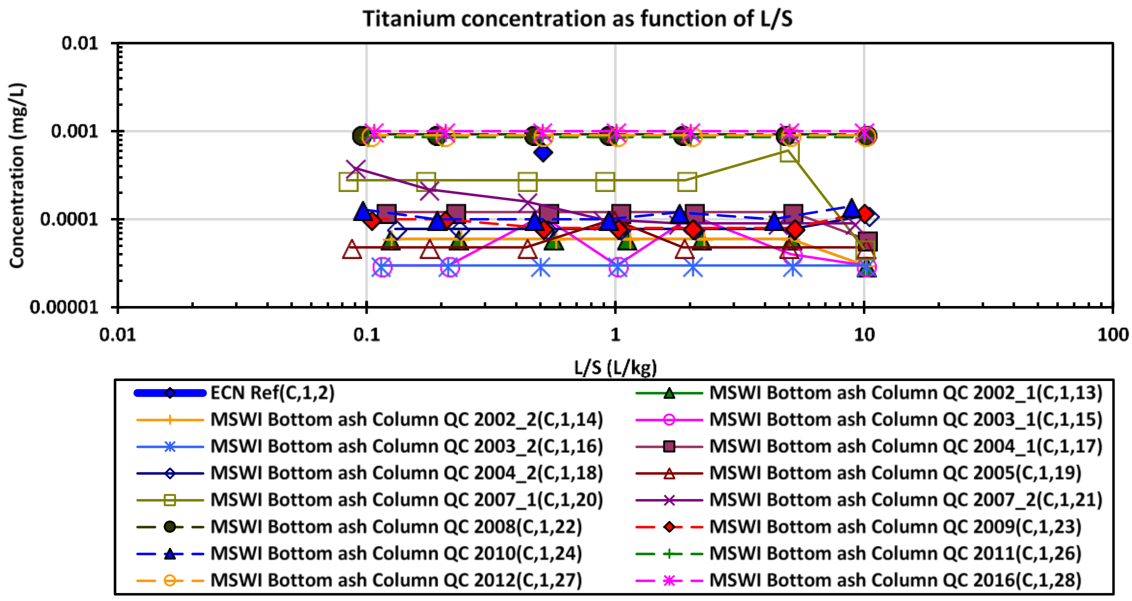

Selenium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

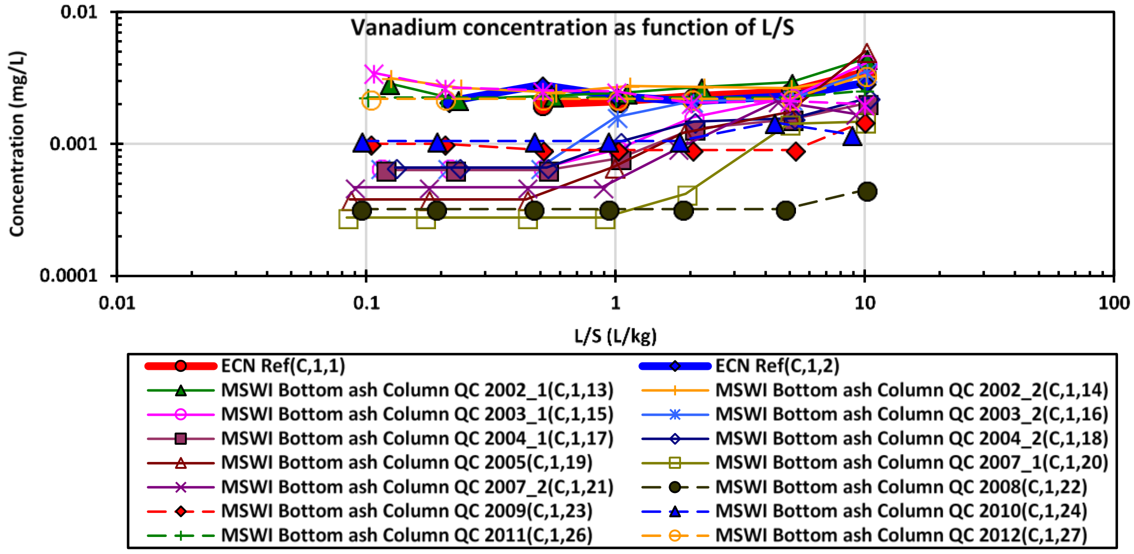

Silicon concentration as function of L/S
Concentration (mg/L)
1000
10
0.1
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)

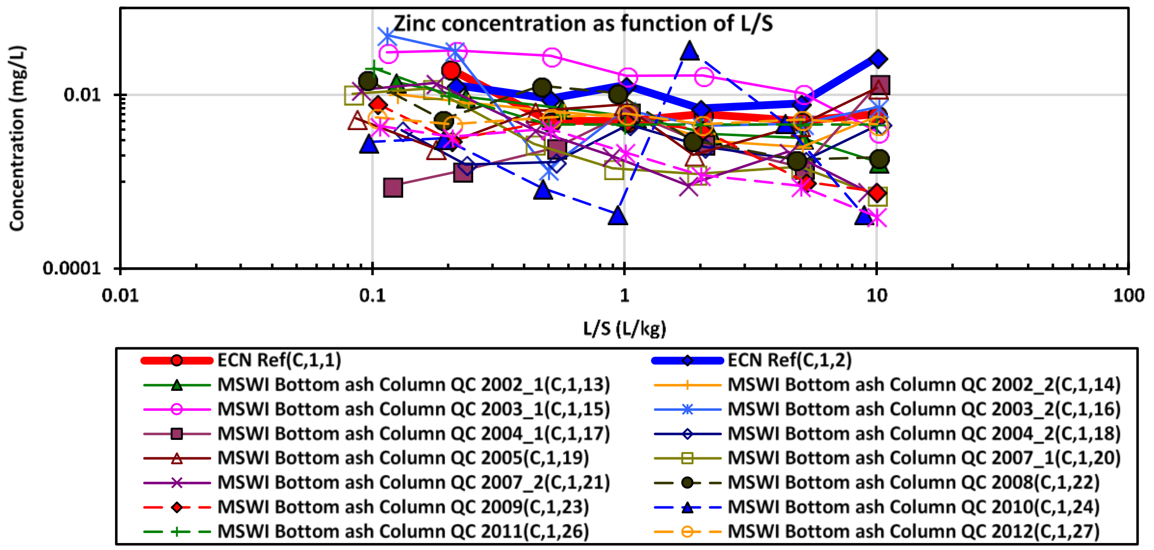

Tin concentration as function of L/S
Concentration (mg/L)
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)


Sulphate concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)


Strontium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)


Titanium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
0.0001
0.00001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)


Vanadium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)


Zinc concentration as function of L/S
Concentration (mg/L)
0.01
0.0001
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)

Appendix A2.1: Percolation LEAF 1314 method performed by ChemCentre in duplicate on ECN Reference Material.

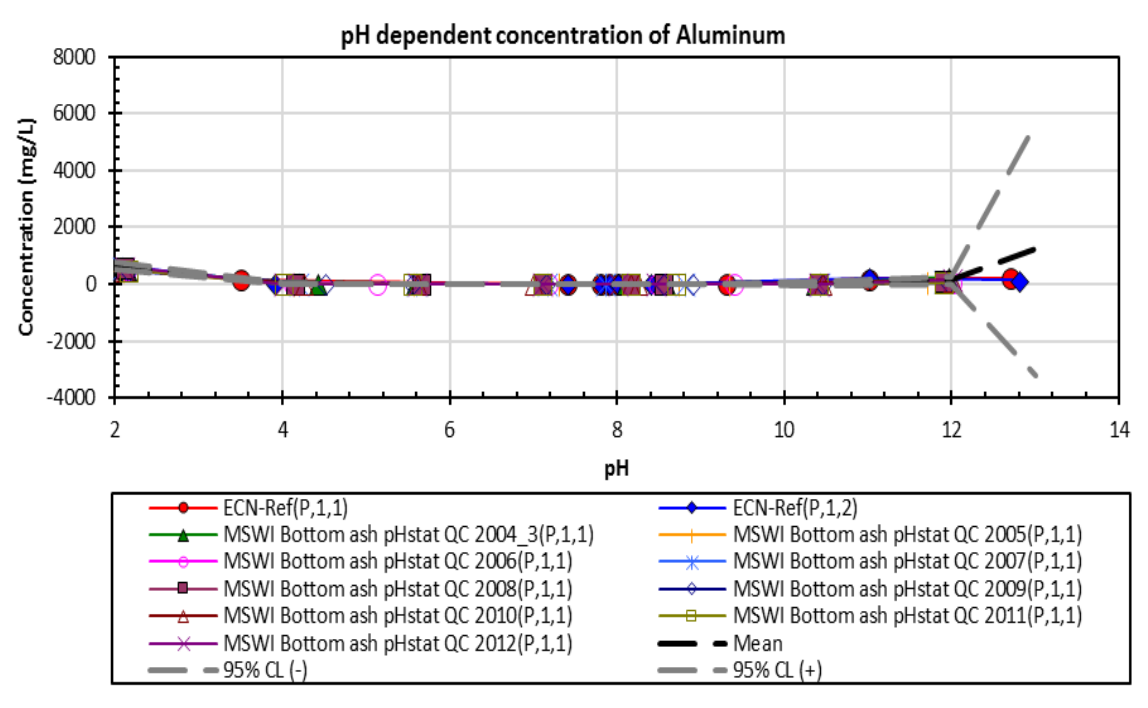
L/S Ratio	1T01 (0.2)		1T02 (0.5)		1T03 (1.0)		1T05 (2.0)		1T07 (5.0)		1T09 (10)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
pH	9.60	0.30	9.65	0.15	10.1	0.10	9.50	0.10	9.75	0.05	10.2	0.05
EC (mS/m)	1145	45.0	380	49.0	185	24.5	111	18.6	61.9	13.3	30.6	1.30
Eh (mV)	300	0.00	273	1.50	266	1.50	266	2.00	260	2.00	256	0.50
DOC (mg/L)	345	15.0	140	30.0	77.5	22.5	39.0	10.0	20.5	8.50	10.5	0.50
Al (mg/L)	32.0	5.00	60.5	9.50	69.0	9.00	68.0	8.00	53.5	6.50	32.5	1.50
B (mg/L)	0.03	0.00	0.03	0.00	0.02	0.00	0.03	0.00	0.03	0.00	0.03	0.00
Ba (mg/L)	0.22	0.01	0.12	0.00	0.09	0.00	0.11	0.01	0.09	0.00	0.08	0.00
Ca (mg/L)	635	110	261	54.5	161	17.5	116	8.50	77.8	3.05	49.6	0.70
Co (mg/L)	0.001	0.00	0.00	0.00	0.00	0.00	ND	ND	ND	ND	ND	ND
Cr (mg/L)	0.07	0.04	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00
Cu (mg/L)	2.20	0.10	1.01	0.10	0.50	0.05	0.29	0.03	0.17	0.02	0.08	0.02
Fe (mg/L)	0.01	0.00	0.01	0.00	ND	ND	ND	ND	ND	ND	ND	ND
Hg (mg/L)	0.002	0.00	0.002	0.00	0.00	0.00	0.00	0.00	0.001	0.00	0.0004	0.00
K (mg/L)	358	2.50	117	10.0	55.1	4.75	33.5	4.95	15.9	3.85	6.05	0.65
Mg (mg/L)	0.20	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mn (mg/L)	0.001	0.00	0.001	0.00	0.00	0.00	0.00	0.00	0.0001	0.00	0.0001	0.00
Mo (mg/L)	0.54	0.01	0.28	0.01	0.15	0.00	0.08	0.00	0.04	0.01	0.02	0.00
Na (mg/L)	1690	30.0	487	56.0	194	22.00	102	22.8	44.2	20.1	10.9	2.60
Ni (mg/L)	0.01	0.00	0.004	0.00	0.002	0.00	0.00	0.00	ND	ND	ND	ND
P (mg/L)	0.30	0.00	0.20	0.00	0.10	0.00	ND	ND	ND	ND	ND	ND
Pb (mg/L)	0.001	0.00	0.00	0.00	ND	ND	0.00	0.00	ND	ND	0.00	0.00
S (mg/L)	205	35.0	115	25.5	72.5	10.5	47.0	5.00	27.0	3.00	16.5	1.50
Sb (mg/L)	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.02	0.00	0.03	0.00
Se (mg/L)	0.01	0.00	0.004	0.00	0.002	0.00	0.001	0.00	ND	ND	ND	ND
Sn (mg/L)	0.001	0.00	0.000	0.00	0.000	0.00	0.0003	0.00	0.0003	0.00	0.00	0.00
V (mg/L)	0.002	0.00	0.002	0.00	0.002	0.00	0.002	0.00	0.002	0.00	0.00	0.00
Zn (mg/L)	0.02	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.02	0.01
Br (mg/L)	3.45	0.15	0.80	0.10	0.25	0.05	0.10	0.00	ND	ND	ND	ND
Cl (mg/L)	3400	100	905	95.0	345	65.0	165	45.0	66.0	34.0	10.8	2.25
SO4 (mg/L)	579	119	313	71.0	206	33.0	138	12.5	81.7	6.05	49.2	6.35

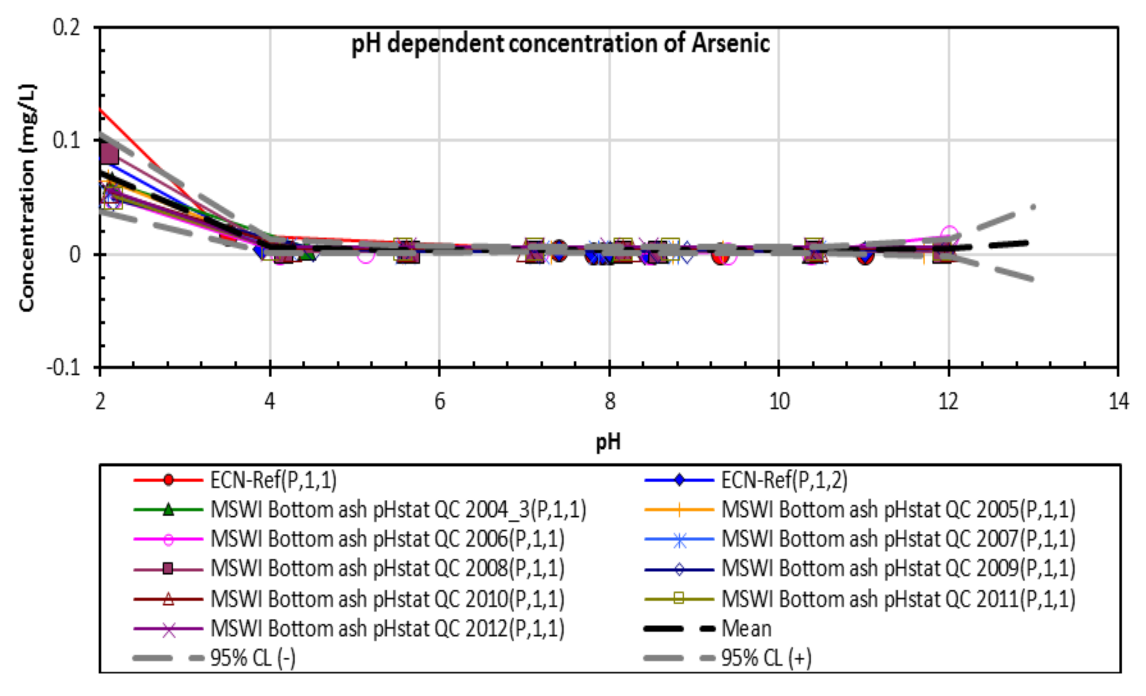
Note: SE- standard error of mean.

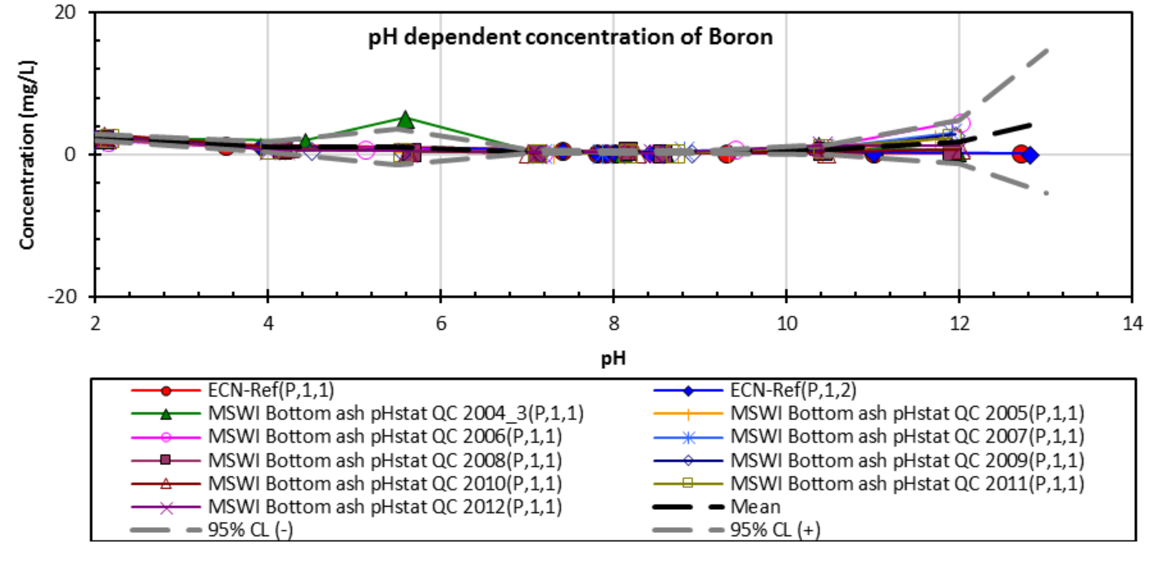
Appendix A2.2: Inter-lab LEAF 1314 method comparison between ECN and ChemCentre for ECN Reference Material.

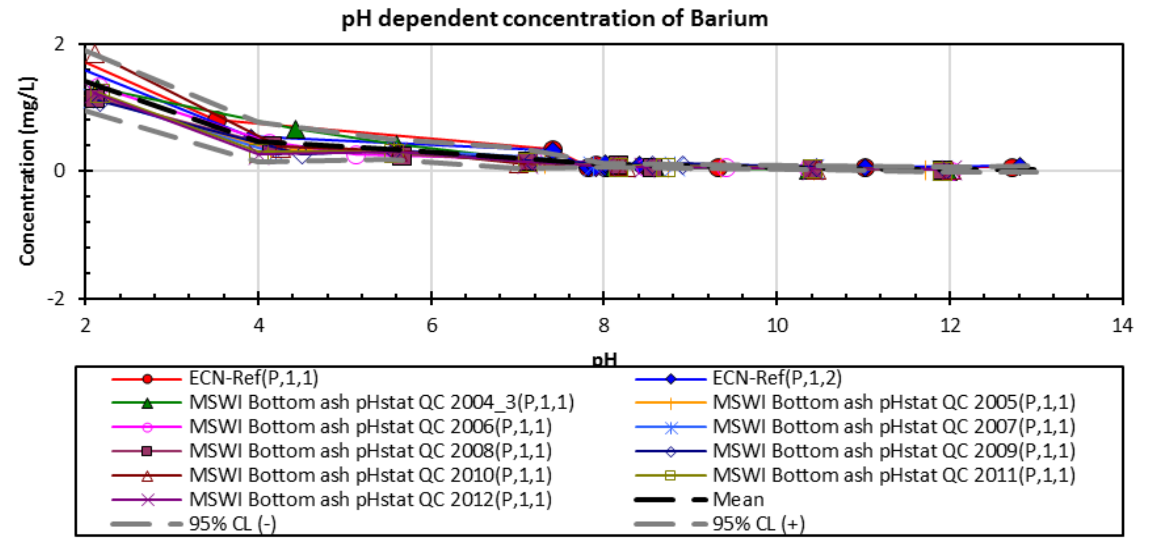
L/S Ratio		1T01 (0.2)	1T02 (0.5)	1T03 (1.0)	1T05 (2.0)	1T07 (5.0)	1T09 (10)
pH		9.60	9.65	10.1	9.50	9.75	10.2
DOC (mg/L)	**ChemCentre**	345	140	77.5	39.0	20.5	10.5
	ECN	320	121	43.0	19.4	8.75	6.12
Al (mg/L)	**ChemCentre**	32.0	60.5	69.0	68.0	53.5	32.5
	ECN	23.3	41.4	60.2	65.5	52.8	32.2
B (mg/L)	**ChemCentre**	0.03	0.03	0.02	0.03	0.03	0.03
	ECN	0.02	0.02	0.02	0.02	0.03	0.03
Ba (mg/L)	**ChemCentre**	0.22	0.12	0.09	0.11	0.09	0.08
	ECN	0.37	0.20	0.10	0.09	0.09	0.08
Ca (mg/L)	**ChemCentre**	635	261	161	116	77.8	49.6
	ECN	796	310	145	106	75.5	51.9
Co (mg/L)	**ChemCentre**	0.001	0.00	0.00	ND	ND	ND
	ECN	0.001	0.000	0.000	0.000	0.000	0.000
Cr (mg/L)	**ChemCentre**	0.07	0.03	0.01	0.01	0.00	0.01
	ECN	0.01	0.01	0.00	0.00	0.00	0.00
Cu (mg/L)	**ChemCentre**	2.20	1.01	0.50	0.29	0.17	0.08
	ECN	3.31	1.66	0.72	0.32	0.13	0.07
Fe (mg/L)	**ChemCentre**	0.01	0.01	ND	ND	ND	ND
	ECN	0.01	0.01	0.01	0.01	0.01	0.00
K (mg/L)	**ChemCentre**	358	117	55.1	33.5	15.9	6.05
	ECN	625	218	75.4	31.7	12.6	5.85
Mg (mg/L)	**ChemCentre**	0.20	ND	ND	ND	ND	ND
	ECN	0.26	0.11	0.03	0.02	0.02	0.01
Mn (mg/L)	**ChemCentre**	0.001	0.001	0.0004	0.0002	0.0001	0.0001
	ECN	0.002	0.001	0.001	0.0003	0.0004	0.0003
Mo (mg/L)	**ChemCentre**	0.54	0.28	0.15	0.08	0.04	0.02
	ECN	0.54	0.43	0.19	0.08	0.03	0.01
Na (mg/L)	**ChemCentre**	1690	487	194	102	44.2	10.9
	ECN	2609	844	239	72.1	19.4	6.65
Ni (mg/L)	**ChemCentre**	0.01	0.004	0.002	0.001	ND	ND
	ECN	0.02	0.011	0.004	0.002	0.001	0.001
P (mg/L)	**ChemCentre**	0.30	0.20	0.10	ND	ND	ND
	ECN	0.37	0.22	0.13	0.10	0.06	0.04
Pb (mg/L)	**ChemCentre**	0.0006	0.0002	ND	0.0002	ND	0.0003
	ECN	0.0101	0.0027	0.0021	0.0017	0.0019	0.0015
S (mg/L)	**ChemCentre**	205	115	72.5	47.0	27.0	16.5
	ECN	186	107	63.4	41.0	23.4	13.7
Sb (mg/L)	**ChemCentre**	0.01	0.01	0.01	0.02	0.02	0.03
	ECN	0.01	0.01	0.01	0.01	0.02	0.02
Se (mg/L)	**ChemCentre**	0.008	0.004	0.002	0.001	ND	ND
	ECN	0.021	0.013	0.007	0.006	0.005	0.005
Sn (mg/L)	**ChemCentre**	0.0006	0.0003	0.0003	0.0003	0.0003	0.0003
	ECN	0.001	0.001	0.001	0.001	0.001	0.001
V (mg/L)	**ChemCentre**	0.002	0.002	0.002	0.002	0.002	0.00
	ECN	0.001	0.001	0.001	0.002	0.002	0.003
Zn (mg/L)	**ChemCentre**	0.017	0.006	0.008	0.007	0.005	0.017
	ECN	0.010	0.006	0.006	0.006	0.003	0.004
SO4 (mg/L)	**ChemCentre**	579	313	206	138	81.7	49.2
	ECN	552	319	181	113	61.4	37.9
Si (mg/L)	**ChemCentre**	2.30	0.93	0.55	0.50	0.46	1.10
	ECN	30.3	9.0	2.4	1.1	0.8	1.0
As (mg/L)	**ChemCentre**	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000
	ECN	0.0071	0.0040	0.0032	0.0032	0.0031	0.0025
Cd (mg/L)	**ChemCentre**	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	ECN	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001

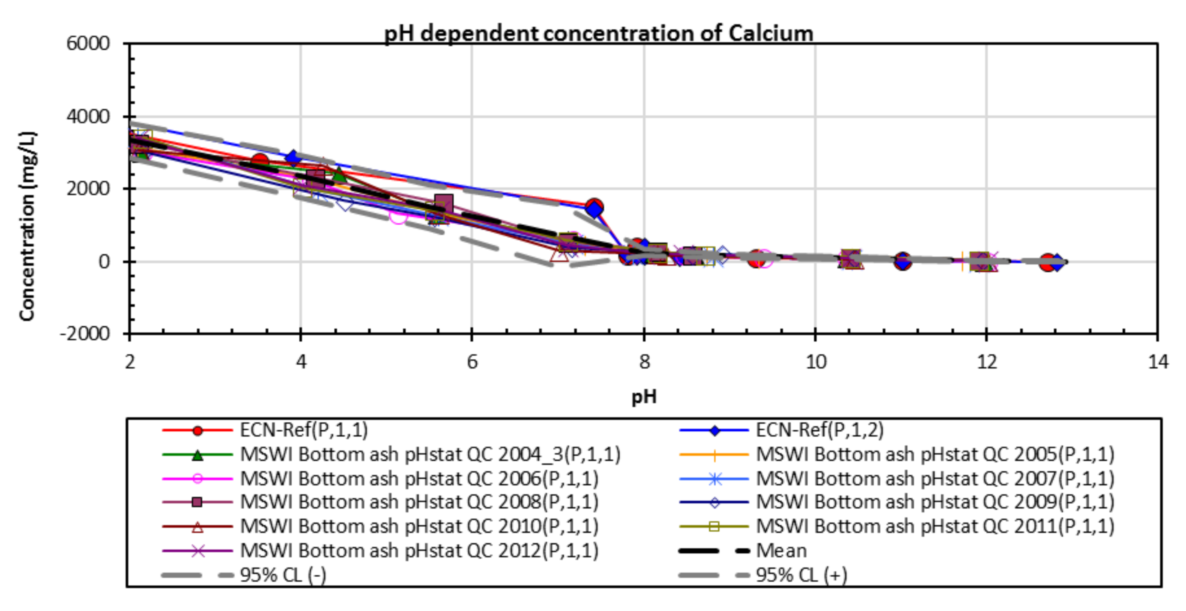
Appendix A3: Graphical Presentation of statistical analysis for Method 1313 (Note: Refence laboratory mean and 95 % confidence limits compared to the median of the ChemCentre mean for ECN reference material).

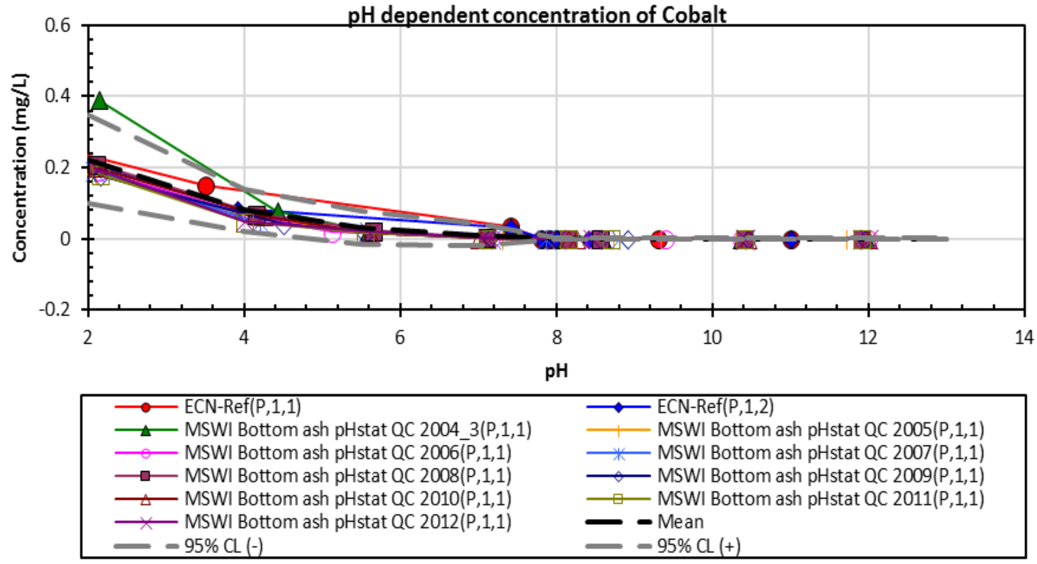


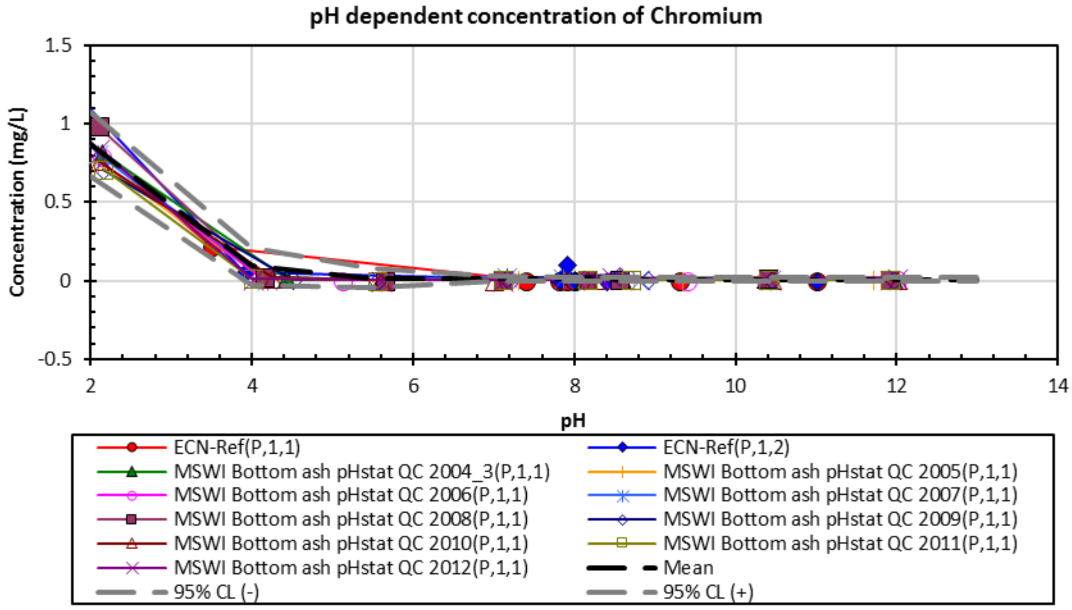


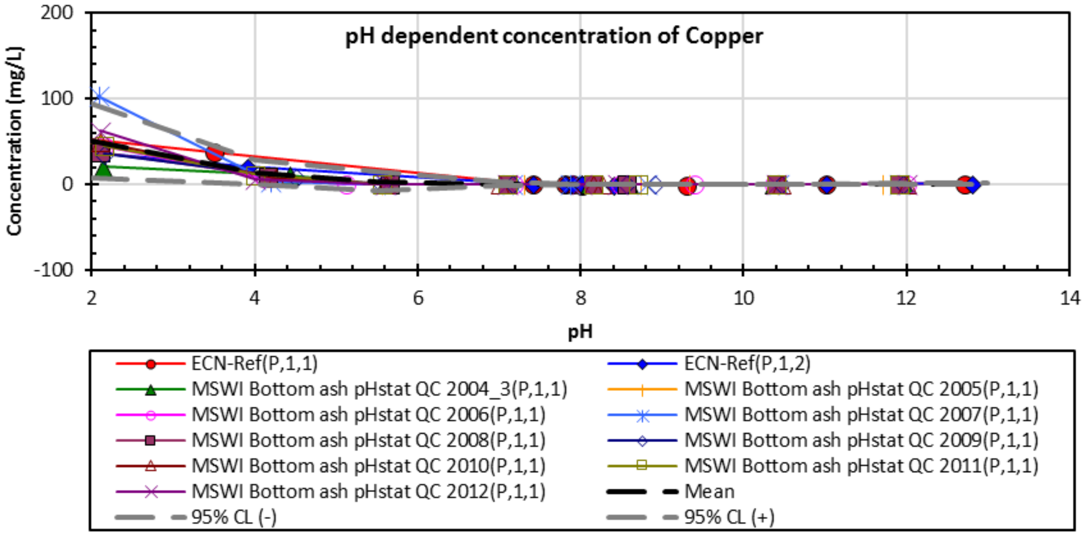

pH dependent concentration of Boron
Concentration (mg/L)
20
0
-20
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

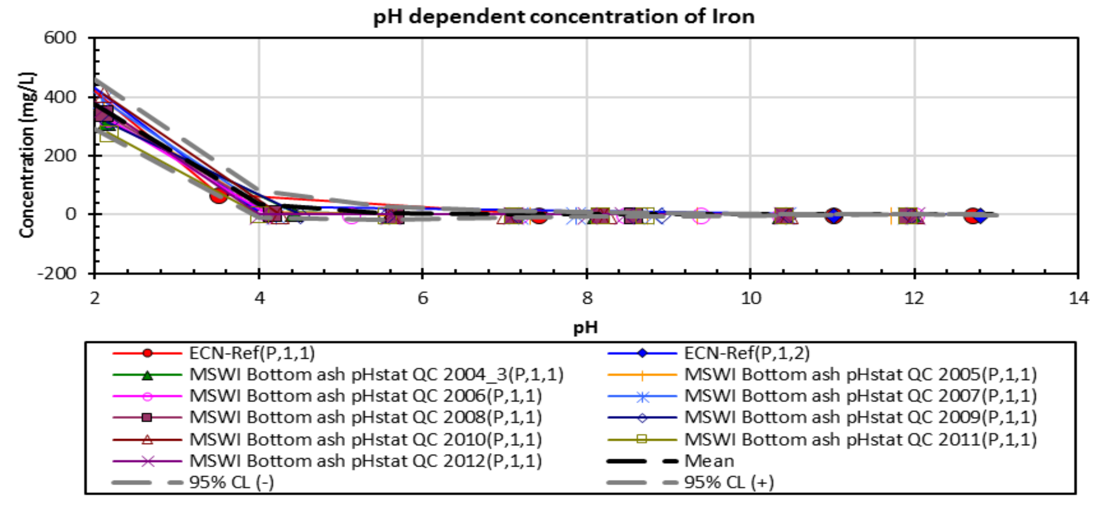

pH dependent concentration of Barium
Concentration (mg/L)
2
0
-2
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

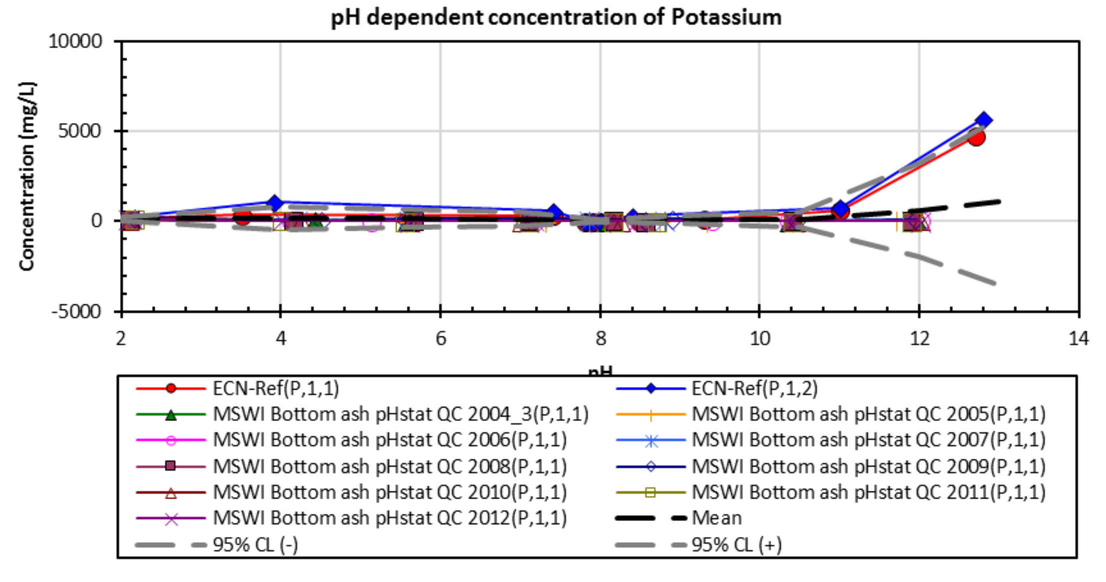

pH dependent concentration of Calcium
Concentration (mg/L)
6000
4000
2000
0
-2000
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

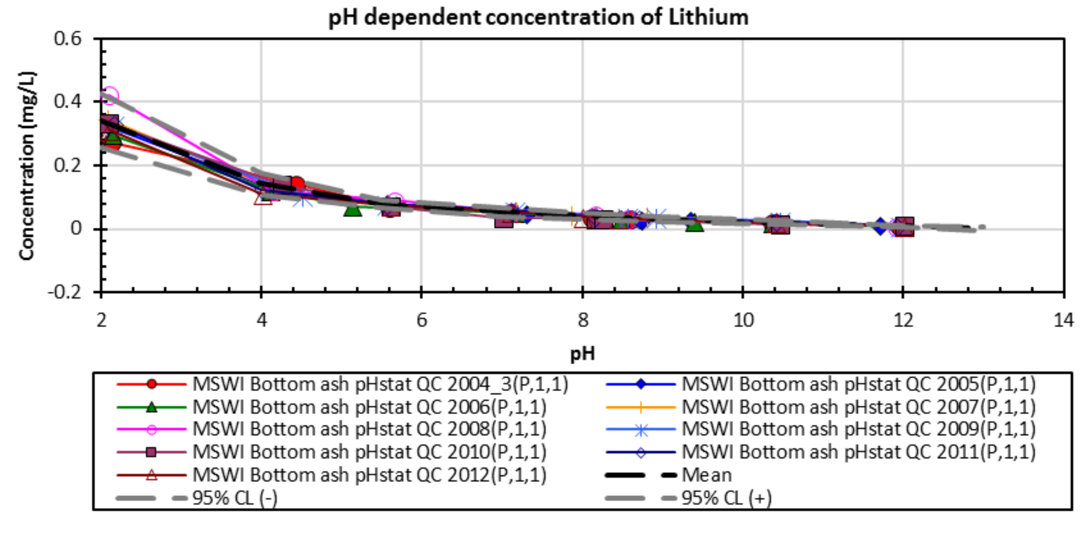

pH dependent concentration of Cobalt
Concentration (mg/L)
0.6
0.4
0.2
0
-0.2
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

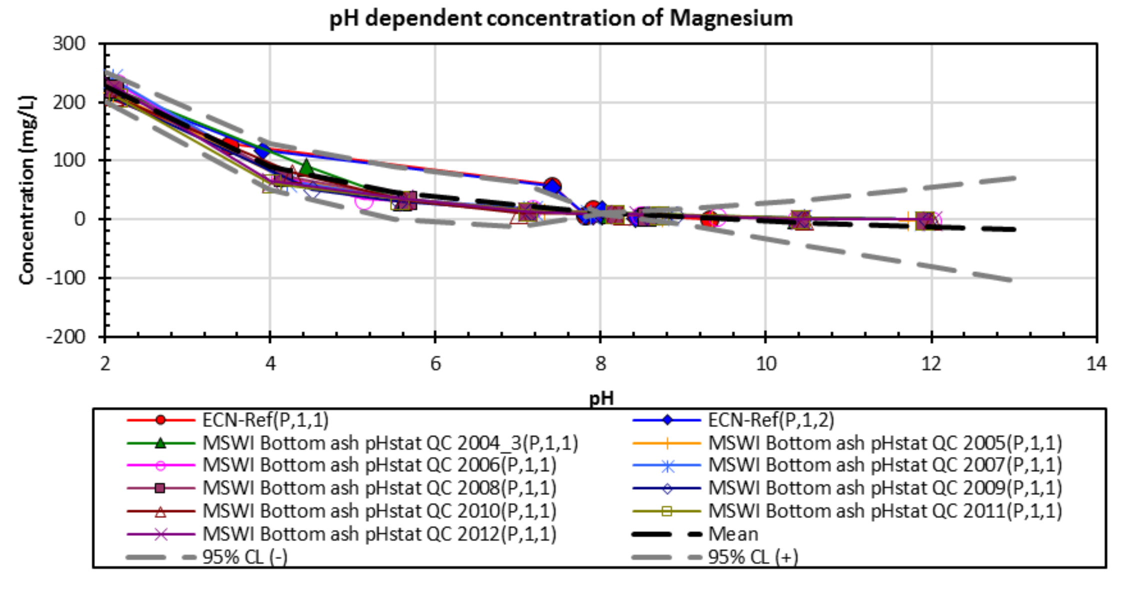

pH dependent concentration of Chromium
Concentration (mg/L)
1.5
1
0.5
0
-0.5
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

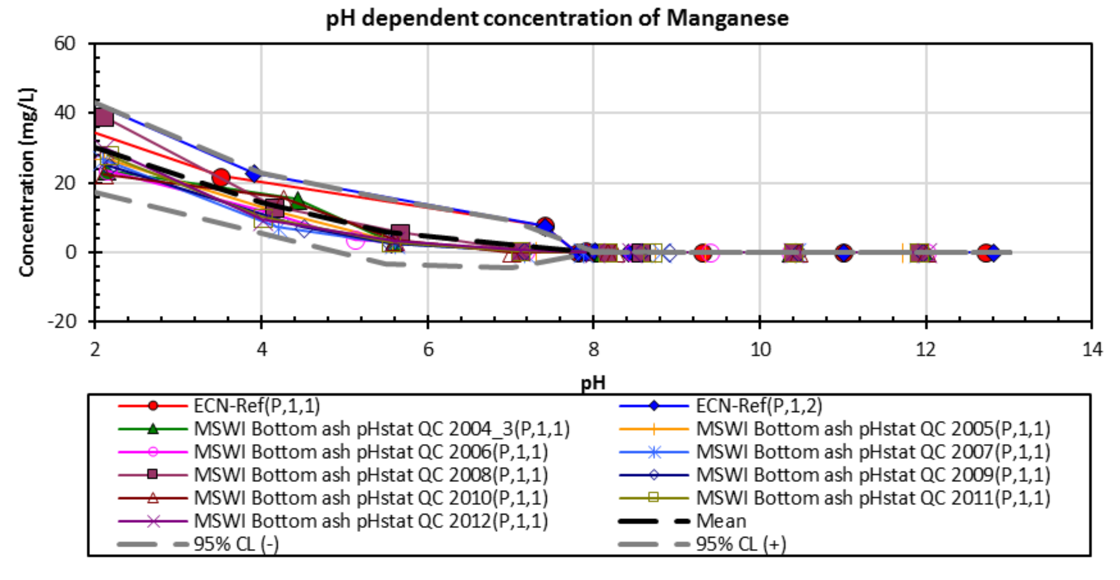

pH dependent concentration of Copper
Concentration (mg/L)
200
100
0
-100
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

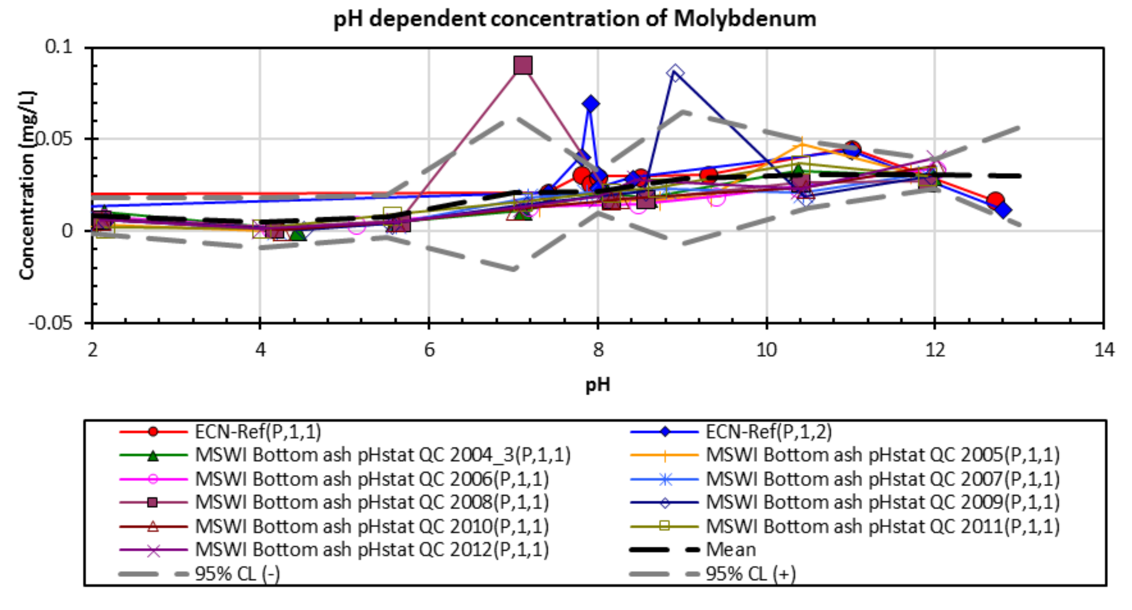

pH dependent concentration of Iron
Concentration (mg/L)
600
400
200
0
-200
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

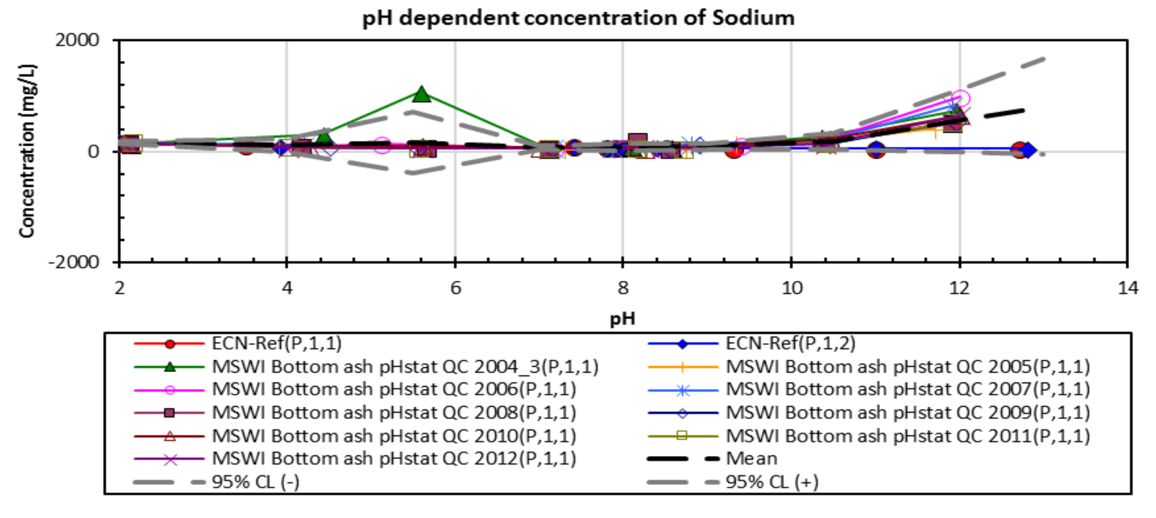

pH dependent concentration of Potassium
Concentration (mg/L)
10000
5000
0
-5000
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

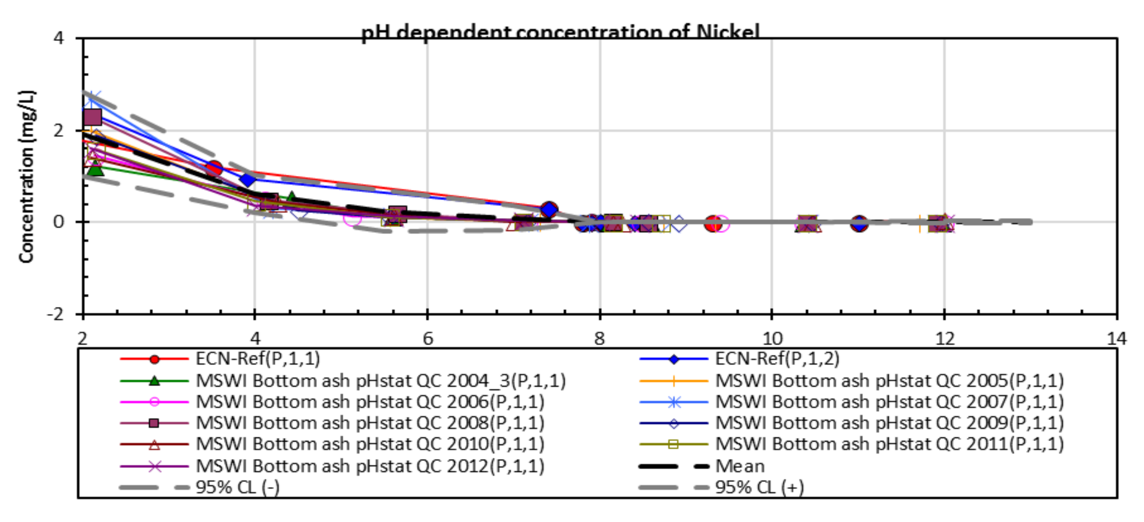

pH dependent concentration of Lithium
Concentration (mg/L)
0.6
0.4
0.2
0
-0.2
2
4
6
8
10
12
14
pH
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

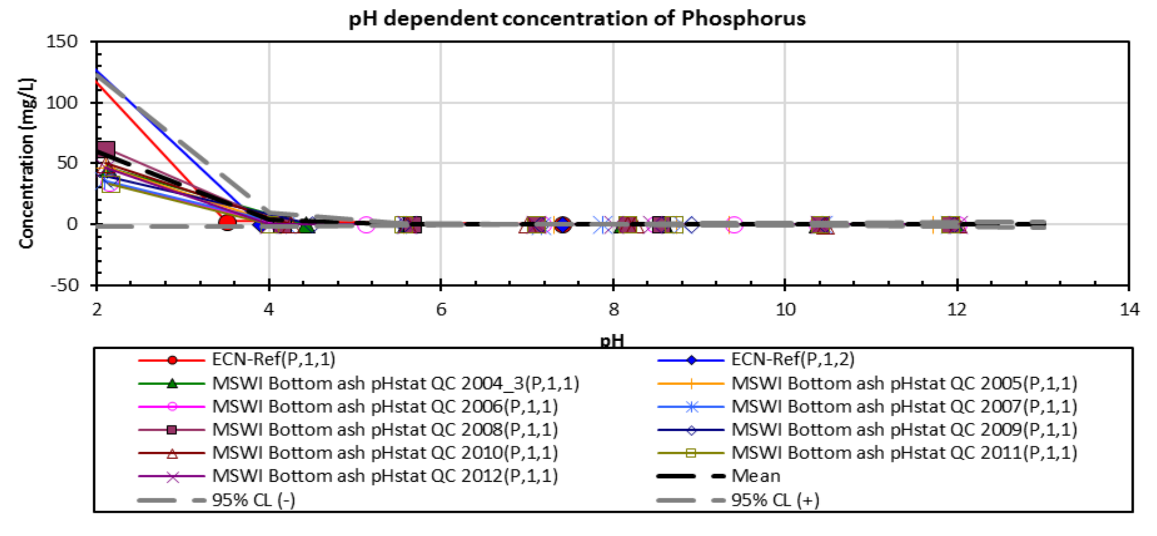

pH dependent concentration of Magnesium
Concentration (mg/L)
300
200
100
0
-100
-200
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

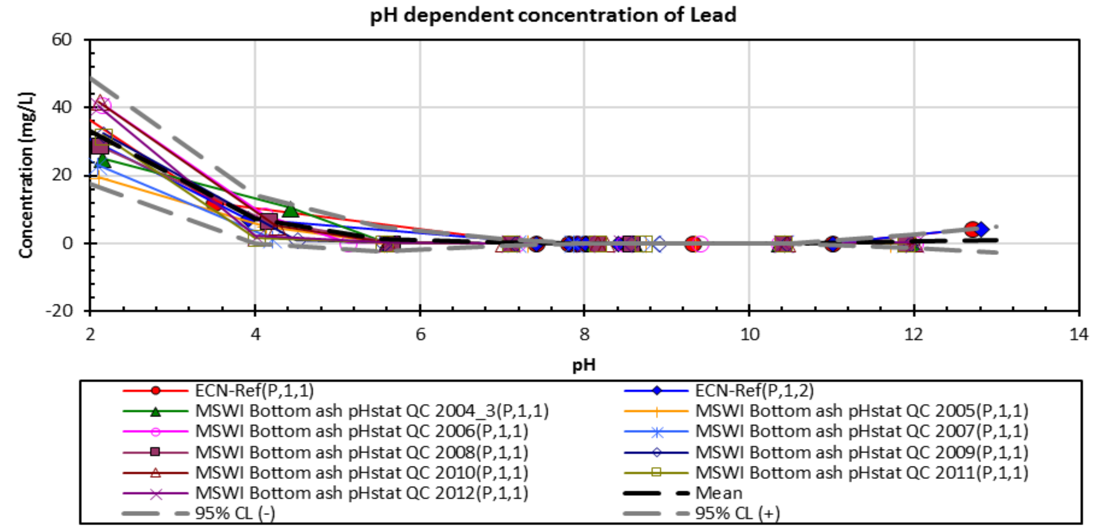

pH dependent concentration of Manganese
Concentration (mg/L)
60
40
20
0
-20
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

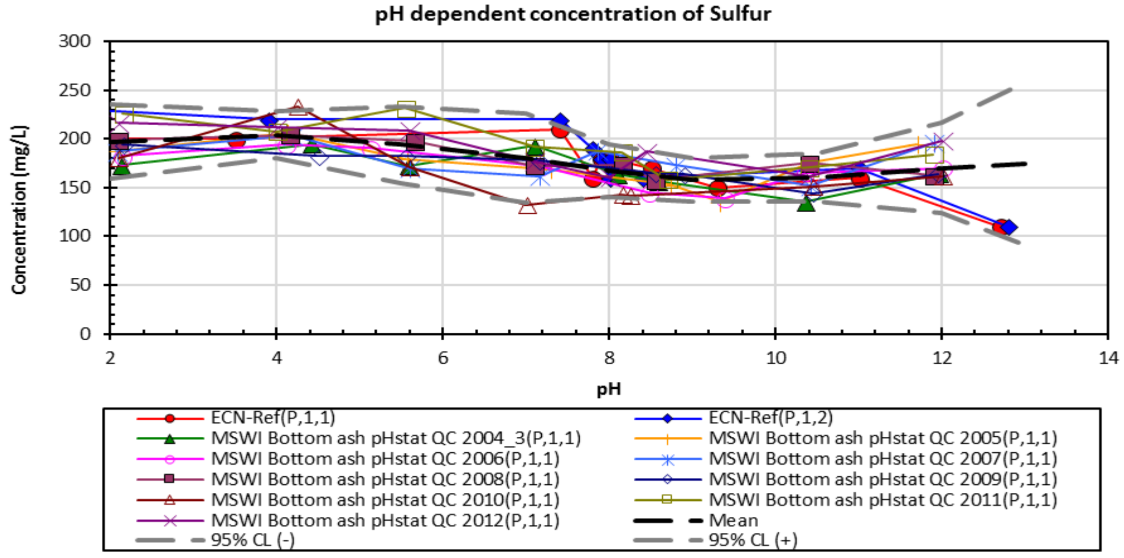

pH dependent concentration of Molybdenum
Concentration (mg/L)
0.1
0.05
0
-0.05
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

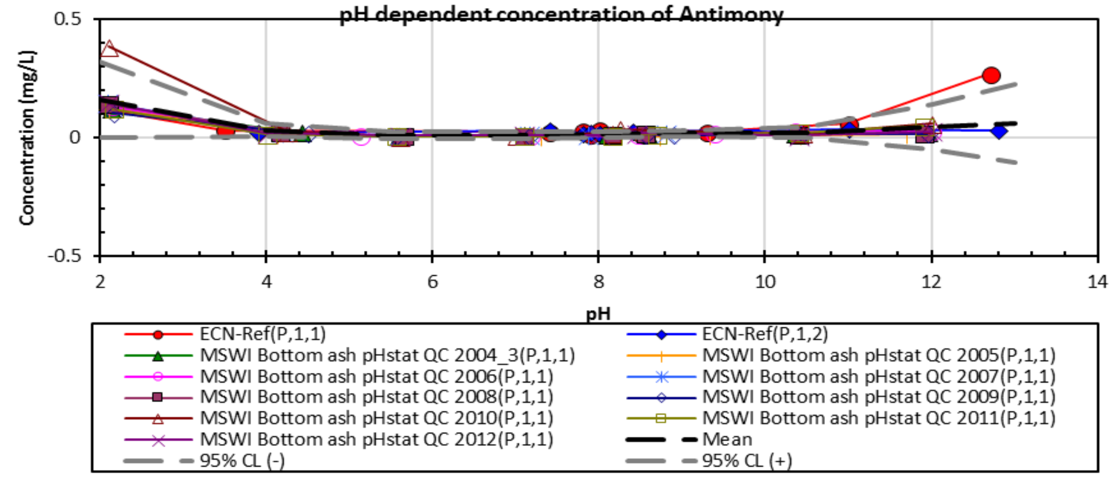

pH dependent concentration of Sodium
Concentration (mg/L)
2000
0
-2000
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

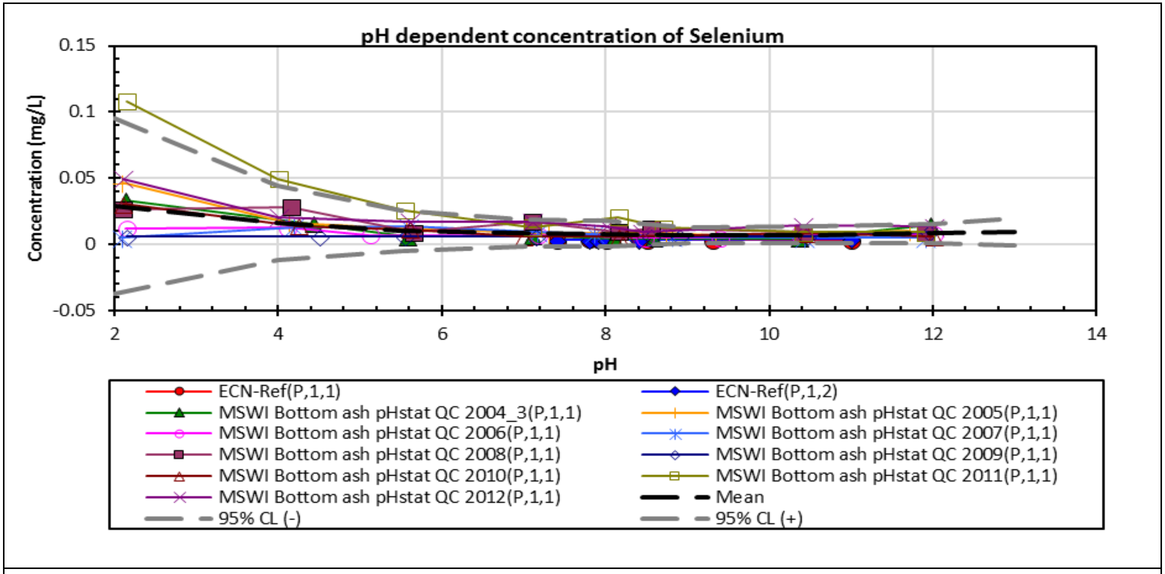

pH dependent concentration of Nickel
Concentration (mg/L)
4
2
0
-2
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

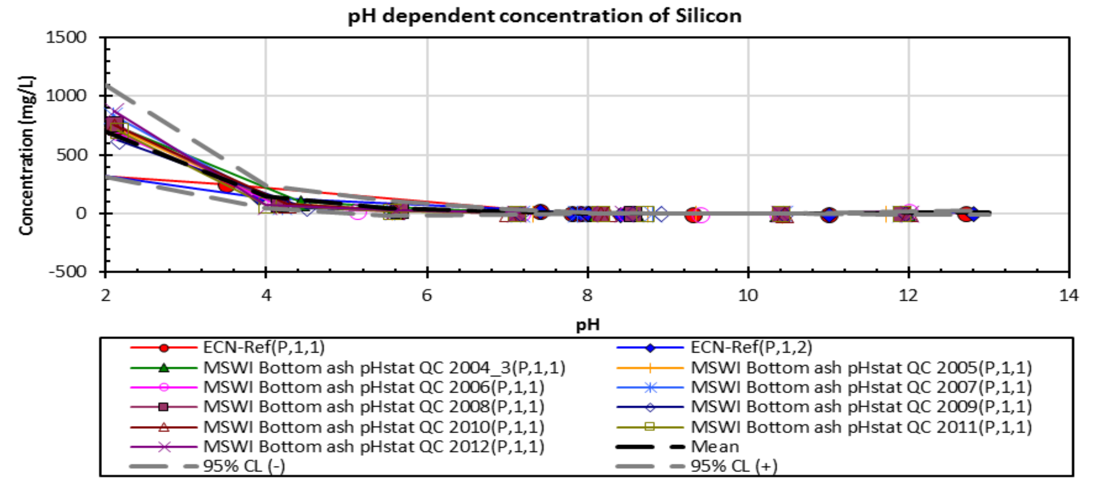

pH dependent concentration of Phosphorus
Concentration (mg/L)
150
100
50
0
-50
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

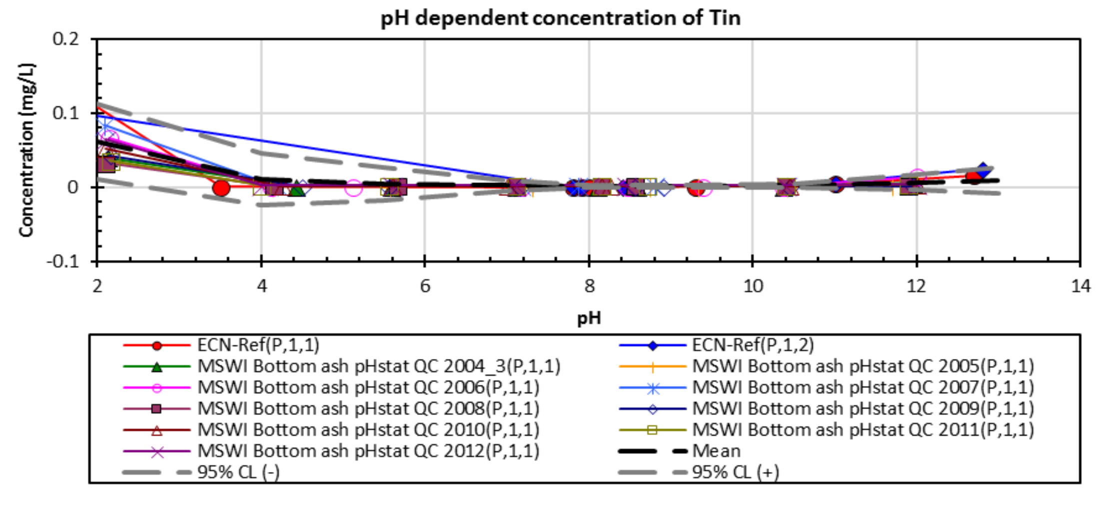

pH dependent concentration of Lead
Concentration (mg/L)
60
40
20
0
-20
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

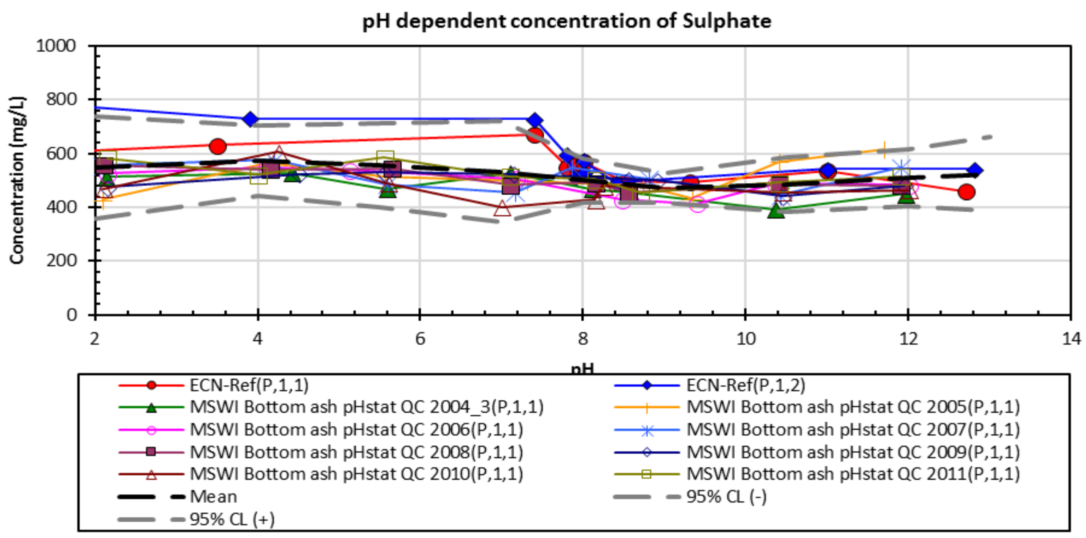

pH dependent concentration of Sulfur
Concentration (mg/L)
300
250
200
150
100
50
0
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

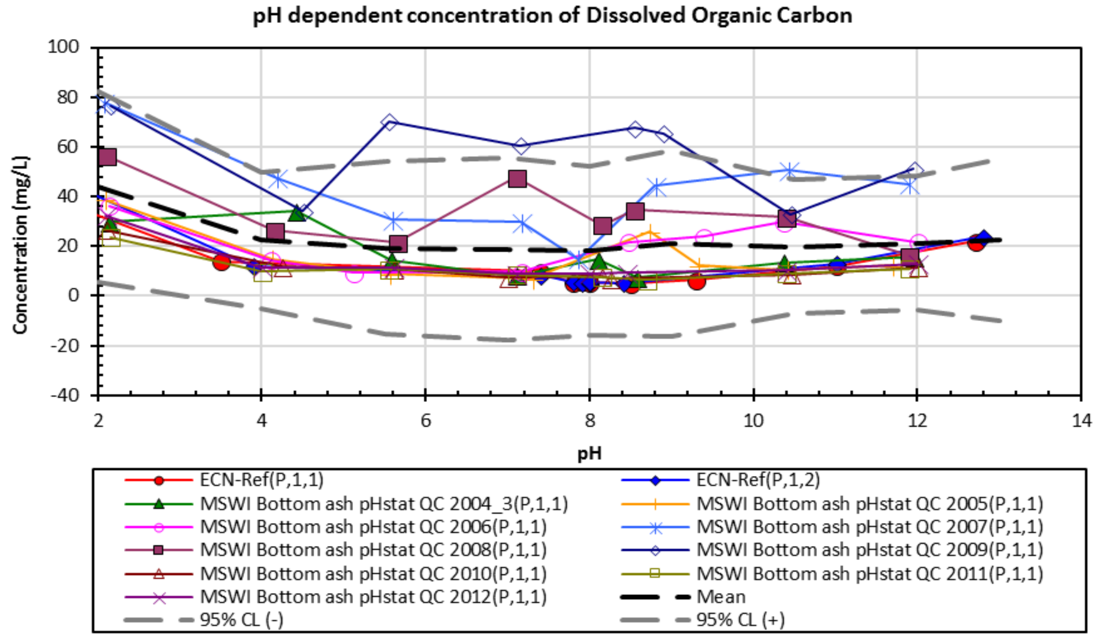

pH dependent concentration of Antimony
Concentration (mg/L)
0.5
0
-0.5
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

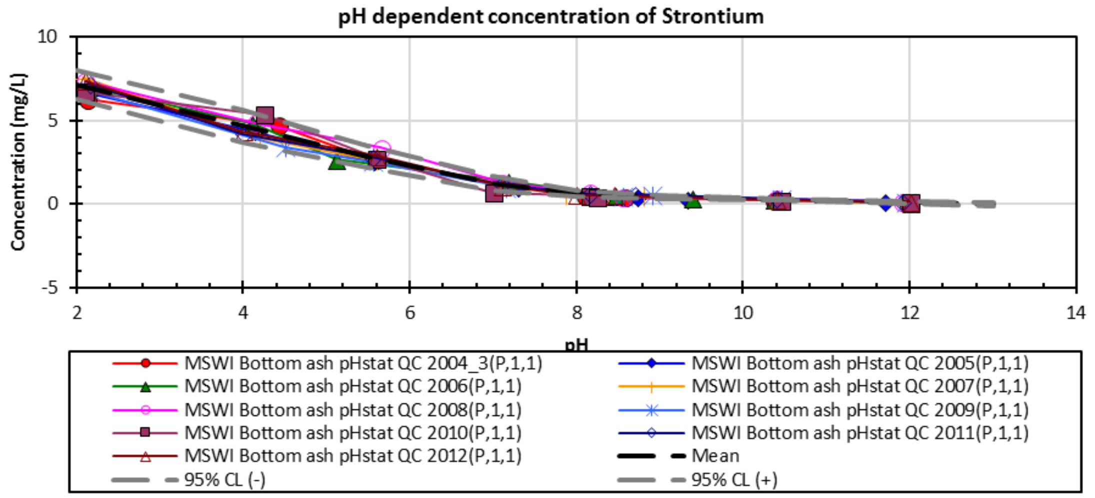

pH dependent concentration of Selenium
Concentration (mg/L)
0.15
0.1
0.05
0
-0.05
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

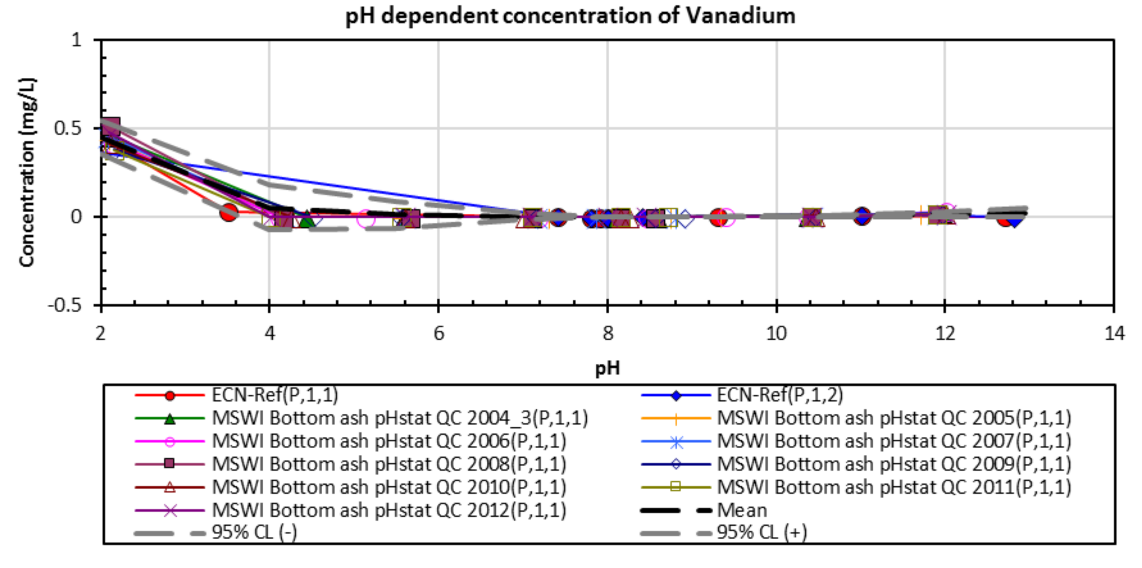

pH dependent concentration of Silicon
Concentration (mg/L)
1500
1000
500
0
-500
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

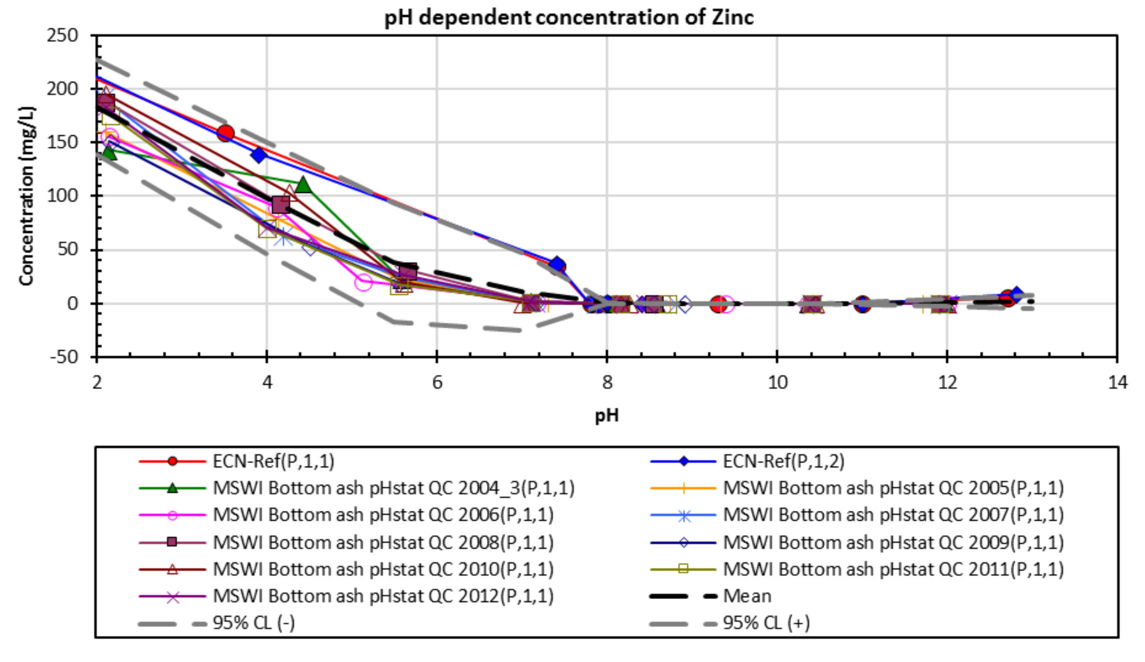

pH dependent concentration of Tin
Concentration (mg/L)
0.2
0.1
0
-0.1
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)


pH dependent concentration of Sulphate
Concentration (mg/L)
0
200
400
600
800
1000
pH
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
Mean
95% CL (-)
95% CL (+)

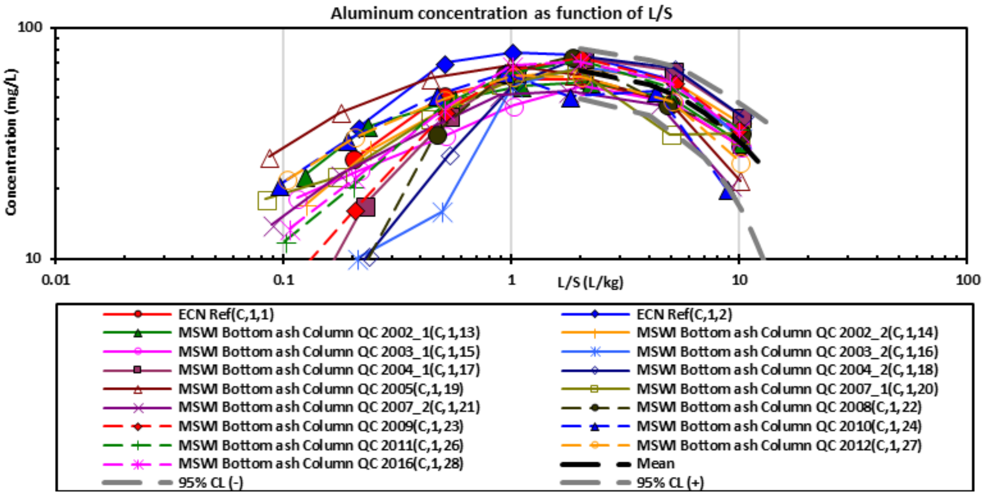

pH dependent concentration of Dissolved Organic Carbon
Concentration (mg/L)
-40
-20
0
20
40
60
80
100
pH
2
4
6
8
10
12
14
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

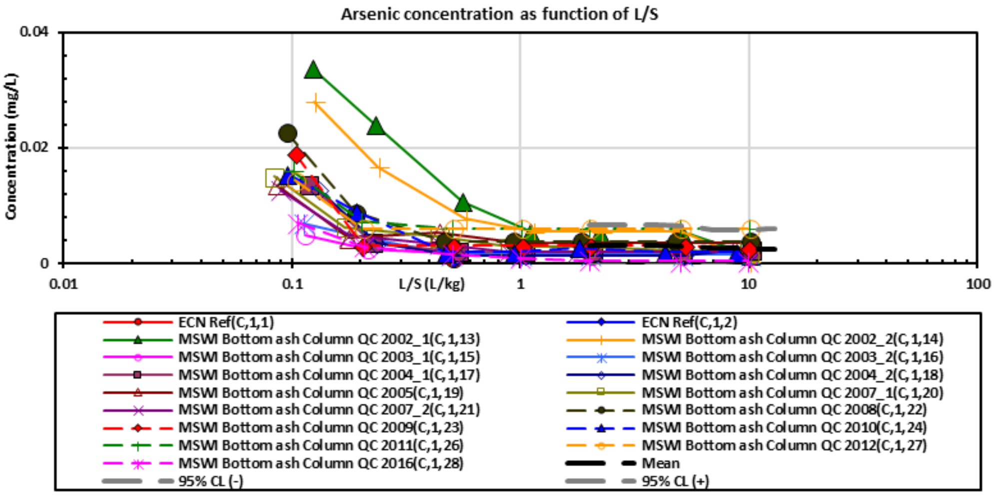

pH dependent concentration of Strontium
Concentration (mg/L)
-5
0
5
10
pH
2
4
6
8
10
12
14
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

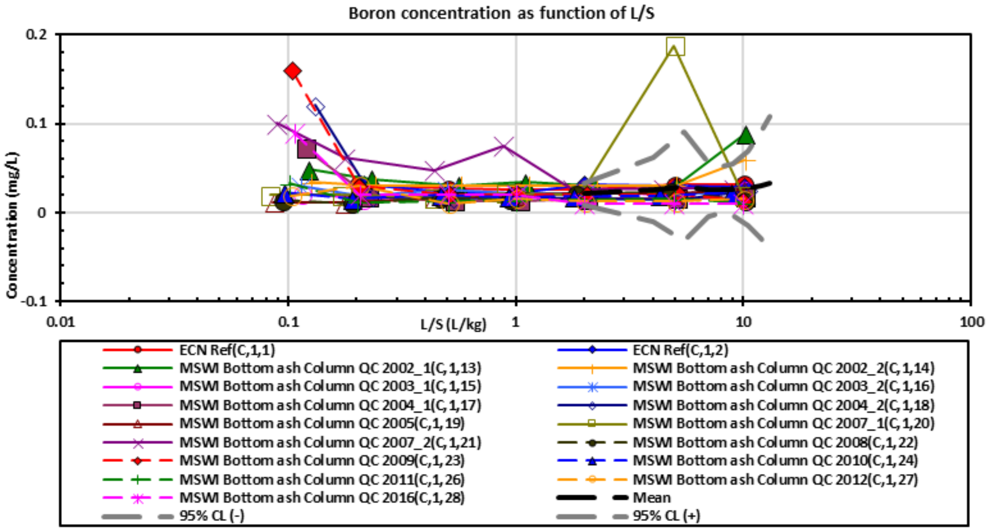

pH dependent concentration of Vanadium
Concentration (mg/L)
1
0.5
0
-0.5
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

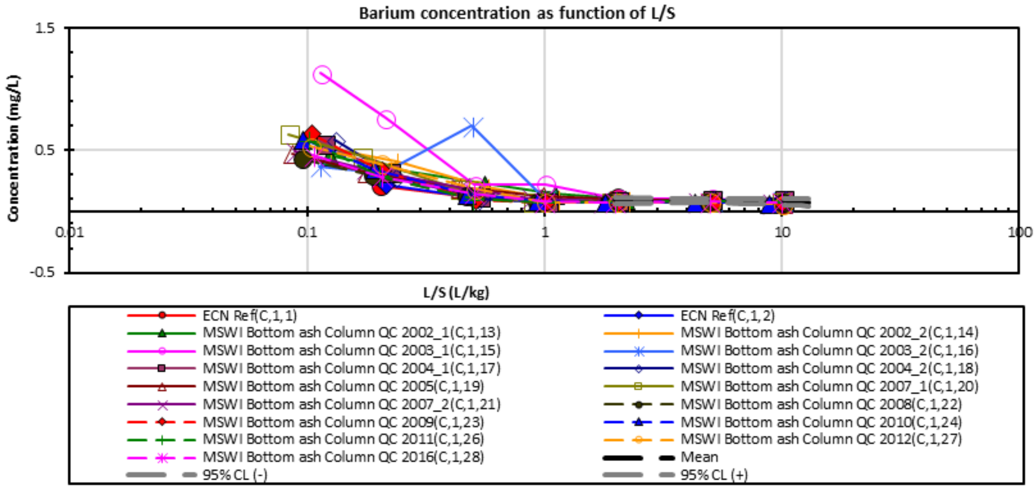

pH dependent concentration of Zinc
Concentration (mg/L)
250
200
150
100
50
0
-50
2
4
6
8
10
12
14
pH
ECN-Ref(P,1,1)
ECN-Ref(P,1,2)
MSWI Bottom ash pHstat QC 2004_3(P,1,1)
MSWI Bottom ash pHstat QC 2005(P,1,1)
MSWI Bottom ash pHstat QC 2006(P,1,1)
MSWI Bottom ash pHstat QC 2007(P,1,1)
MSWI Bottom ash pHstat QC 2008(P,1,1)
MSWI Bottom ash pHstat QC 2009(P,1,1)
MSWI Bottom ash pHstat QC 2010(P,1,1)
MSWI Bottom ash pHstat QC 2011(P,1,1)
MSWI Bottom ash pHstat QC 2012(P,1,1)
Mean
95% CL (-)
95% CL (+)

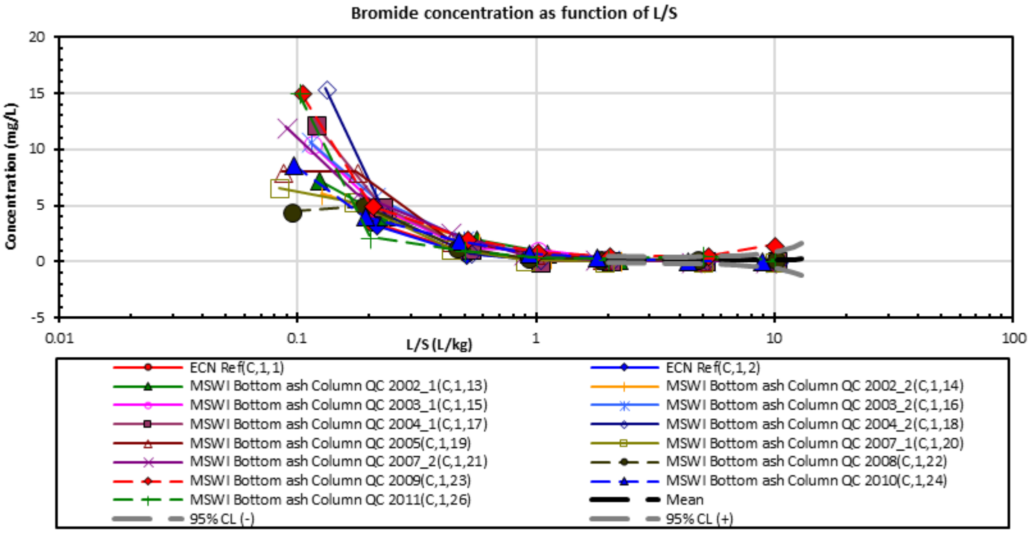
Appendix A4: Graphical Presentation of statistical analysis for Method 1314 (Note: Refence laboratory mean and 95 % confidence limits compared to the median of the ChemCentre mean for ECN reference material).

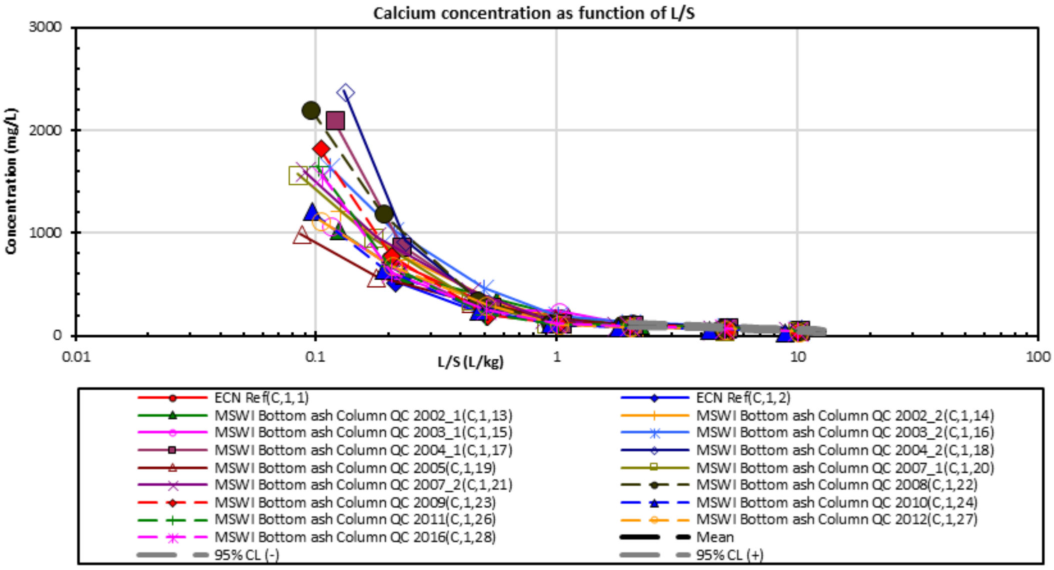


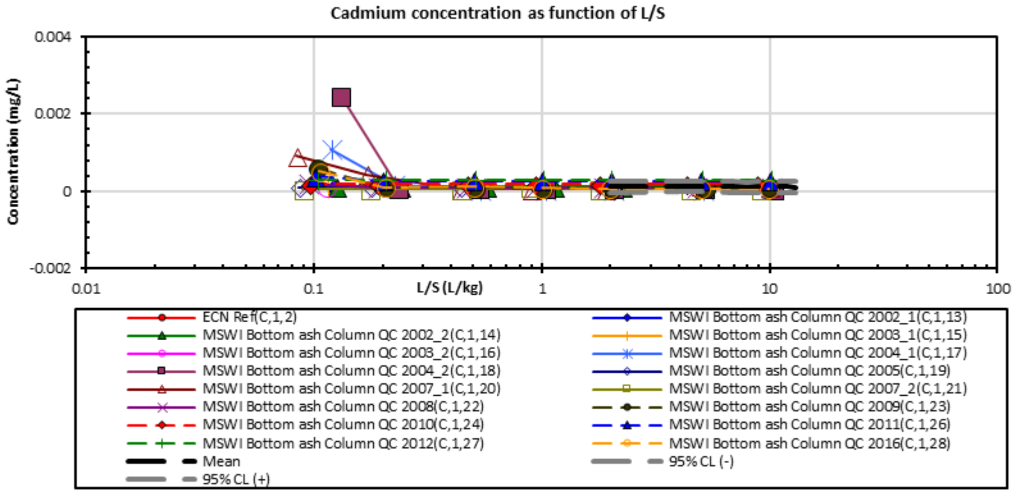


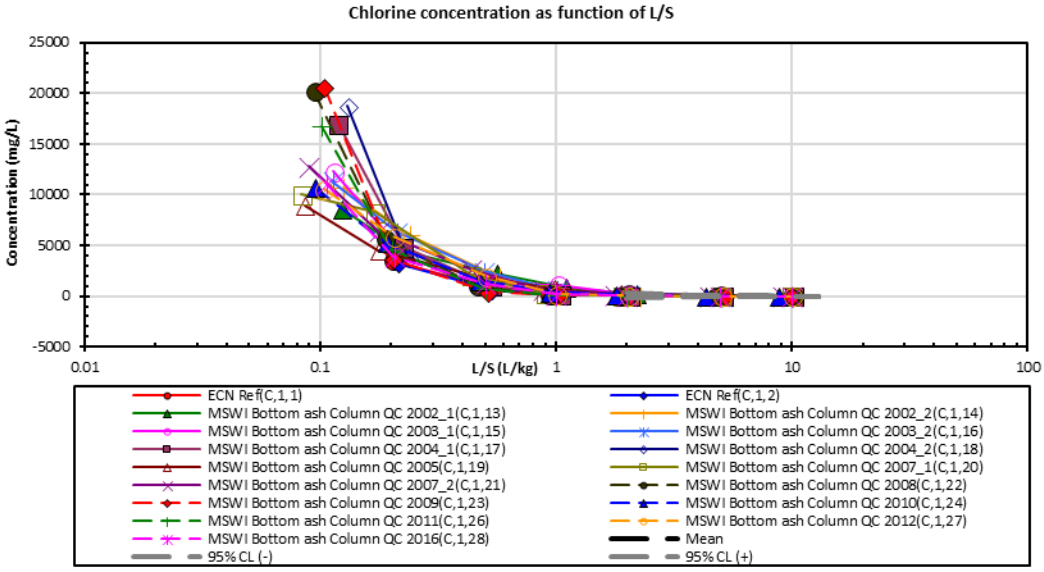


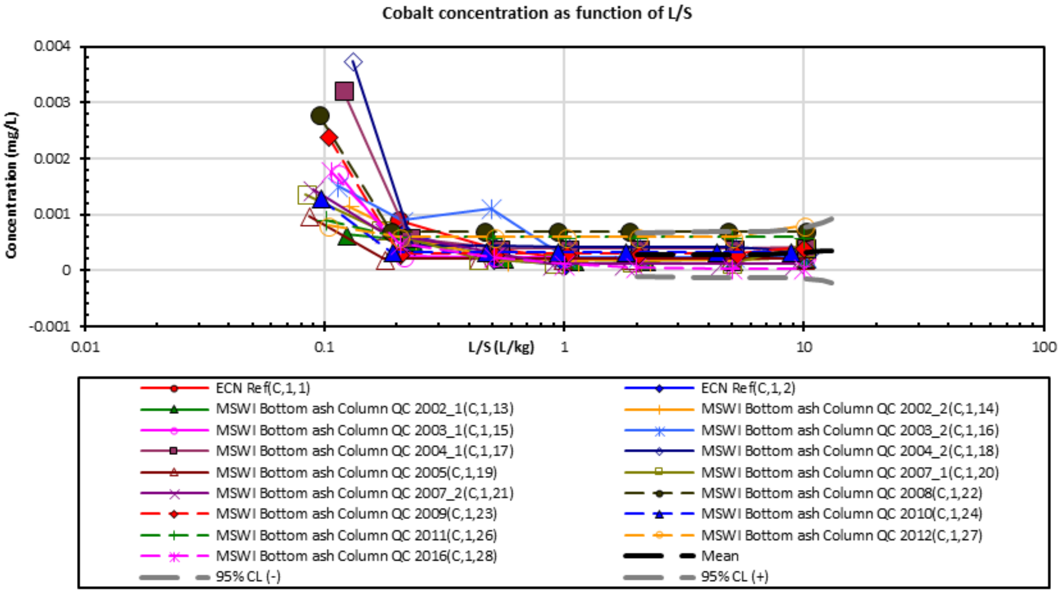

Barium concentration as function of L/S
Concentration (mg/L)
1.5
0.5
-0.5
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

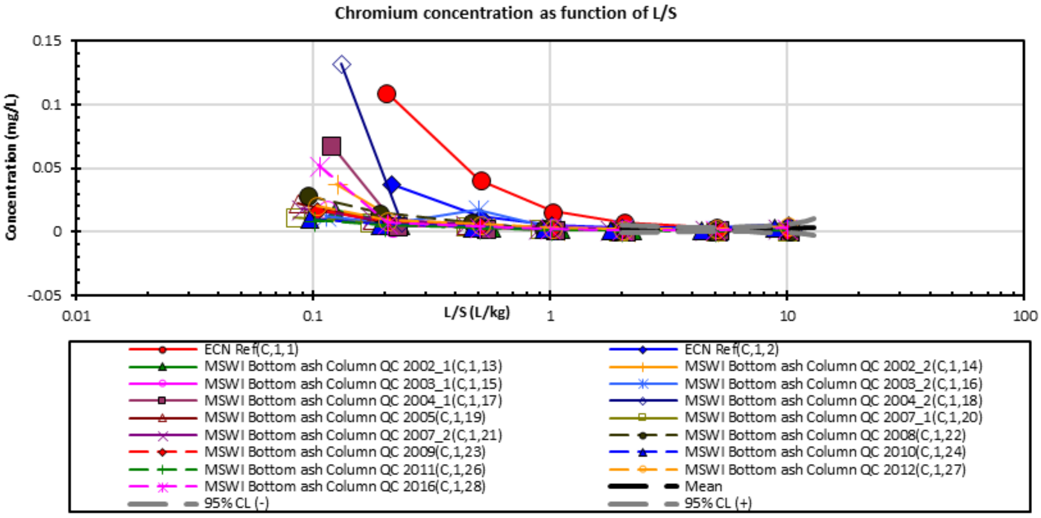

Bromide concentration as function of L/S
Concentration (mg/L)
20
15
10
5
0
-5
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
Mean
95% CL (-)
95% CL (+)

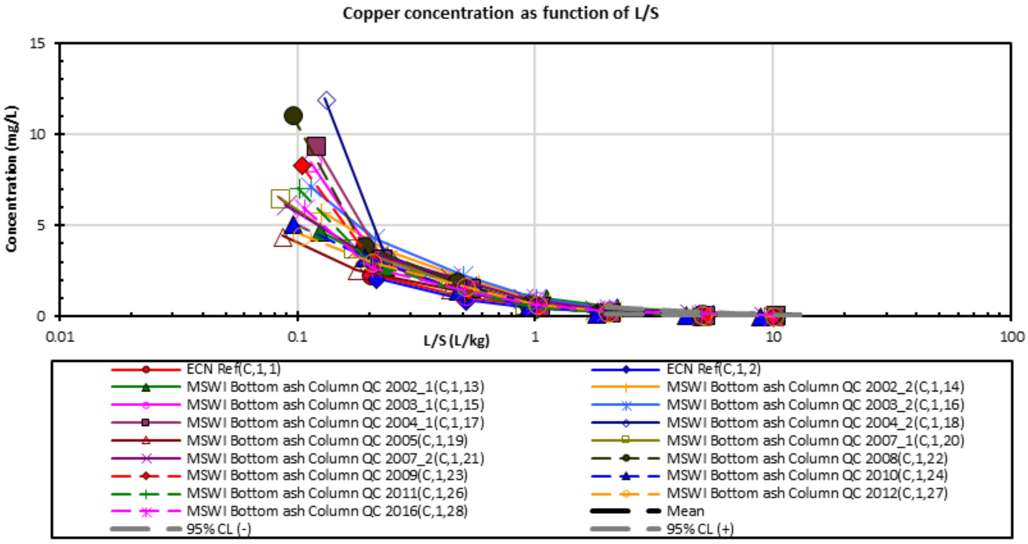

Calcium concentration as function of L/S
Concentration (mg/L)
3000
2000
1000
0
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

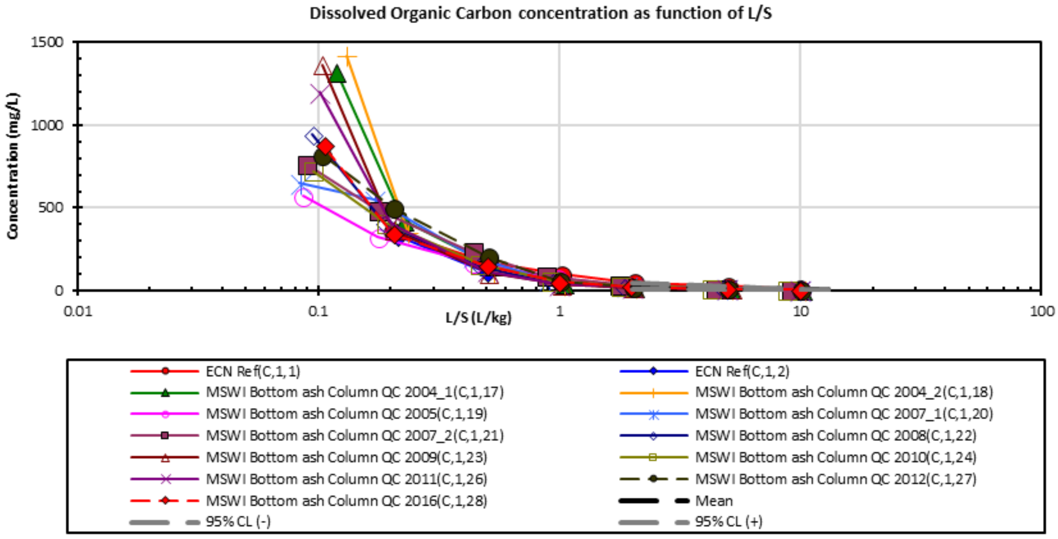

Cadmium concentration as function of L/S
Concentration (mg/L)
0.004
0.002
0
-0.002
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

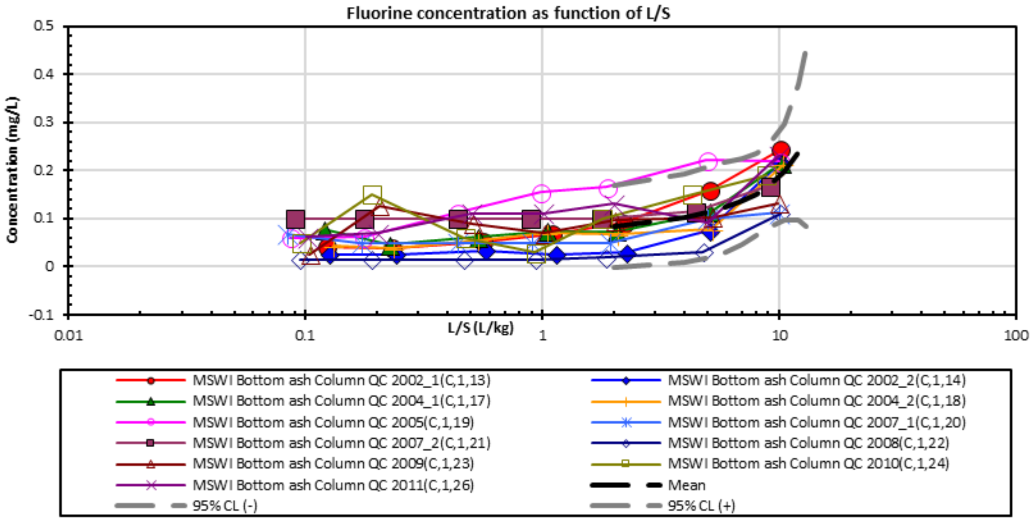

Chlorine concentration as function of L/S
Concentration (mg/L)
25000
20000
15000
10000
5000
0
-5000
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

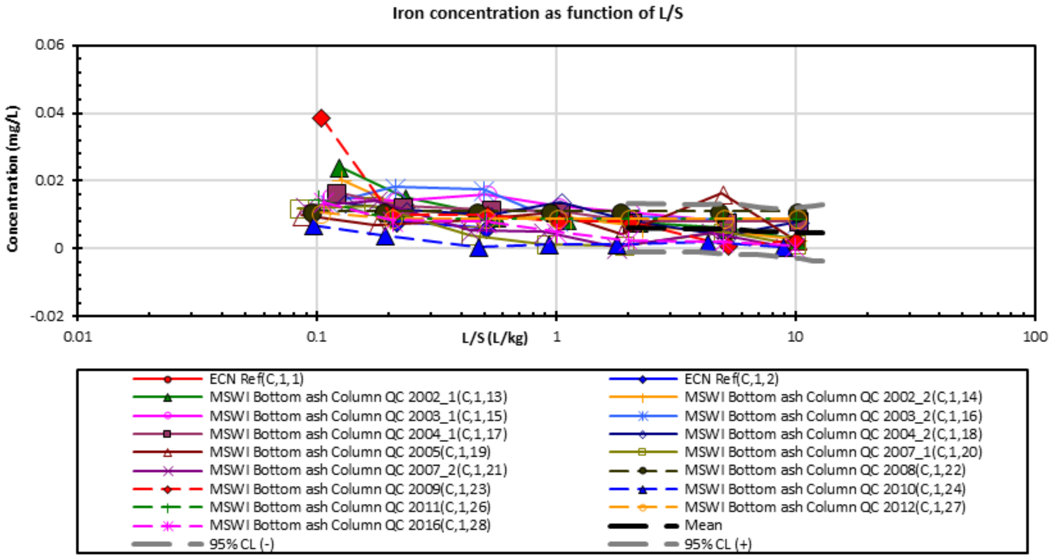

Cobalt concentration as function of L/S
Concentration (mg/L)
0.004
0.003
0.002
0.001
0
-0.001
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

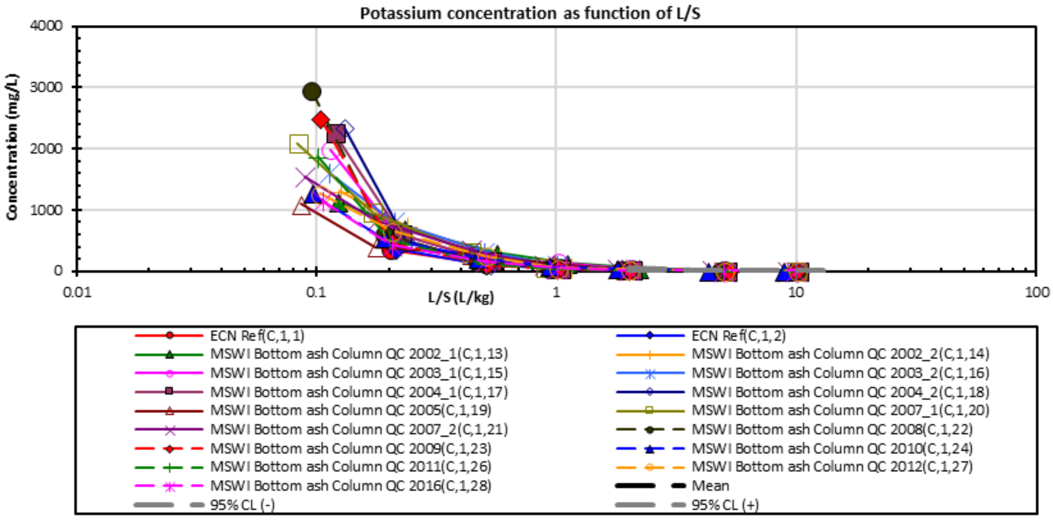

Chromium concentration as function of L/S
Concentration (mg/L)
0.15
0.1
0.05
0
-0.05
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

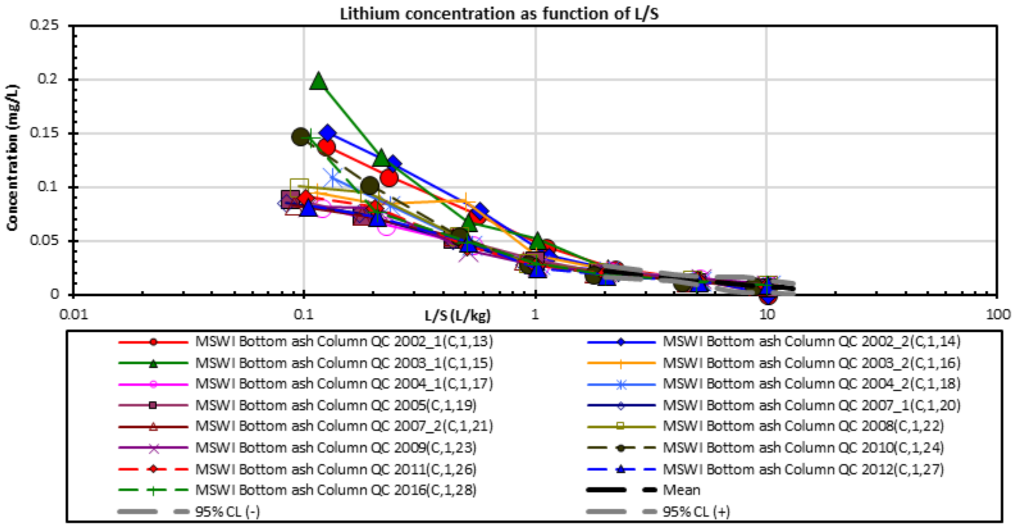

Copper concentration as function of L/S
Concentration (mg/L)
15
10
5
0
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

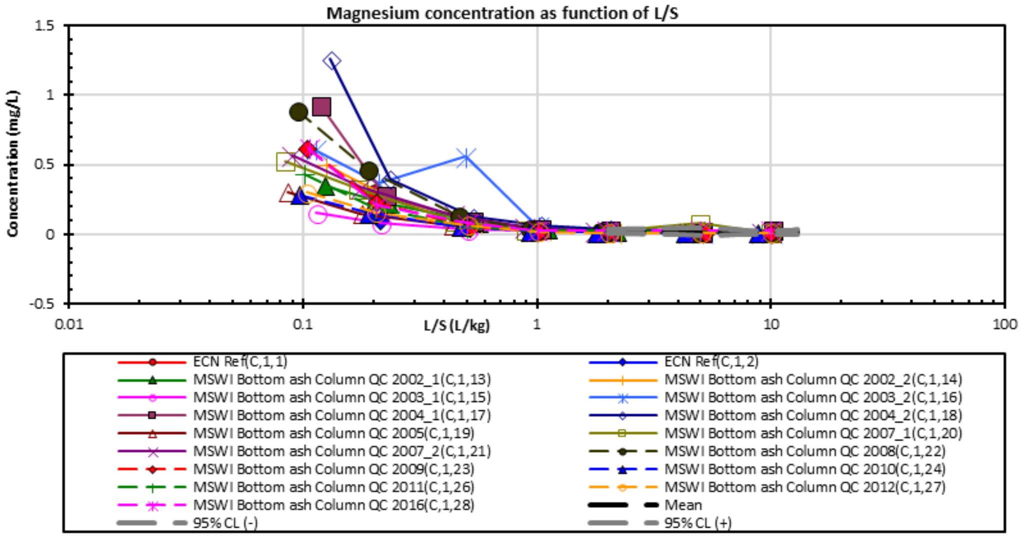

Dissolved Organic Carbon concentration as function of L/S
Concentration (mg/L)
1500
1000
500
0
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

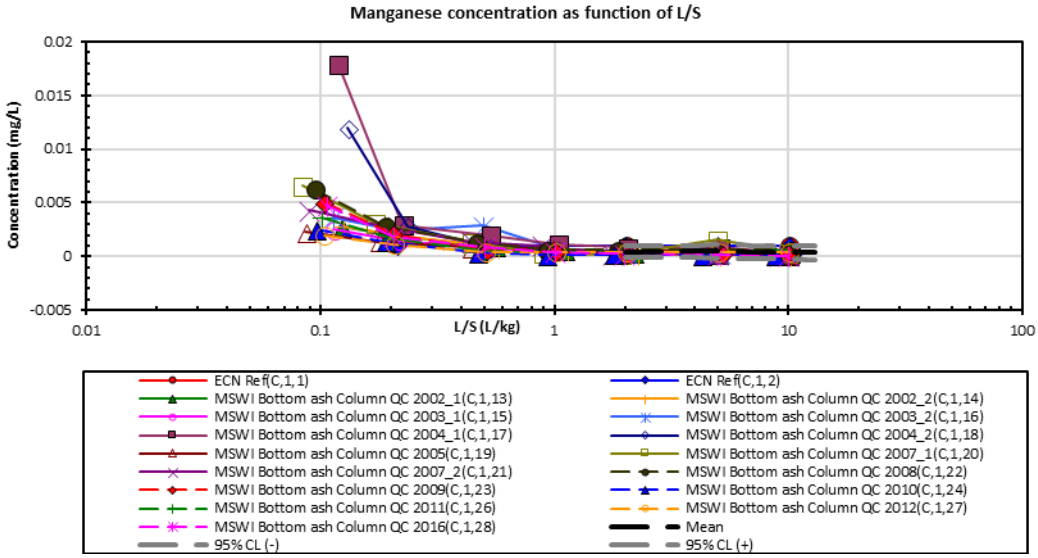

Fluorine concentration as function of L/S
Concentration (mg/L)
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.01
0.1
L/S (L/kg)
1
10
100
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
Mean
95% CL (-)
95% CL (+)

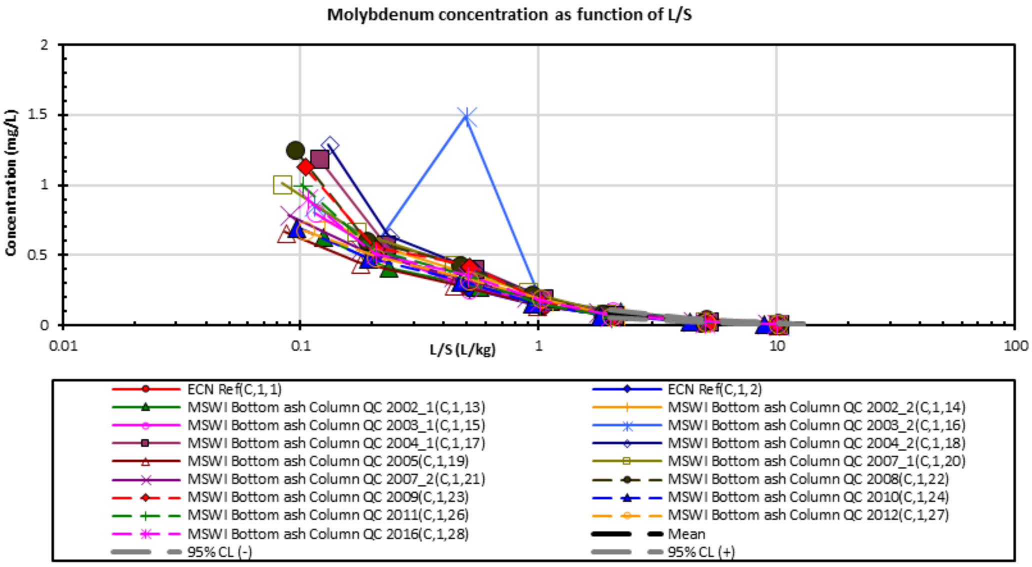

Iron concentration as function of L/S
Concentration (mg/L)
0.06
0.04
0.02
0
-0.02
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

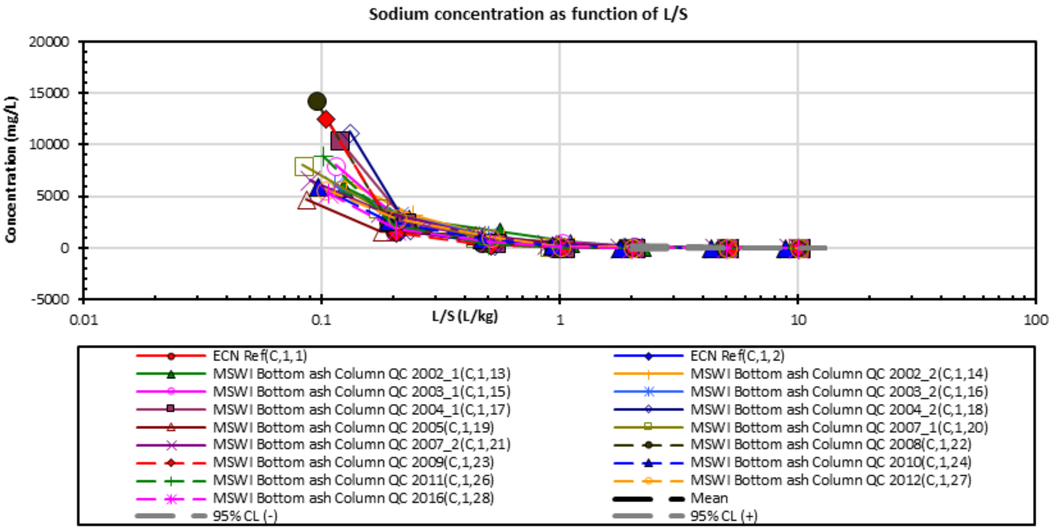

Potassium concentration as function of L/S
Concentration (mg/L)
4000
3000
2000
1000
0
0.01
0.1
L/S (L/kg)
1
10
100
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

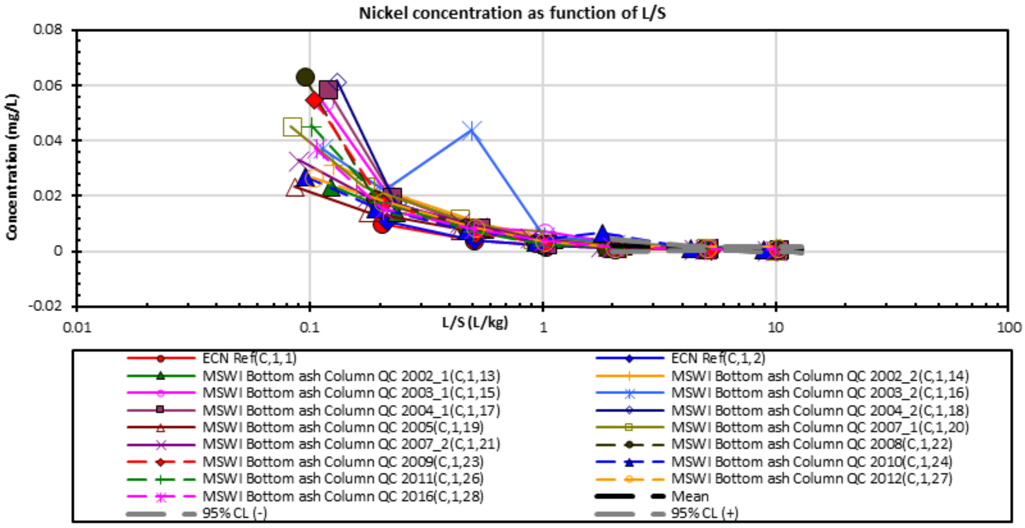

Lithium concentration as function of L/S
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
0.01
0.1
1
10
100
L/S (L/kg)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

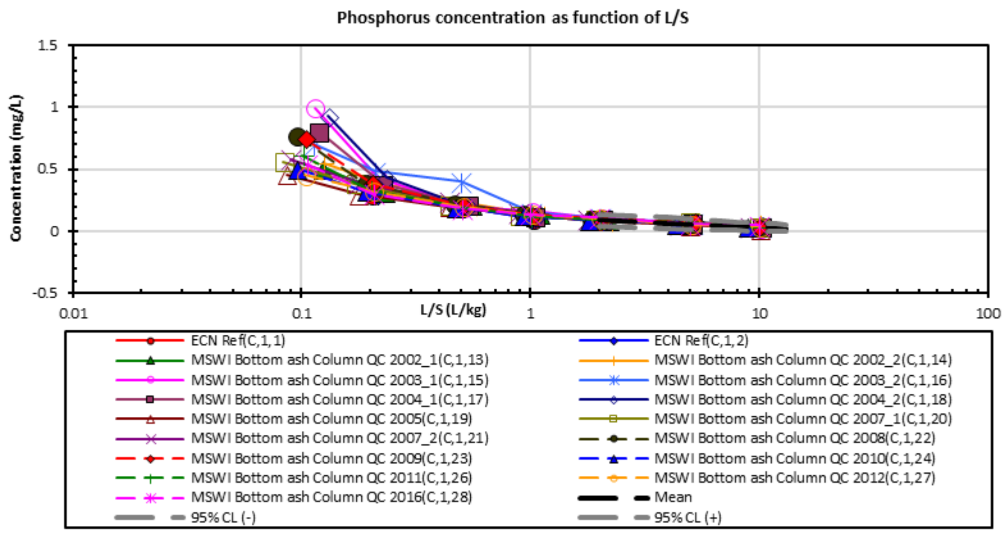

Magnesium concentration as function of L/S
Concentration (mg/L)
1.5
1
0.5
0
-0.5
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

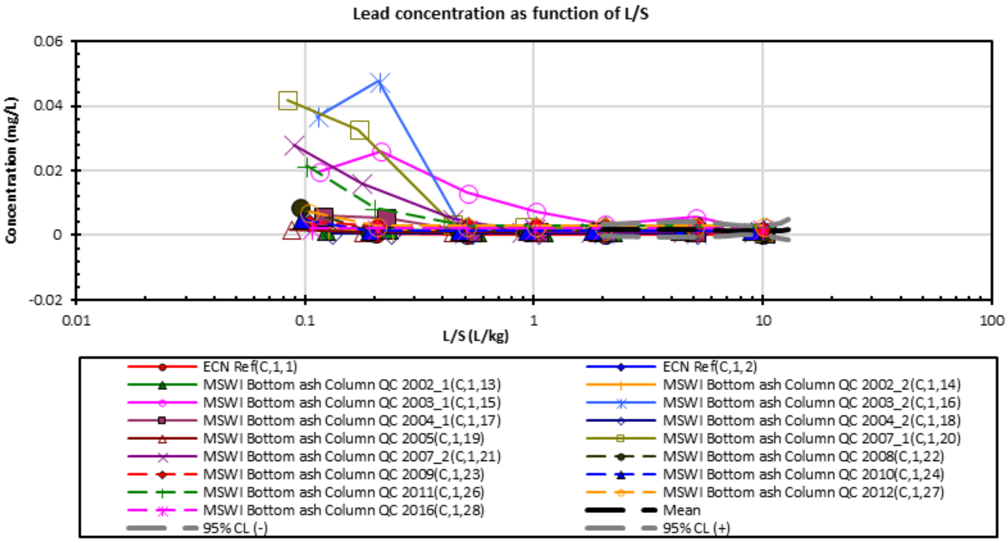

Manganese concentration as function of L/S
Concentration (mg/L)
0.02
0.015
0.01
0.005
0
-0.005
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

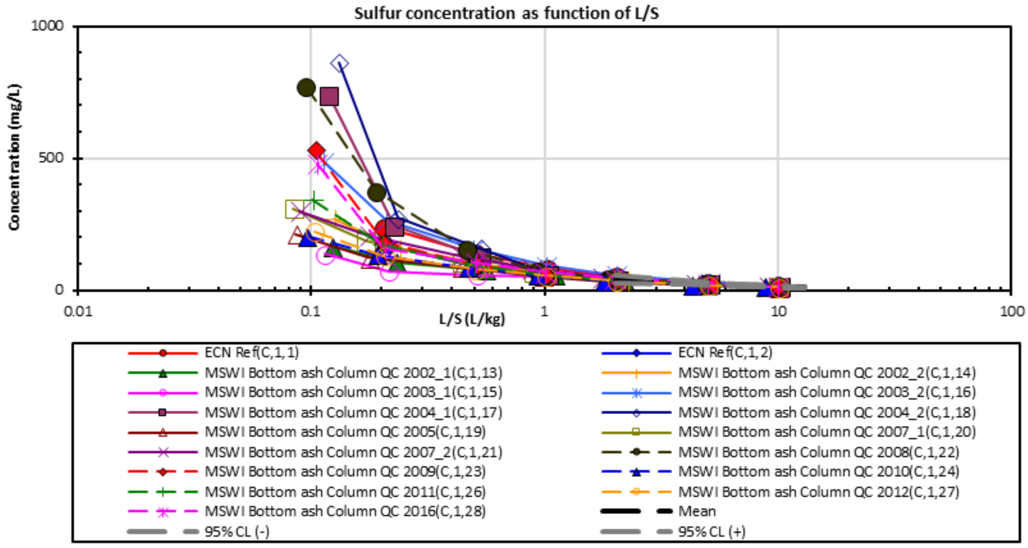

Molybdenum concentration as function of L/S
Concentration (mg/L)
2
1.5
1
0.5
0
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

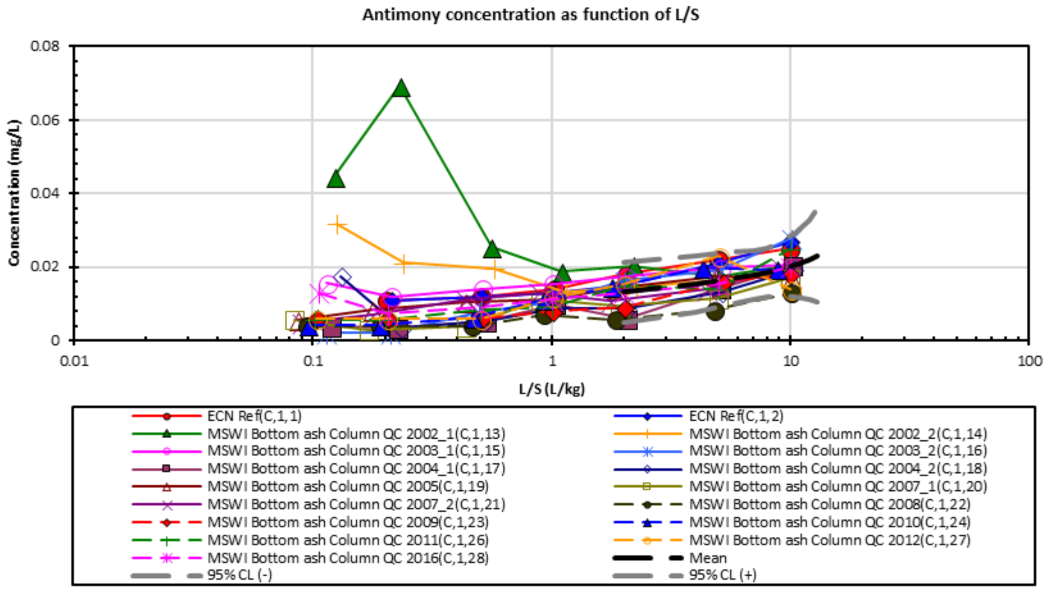

Sodium concentration as function of L/S
Concentration (mg/L)
20000
15000
10000
5000
0
-5000
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

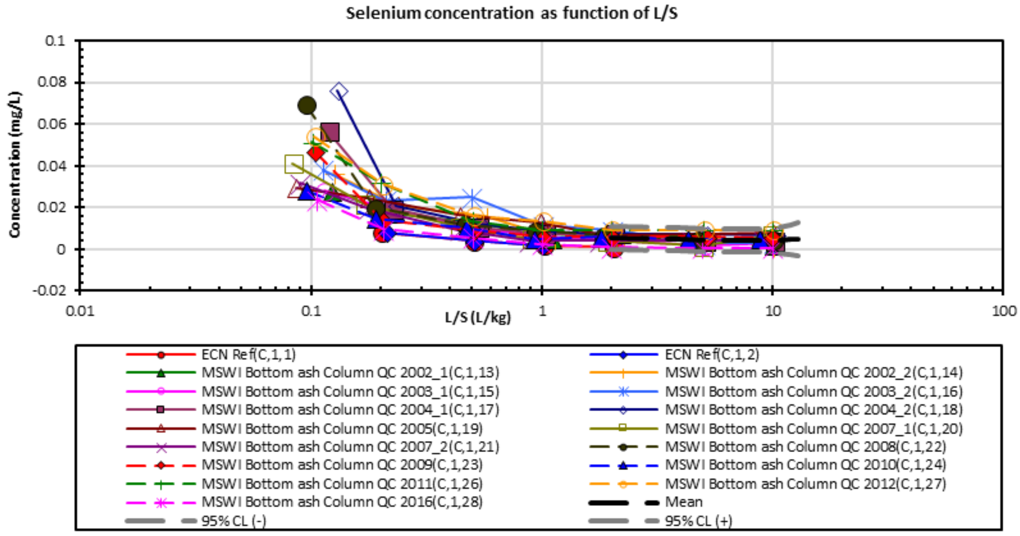

Nickel concentration as function of L/S
Concentration (mg/L)
0.08
0.06
0.04
0.02
0
-0.02
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

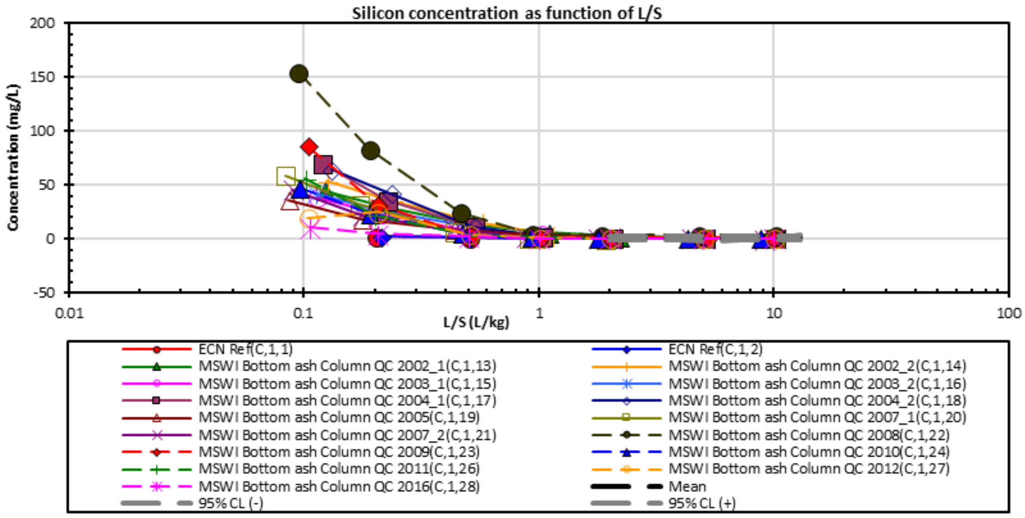

Phosphorus concentration as function of L/S
Concentration (mg/L)
1.5
1
0.5
0
-0.5
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

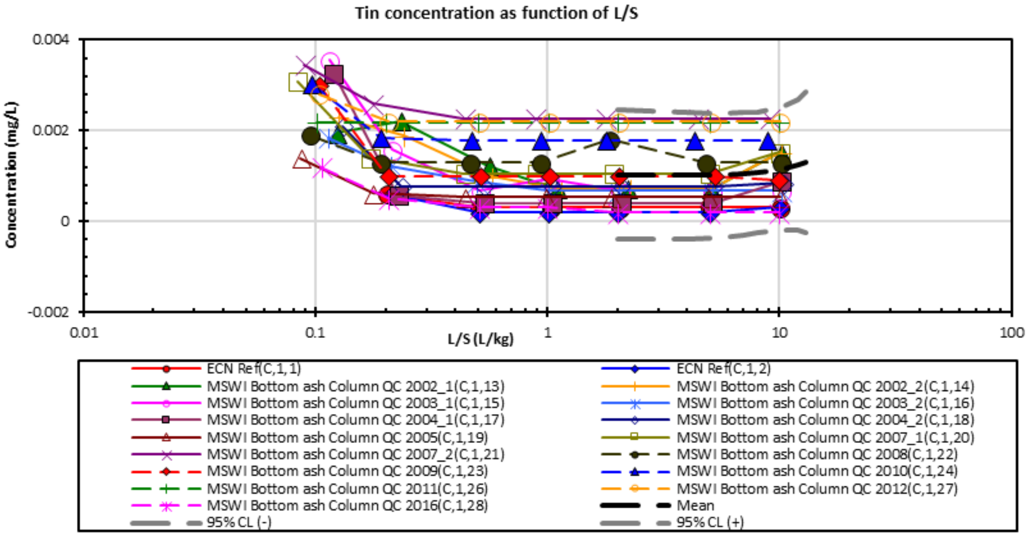

Lead concentration as function of L/S
Concentration (mg/L)
0.06
0.04
0.02
0
-0.02
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

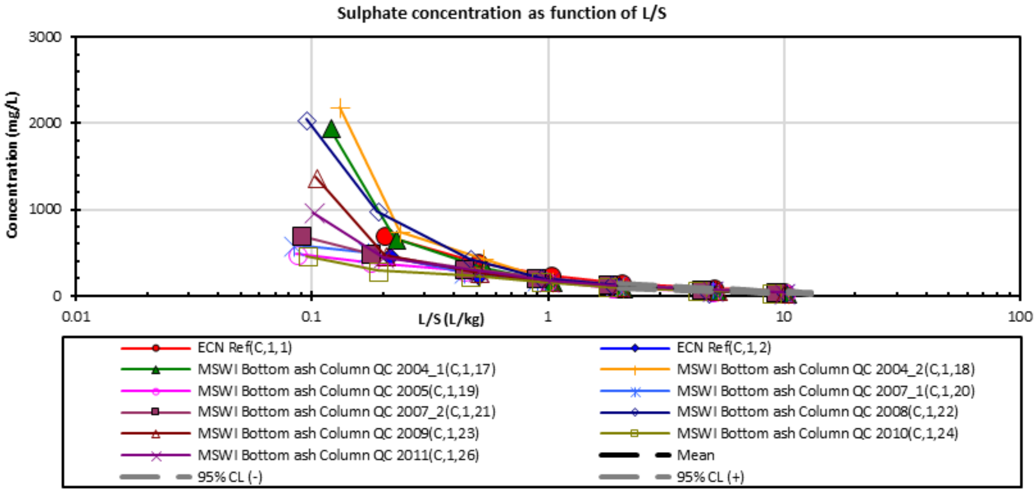

Sulfur concentration as function of L/S
Concentration (mg/L)
1000
500
0
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

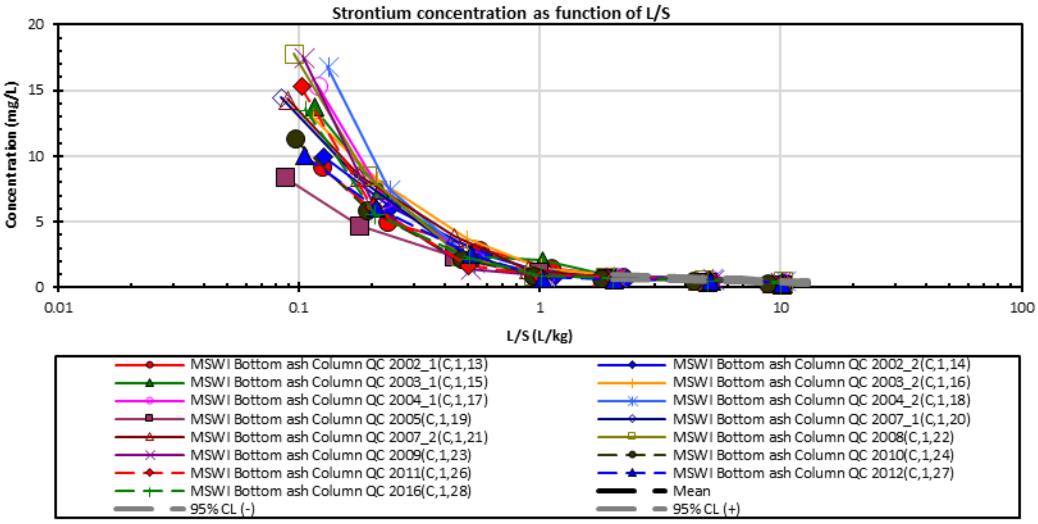

Antimony concentration as function of L/S
Concentration (mg/L)
0.08
0.06
0.04
0.02
0
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

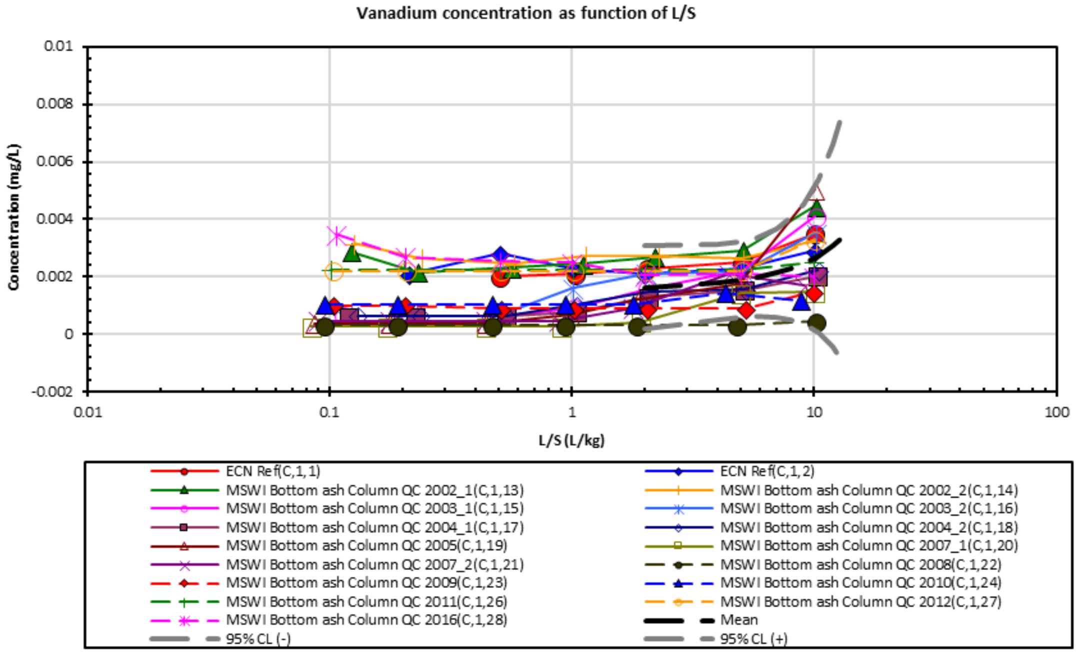

Selenium concentration as function of L/S
Concentration (mg/L)
0.1
0.08
0.06
0.04
0.02
0
-0.02
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

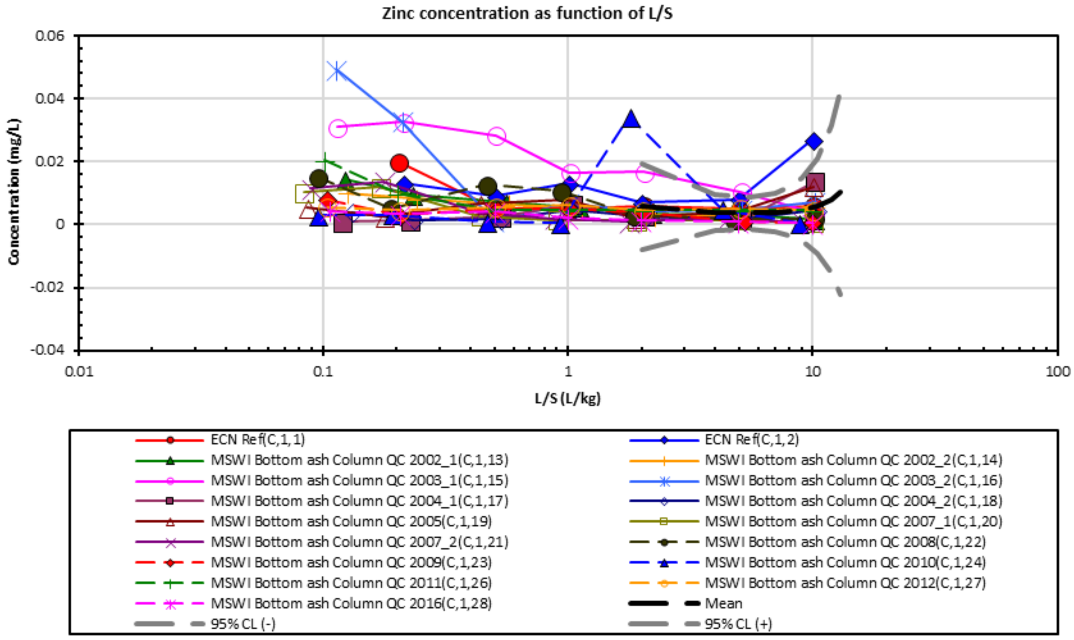

Silicon concentration as function of L/S
Concentration (mg/L)
200
150
100
50
0
-50
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
95% CL (-)
Mean
95% CL (+)


Tin concentration as function of L/S
Concentration (mg/L)
0.004
0.002
0
-0.002
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)


Sulphate concentration as function of L/S
Concentration (mg/L)
3000
2000
1000
0
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
Mean
95% CL (-)
95% CL (+)


Strontium concentration as function of L/S
Concentration (mg/L)
20
15
10
5
0
0.01
0.1
1
10
100
L/S (L/kg)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

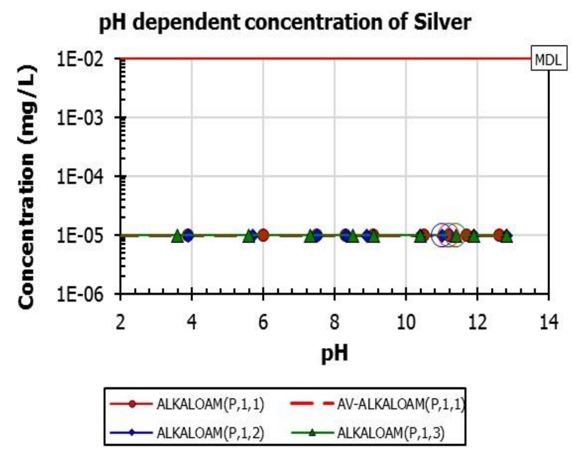

Vanadium concentration as function of L/S
Concentration (mg/L)
0.01
0.008
0.006
0.004
0.002
0
-0.002
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

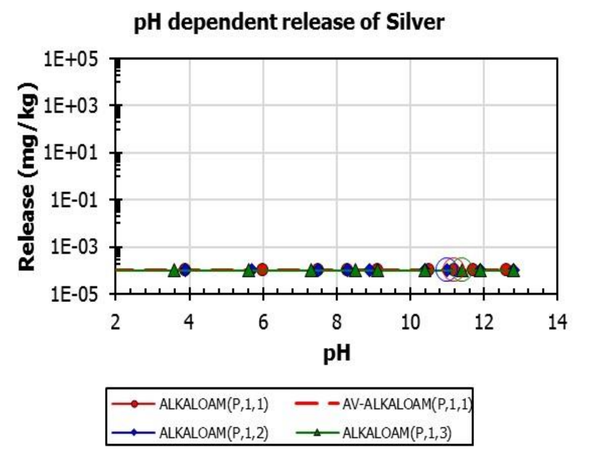

Zinc concentration as function of L/S
Concentration (mg/L)
0.06
0.04
0.02
0
-0.02
-0.04
0.01
0.1
1
10
100
L/S (L/kg)
ECN Ref(C,1,1)
ECN Ref(C,1,2)
MSWI Bottom ash Column QC 2002_1(C,1,13)
MSWI Bottom ash Column QC 2002_2(C,1,14)
MSWI Bottom ash Column QC 2003_1(C,1,15)
MSWI Bottom ash Column QC 2003_2(C,1,16)
MSWI Bottom ash Column QC 2004_1(C,1,17)
MSWI Bottom ash Column QC 2004_2(C,1,18)
MSWI Bottom ash Column QC 2005(C,1,19)
MSWI Bottom ash Column QC 2007_1(C,1,20)
MSWI Bottom ash Column QC 2007_2(C,1,21)
MSWI Bottom ash Column QC 2008(C,1,22)
MSWI Bottom ash Column QC 2009(C,1,23)
MSWI Bottom ash Column QC 2010(C,1,24)
MSWI Bottom ash Column QC 2011(C,1,26)
MSWI Bottom ash Column QC 2012(C,1,27)
MSWI Bottom ash Column QC 2016(C,1,28)
Mean
95% CL (-)
95% CL (+)

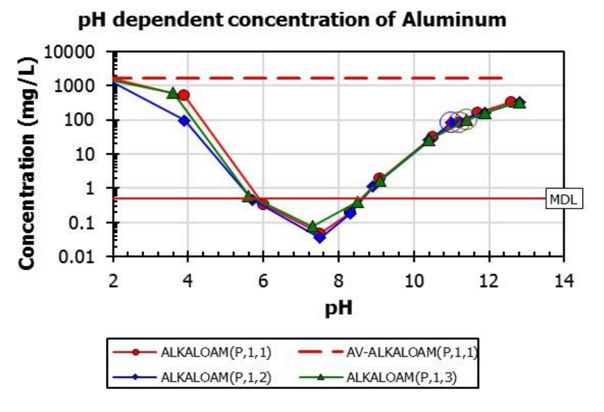
Appendix A5: Graphical Presentation of Analytical Data for Method 1313.

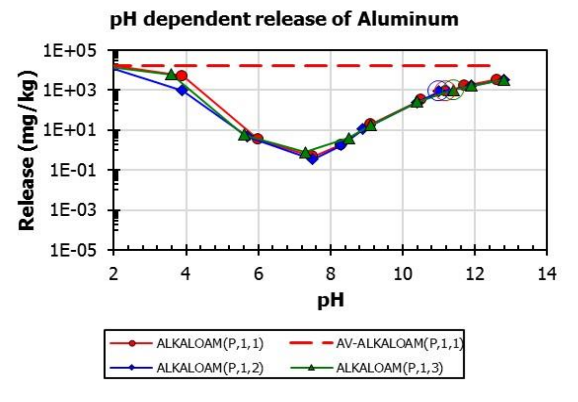
A5-1: Alkaloam by-product

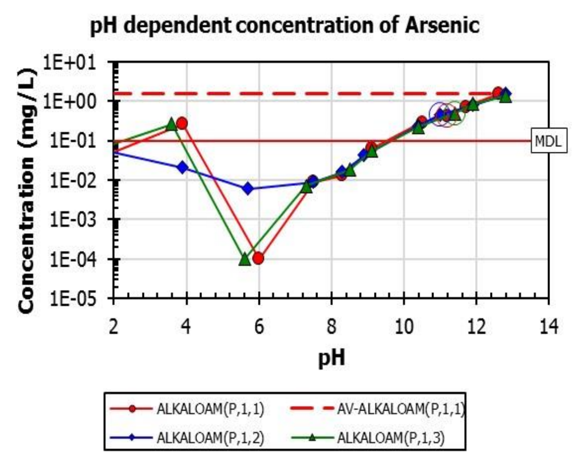
(Note: AV-Alkaloam – represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

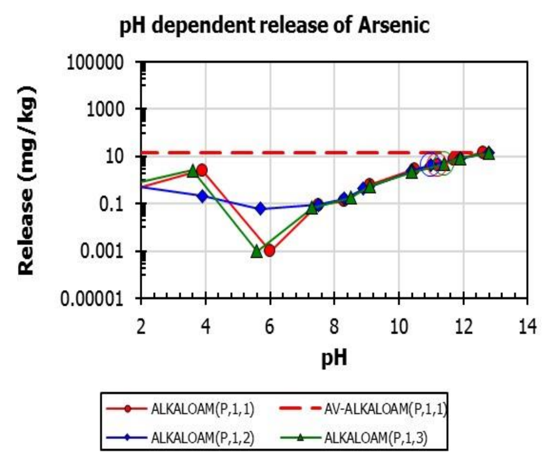


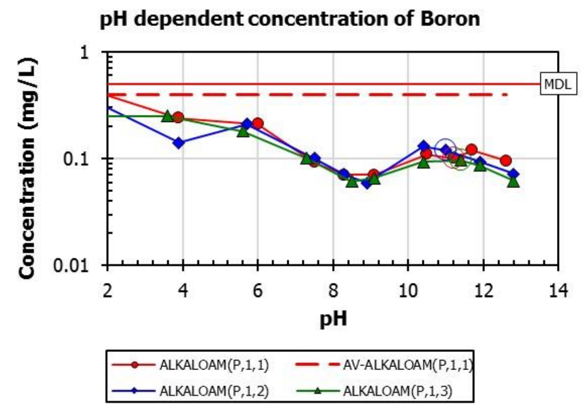


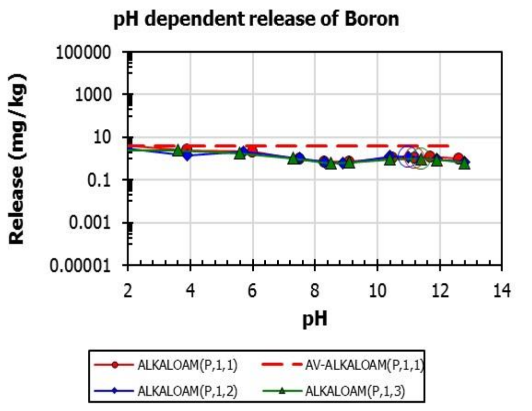


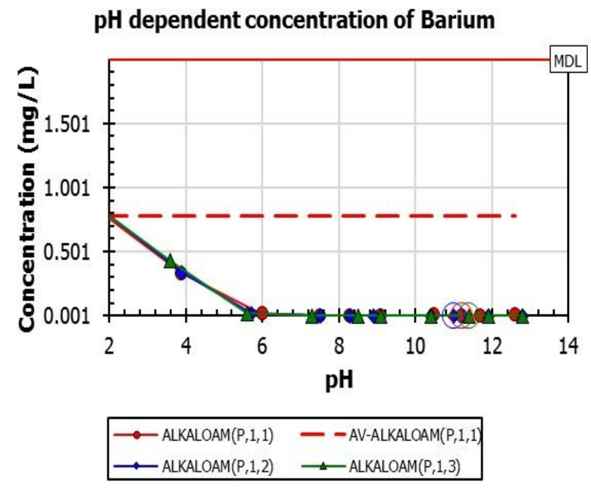


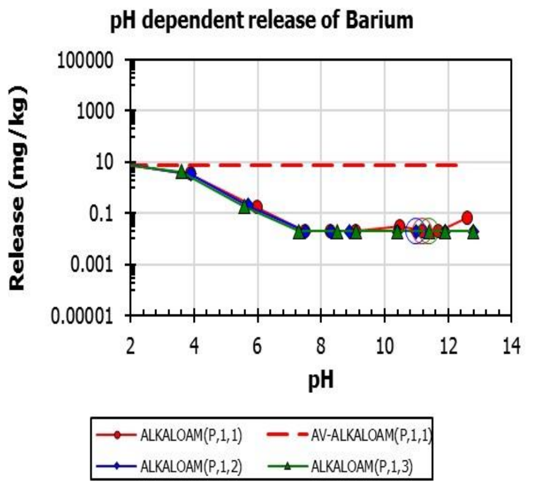


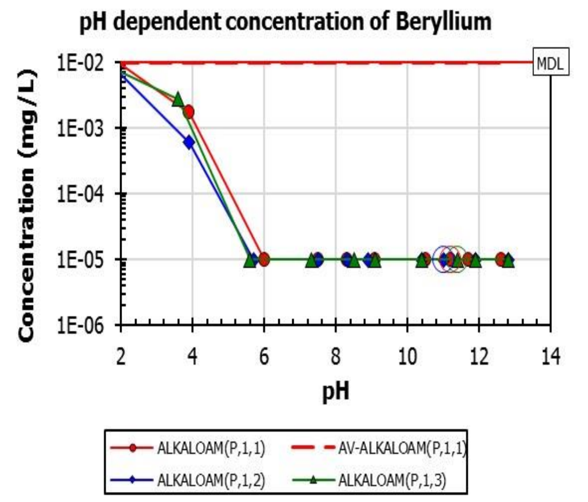


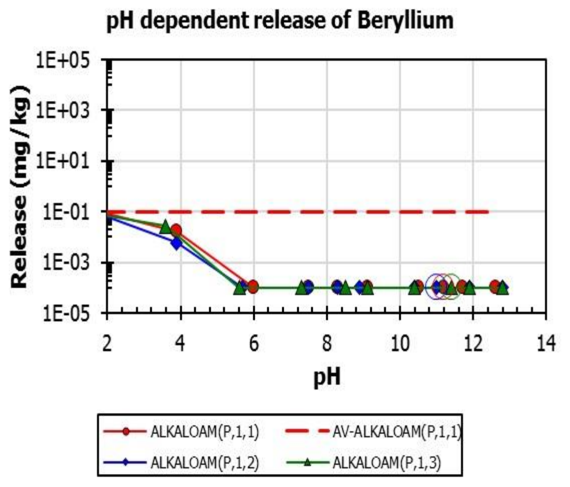

pH dependent concentration of Boron
Concentration (mg/L)
1
0.1
0.01
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

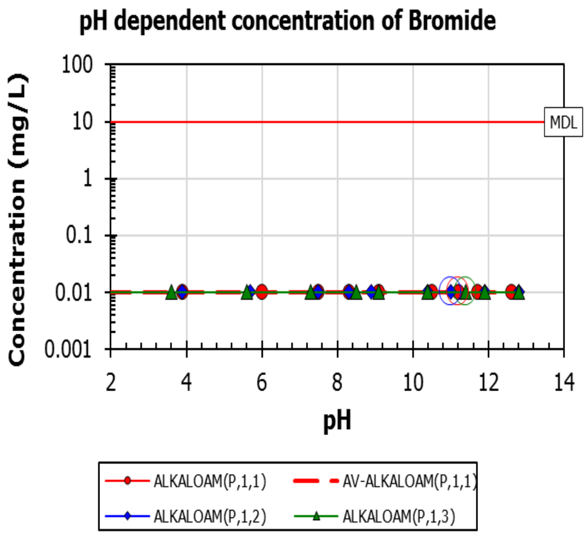

pH dependent release of Boron
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

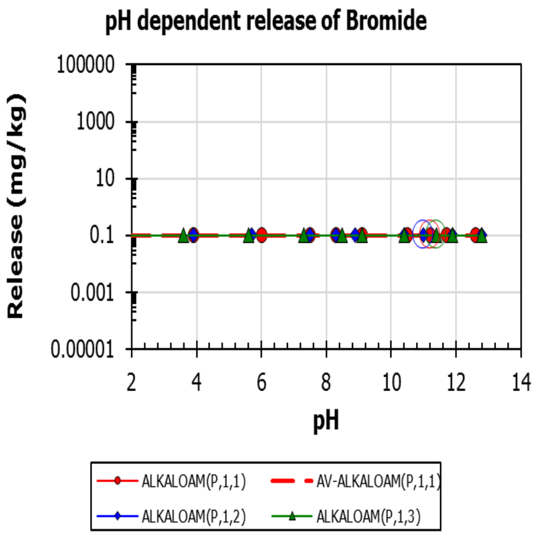

pH dependent concentration of Barium
Concentration (mg/L)
1.501
1.001
0.501
0.001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

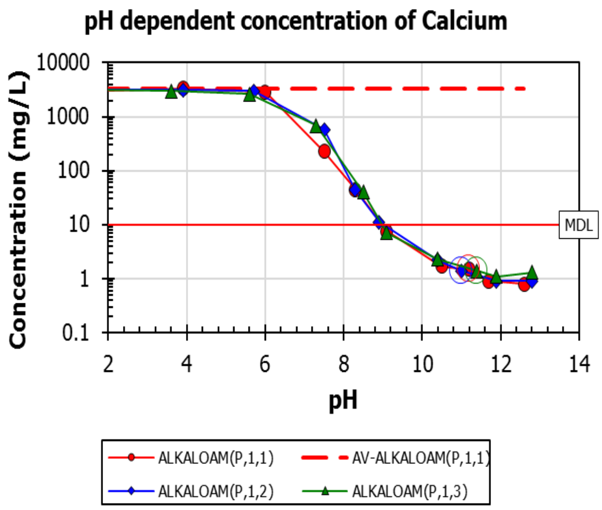

pH dependent release of Barium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

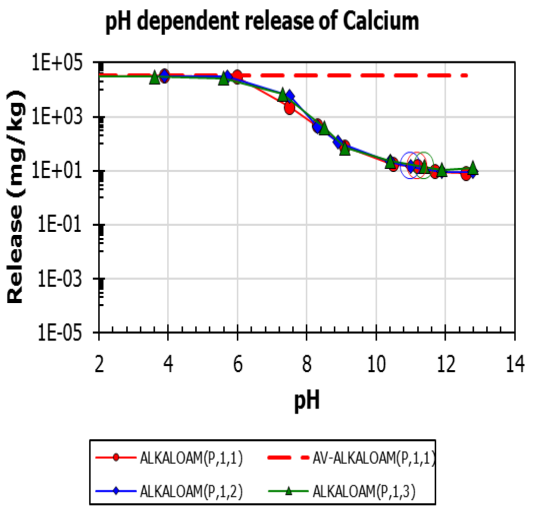

pH dependent concentration of Beryllium
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

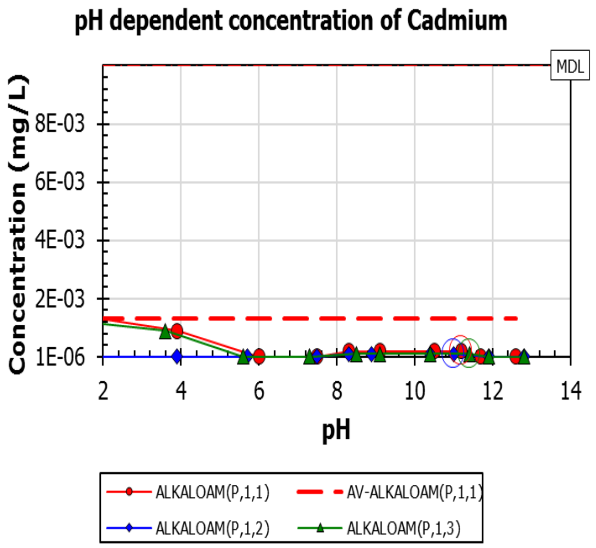

pH dependent release of Beryllium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

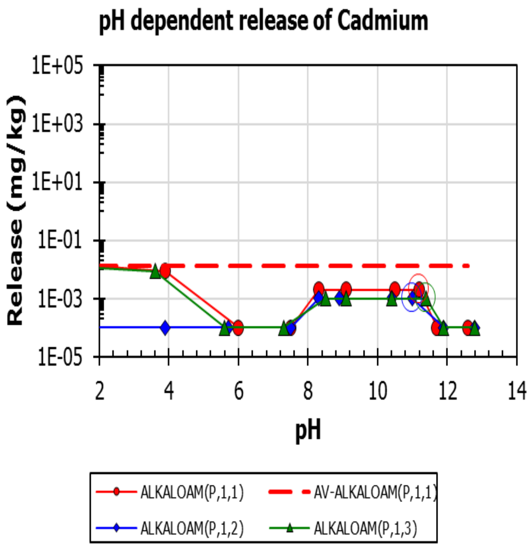

pH dependent concentration of Bromide
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

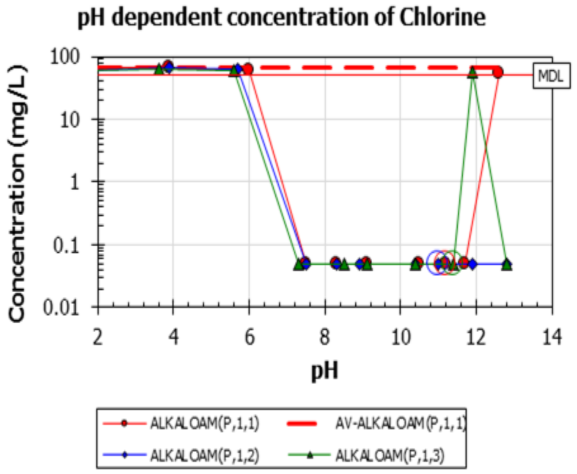

pH dependent release of Bromide
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

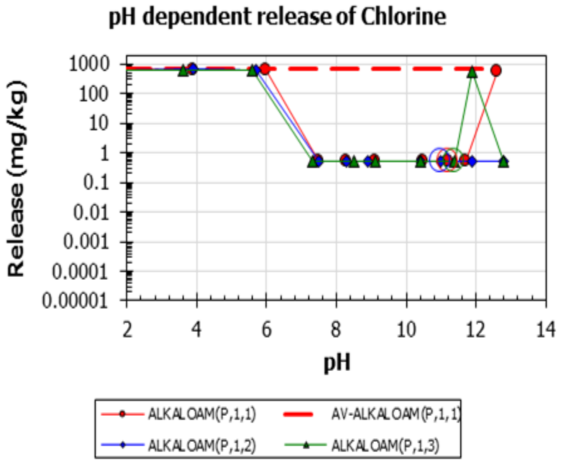

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1000
100
10
1
0.1
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

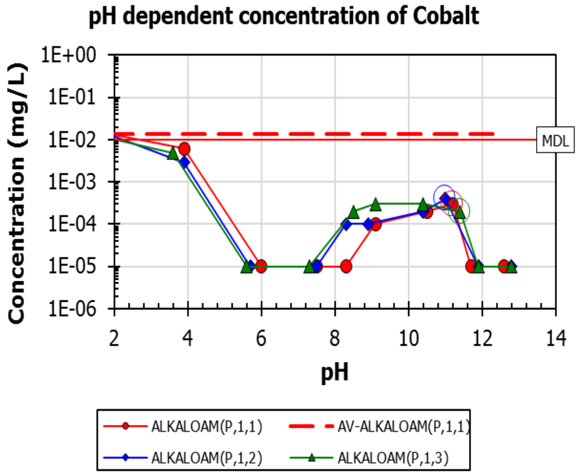

pH dependent release of Calcium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

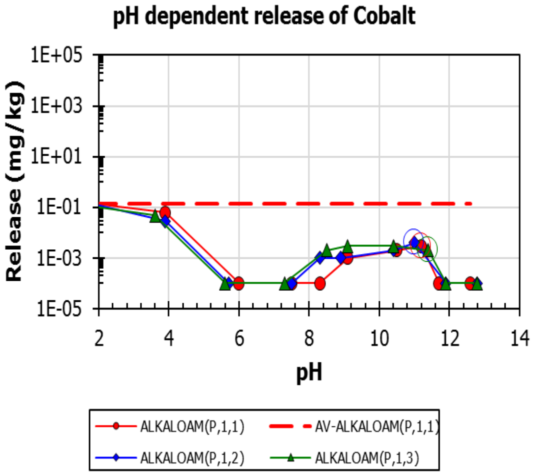

pH dependent concentration of Cadmium
Concentration (mg/L)
MDL
8E-03
6E-03
4E-03
2E-03
1E-06
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

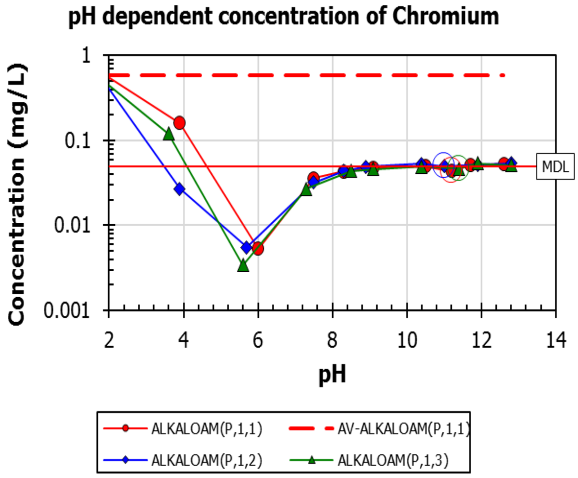

pH dependent release of Cadmium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

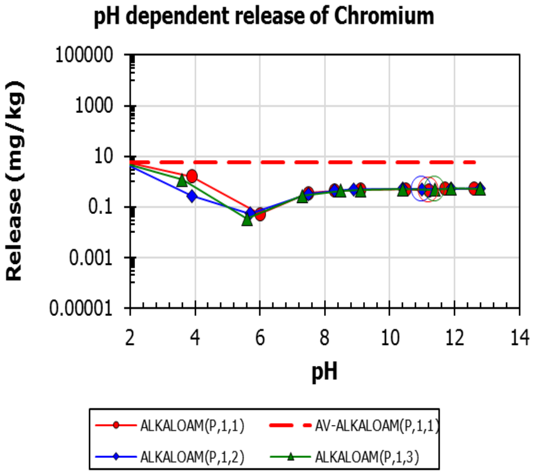

pH dependent concentration of Chlorine
Concentration (mg/L)
100
10
1
0.1
0.01
2
4
6
8
10
12
14
pH
MDL
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

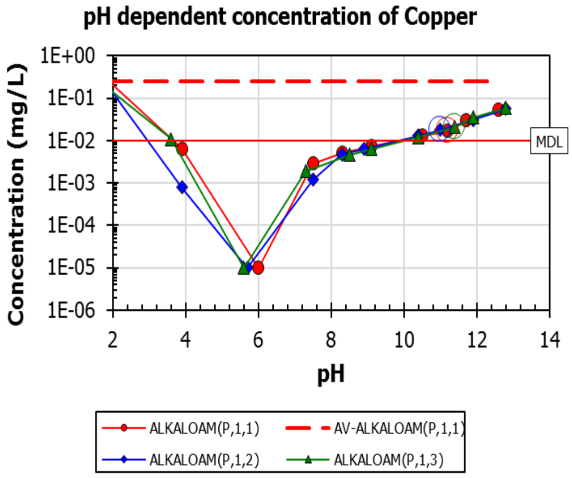

pH dependent release of Chlorine
Release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

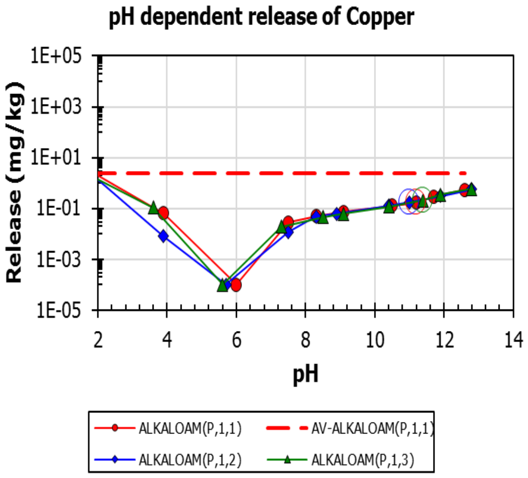

pH dependent concentration of Cobalt
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
2
4
6
8
10
12
14
pH
MDL
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

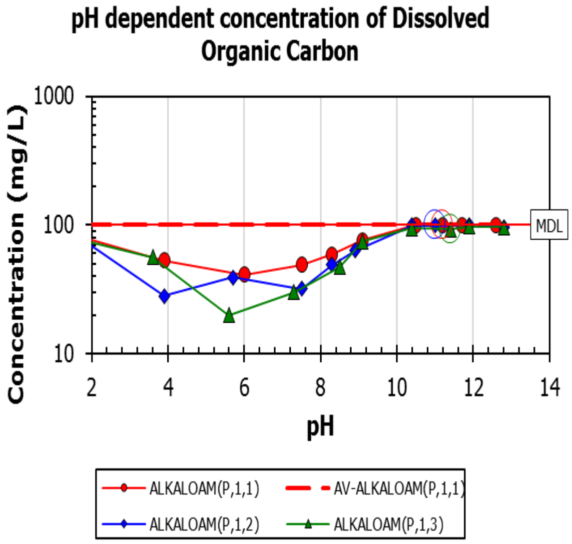

pH dependent release of Cobalt
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

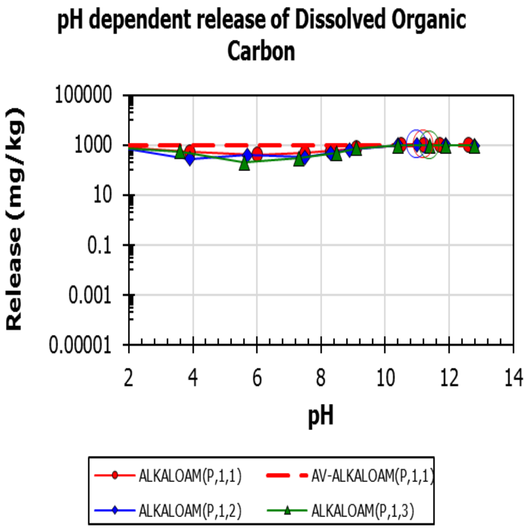

pH dependent concentration of Chromium
Concentration (mg/L)
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
MDL
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

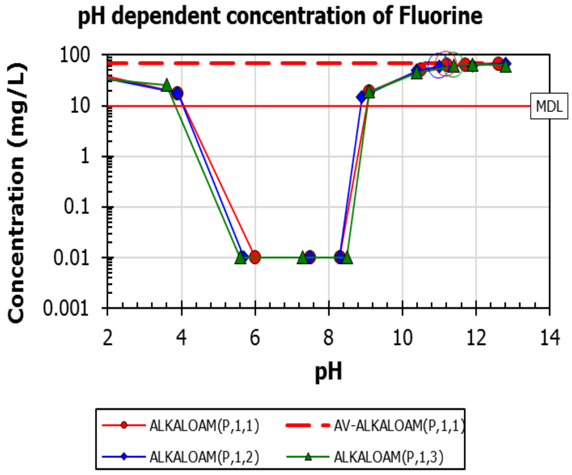

pH dependent release of Chromium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

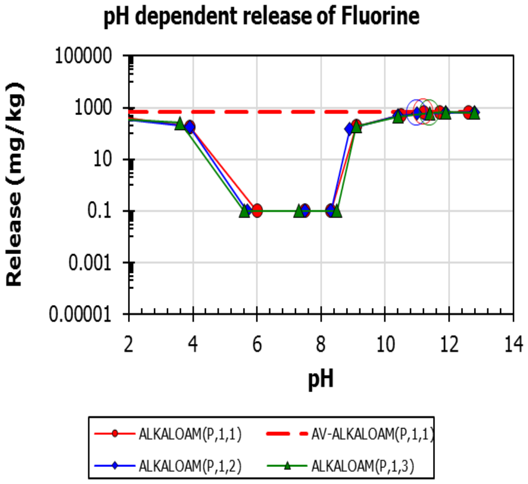

pH dependent concentration of Copper

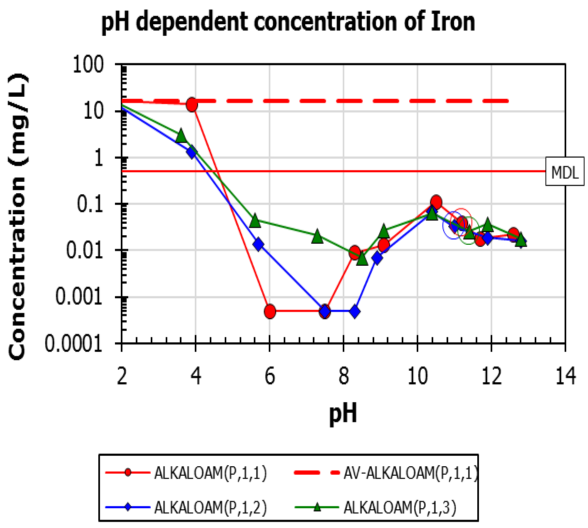

pH dependent release of Copper

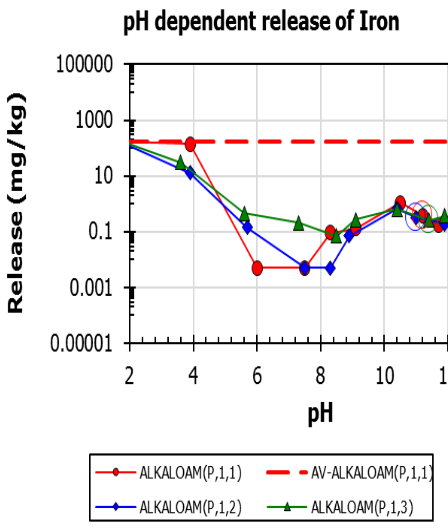

pH dependent concentration of Dissolved Organic Carbon

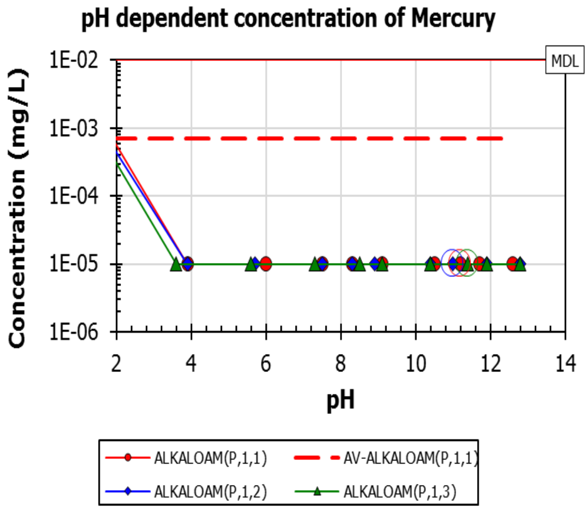

pH dependent release of Dissolved Organic Carbon

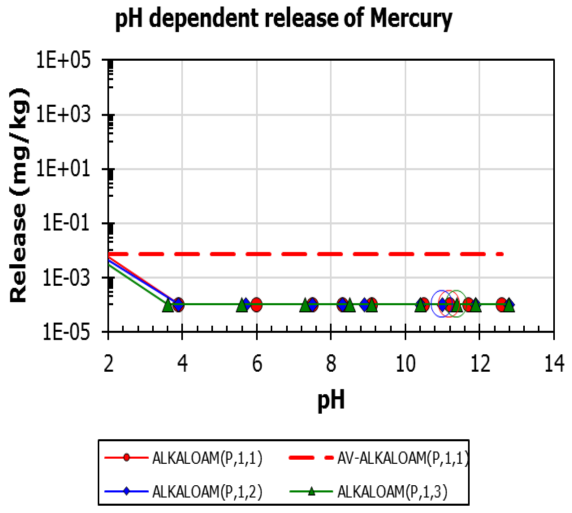

pH dependent concentration of Fluorine

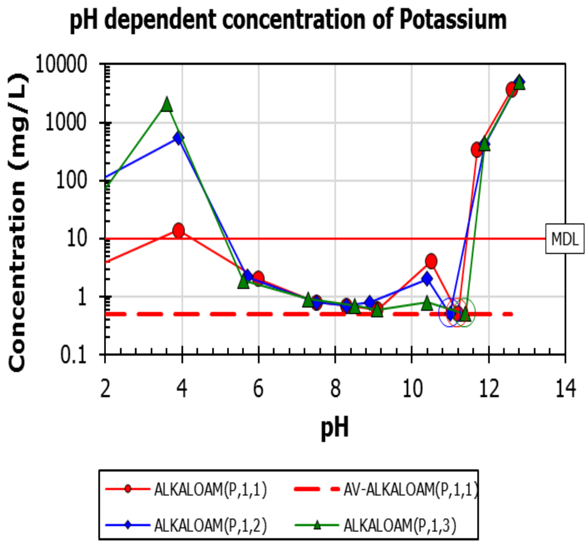

pH dependent release of Fluorine

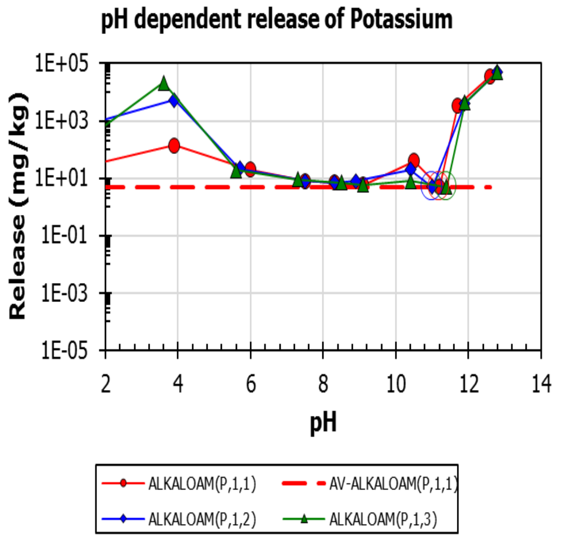

pH dependent concentration of Iron
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)


pH dependent release of Iron
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

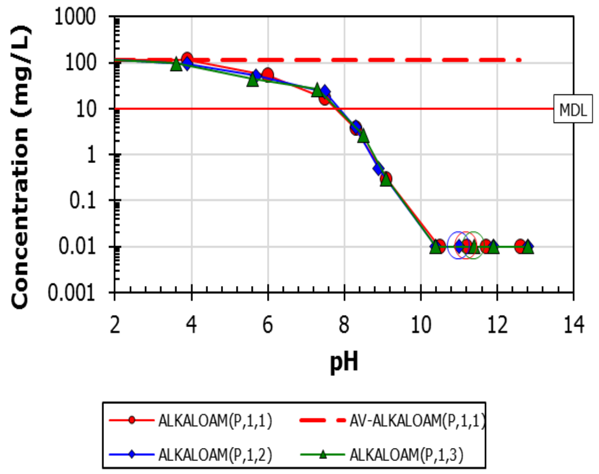

pH dependent concentration of Mercury
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)


pH dependent release of Mercury
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

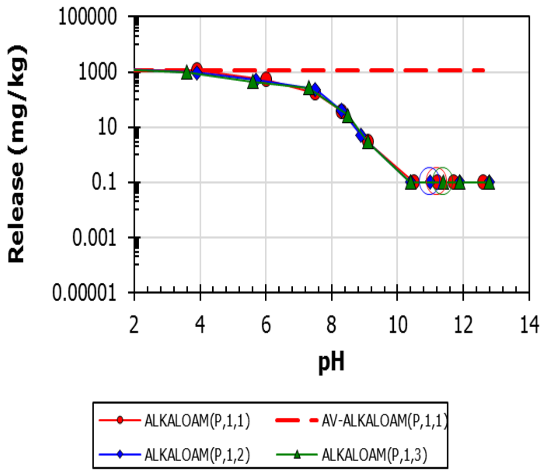

pH dependent concentration of Potassium
Concentration (mg/L)
10000
1000
100
10
1
0.1
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)


pH dependent release of Potassium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

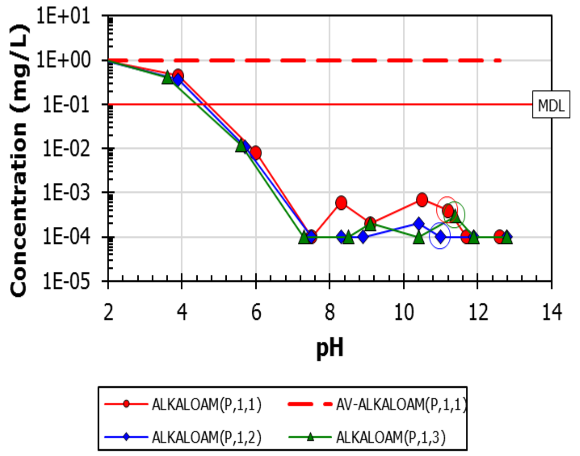
pH dependent concentration of Magnesium



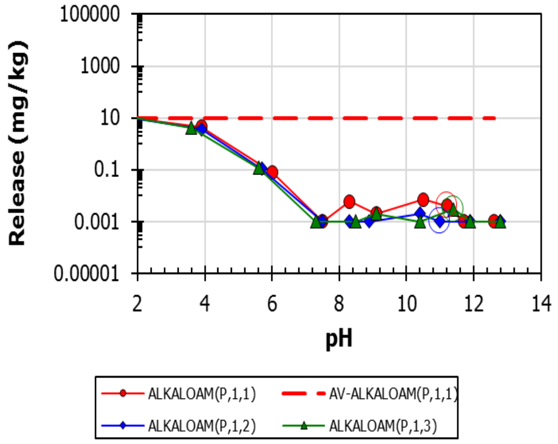
pH dependent release of Magnesium



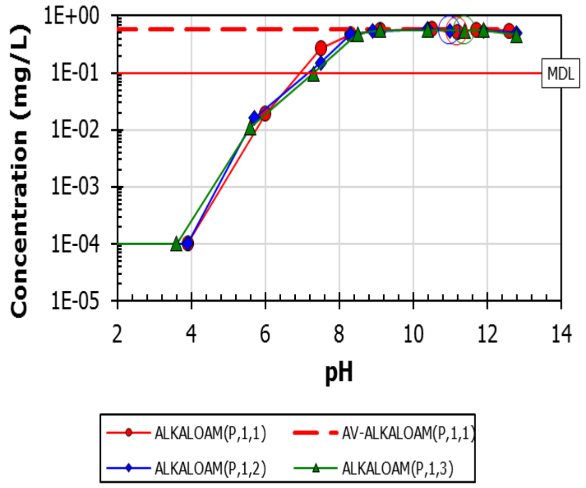
pH dependent concentration of Manganese



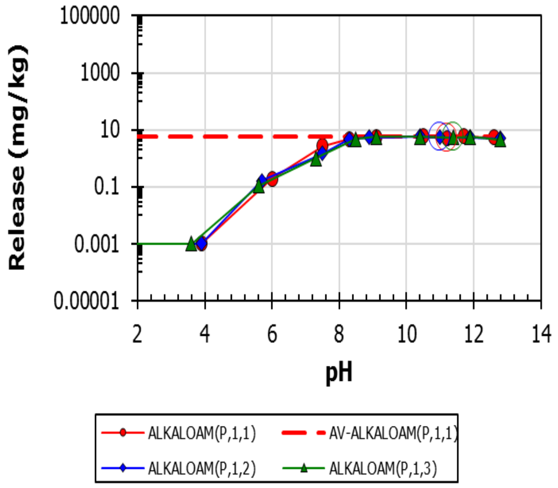
pH dependent release of Manganese

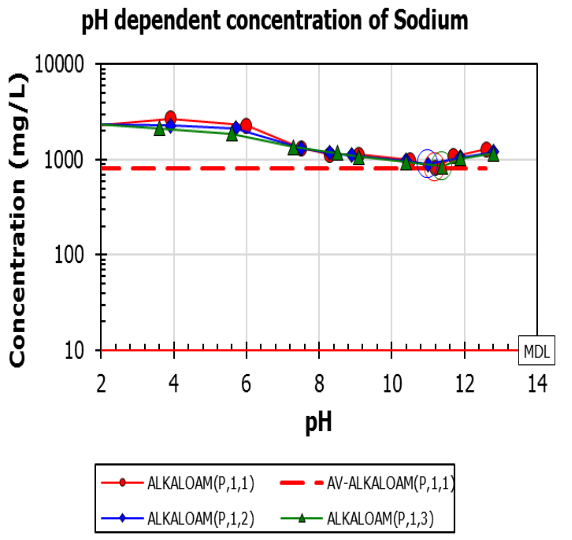


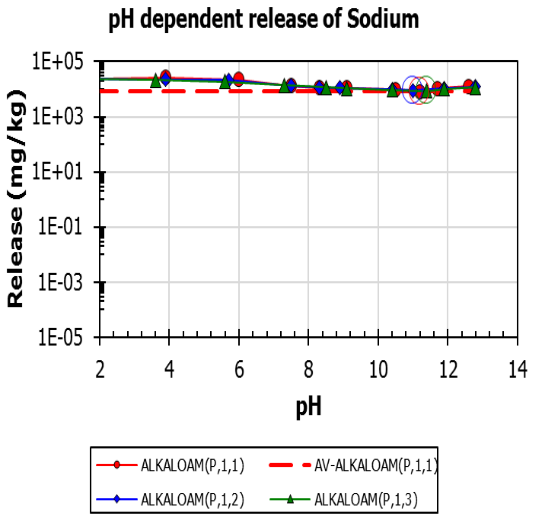
pH dependent concentration of Molybdenum

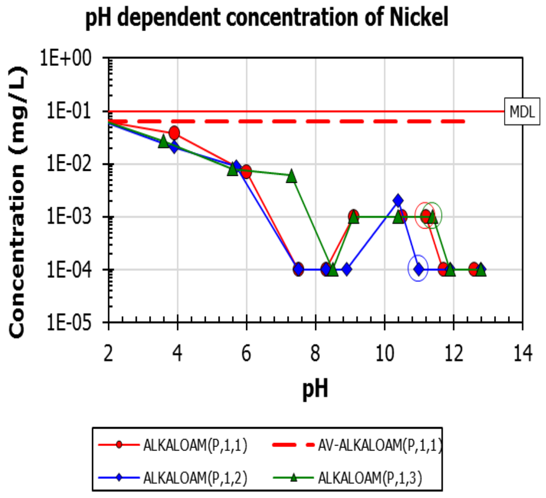


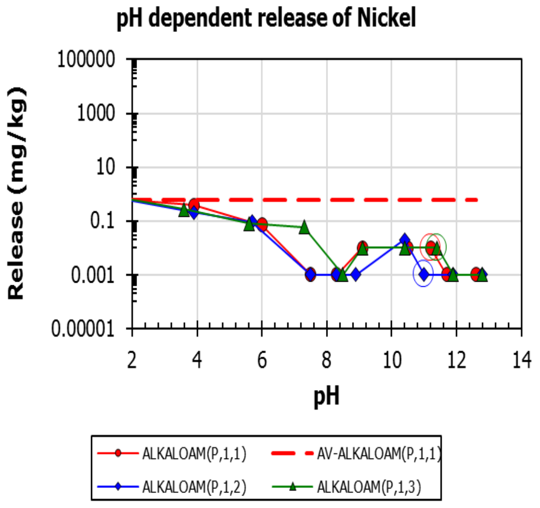
pH dependent release of Molybdenum

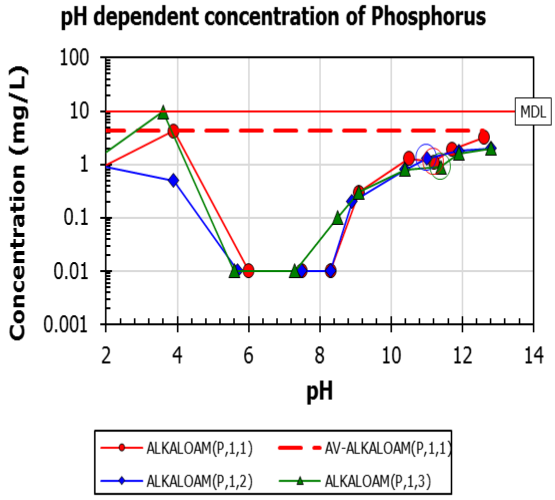


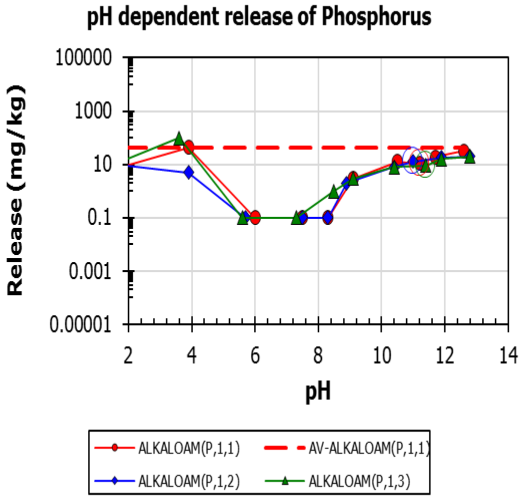

pH dependent concentration of Sodium
Concentration (mg/L)
10000
1000
100
10
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

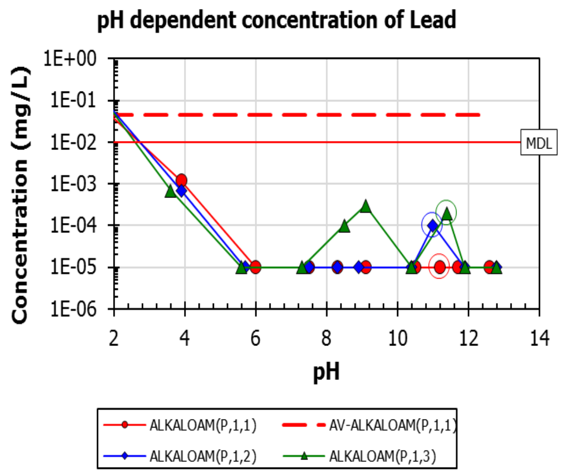

pH dependent release of Sodium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

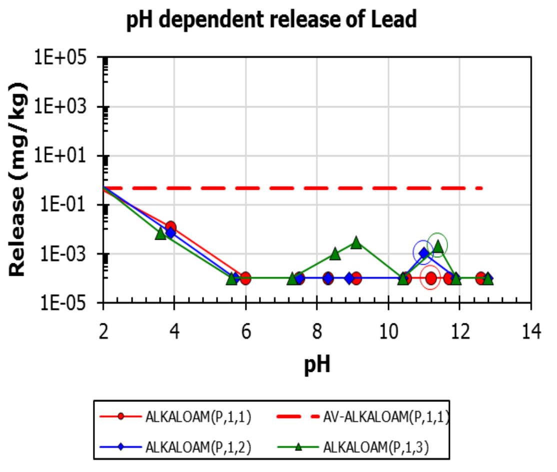

pH dependent concentration of Nickel
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

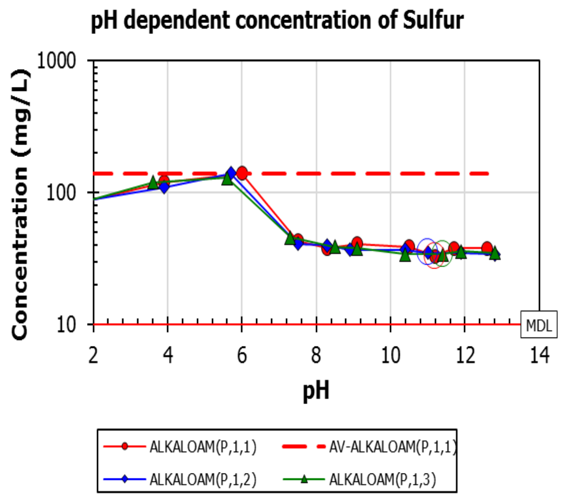

pH dependent release of Nickel
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

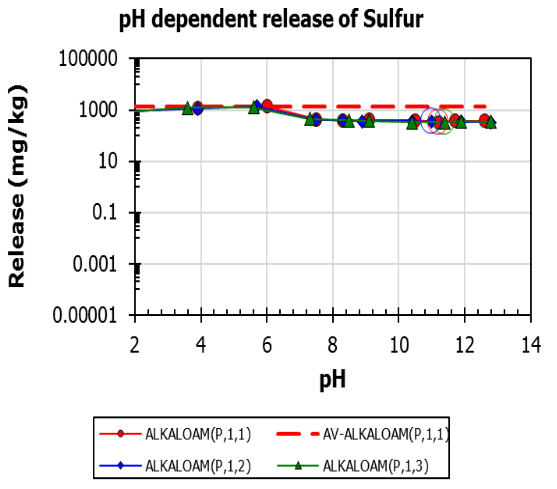

pH dependent concentration of Phosphorus
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

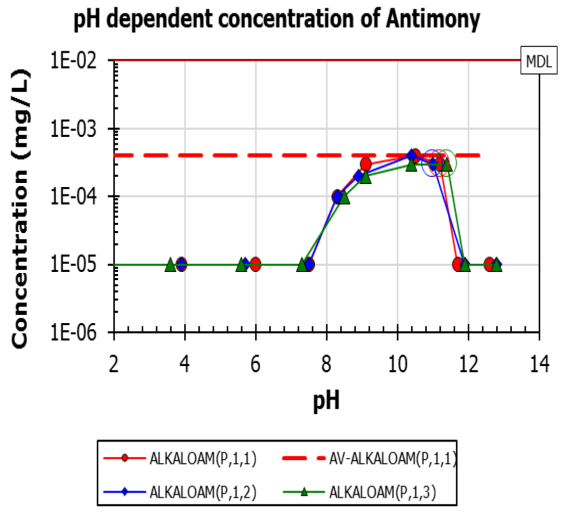

pH dependent release of Phosphorus
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

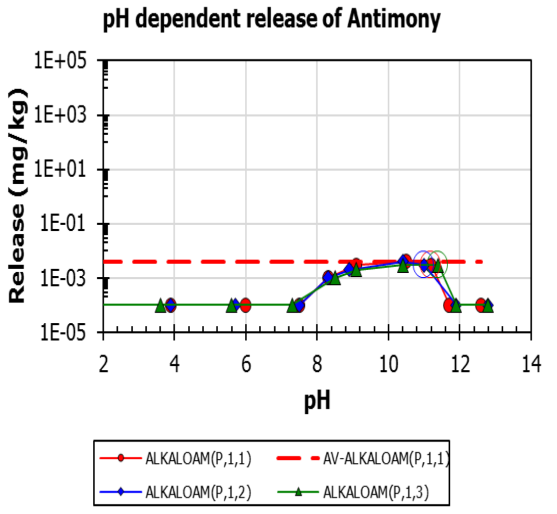

pH dependent concentration of Lead

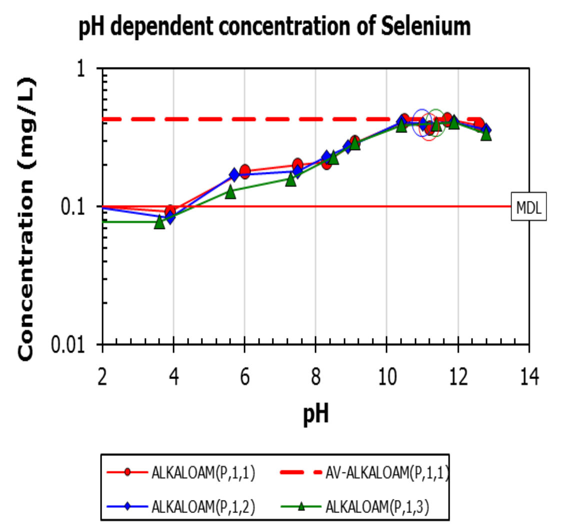

pH dependent release of Lead

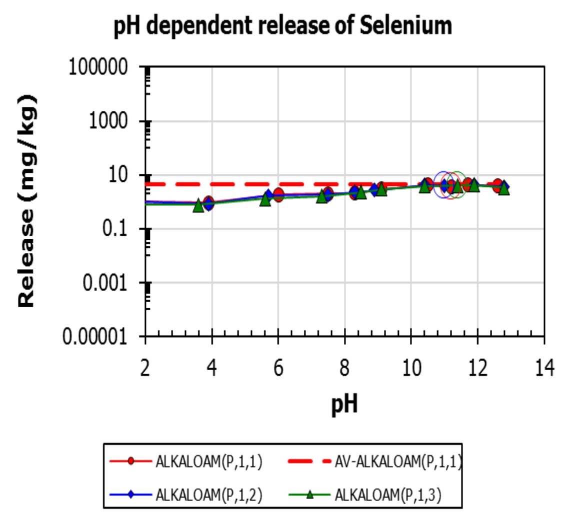

pH dependent concentration of Sulfur

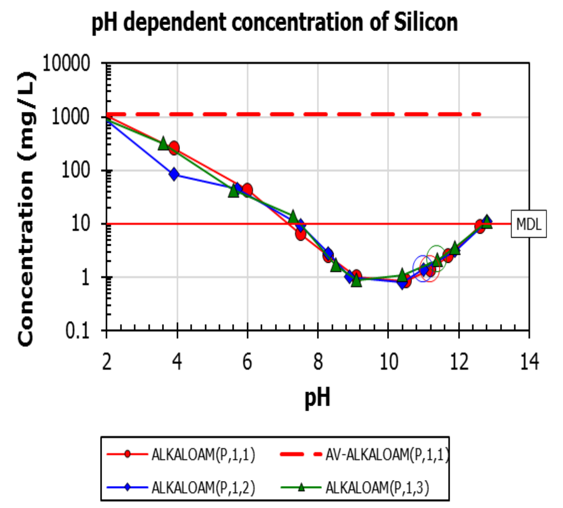

pH dependent release of Sulfur

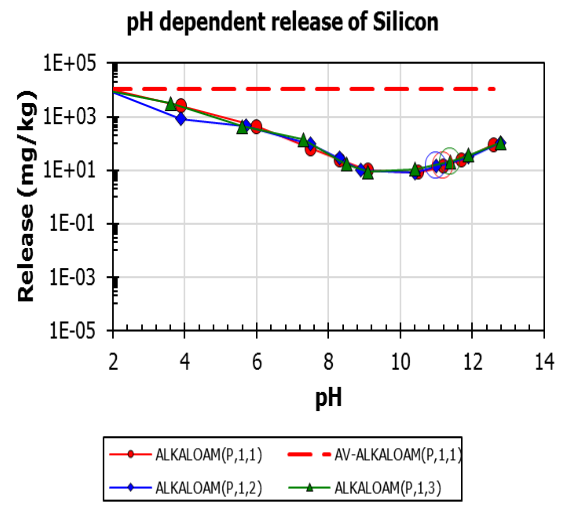

pH dependent concentration of Antimony

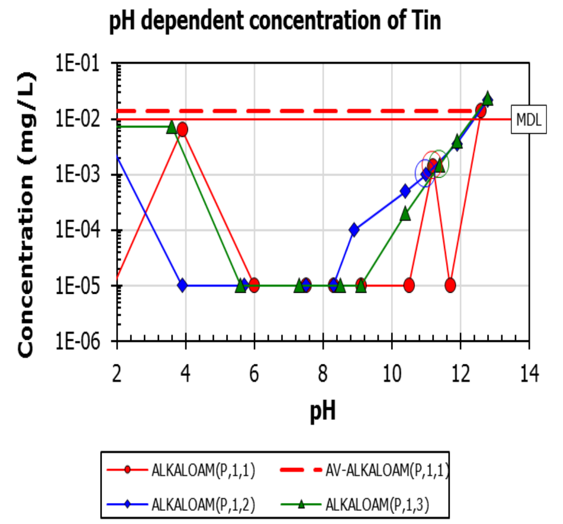

pH dependent release of Antimony

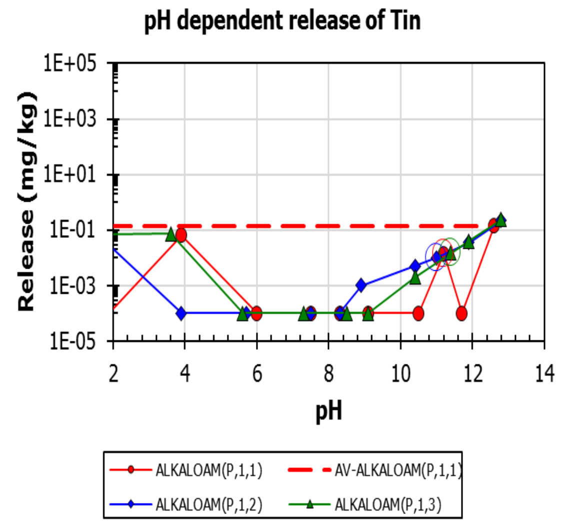

pH dependent concentration of Selenium

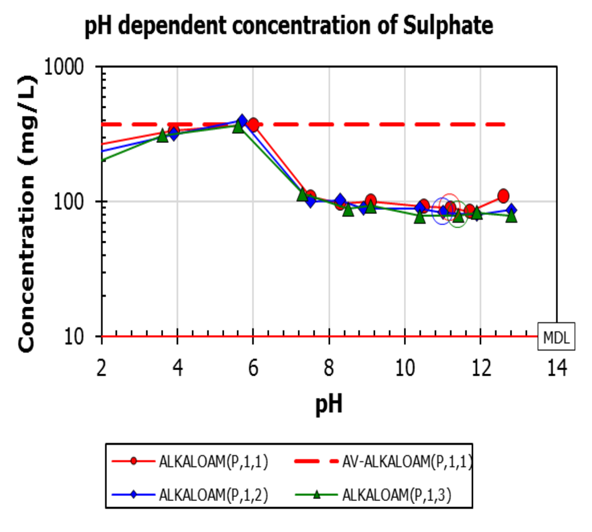

pH dependent release of Selenium

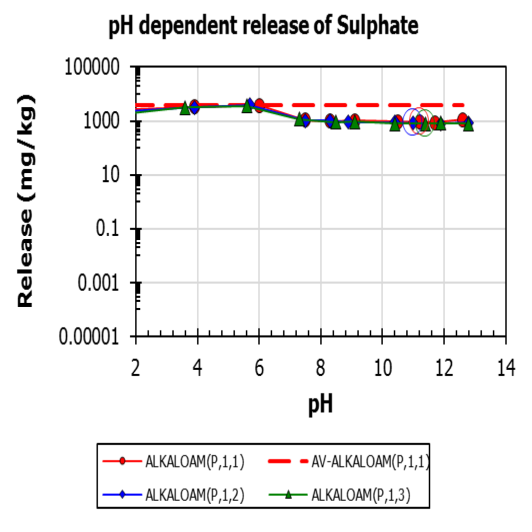

pH dependent concentration of Silicon

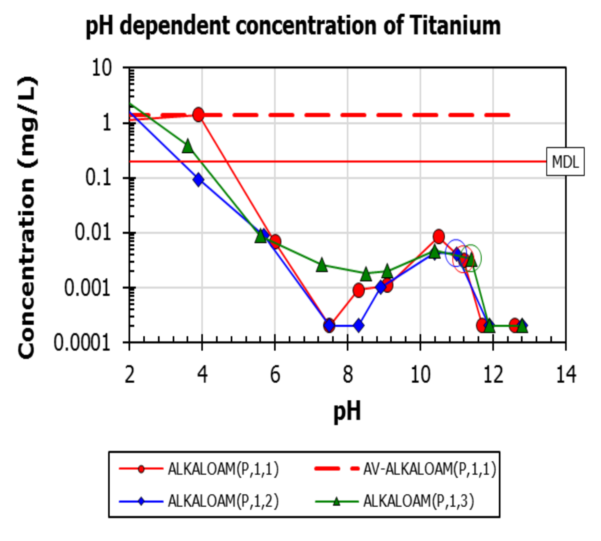

pH dependent release of Silicon

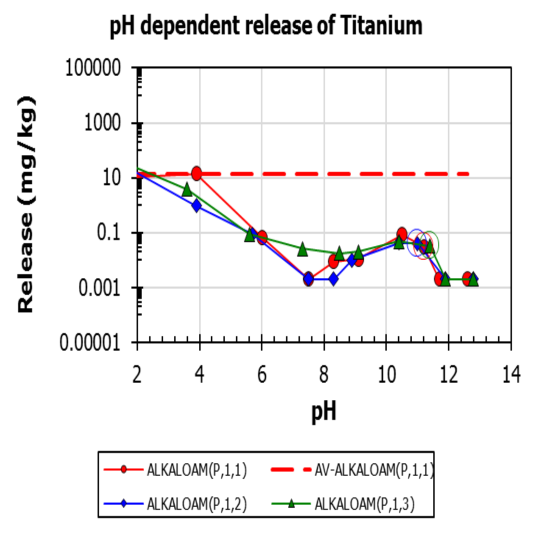

pH dependent concentration of Tin

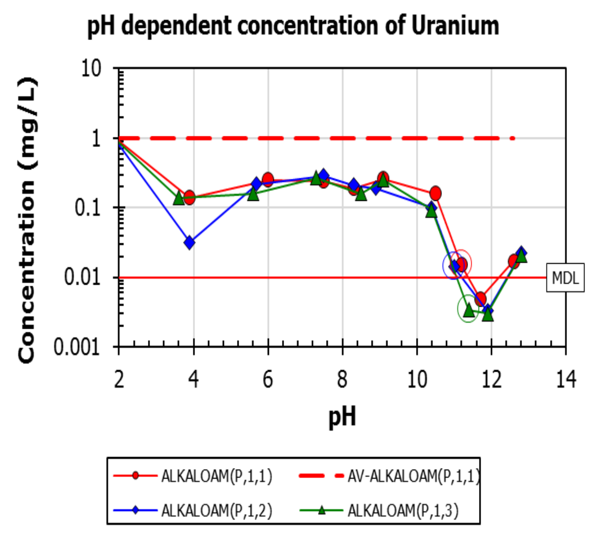

pH dependent release of Tin

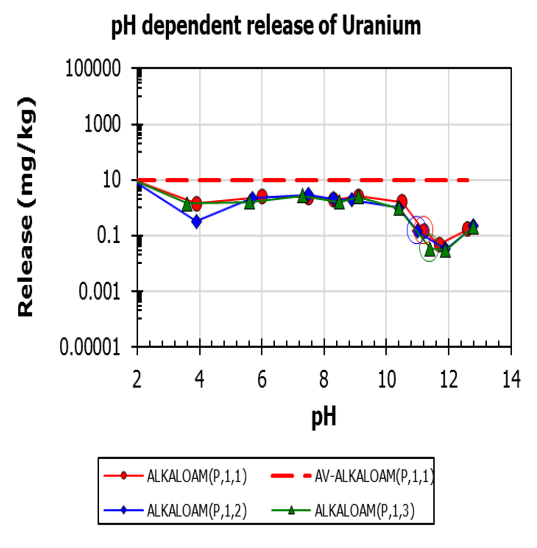

pH dependent concentration of Sulphate
Concentration (mg/L)
1000
100
10
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

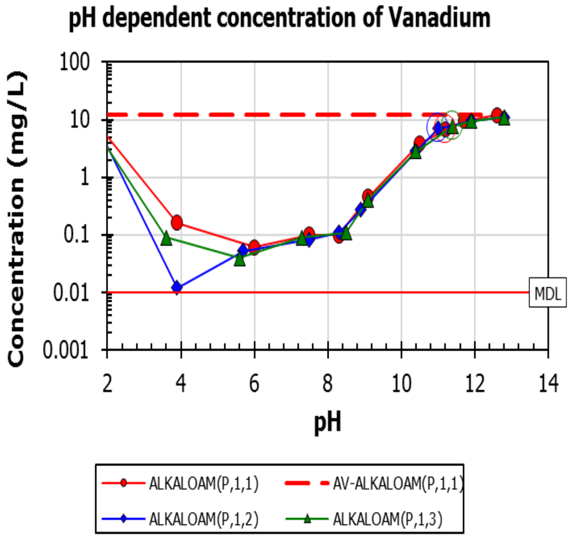

pH dependent release of Sulphate
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

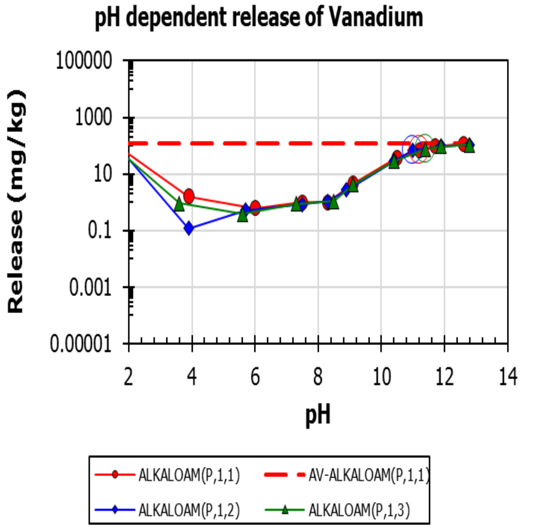

pH dependent concentration of Titanium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

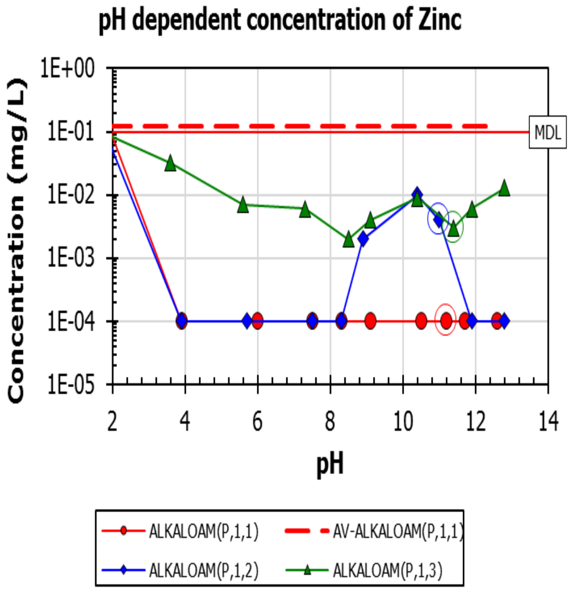

pH dependent release of Titanium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

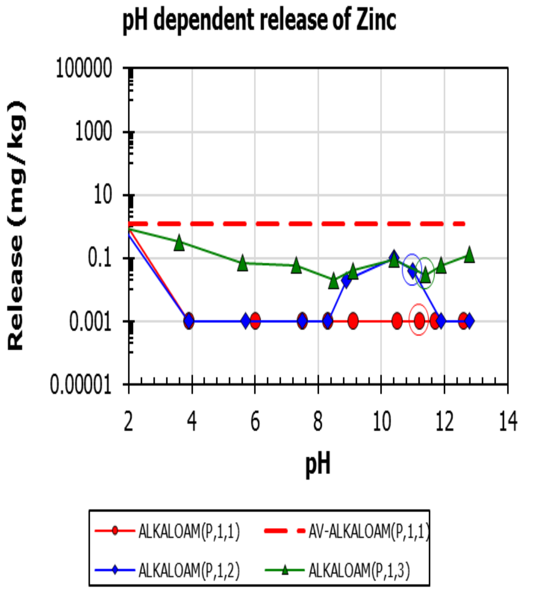

pH dependent concentration of Uranium
Concentration (mg/L)
10
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)


pH dependent release of Uranium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)


pH dependent concentration of Vanadium
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

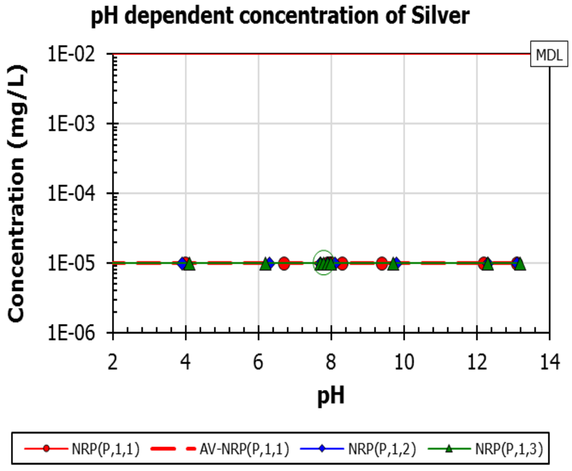

pH dependent release of Vanadium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

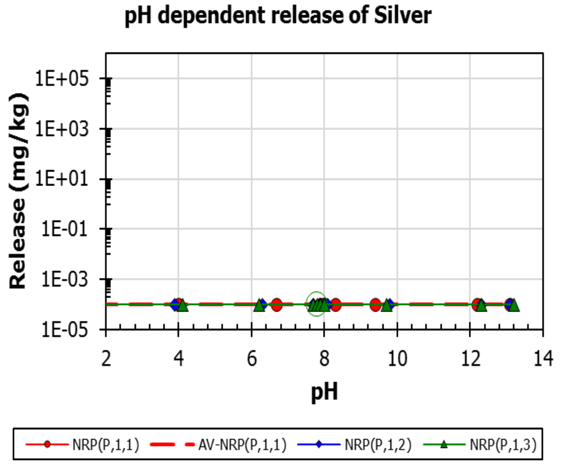

pH dependent concentration of Zinc
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

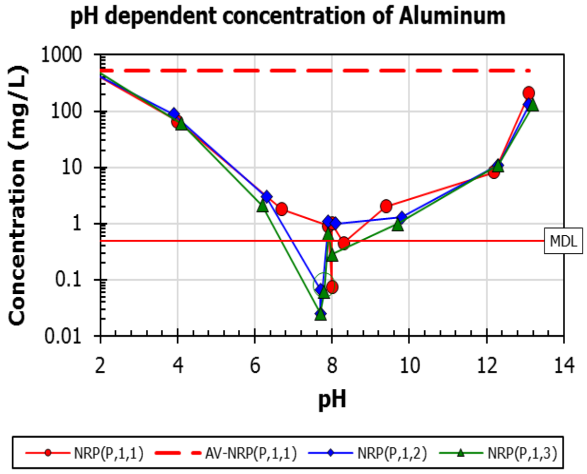

pH dependent release of Zinc
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
ALKALOAM(P,1,1)
AV-ALKALOAM(P,1,1)
ALKALOAM(P,1,2)
ALKALOAM(P,1,3)

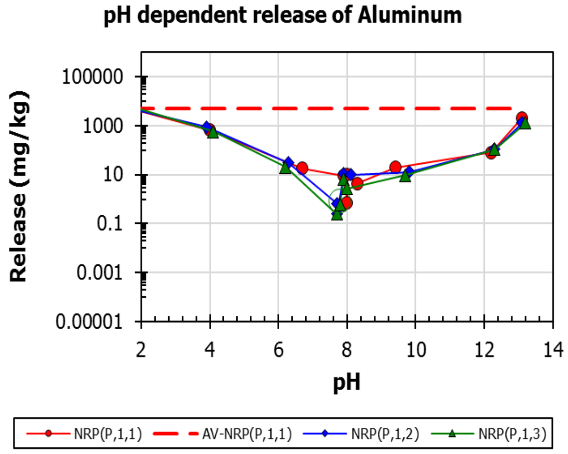
A5-2: NRP by-product

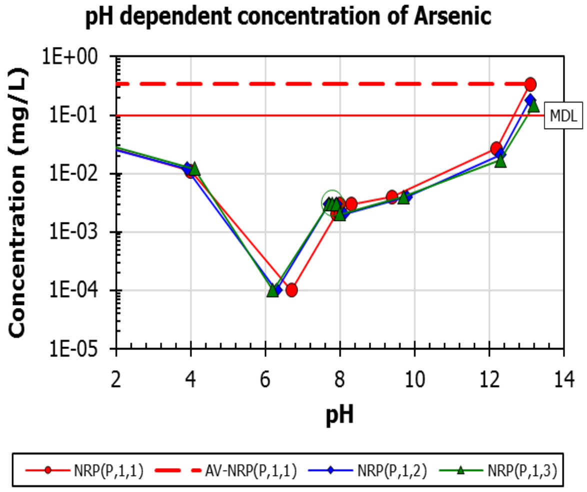
(Note: AV-NRP – represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

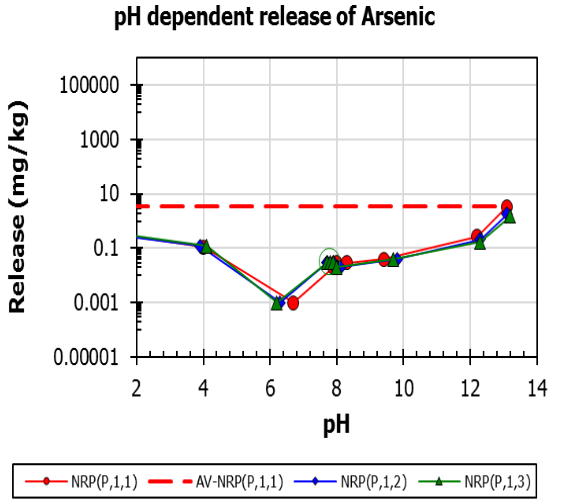

pH dependent concentration of Silver

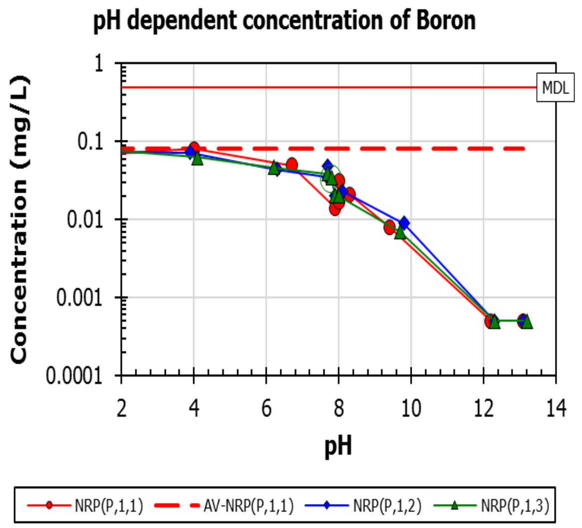

pH dependent release of Silver

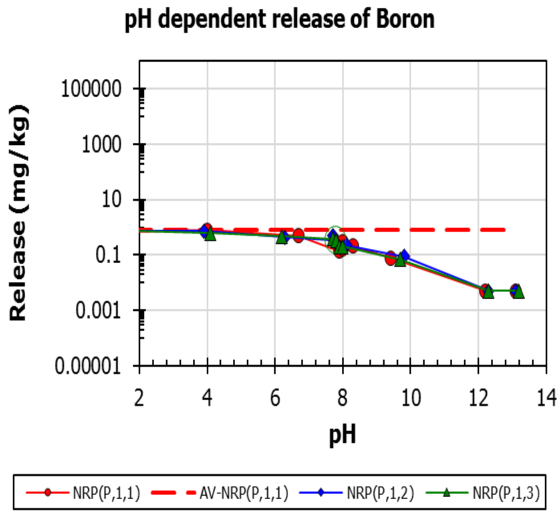

pH dependent concentration of Aluminum

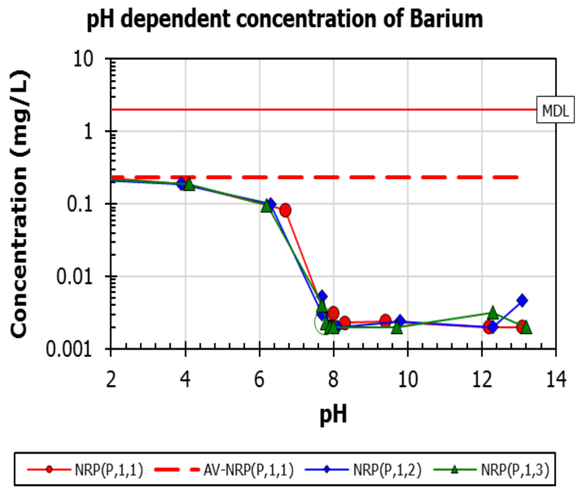

pH dependent release of Aluminum

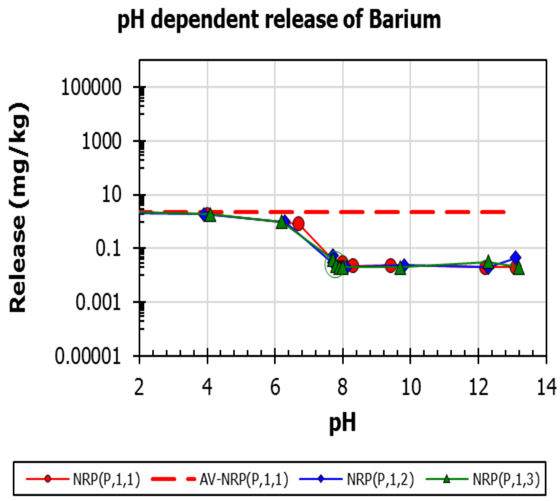

pH dependent concentration of Arsenic

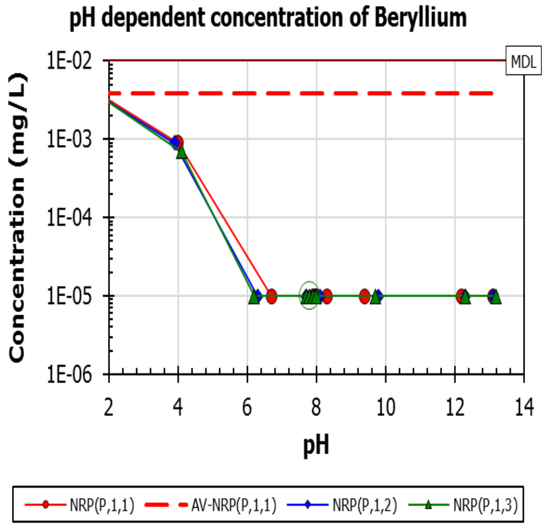

pH dependent release of Arsenic

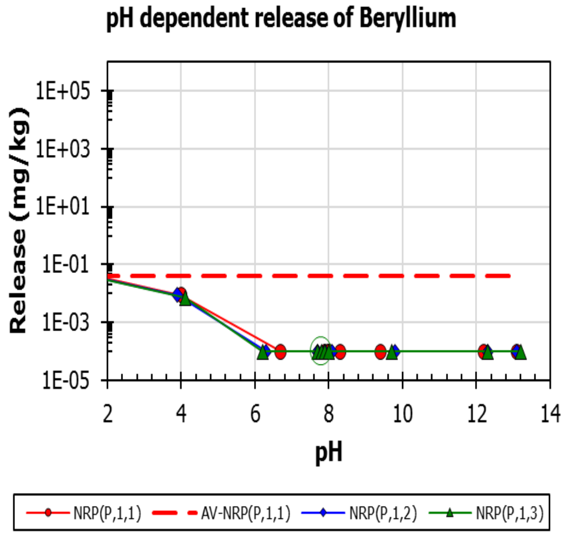

pH dependent concentration of Boron

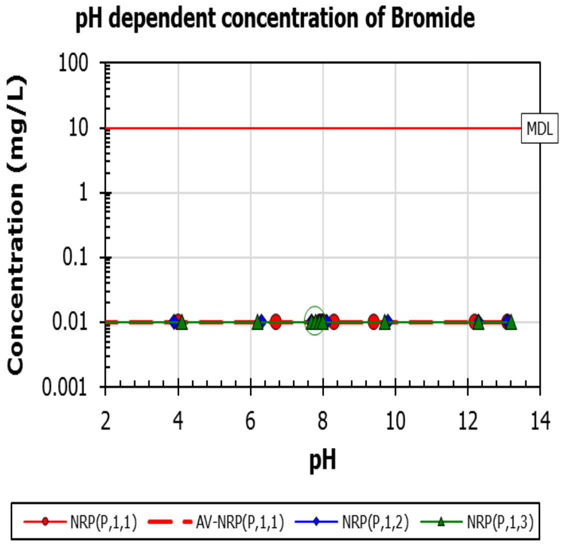

pH dependent release of Boron

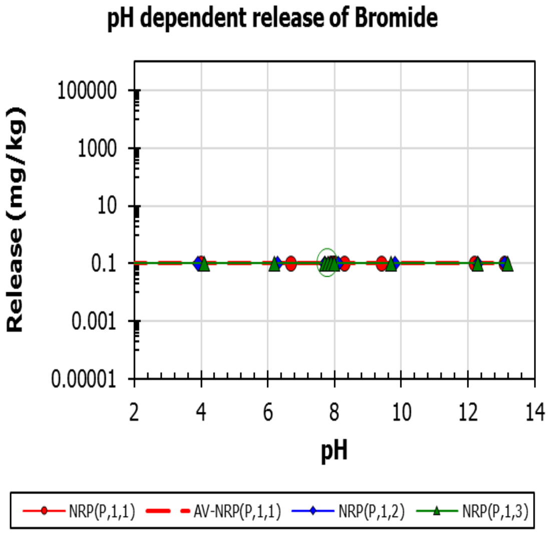

pH dependent concentration of Barium

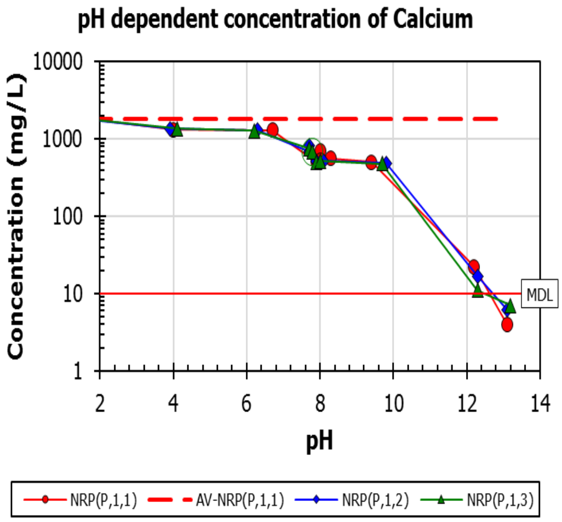

pH dependent release of Barium

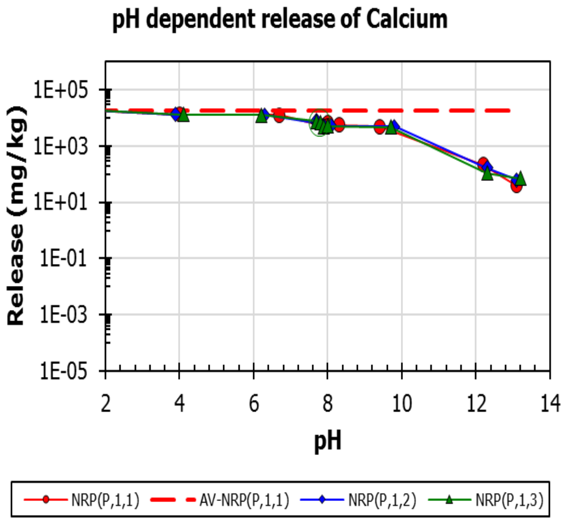

pH dependent concentration of Beryllium

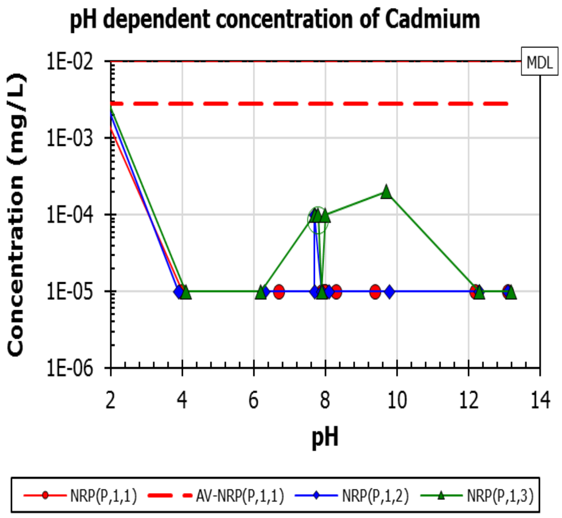

pH dependent release of Beryllium

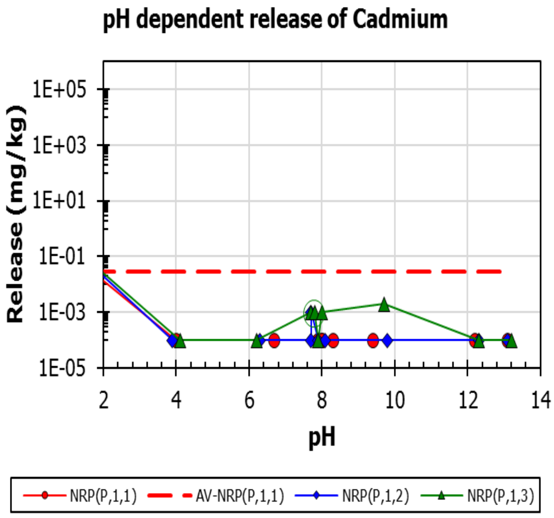

pH dependent concentration of Bromide

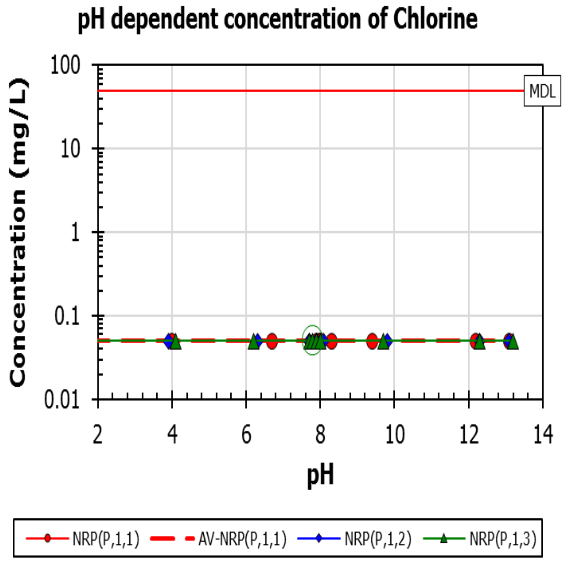

pH dependent release of Bromide

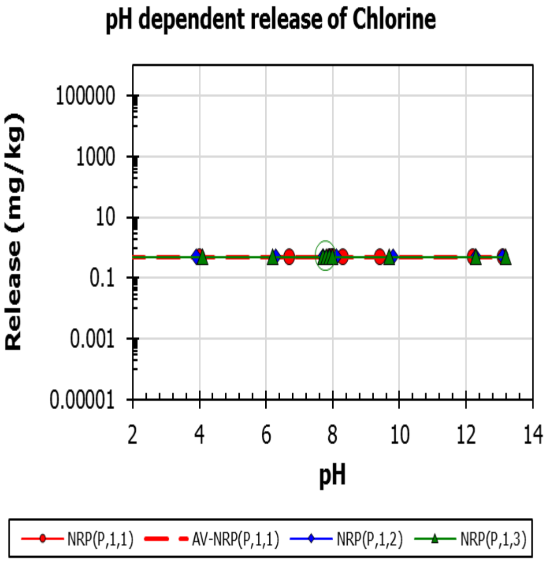

pH dependent concentration of Calcium

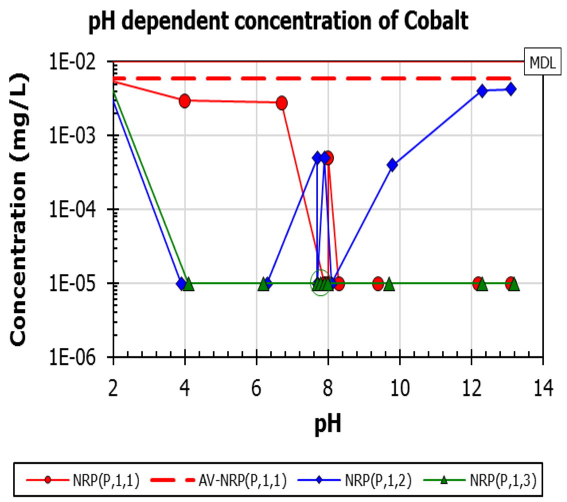

pH dependent release of Calcium

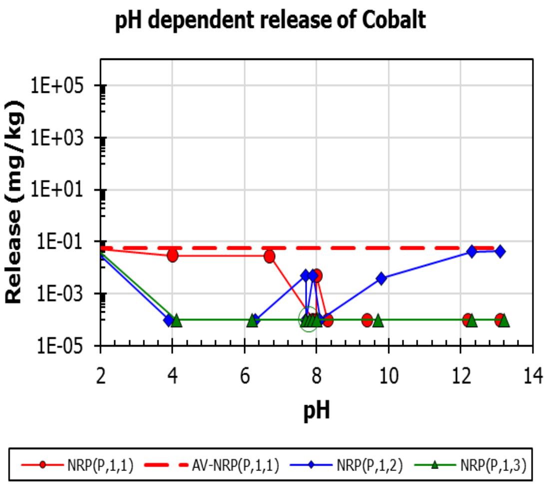

pH dependent concentration of Cadmium

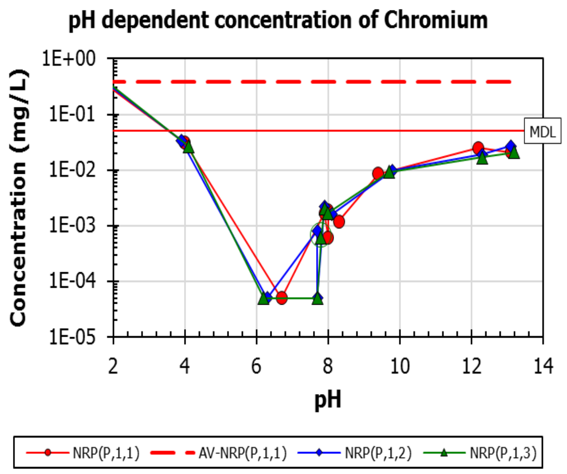

pH dependent release of Cadmium

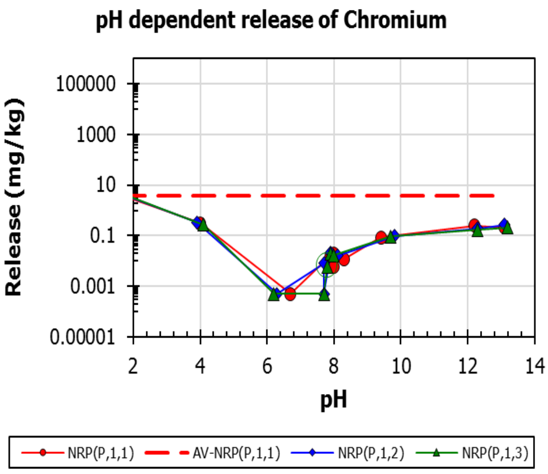

pH dependent concentration of Chlorine
Concentration (mg/L)
100
10
1
0.1
0.01
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

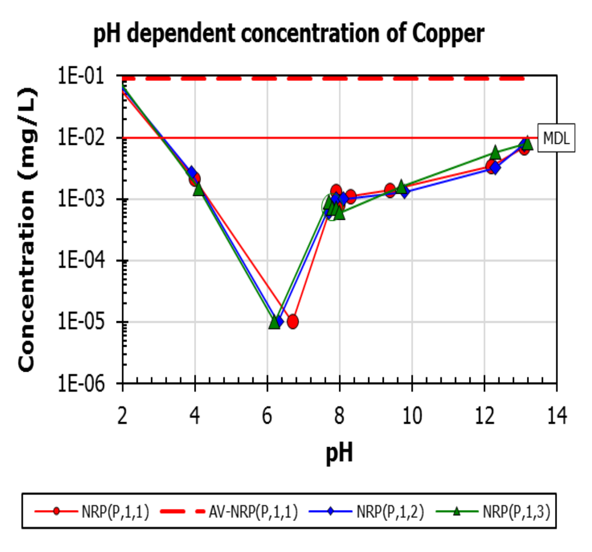

pH dependent release of Chlorine
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

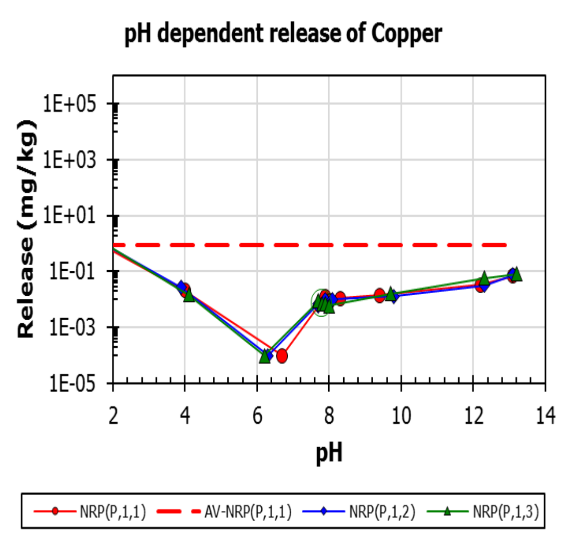

pH dependent concentration of Cobalt
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

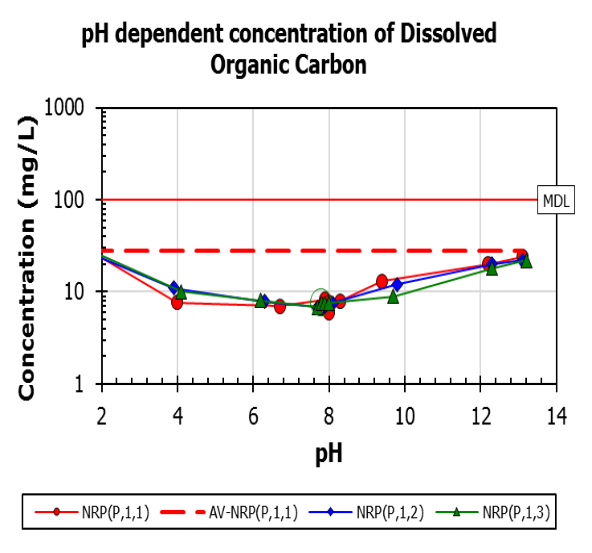

pH dependent release of Cobalt
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

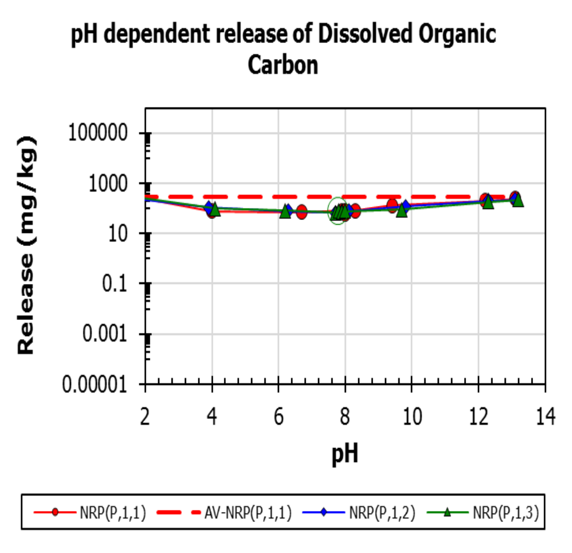

pH dependent concentration of Chromium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

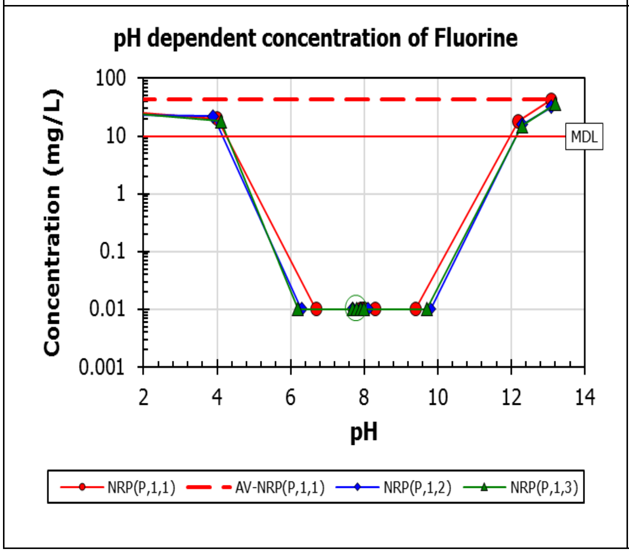

pH dependent release of Chromium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

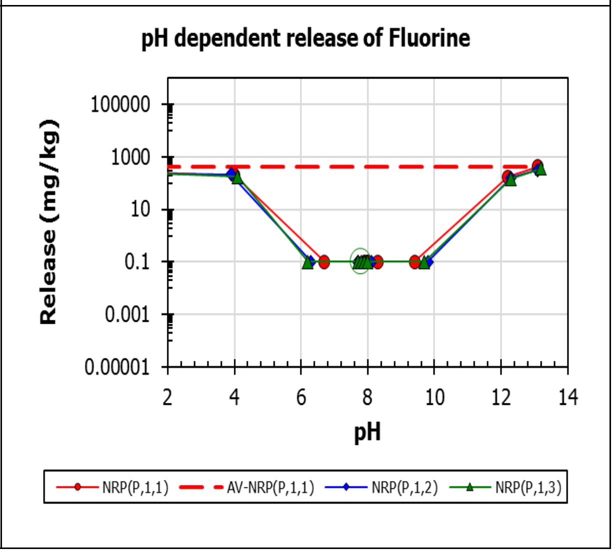

pH dependent concentration of Copper

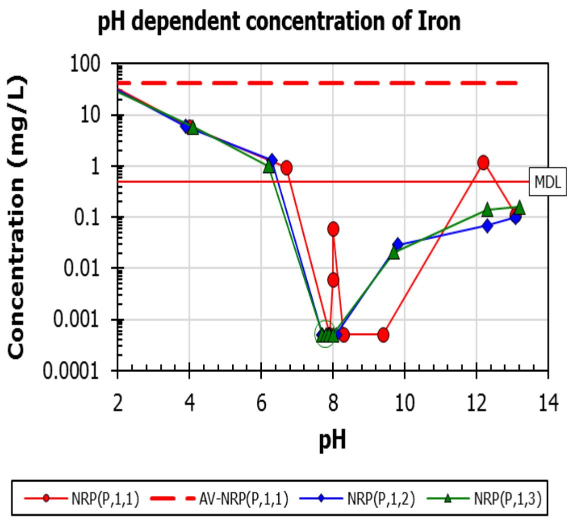

pH dependent release of Copper

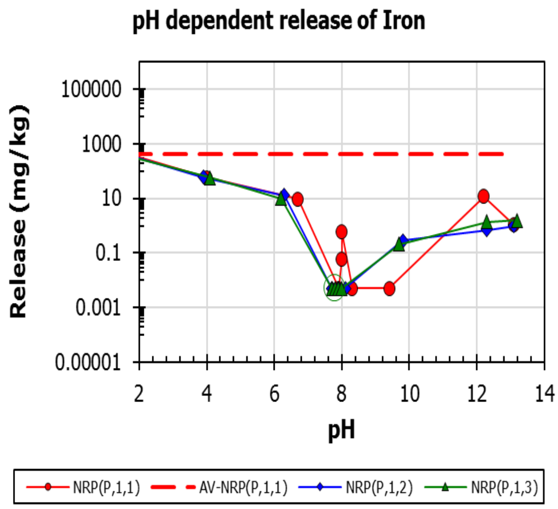

pH dependent concentration of Dissolved Organic Carbon

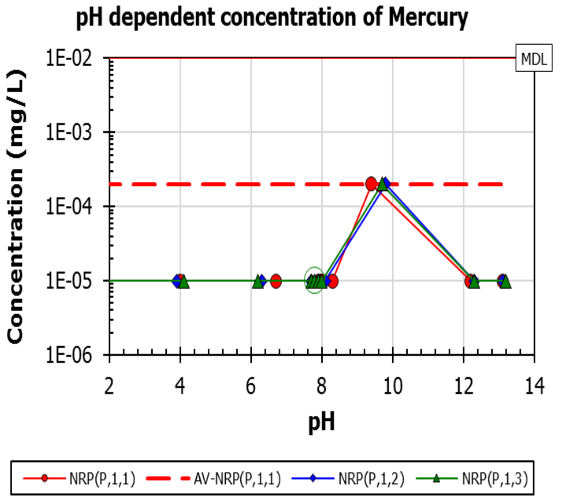

pH dependent release of Dissolved Organic Carbon

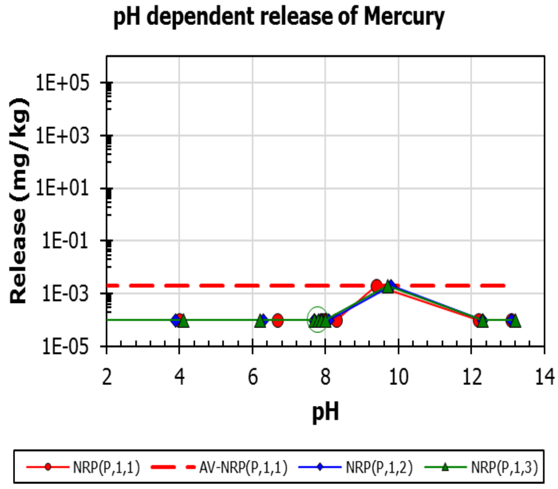

pH dependent concentration of Fluorine

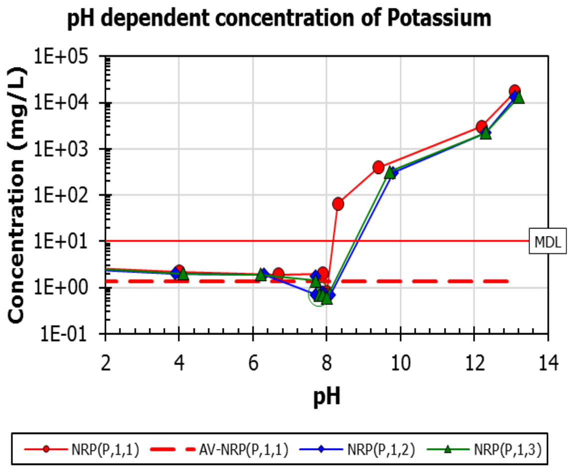

pH dependent release of Fluorine

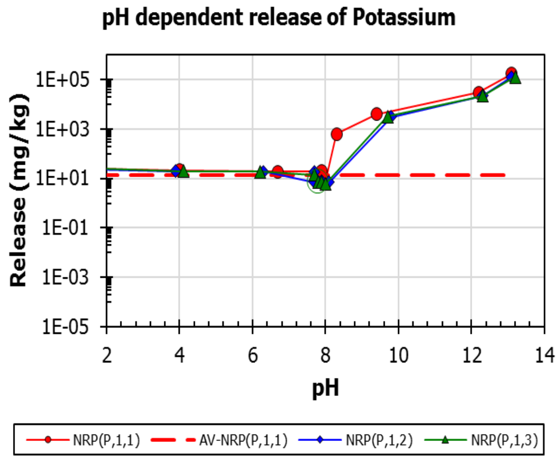

pH dependent concentration of Iron
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

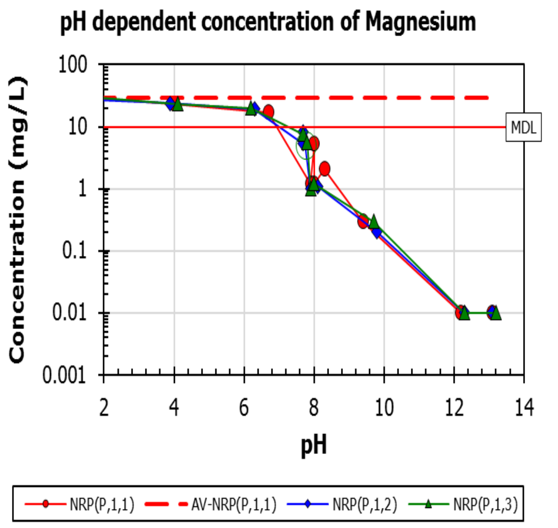

pH dependent release of Iron
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

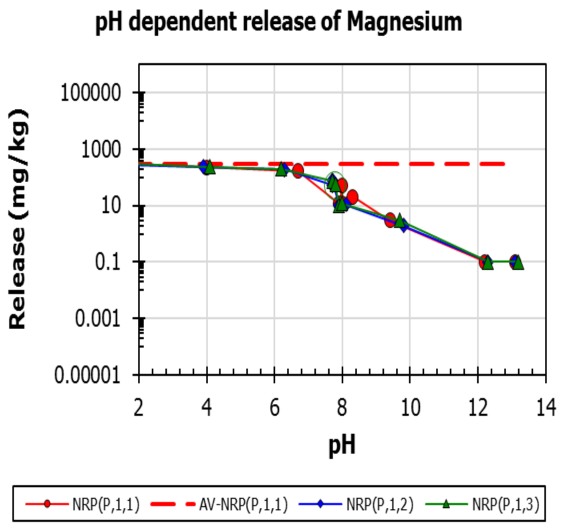

pH dependent concentration of Mercury
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

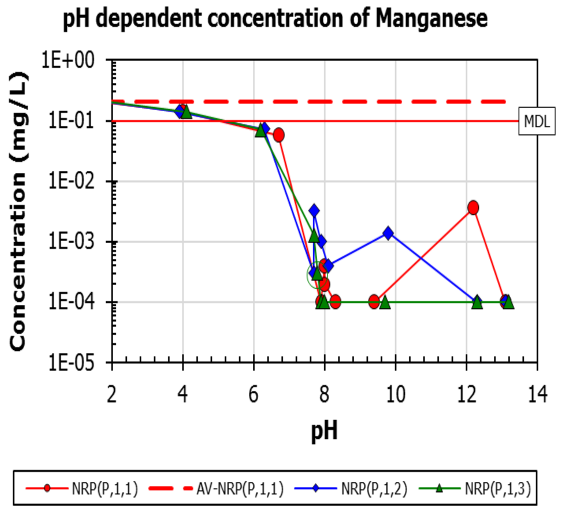

pH dependent release of Mercury
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

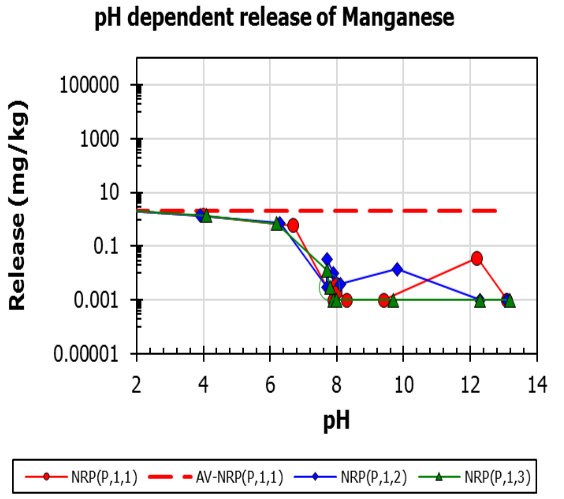

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
MDL
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

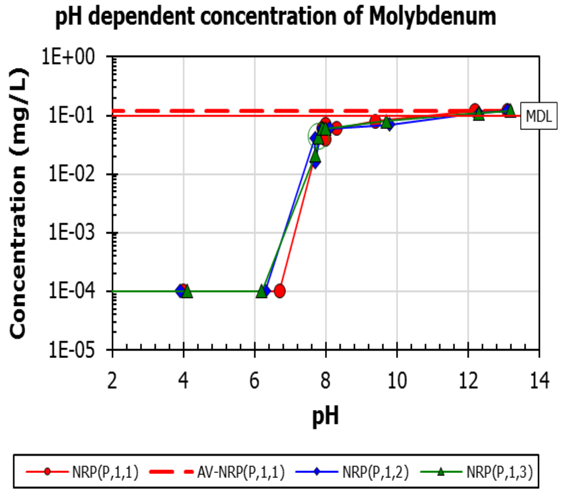

pH dependent release of Potassium
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

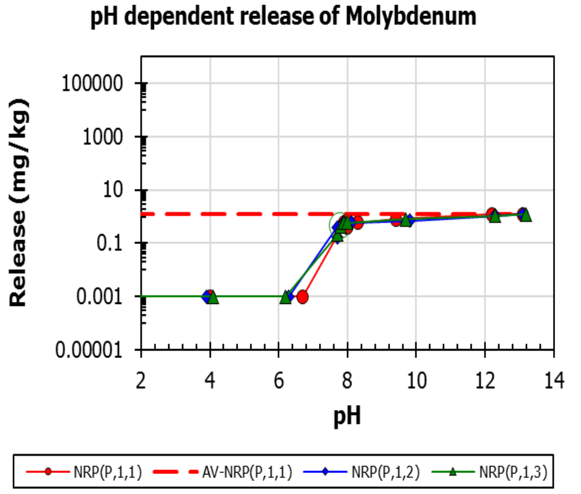

pH dependent concentration of Magnesium


pH dependent release of Magnesium

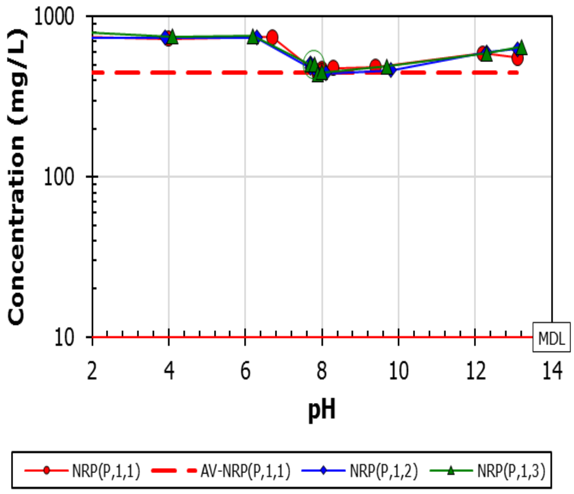

pH dependent concentration of Manganese


pH dependent release of Manganese

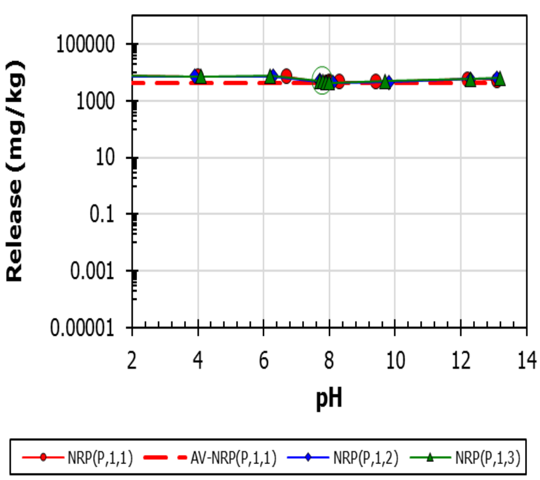

pH dependent concentration of Molybdenum


pH dependent release of Molybdenum

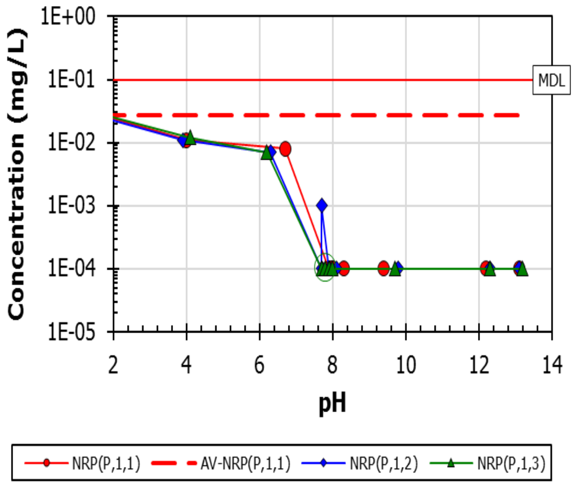
pH dependent concentration of Sodium



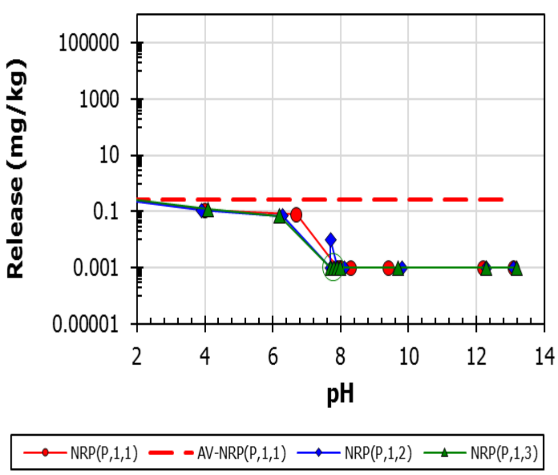
pH dependent release of Sodium



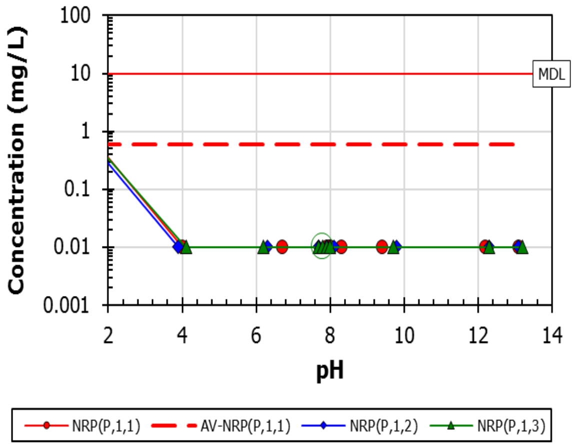
pH dependent concentration of Nickel



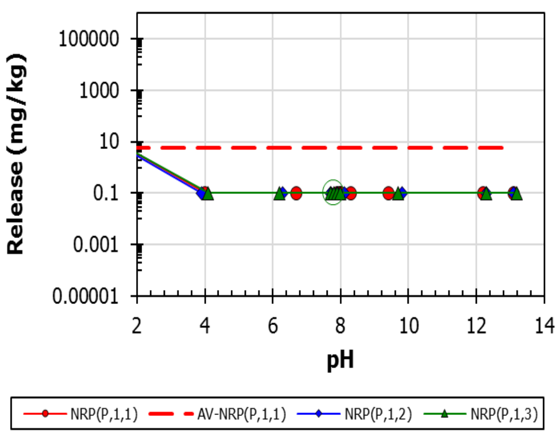
pH dependent release of Nickel

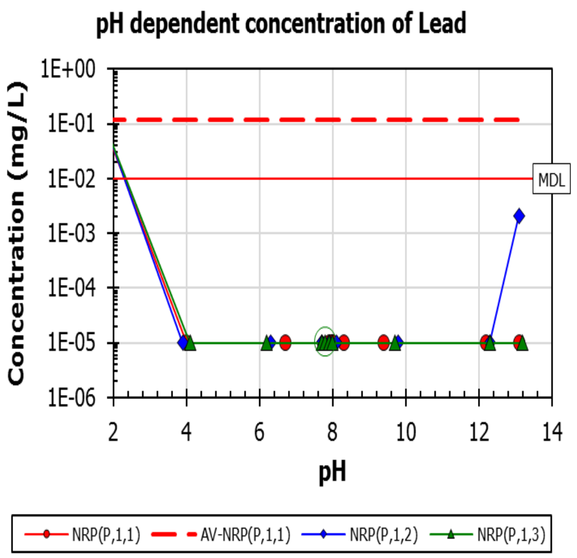


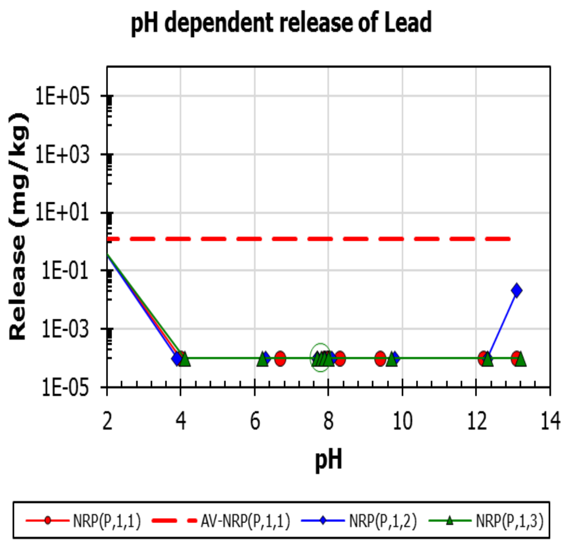
pH dependent concentration of Phosphorus

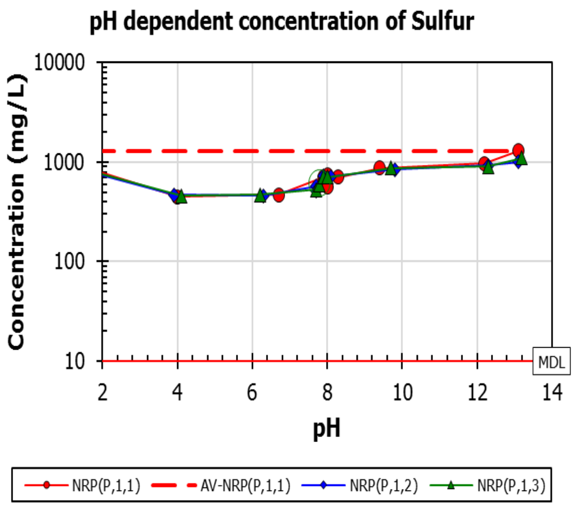


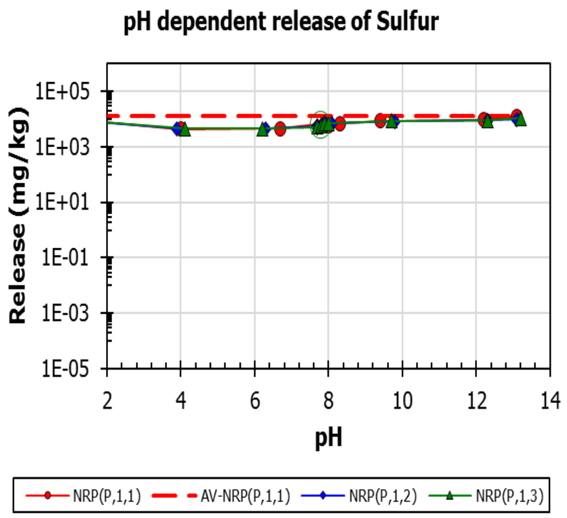
pH dependent release of Phosphorus

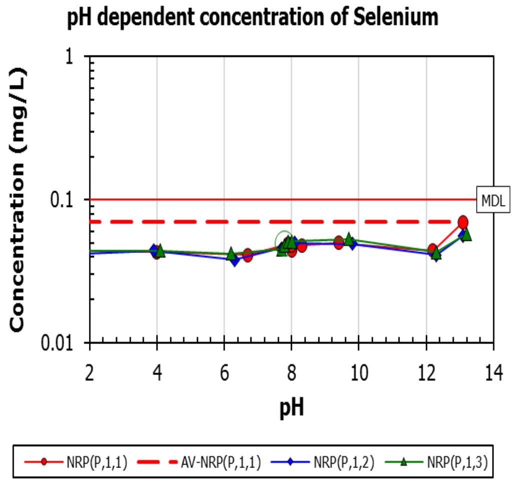


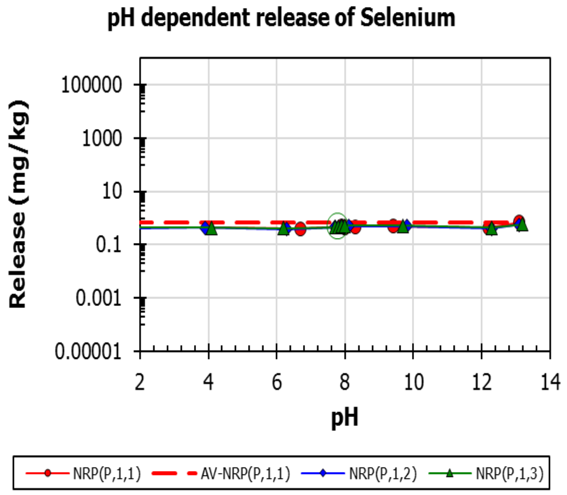

pH dependent concentration of Lead

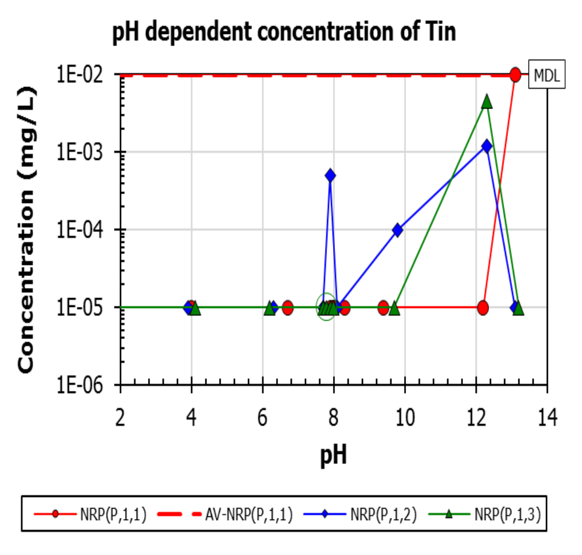

pH dependent release of Lead

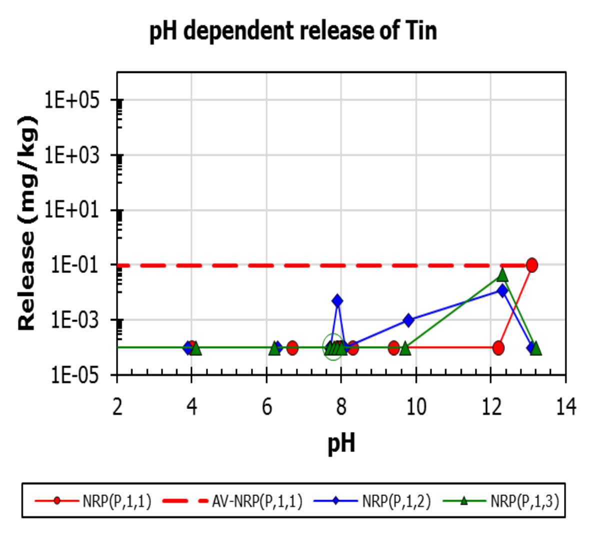

pH dependent concentration of Sulfur

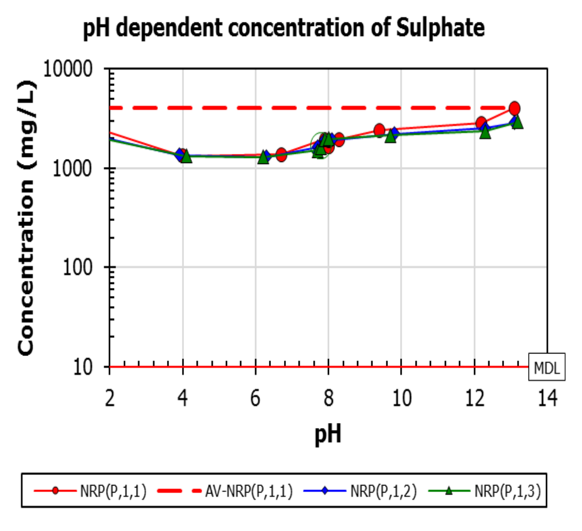

pH dependent release of Sulfur

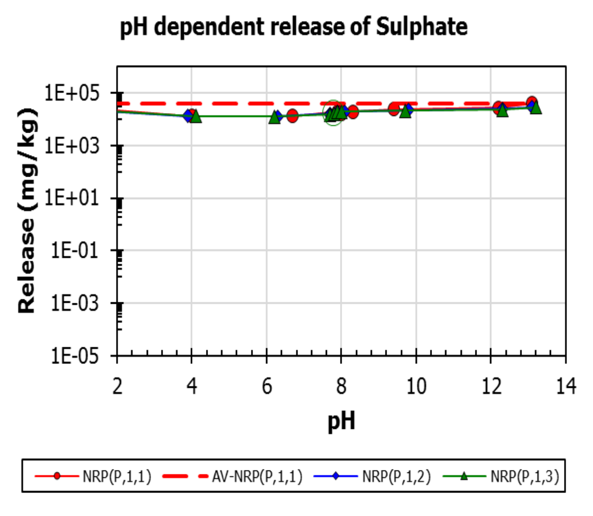

pH dependent concentration of Selenium

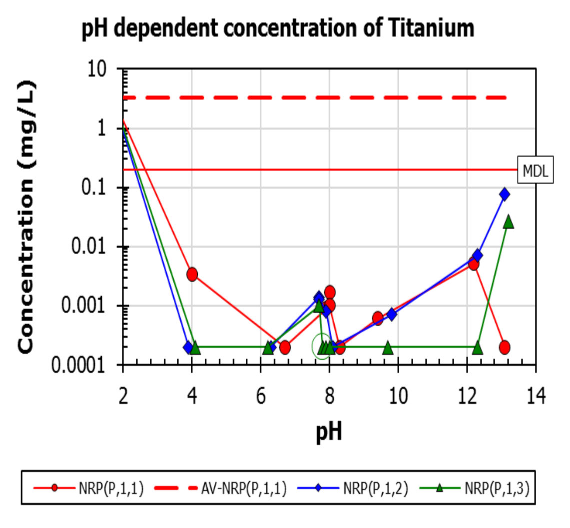

pH dependent release of Selenium

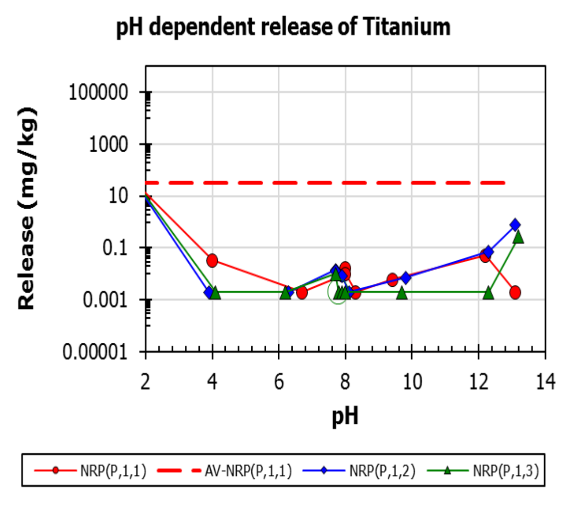

pH dependent concentration of Tin
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
2
4
6
8
10
12
14
pH
MDL
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

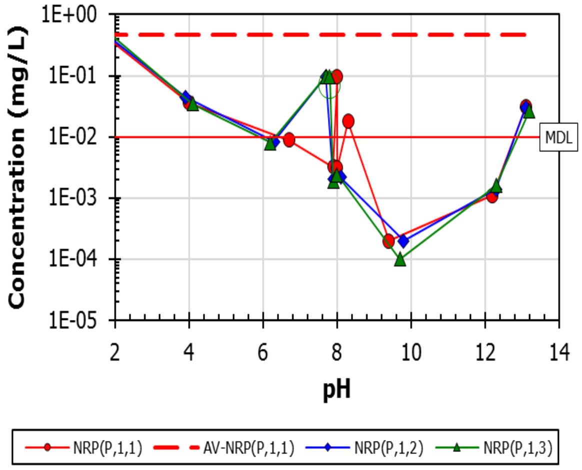

pH dependent release of Tin
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

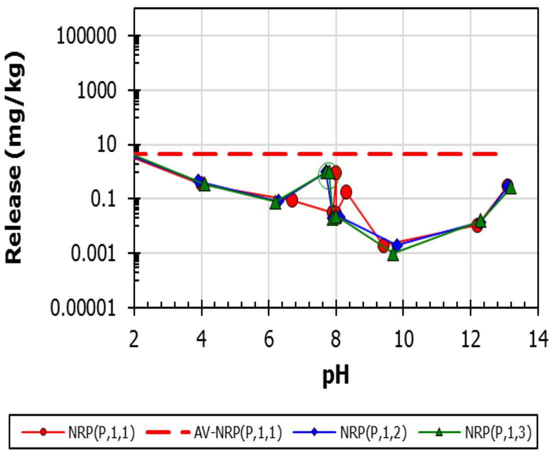

pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
10
2
4
6
8
10
12
14
pH
MDL
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

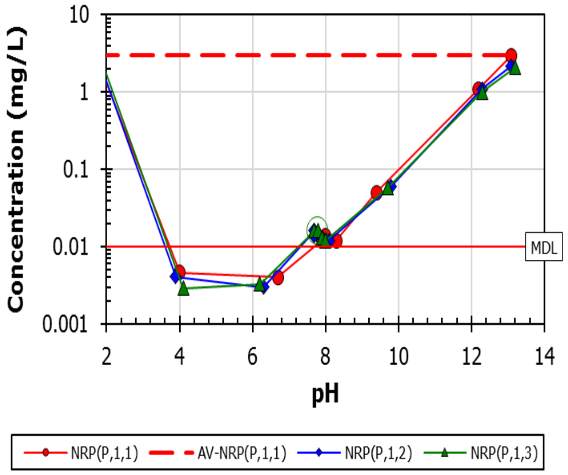

pH dependent release of Sulphate
Release (mg/kg)
1E+05
1E+03
1E+01
1E-01
1E-03
1E-05
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

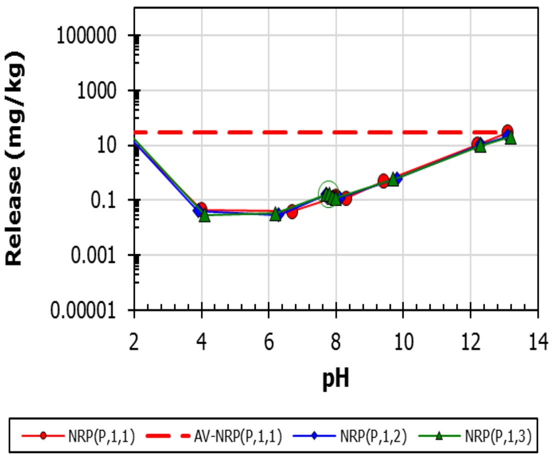

pH dependent concentration of Titanium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
MDL
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

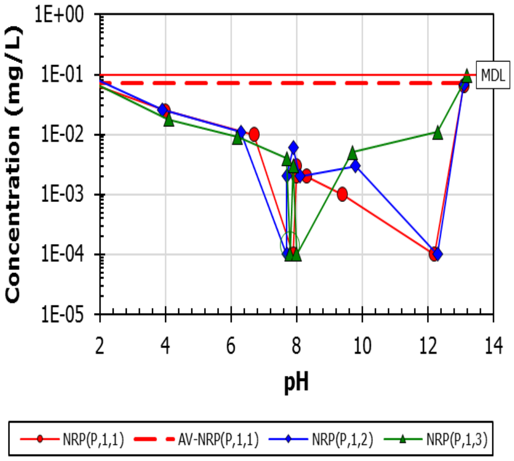

pH dependent release of Titanium
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
2
4
6
8
10
12
14
pH
NRP(P,1,1)
AV-NRP(P,1,1)
NRP(P,1,2)
NRP(P,1,3)

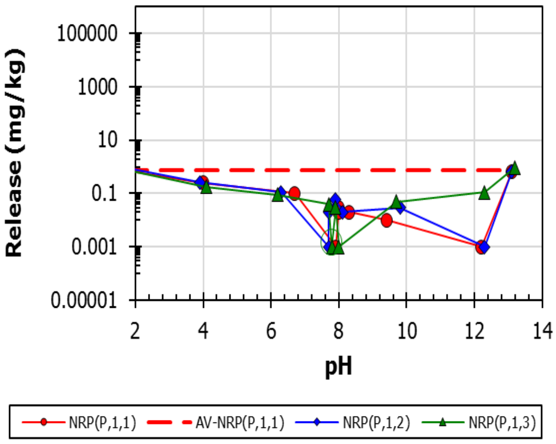

pH dependent concentration of Uranium


pH dependent release of Uranium


pH dependent concentration of Vanadium

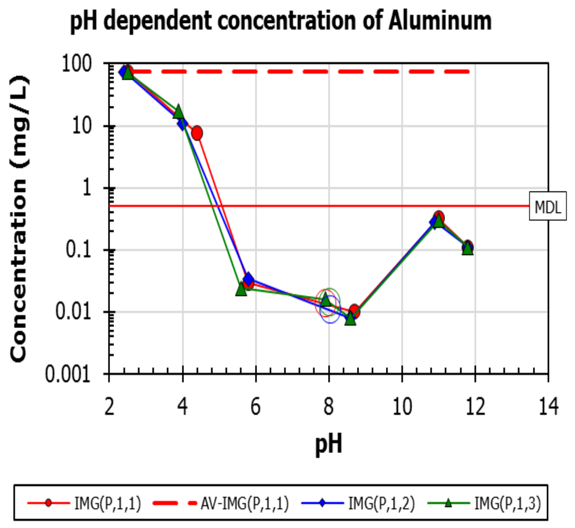

pH dependent release of Vanadium

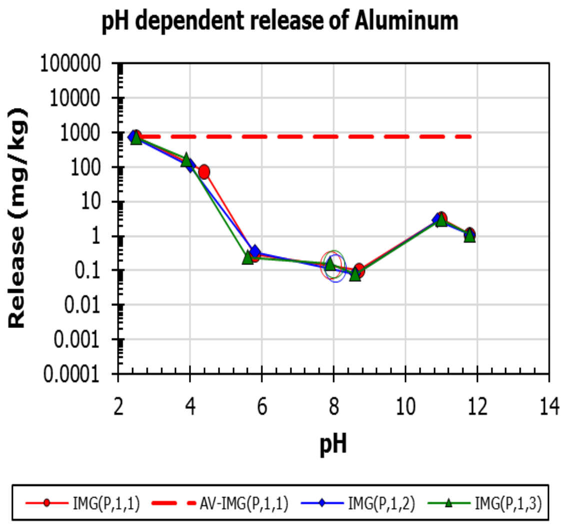

pH dependent concentration of Zinc

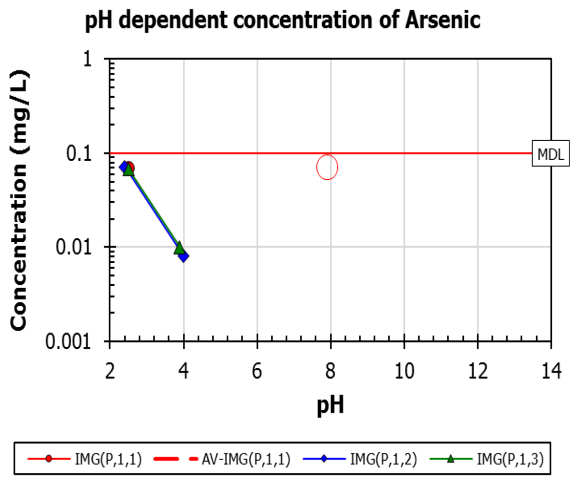

pH dependent release of Zinc

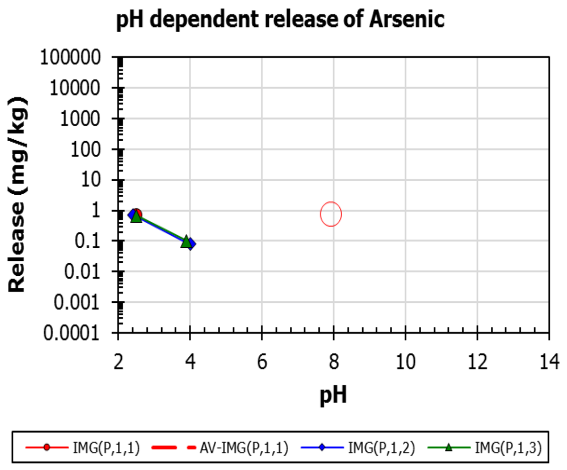
A5-3: Ironman Gypsum by-product

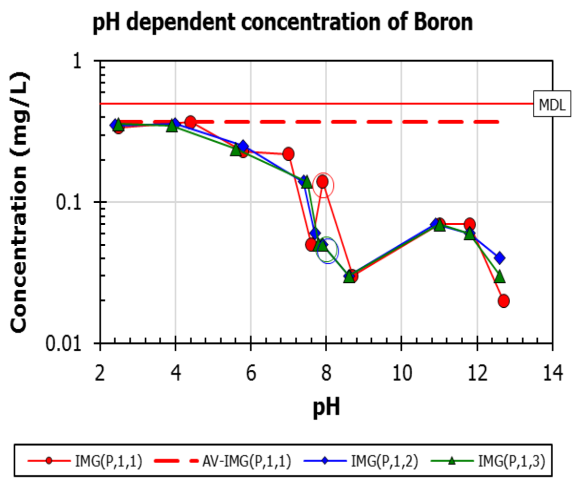
(Note: AV-IMG – represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

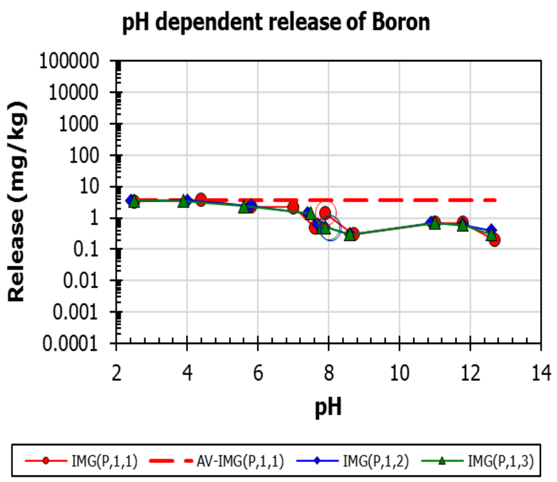

pH dependent concentration of Aluminum

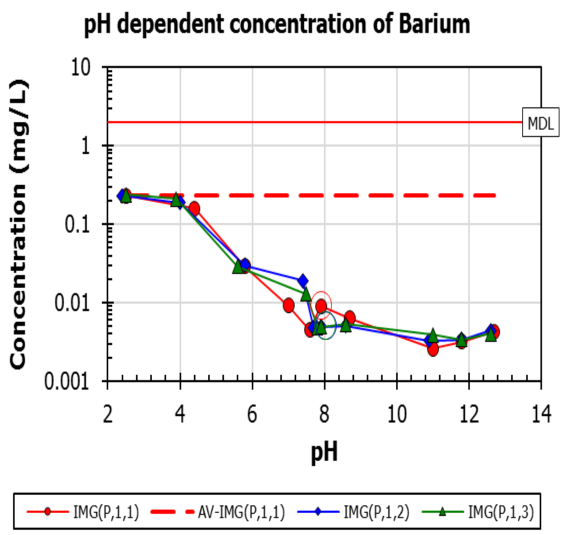

pH dependent release of Aluminum

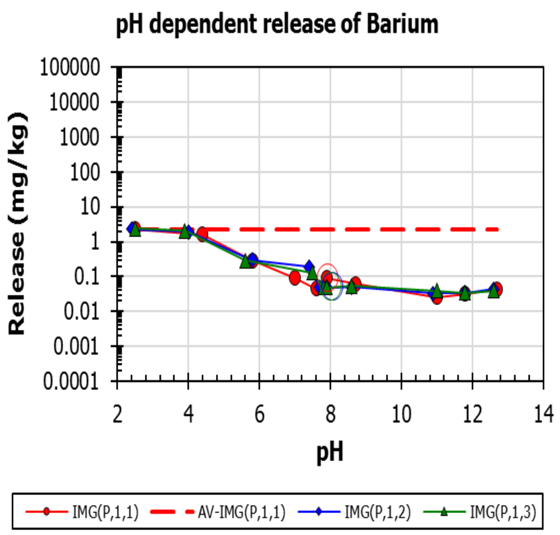

pH dependent concentration of Arsenic

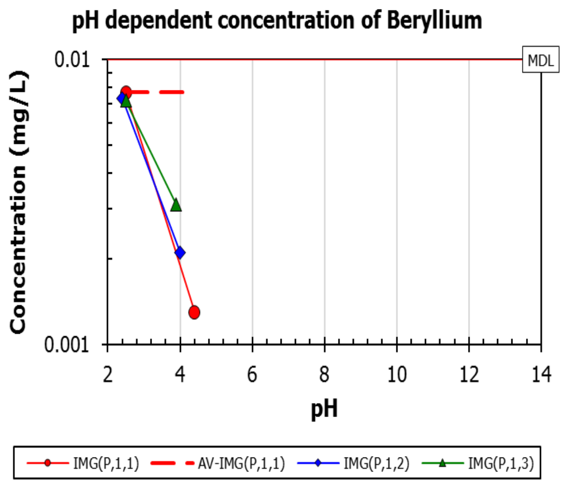

pH dependent release of Arsenic

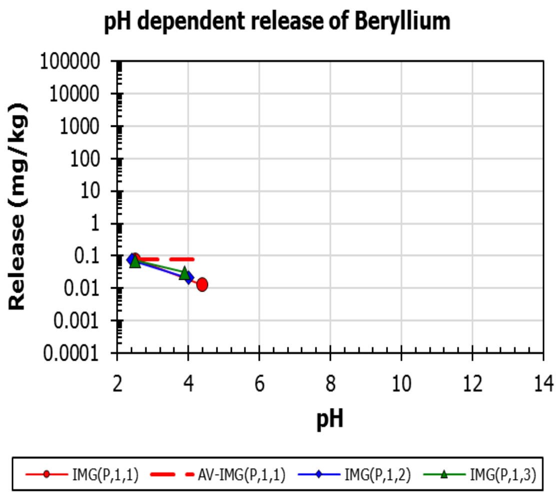

pH dependent concentration of Boron

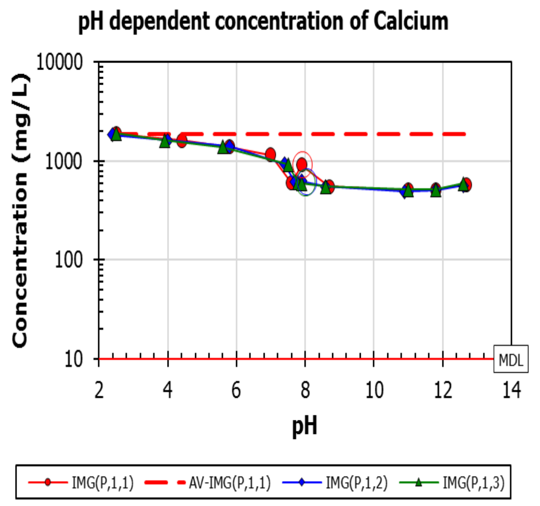

pH dependent release of Boron

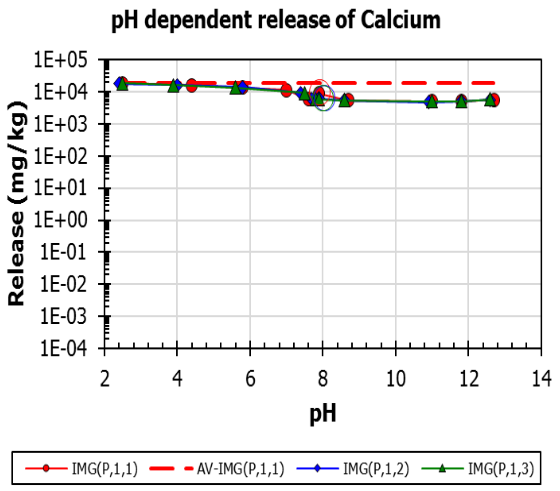

pH dependent concentration of Barium

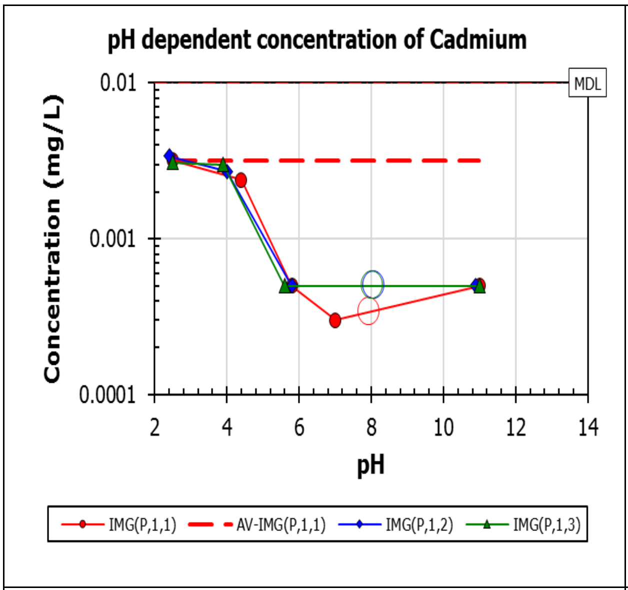

pH dependent release of Barium

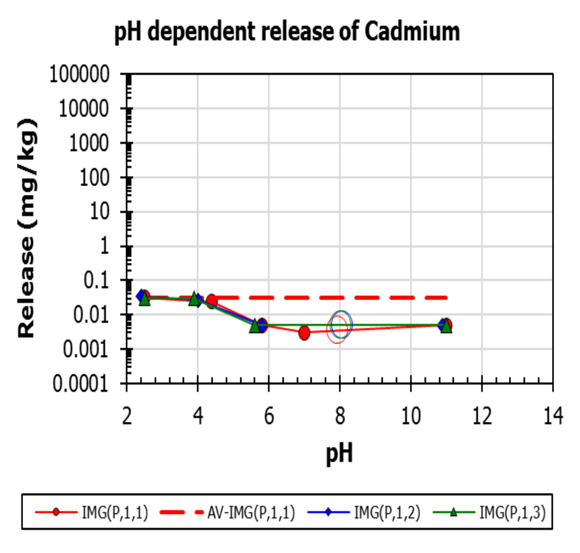

pH dependent concentration of Beryllium

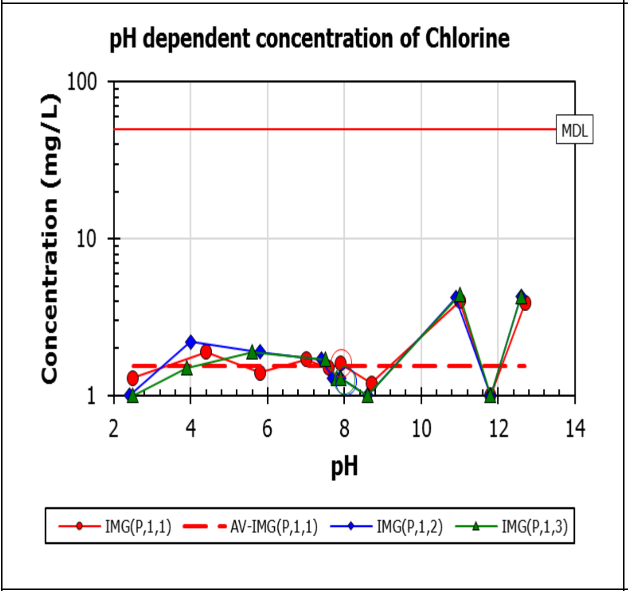

pH dependent release of Beryllium

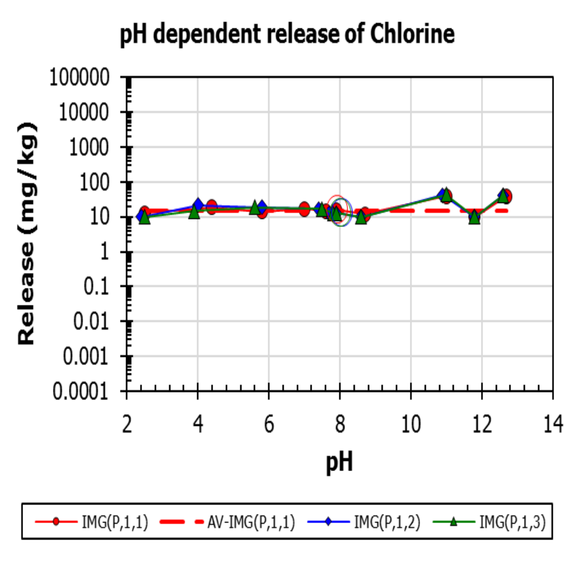

pH dependent concentration of Calcium

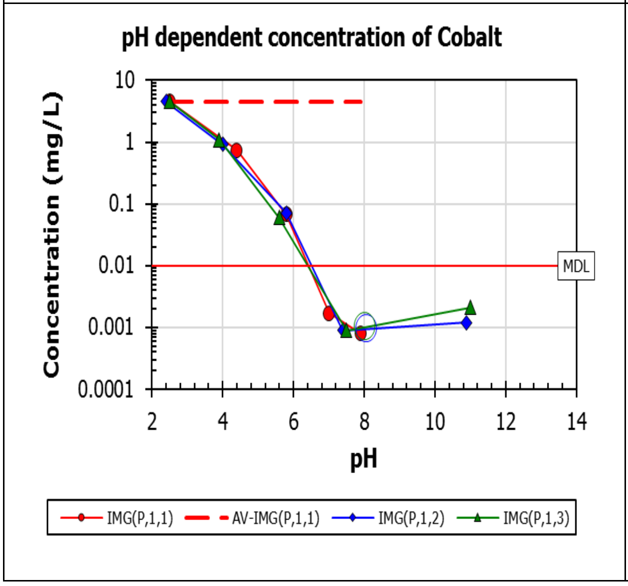

pH dependent release of Calcium

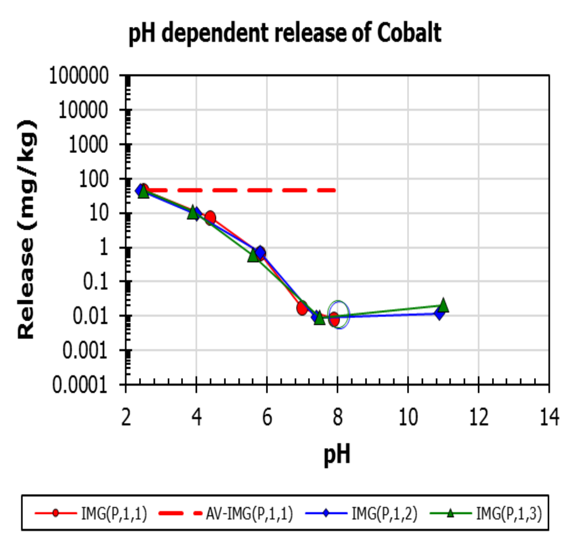

pH dependent concentration of Cadmium

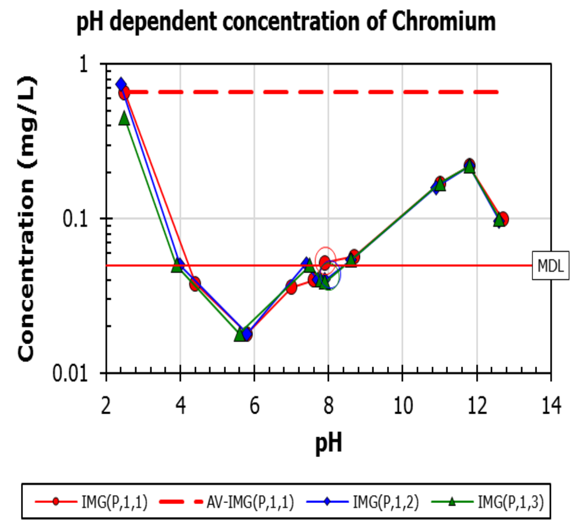

pH dependent release of Cadmium

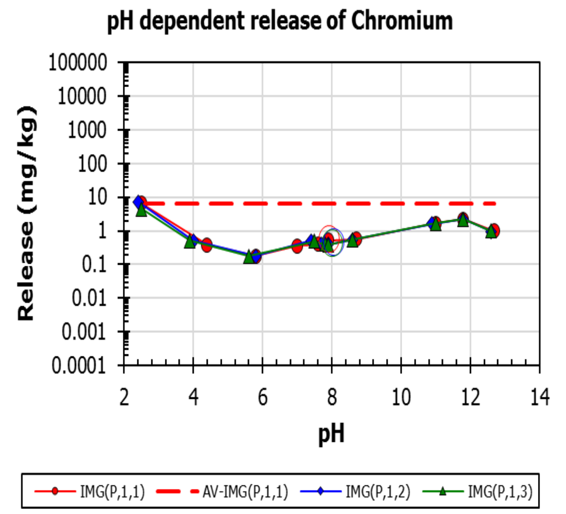

pH dependent concentration of Chlorine

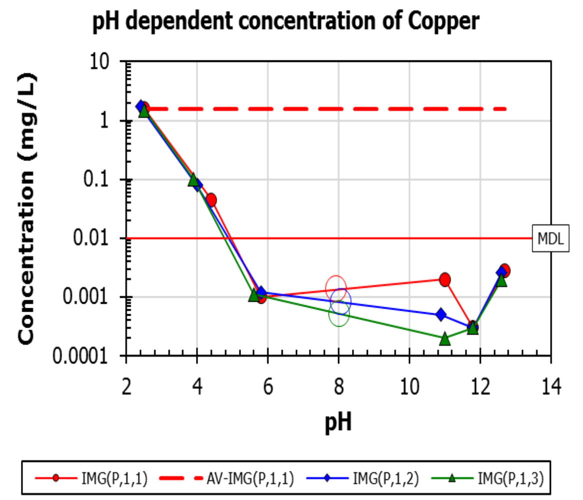

pH dependent release of Chlorine

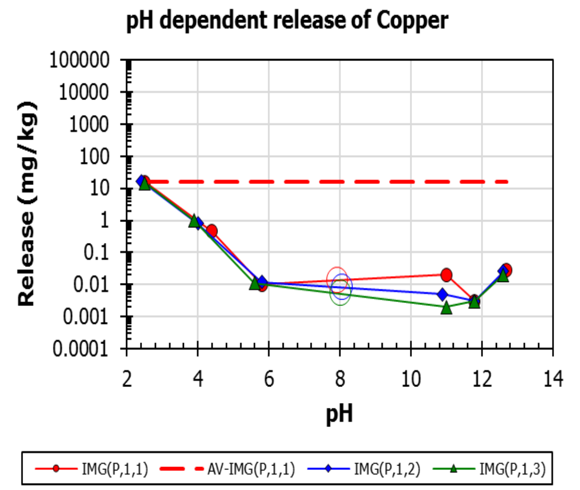

pH dependent concentration of Cobalt

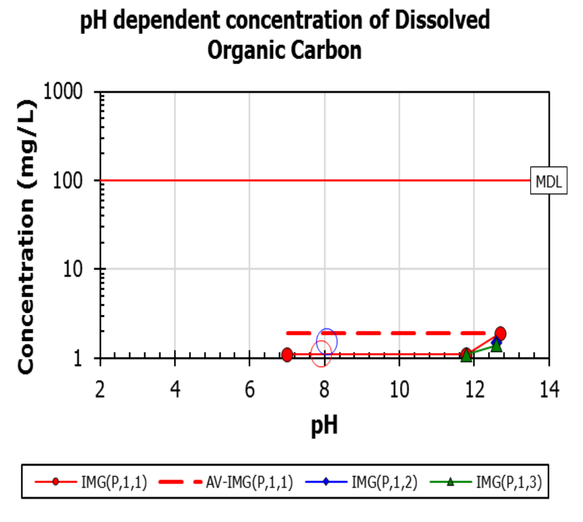

pH dependent release of Cobalt

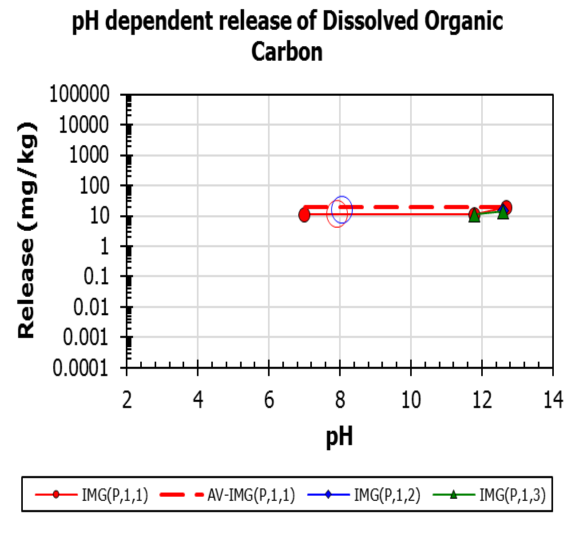

pH dependent concentration of Chromium
Concentration (mg/L)
1
0.1
0.01
2
4
6
8
10
12
14
pH
MDL
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

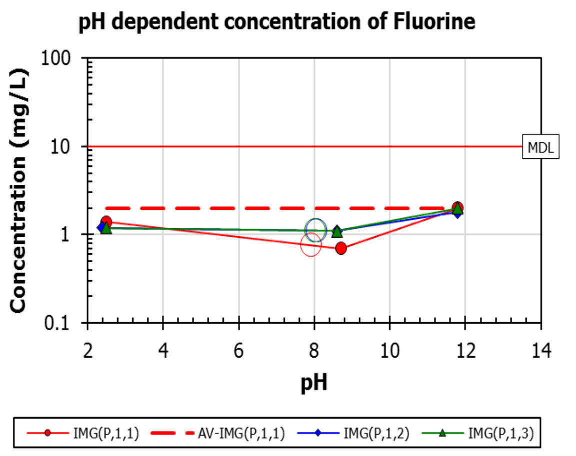

pH dependent release of Chromium
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

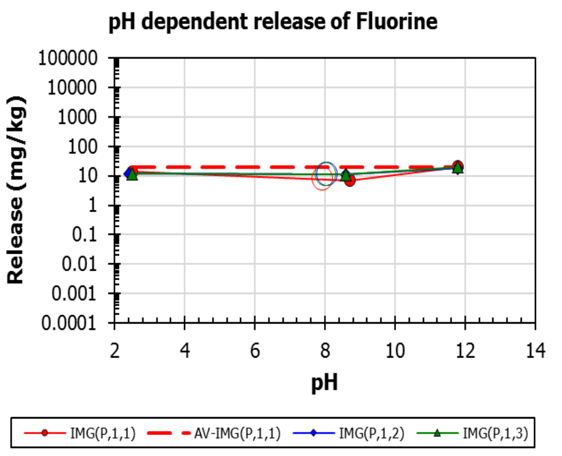

pH dependent concentration of Copper
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
MDL
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

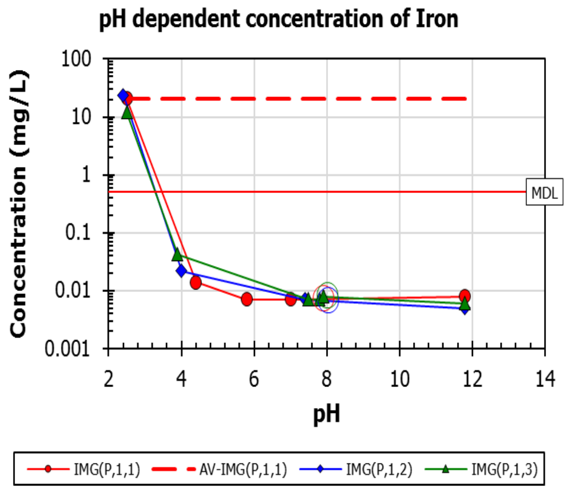

pH dependent release of Copper
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

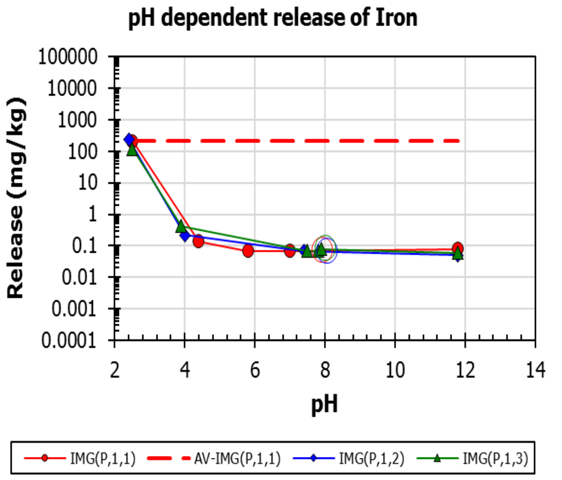

pH dependent concentration of Dissolved Organic Carbon
Concentration (mg/L)
1000
100
10
1
2
4
6
8
10
12
14
pH
MDL
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

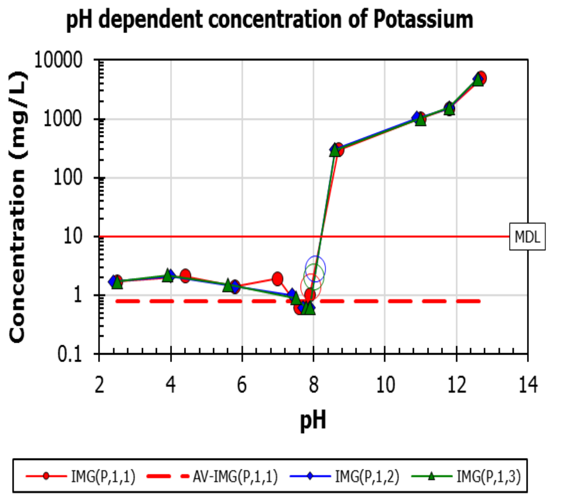

pH dependent release of Dissolved Organic Carbon
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

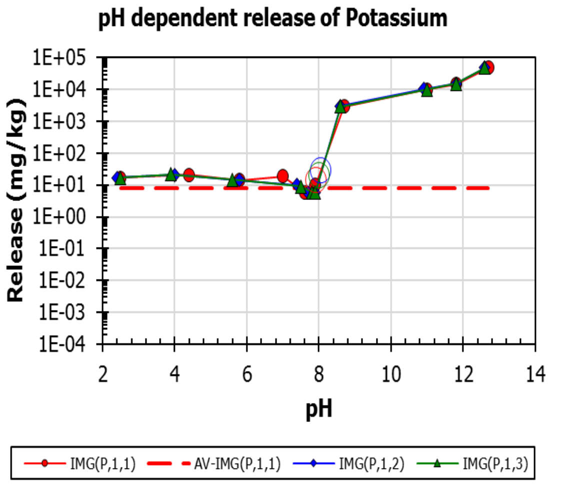

pH dependent concentration of Fluorine

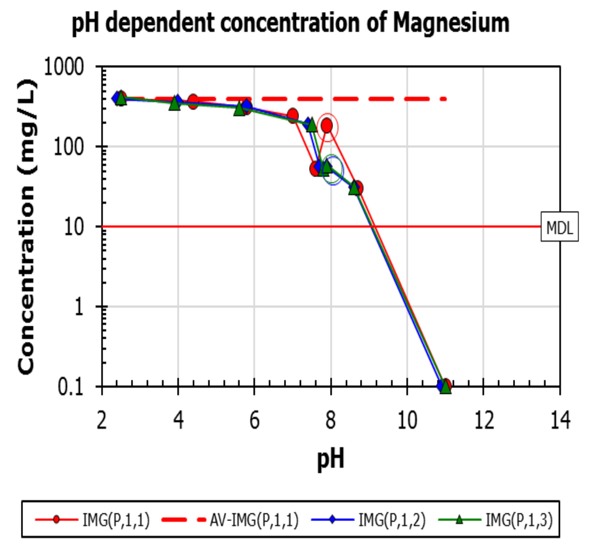

pH dependent release of Fluorine

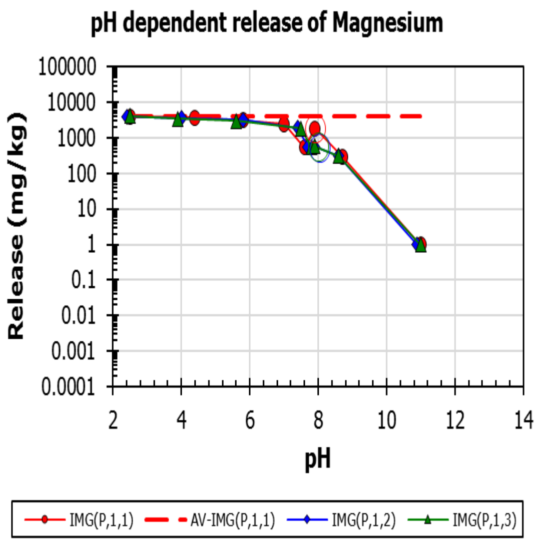

pH dependent concentration of Iron

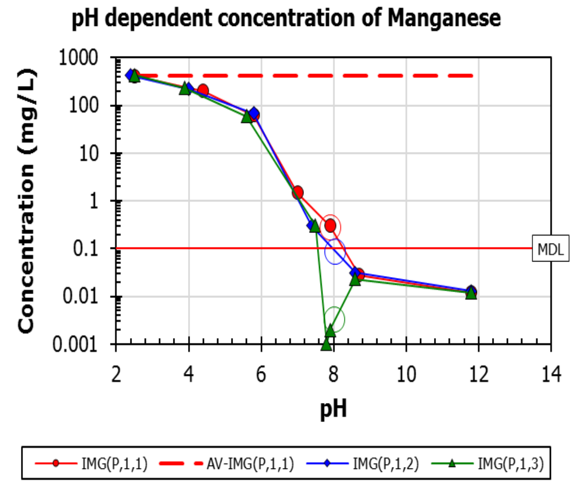

pH dependent release of Iron

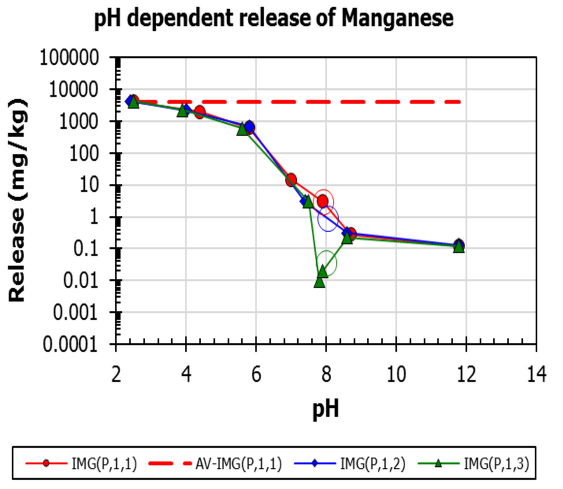

pH dependent concentration of Potassium

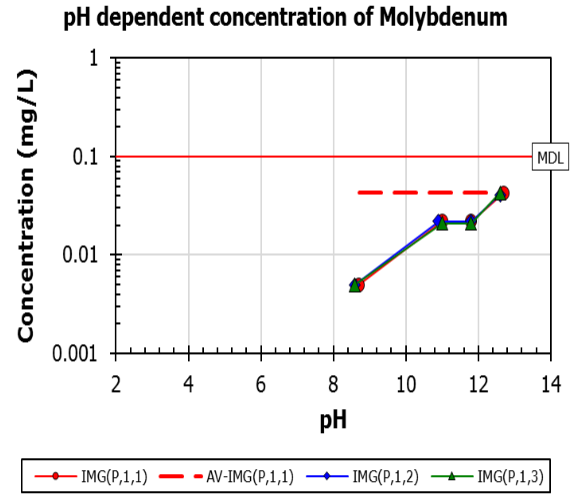

pH dependent release of Potassium

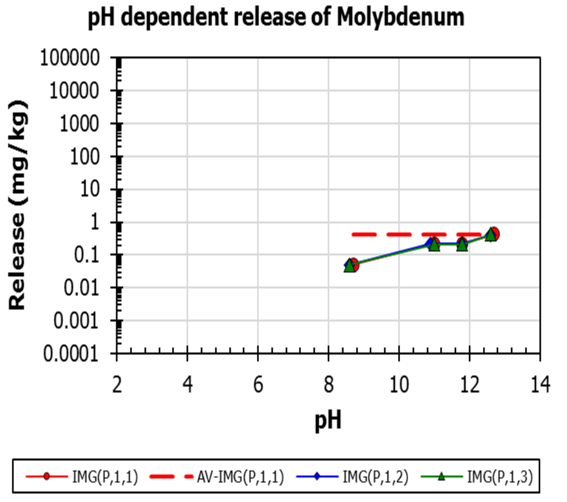

pH dependent concentration of Magnesium

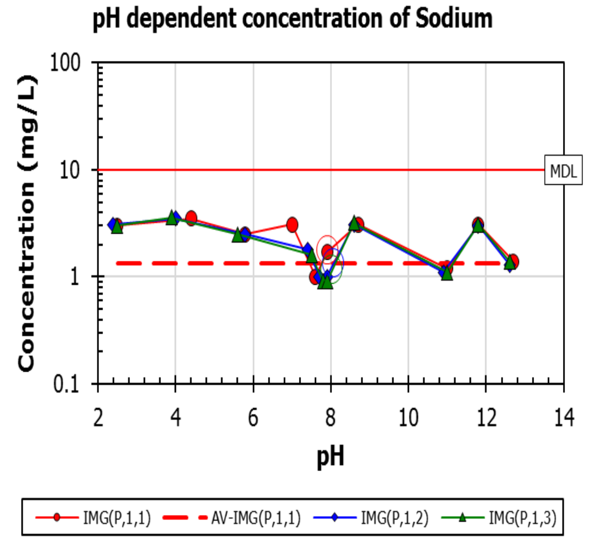

pH dependent release of Magnesium

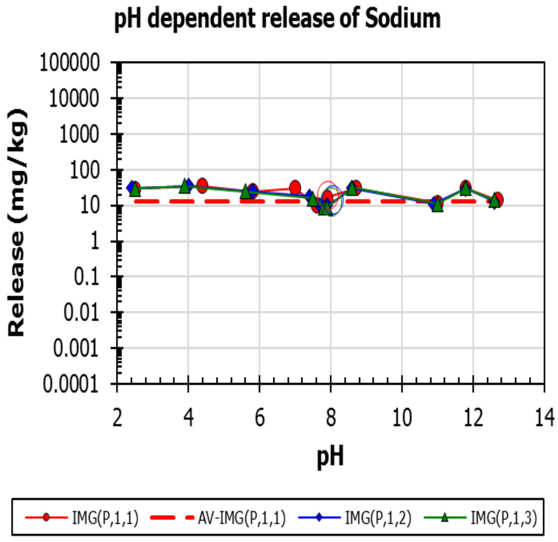

pH dependent concentration of Manganese

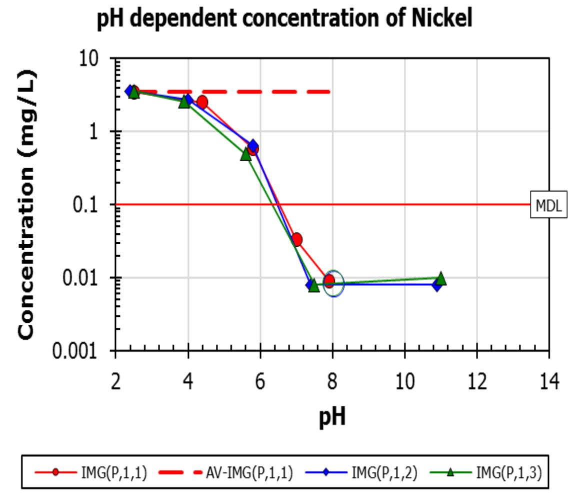

pH dependent release of Manganese

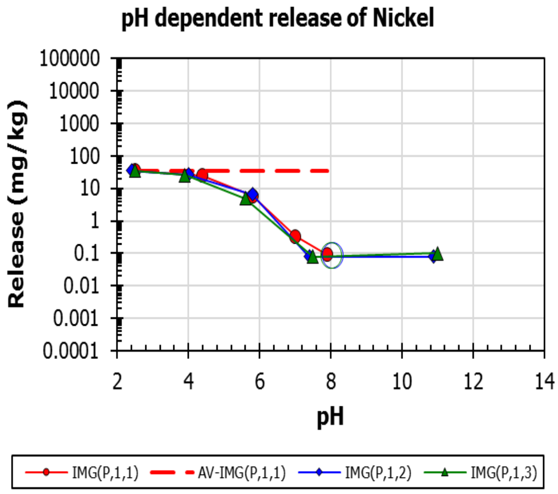

pH dependent concentration of Molybdenum

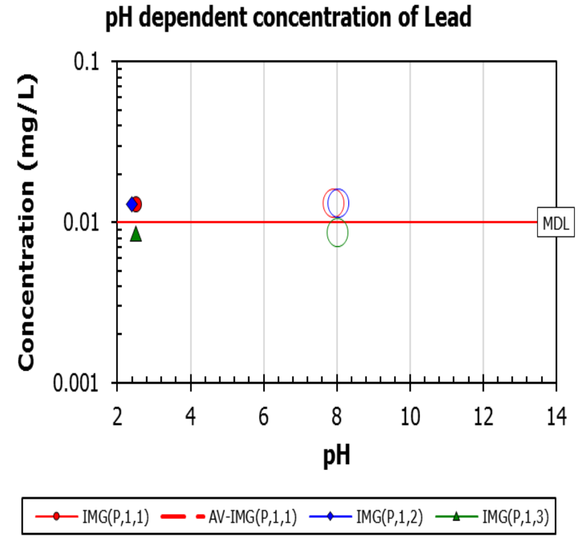

pH dependent release of Molybdenum

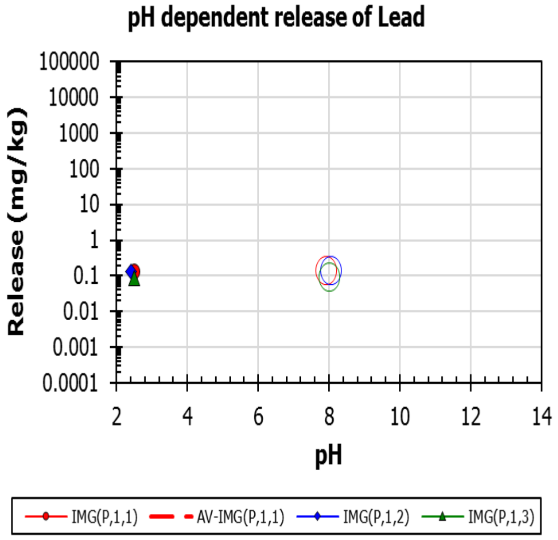

pH dependent concentration of Sodium

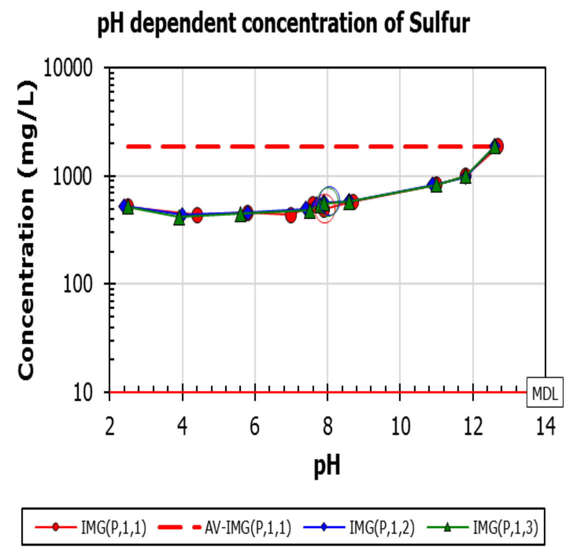

pH dependent release of Sodium

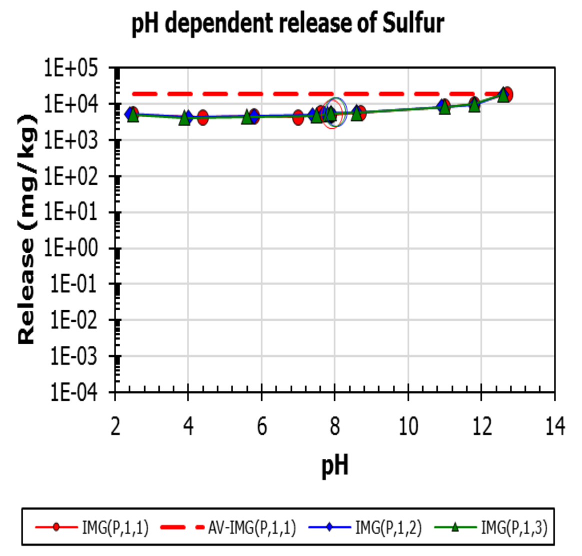

pH dependent concentration of Nickel

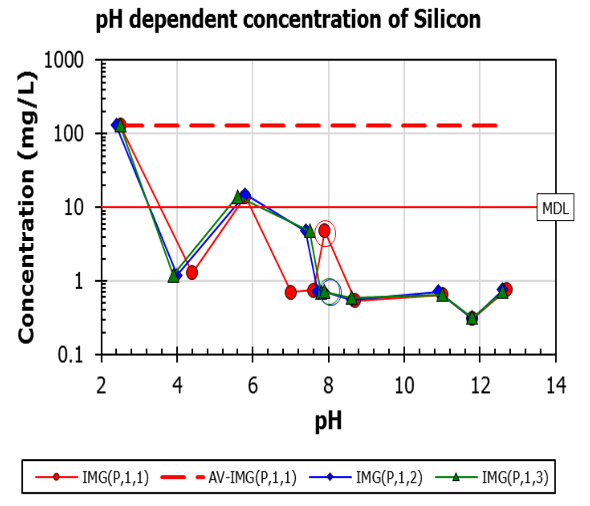

pH dependent release of Nickel

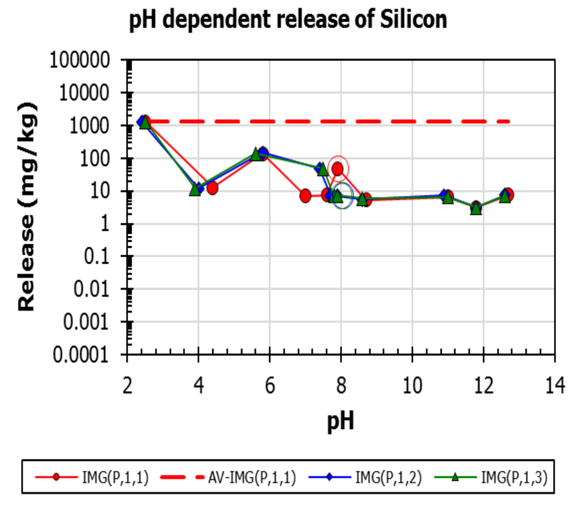

pH dependent concentration of Lead

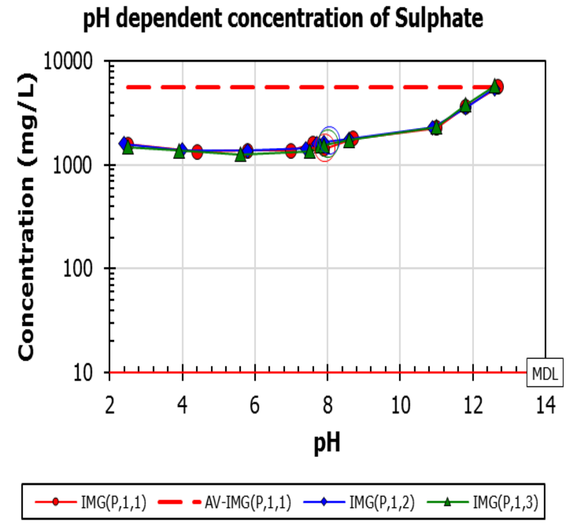

pH dependent release of Lead

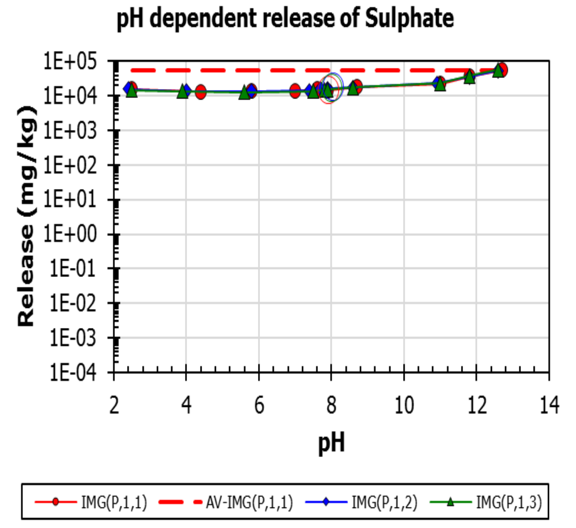

pH dependent concentration of Sulfur
Concentration (mg/L)
10000
1000
100
10
MDL
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

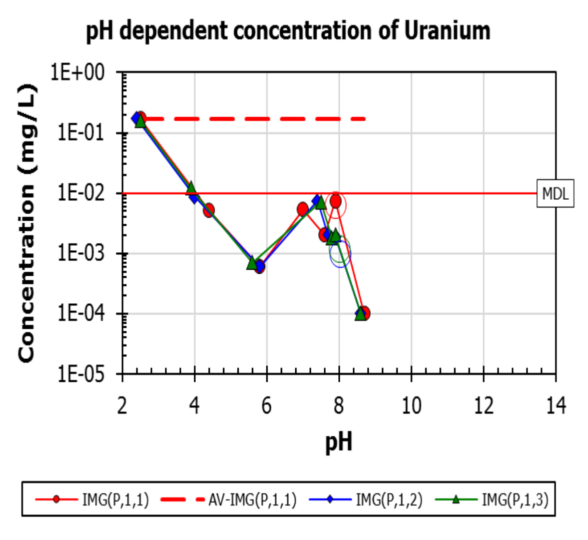

pH dependent release of Sulfur
Release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

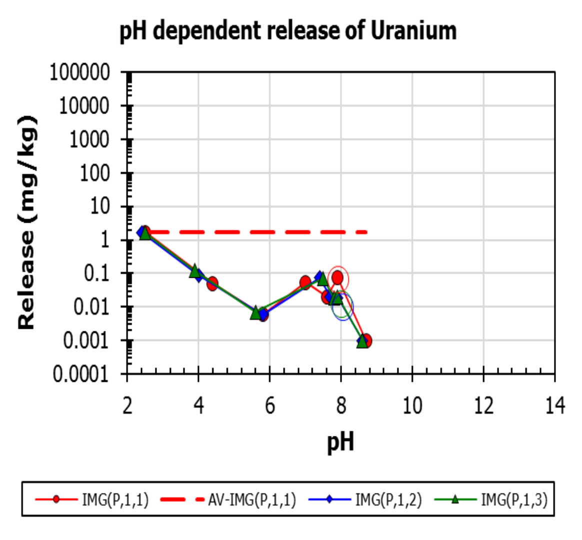

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0.1
MDL
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

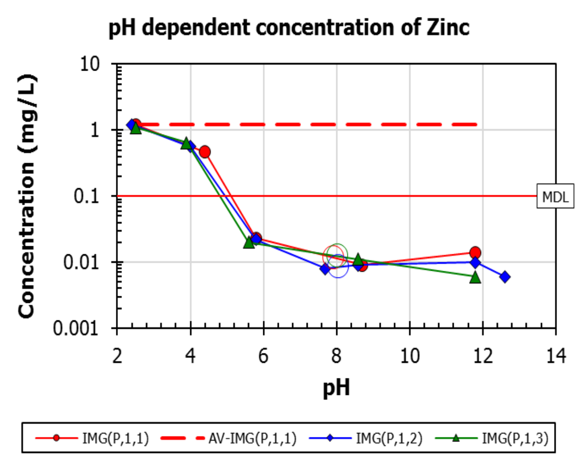

pH dependent release of Silicon
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

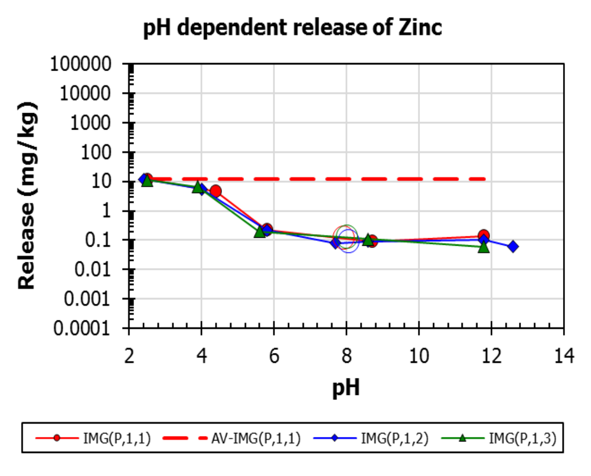

pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
10
MDL
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)


pH dependent release of Sulphate
Release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)


pH dependent concentration of Uranium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

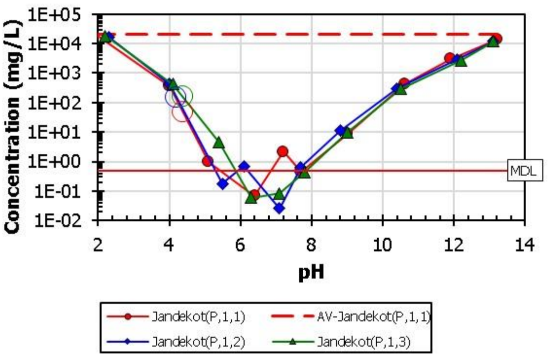

pH dependent release of Uranium
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

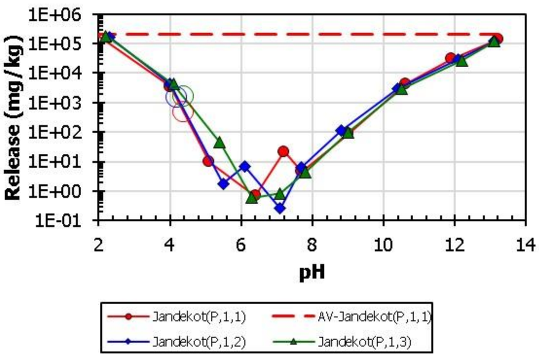

pH dependent concentration of Zinc
Concentration (mg/L)
10
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

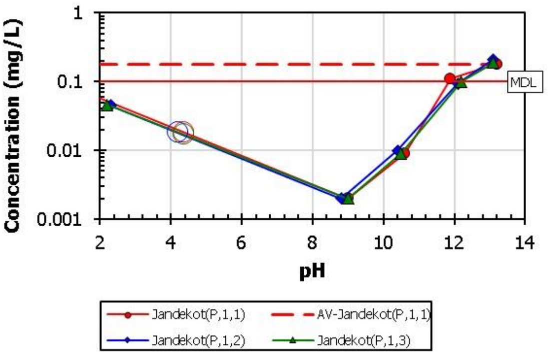

pH dependent release of Zinc
Release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
IMG(P,1,1)
AV-IMG(P,1,1)
IMG(P,1,2)
IMG(P,1,3)

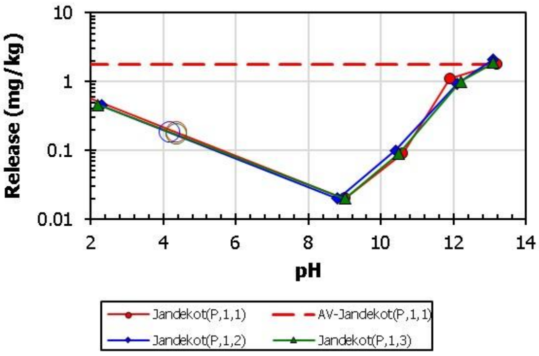
A5-4: Jandakot Groundwater Treatment Residues

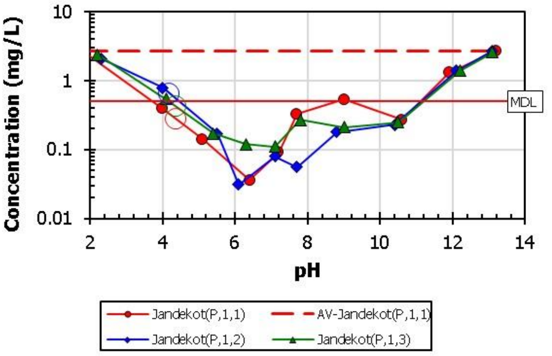
(Note: AV-Jandakot – represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

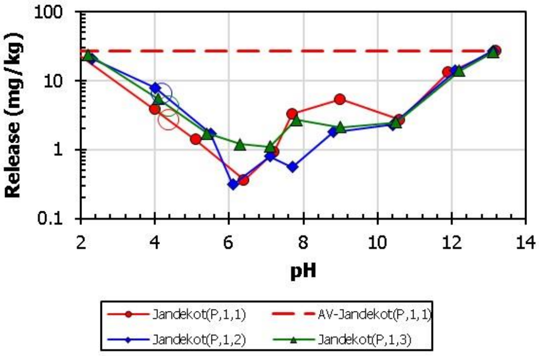

pH dependent concentration of Aluminum

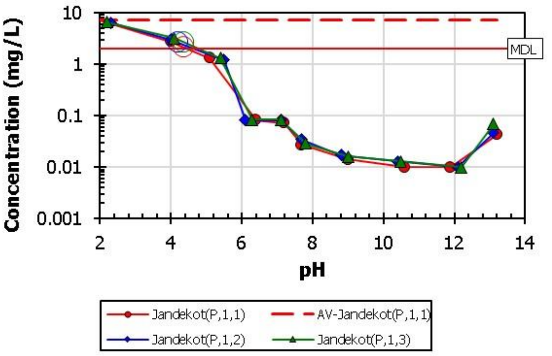

pH dependent release of Aluminum

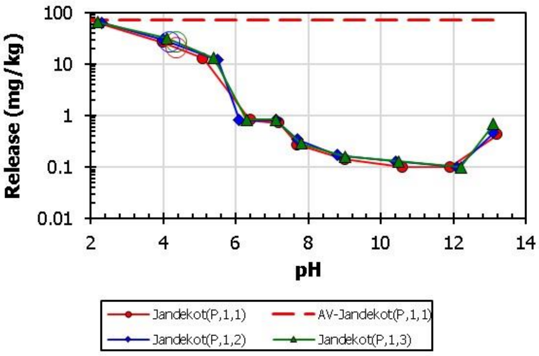

pH dependent concentration of Arsenic


pH dependent release of Arsenic

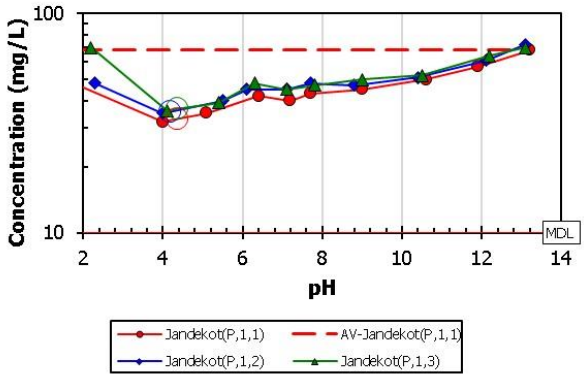

pH dependent concentration of Boron


pH dependent release of Boron

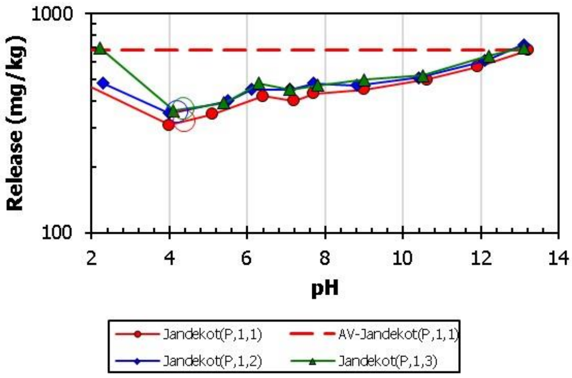

pH dependent concentration of Barium


pH dependent release of Barium

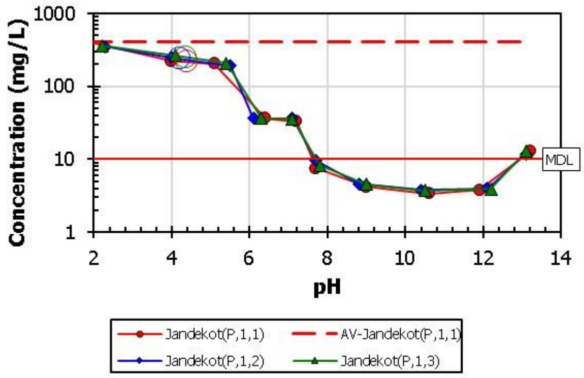
pH dependent concentration of Bromide



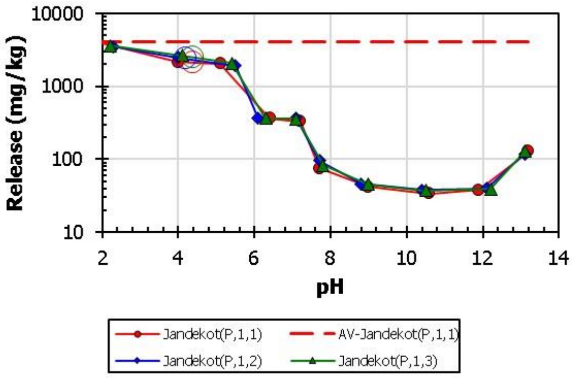
pH dependent release of Bromide



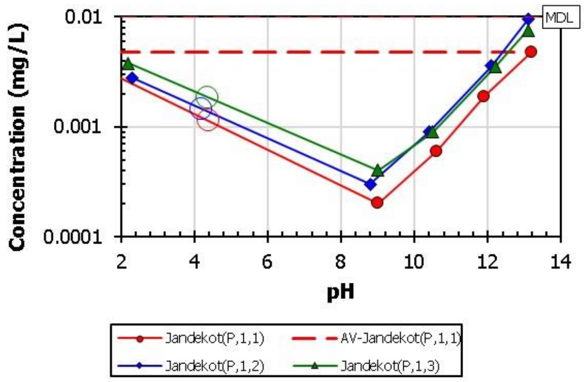
pH dependent concentration of Calcium



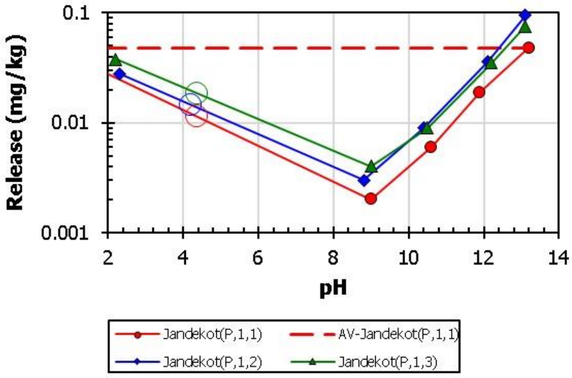
pH dependent release of Calcium



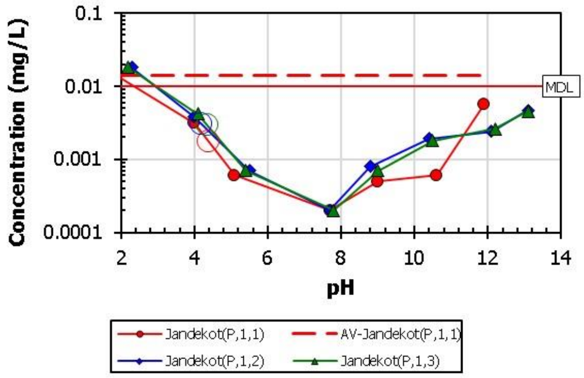
pH dependent concentration of Cadmium



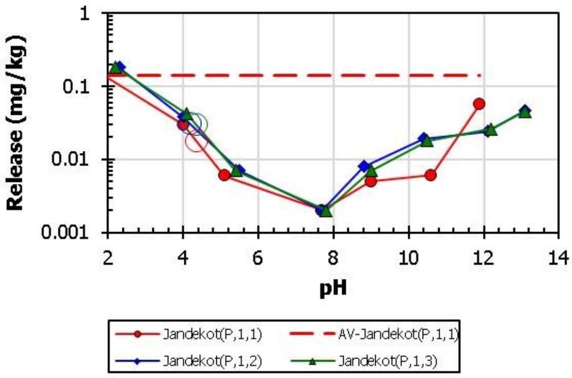
pH dependent release of Cadmium



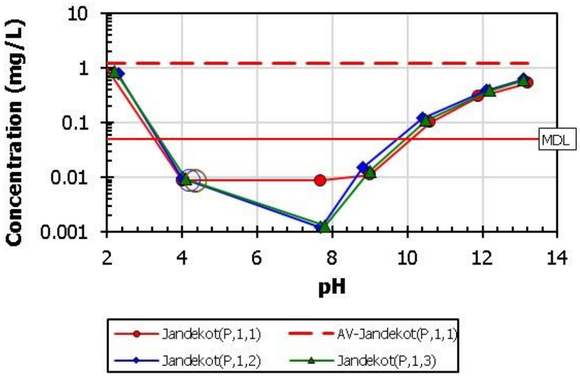
pH dependent concentration of Cobalt



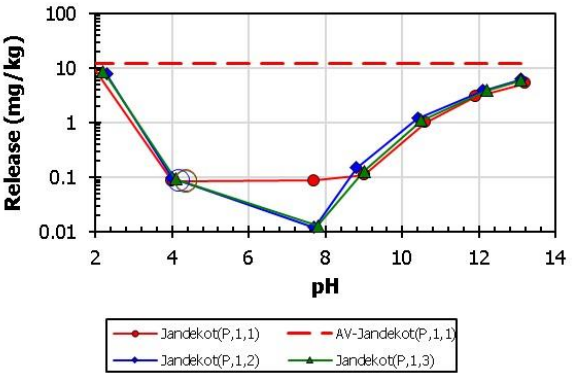
pH dependent release of Cobalt



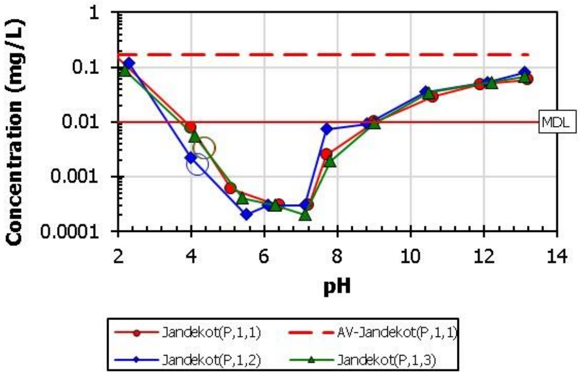
pH dependent concentration of Chromium



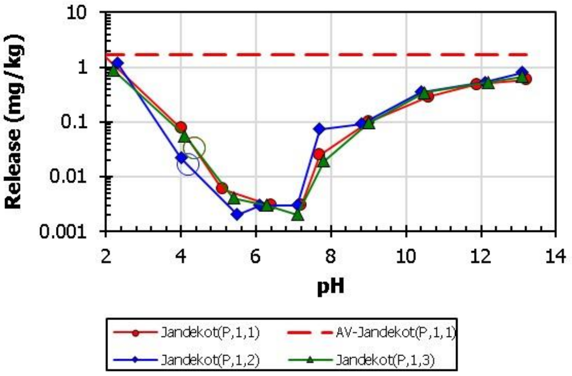
pH dependent release of Chromium



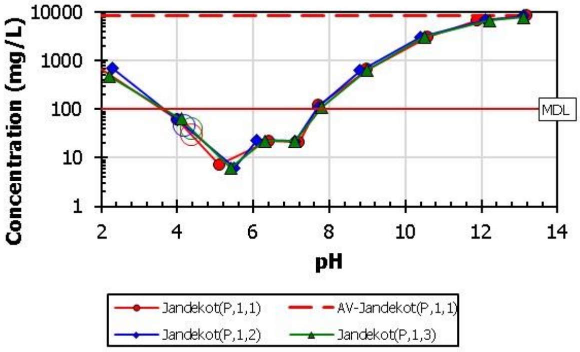
pH dependent concentration of Copper



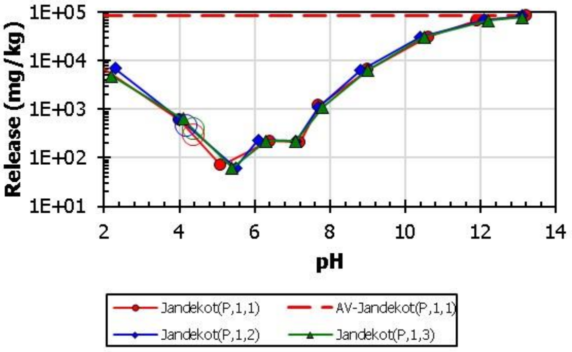
pH dependent release of Copper



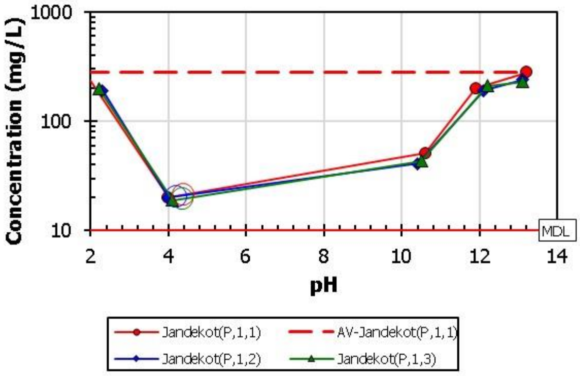
pH dependent concentration of Dissolved Organic Carbon



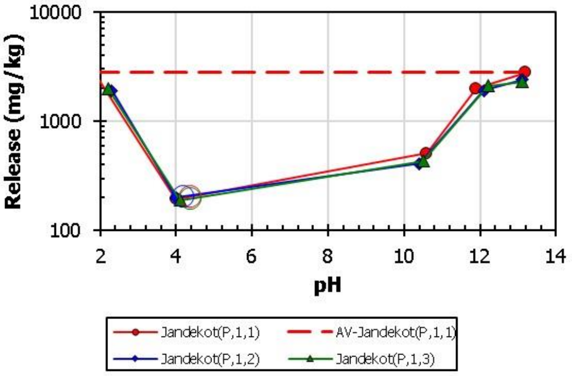
pH dependent release of Dissolved Organic Carbon

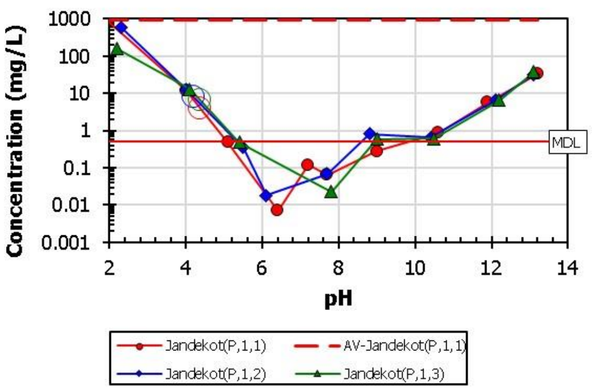


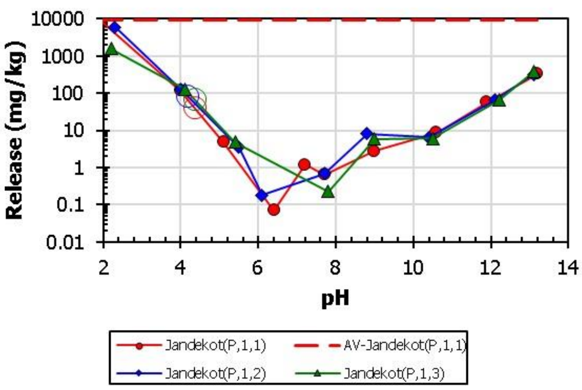
pH dependent concentration of Fluorine

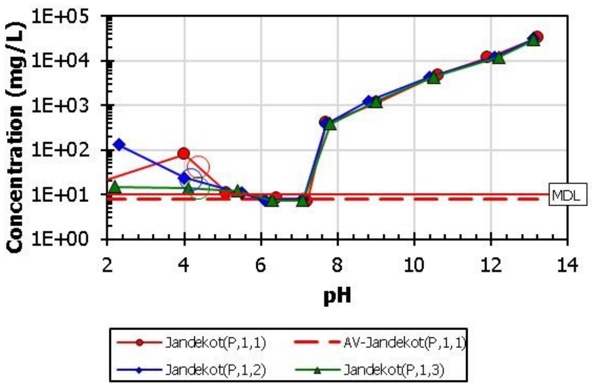


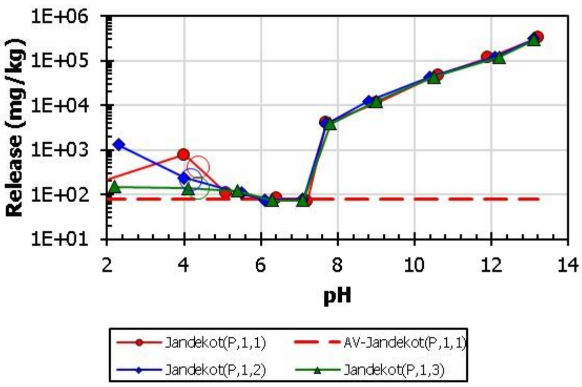
pH dependent release of Fluorine

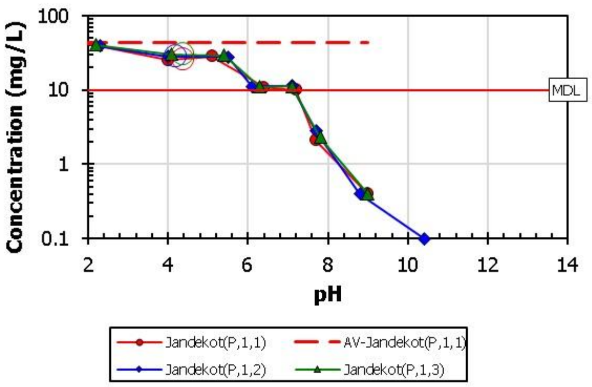


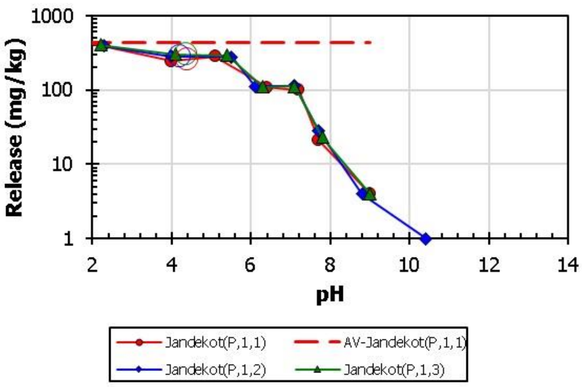

pH dependent concentration of Iron

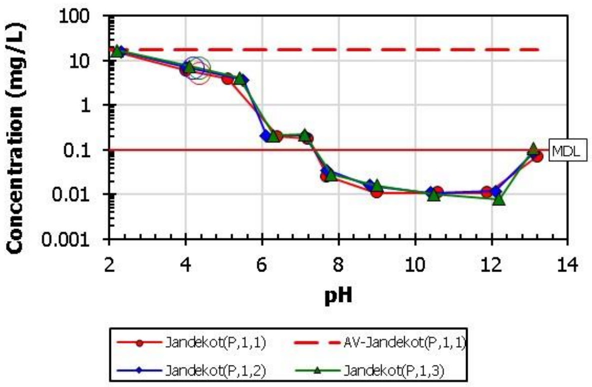

pH dependent release of Iron

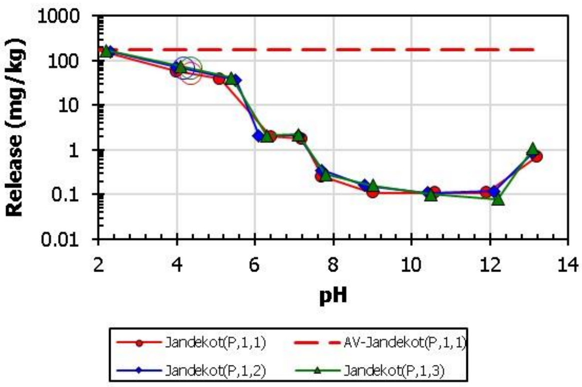

pH dependent concentration of Potassium


pH dependent release of Potassium

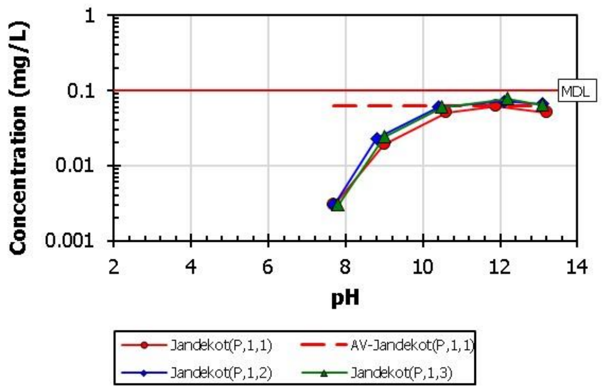

pH dependent concentration of Magnesium


pH dependent release of Magnesium

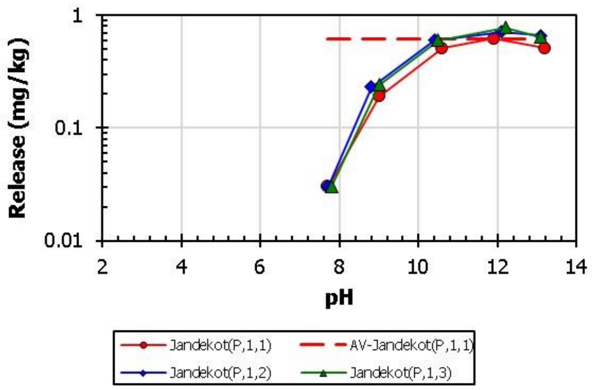

pH dependent concentration of Manganese


pH dependent release of Manganese

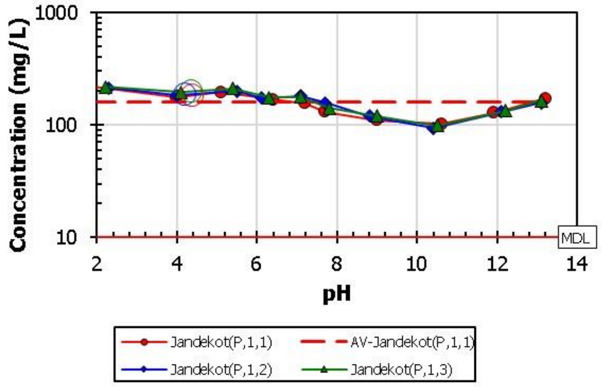
pH dependent concentration of Molybdenum



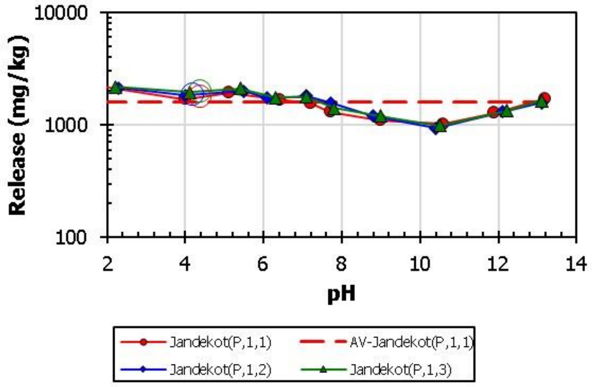
pH dependent release of Molybdenum



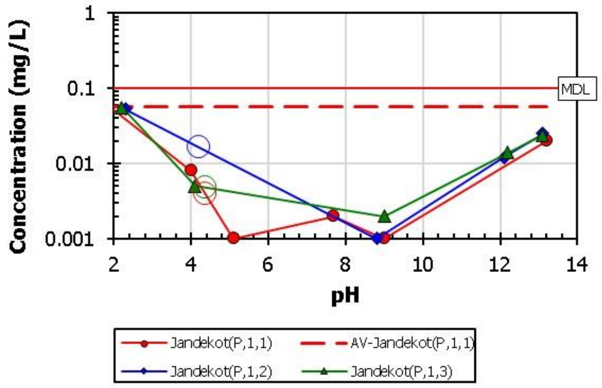
pH dependent concentration of Sodium



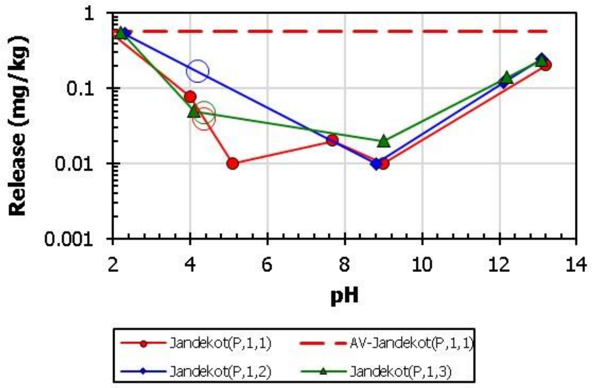
pH dependent release of Sodium



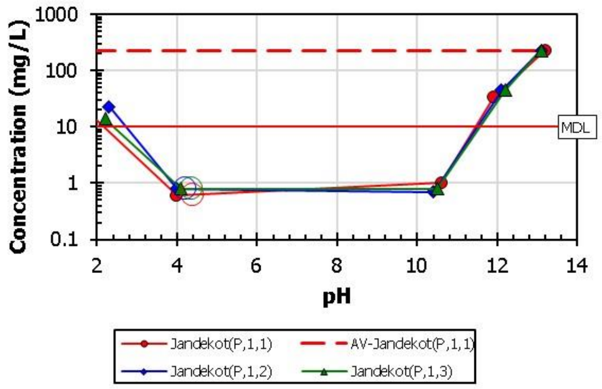
pH dependent concentration of Nickel



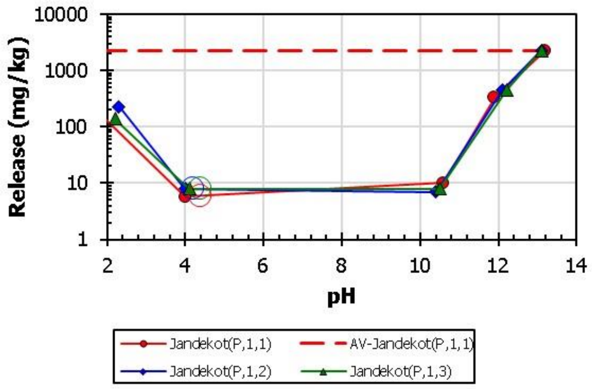
pH dependent release of Nickel

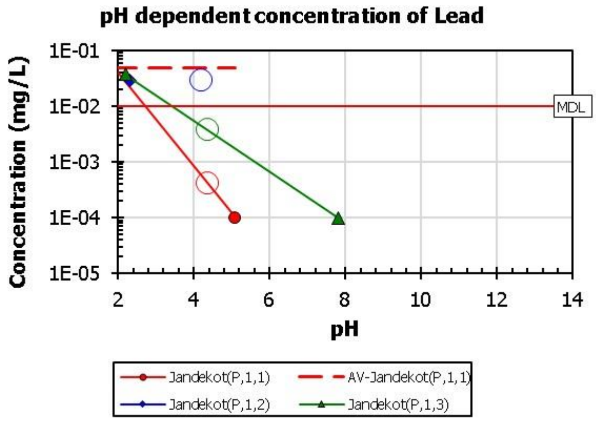


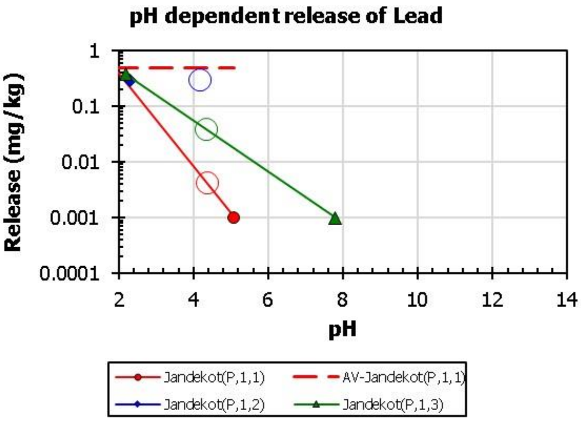
pH dependent concentration of Phosphorus

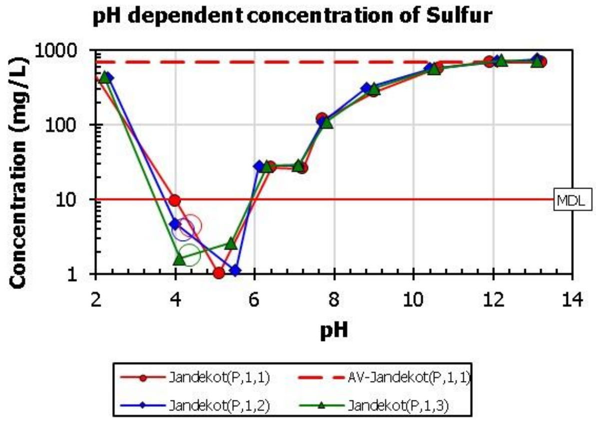


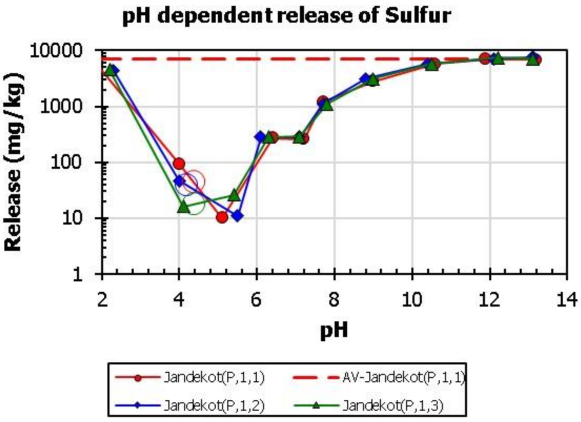
pH dependent release of Phosphorus

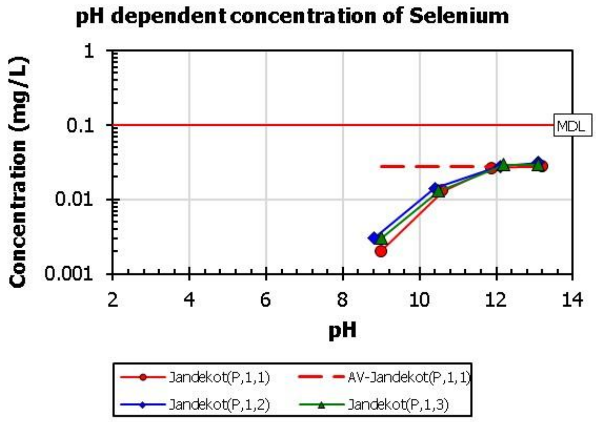


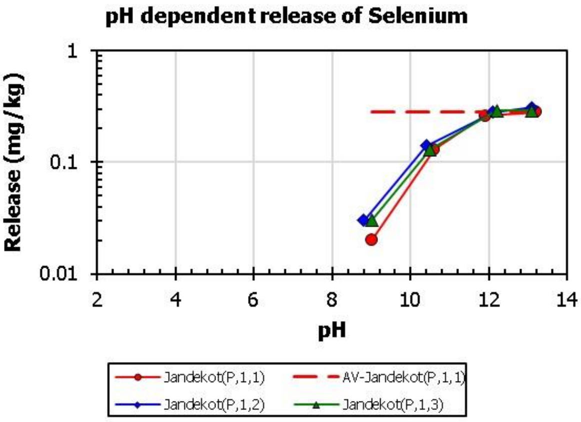

pH dependent concentration of Lead
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

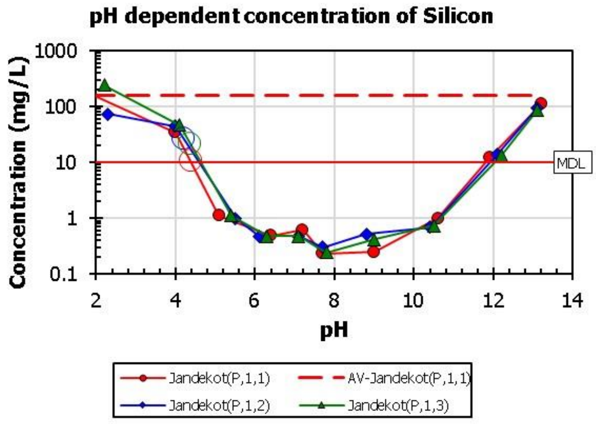

pH dependent release of Lead
Release (mg/kg)
1
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

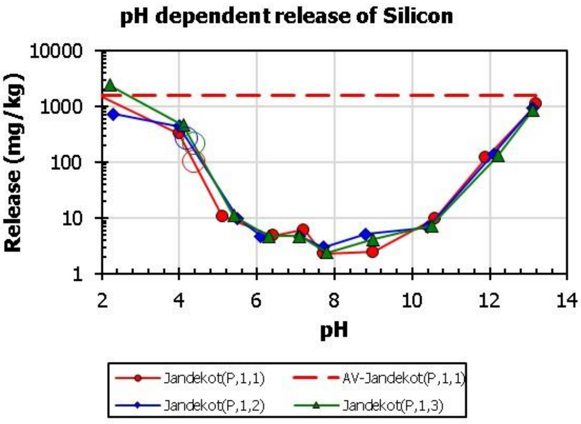

pH dependent concentration of Sulfur
Concentration (mg/L)
1000
100
10
1
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

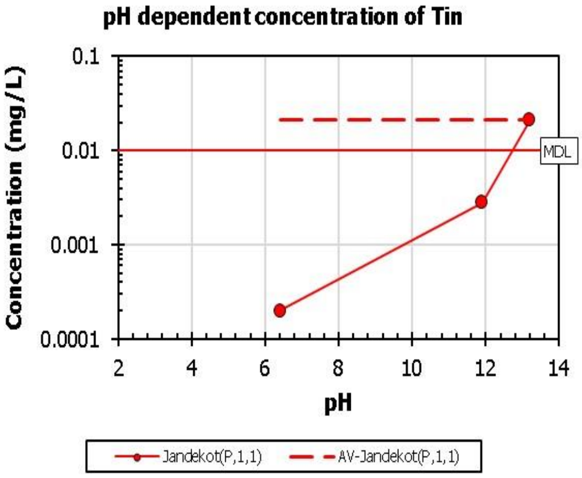

pH dependent release of Sulfur
Release (mg/kg)
10000
1000
100
10
1
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

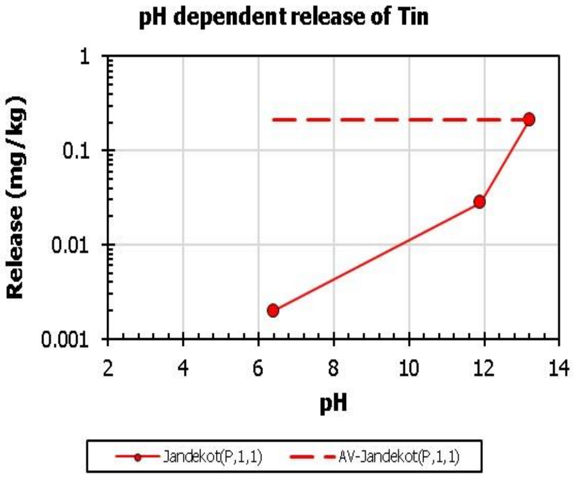

pH dependent concentration of Selenium
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

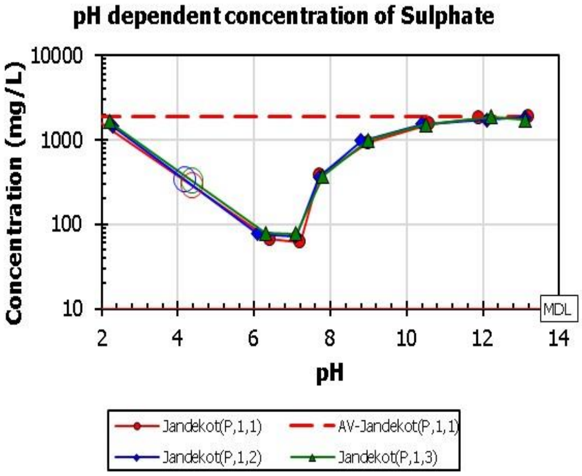

pH dependent release of Selenium
Release (mg/kg)
1
0.1
0.01
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

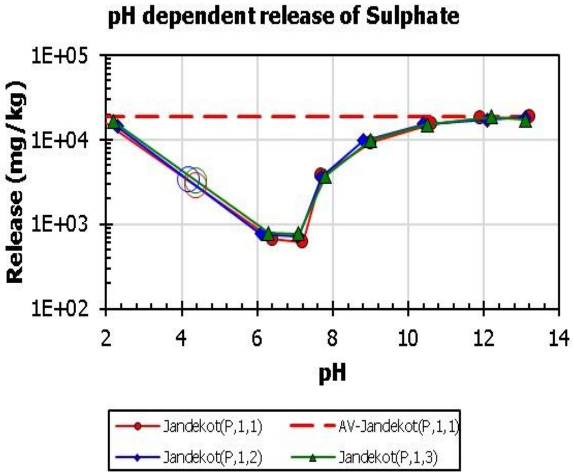

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0.1
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

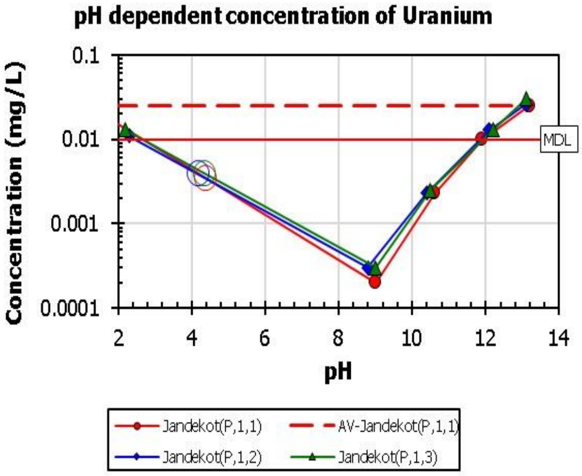

pH dependent release of Silicon
Release (mg/kg)
10000
1000
100
10
1
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

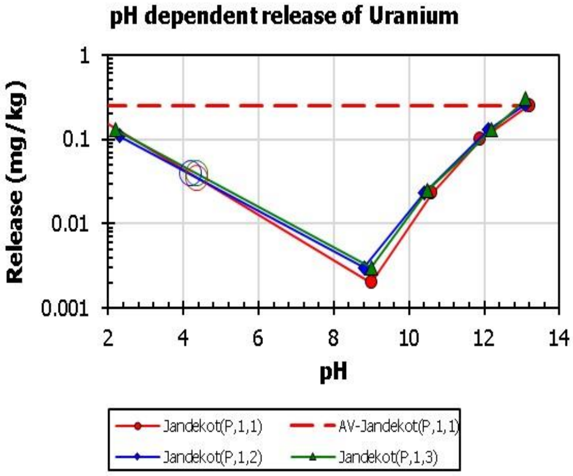

pH dependent concentration of Tin
Concentration (mg/L)
0.1
0.01
0.001
0.0001
MDL
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)

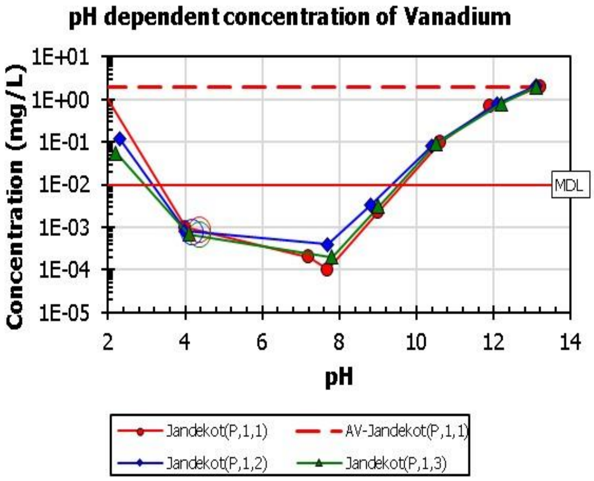

pH dependent release of Tin
Release (mg/kg)
1
0.1
0.01
0.001
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)

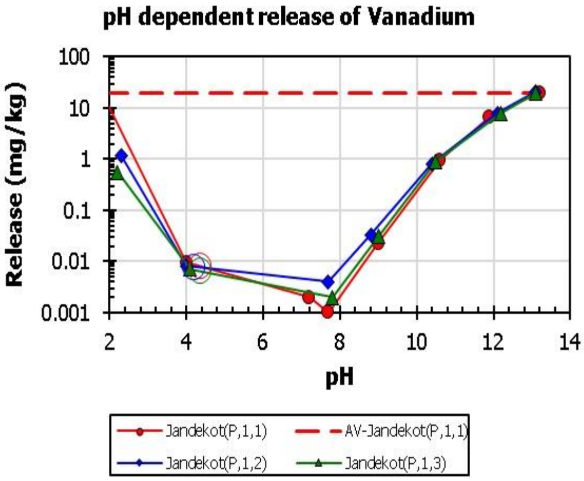

pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
10
MDL
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

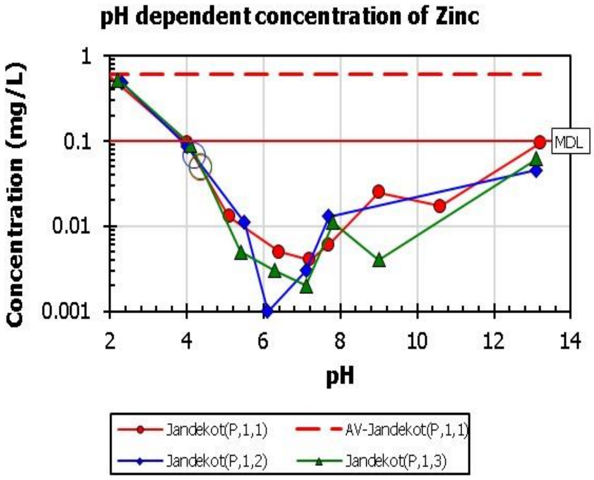

pH dependent release of Sulphate
Release (mg/kg)
1E+05
1E+04
1E+03
1E+02
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

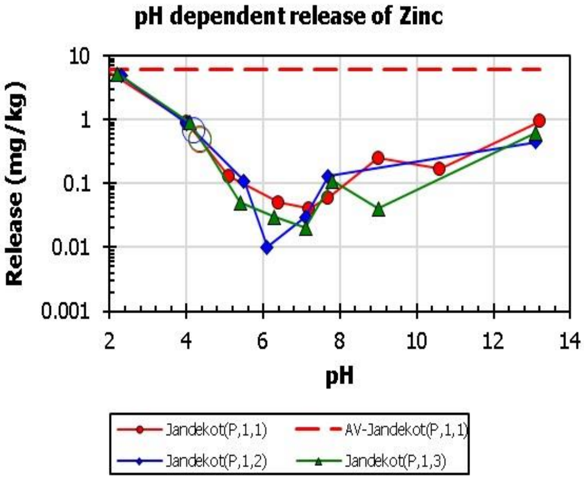

pH dependent concentration of Uranium
Concentration (mg/L)
0.1
0.01
0.001
0.0001
MDL
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)


pH dependent release of Uranium
Release (mg/kg)
1
0.1
0.01
0.001
pH
2
4
6
8
10
12
14
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)


pH dependent concentration of Vanadium
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

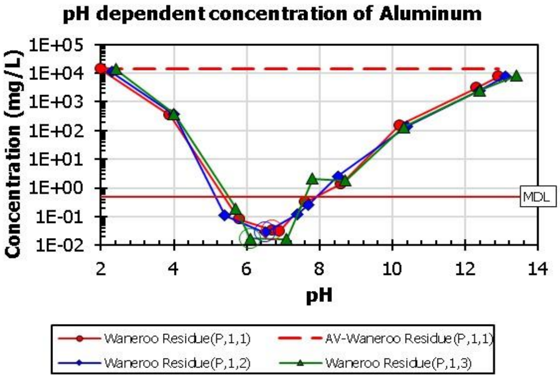

pH dependent release of Vanadium
Release (mg/kg)
100
10
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

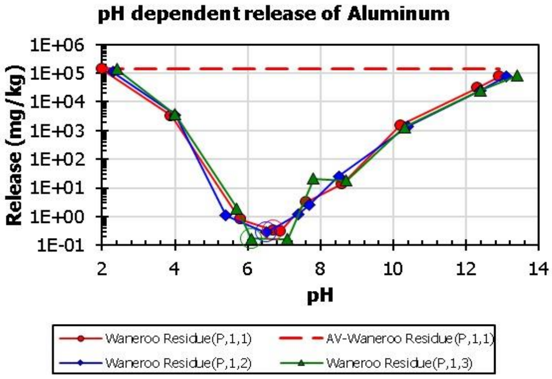

pH dependent concentration of Zinc
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

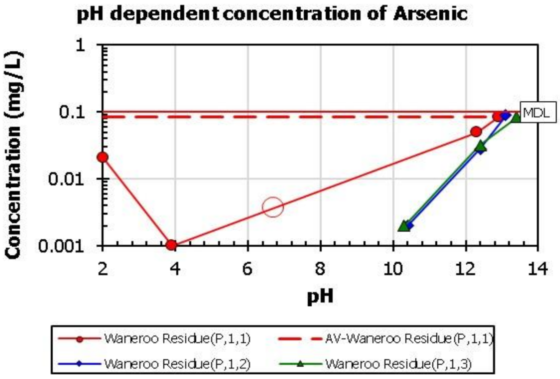

pH dependent release of Zinc
Release (mg/kg)
10
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
Jandekot(P,1,1)
AV-Jandekot(P,1,1)
Jandekot(P,1,2)
Jandekot(P,1,3)

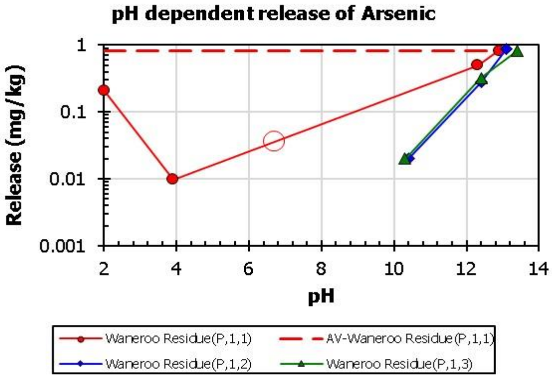
A5-5: Wanneroo Groundwater Treatment Residues

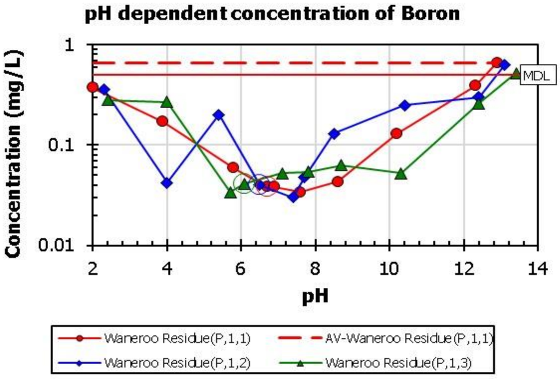
(Note: AV-Wanneroo – represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

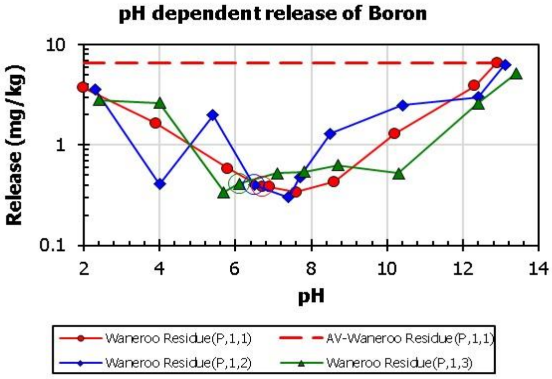


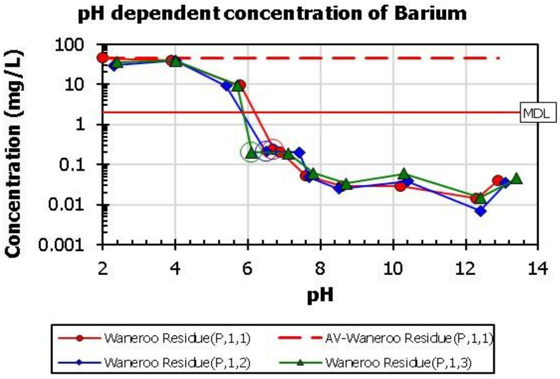


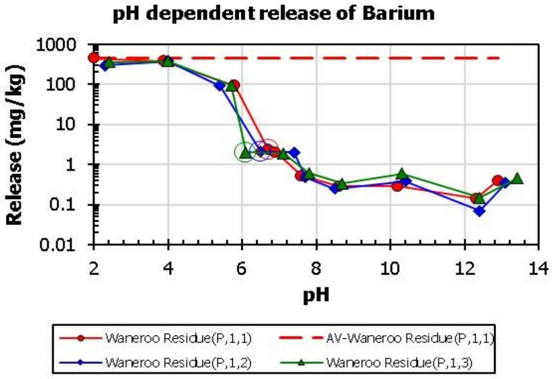


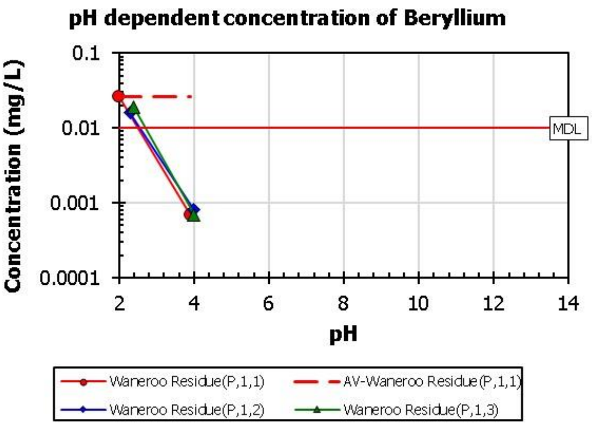


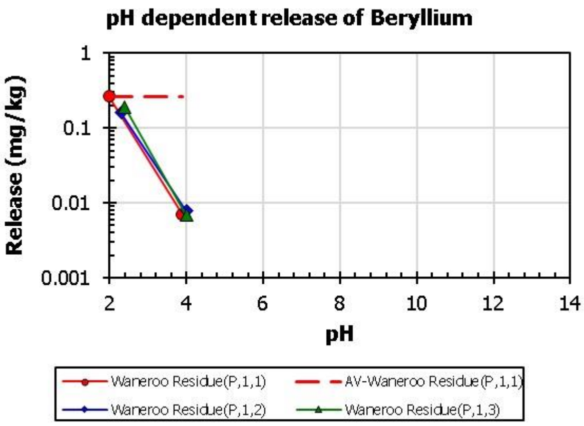


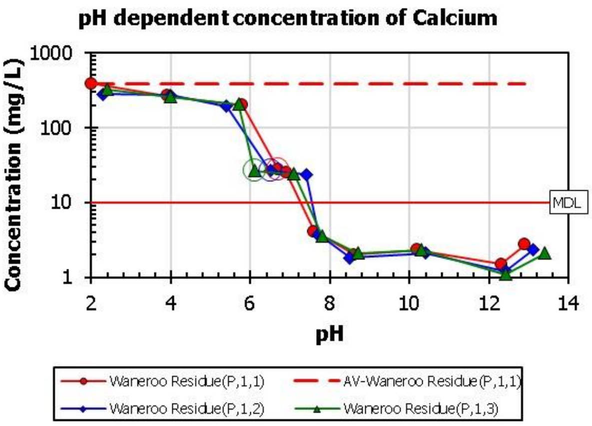


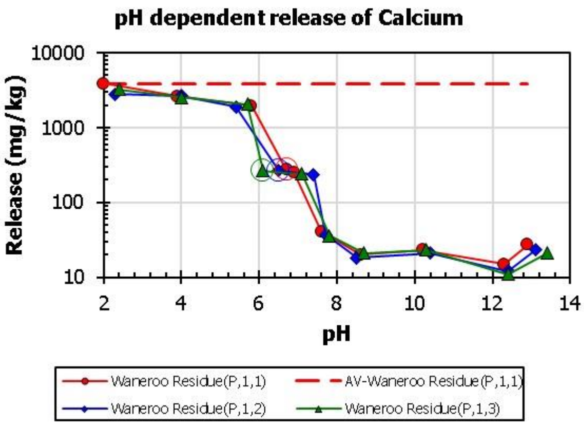


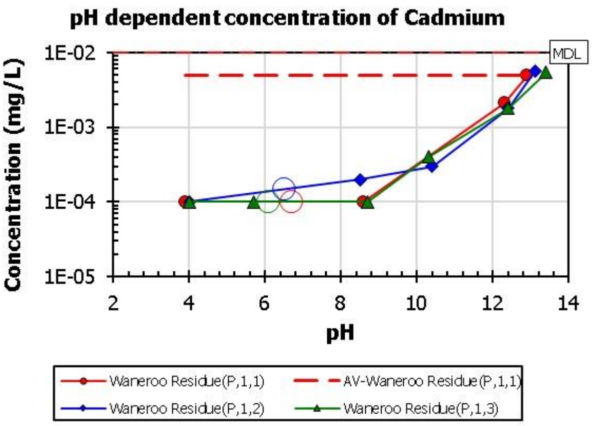


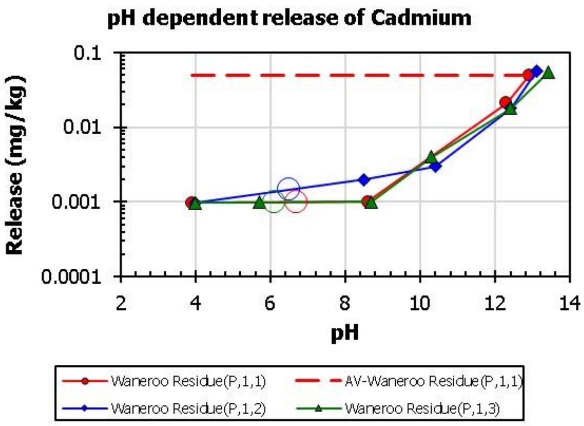

pH dependent concentration of Beryllium
Concentration (mg/L)
0.1
0.01
0.001
0.0001
MDL
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

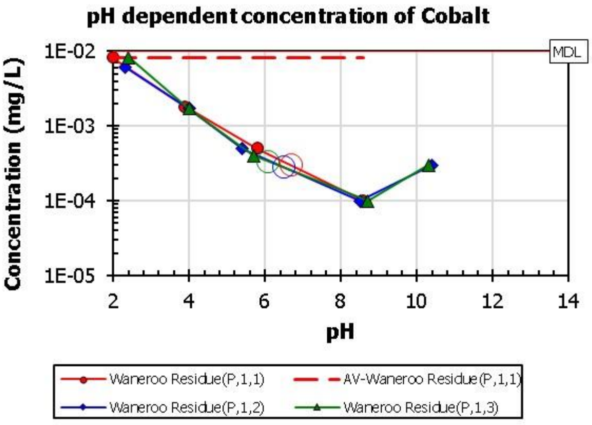

pH dependent release of Beryllium
Release (mg/kg)
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

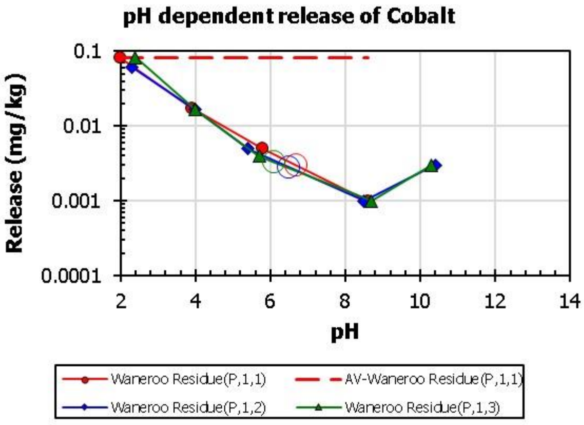

pH dependent concentration of Calcium
Concentration (mg/L)
1000
100
10
1
MDL
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

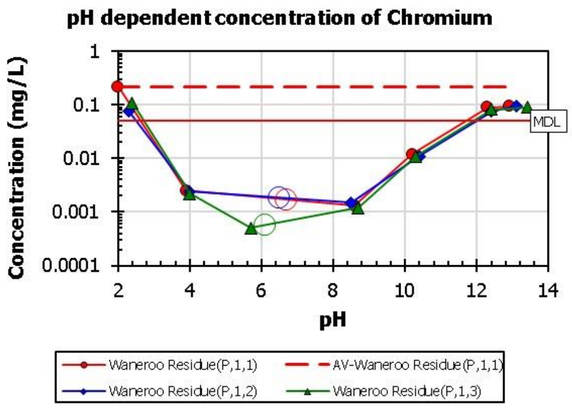

pH dependent release of Calcium
Release (mg/kg)
10000
1000
100
10
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

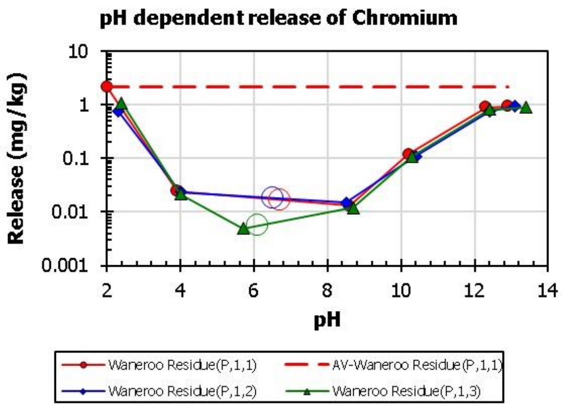

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

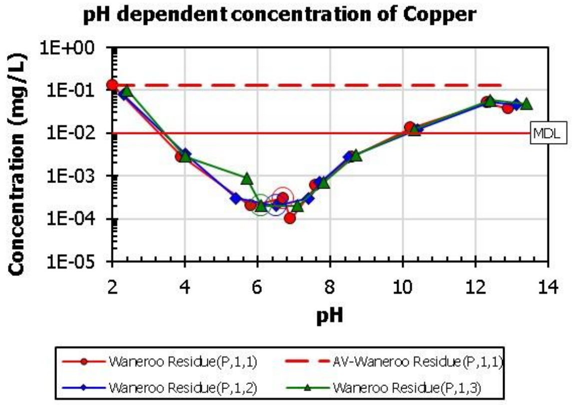

pH dependent release of Cadmium
Release (mg/kg)
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

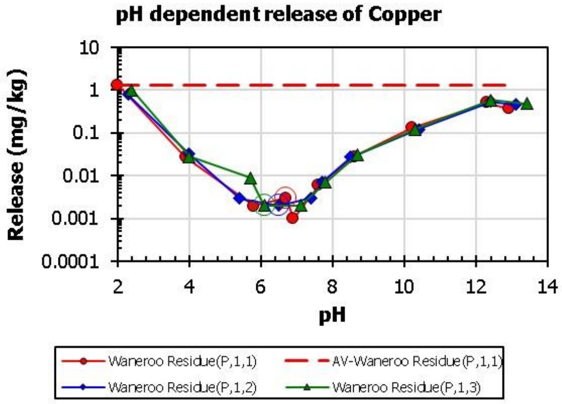

pH dependent concentration of Cobalt
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

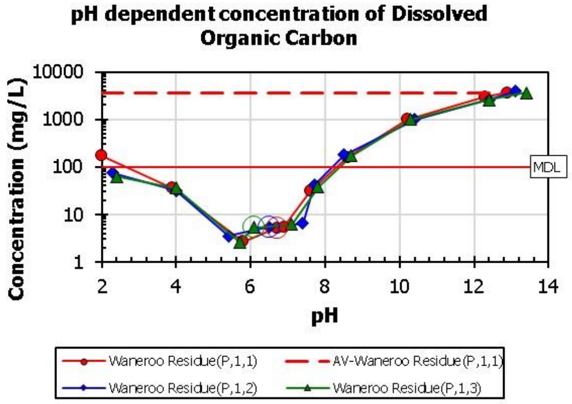

pH dependent release of Cobalt
Release (mg/kg)
0.1
0.01
0.001
0.0001
2
4
6
8
10
12
14
pH
Waneroo Residue(P,1,1)
AV-Waneroo Residue(P,1,1)
Waneroo Residue(P,1,2)
Waneroo Residue(P,1,3)

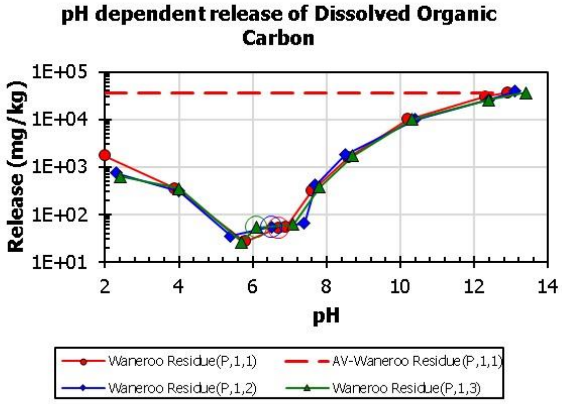

pH dependent concentration of Chromium

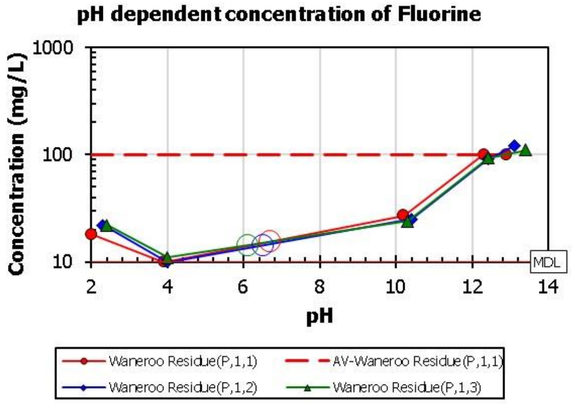

pH dependent release of Chromium

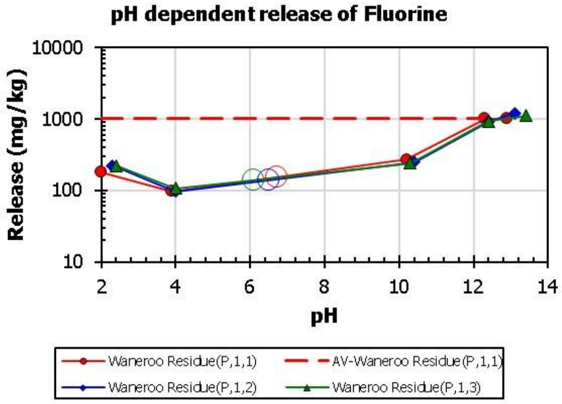

pH dependent concentration of Copper

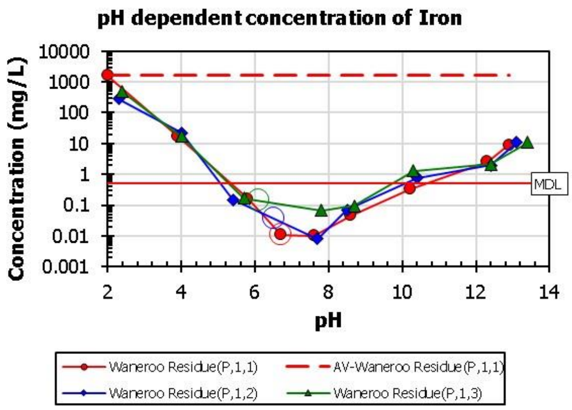

pH dependent release of Copper

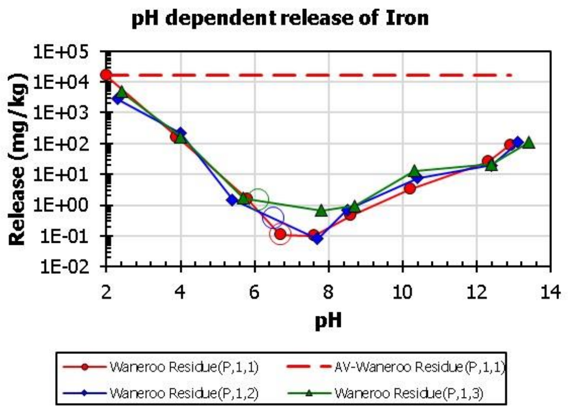

pH dependent concentration of Dissolved Organic Carbon

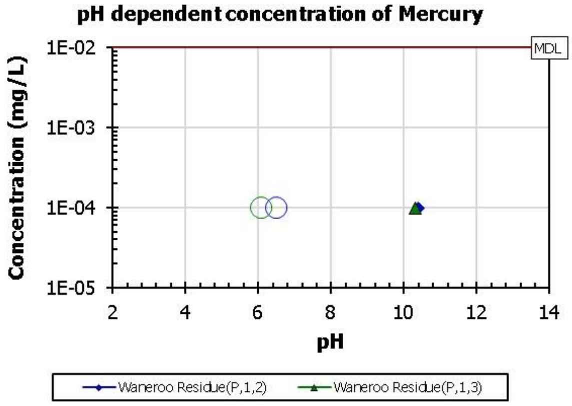

pH dependent release of Dissolved Organic Carbon

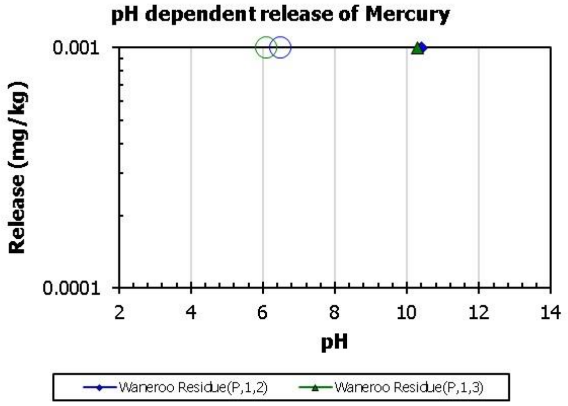

pH dependent concentration of Fluorine

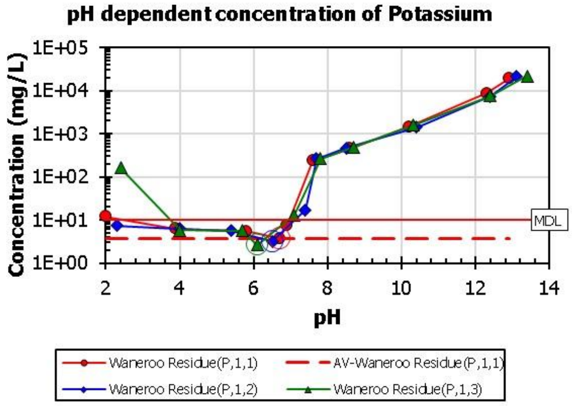

pH dependent release of Fluorine

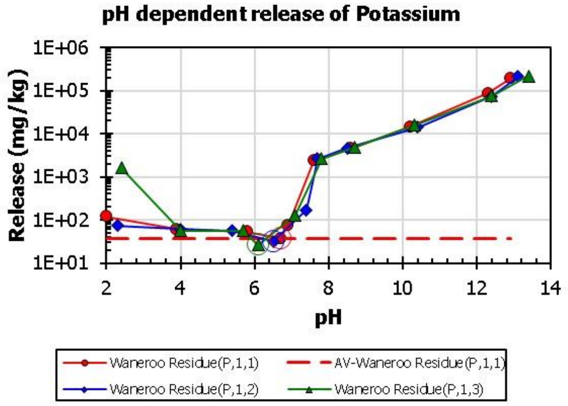

pH dependent concentration of Iron
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
MDL
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)

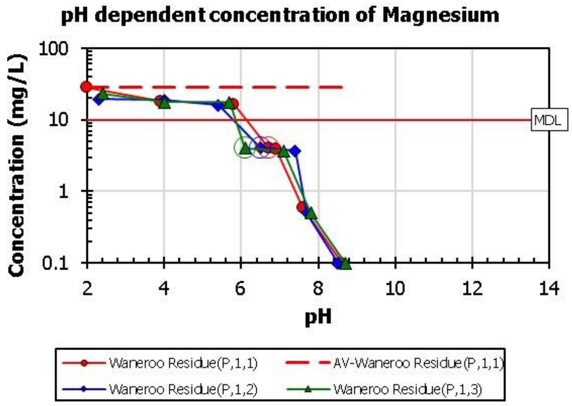

pH dependent release of Iron
Release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
2
4
6
8
10
12
14
pH
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)

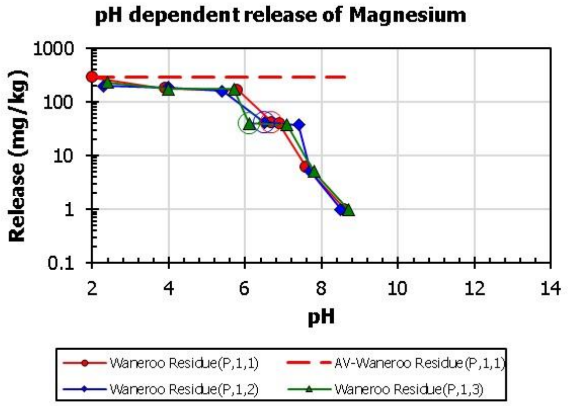

pH dependent concentration of Mercury
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
2
4
6
8
10
12
14
pH
MDL
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)


pH dependent release of Mercury
Release (mg/kg)
0.001
0.0001
2
4
6
8
10
12
14
pH
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)

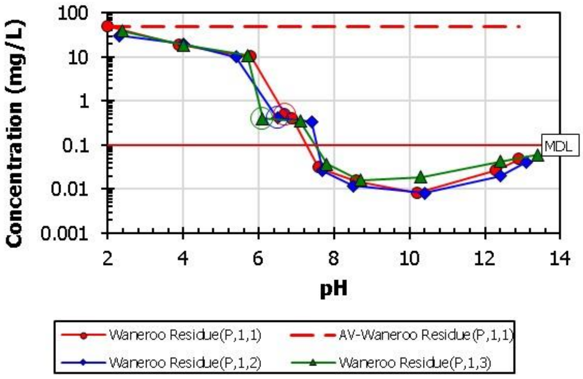

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
2
4
6
8
10
12
14
pH
MDL
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)


pH dependent release of Potassium
Release (mg/kg)
1E+06
1E+05
1E+04
1E+03
1E+02
1E+01
2
4
6
8
10
12
14
pH
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)

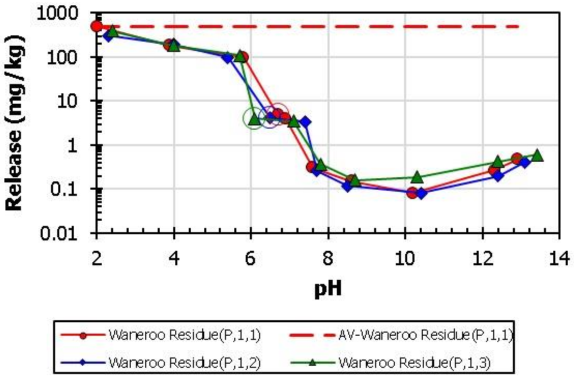

pH dependent concentration of Magnesium
Concentration (mg/L)
100
10
1
0.1
2
4
6
8
10
12
14
pH
MDL
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)


pH dependent release of Magnesium
Release (mg/kg)
1000
100
10
1
0.1
2
4
6
8
10
12
14
pH
Wanneroo Residue(P,1,1)
AV-Wanneroo Residue(P,1,1)
Wanneroo Residue(P,1,2)
Wanneroo Residue(P,1,3)

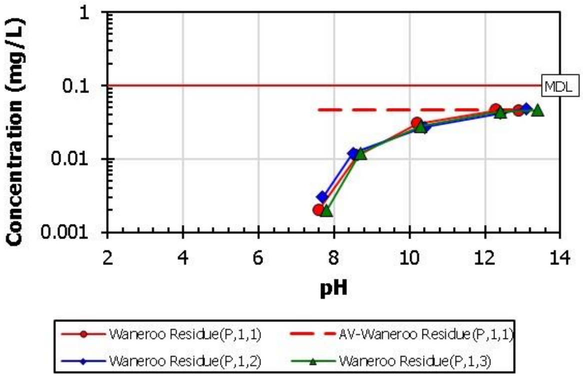
pH dependent concentration of Manganese



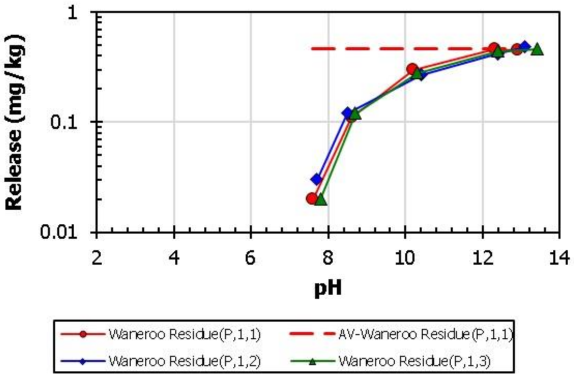
pH dependent release of Manganese



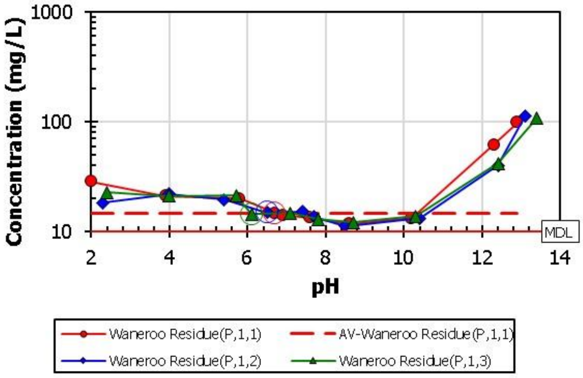
pH dependent concentration of Molybdenum



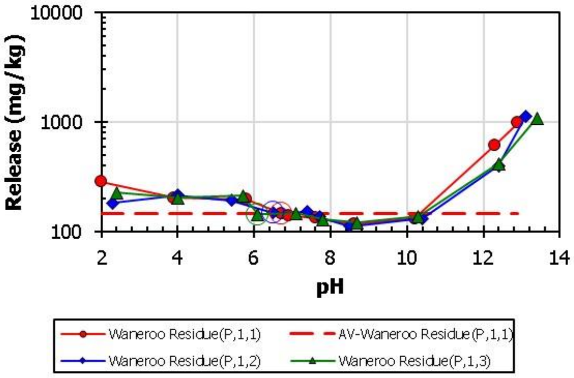
pH dependent release of Molybdenum



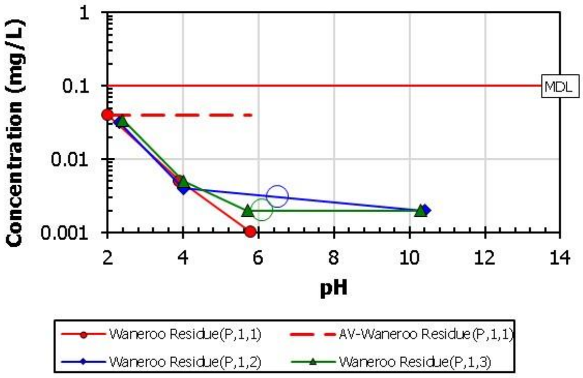
pH dependent concentration of Sodium



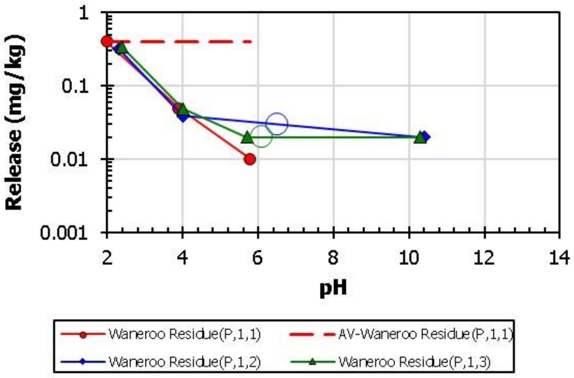
pH dependent release of Sodium

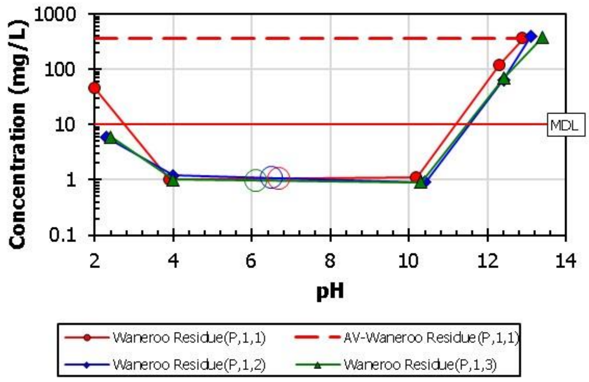


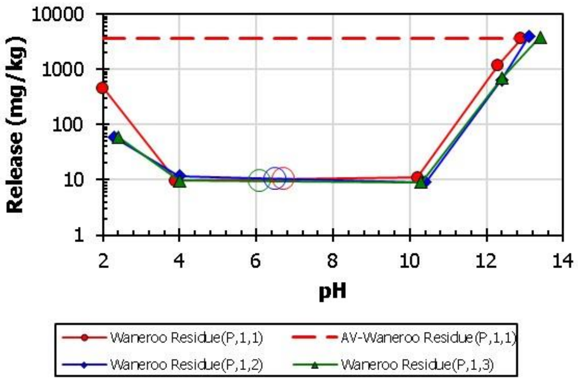
pH dependent concentration of Nickel

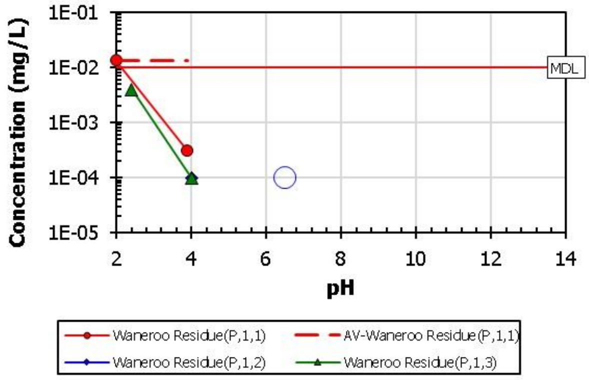


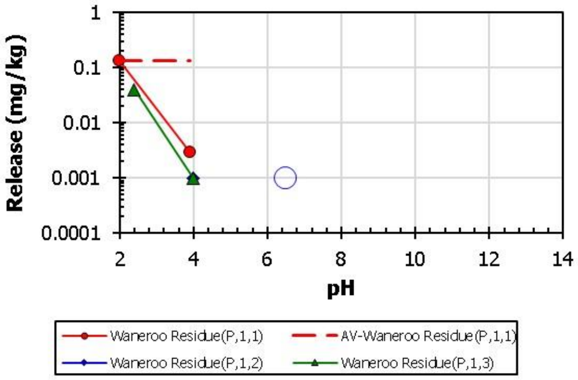
pH dependent release of Nickel

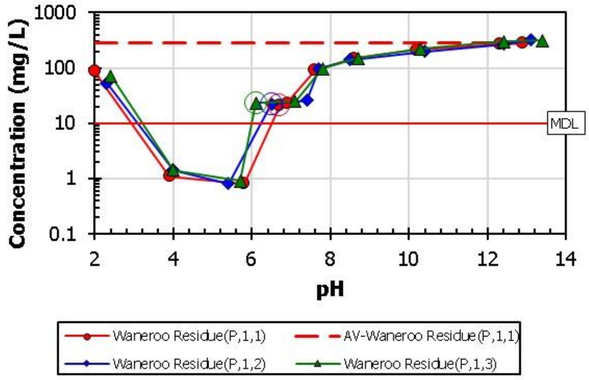


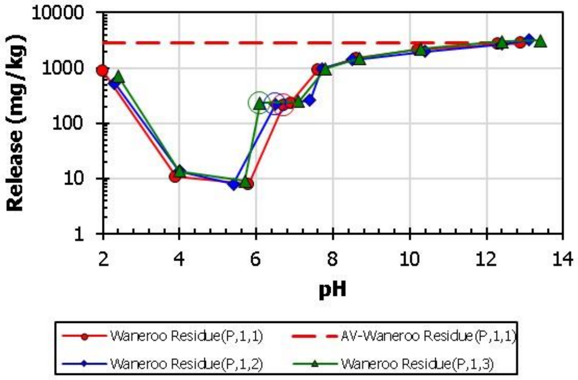

pH dependent concentration of Phosphorus

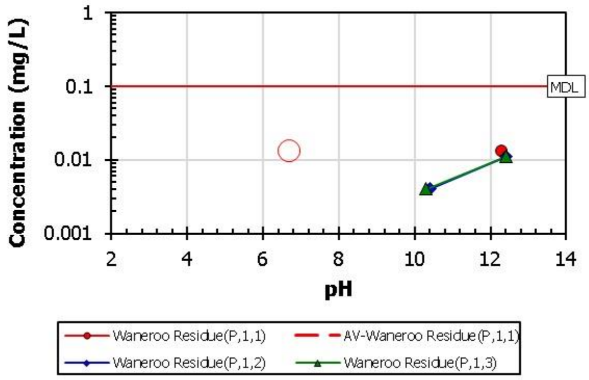

pH dependent release of Phosphorus

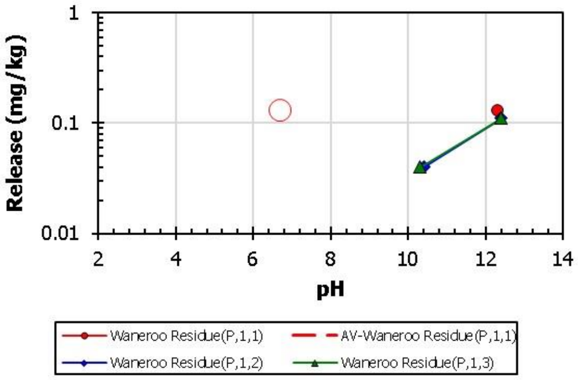

pH dependent concentration of Lead

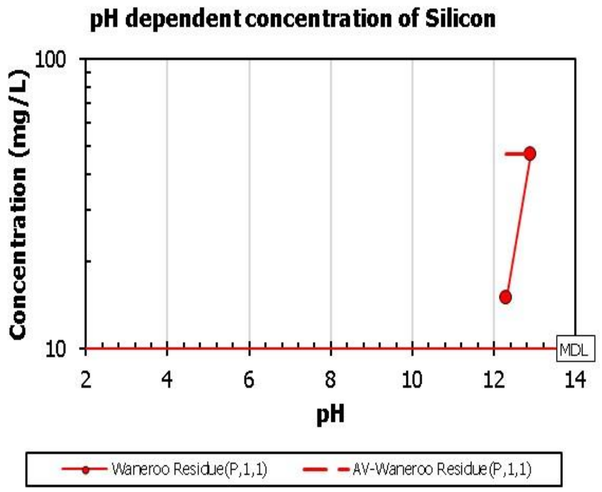

pH dependent release of Lead

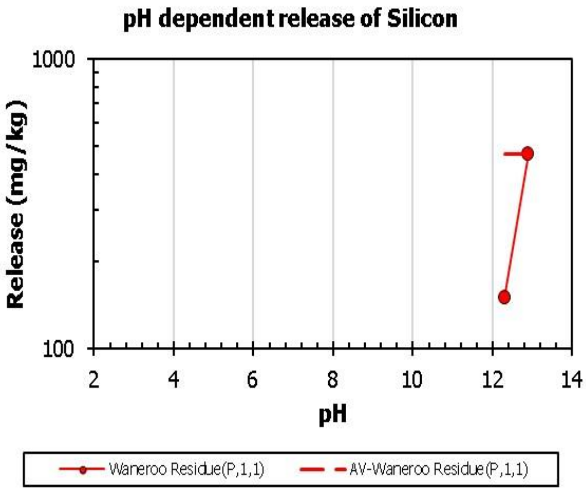

pH dependent concentration of Sulfur

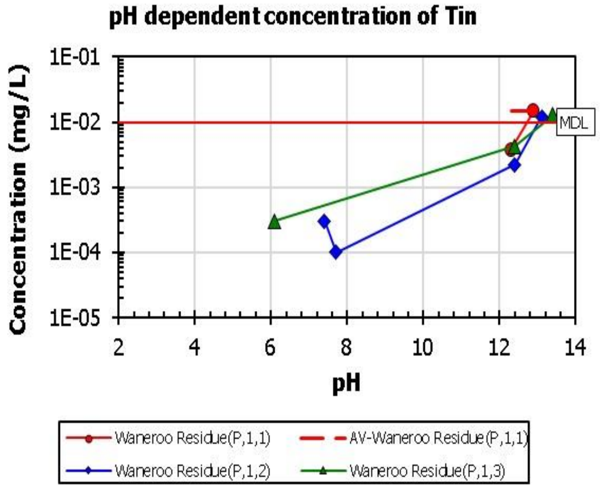

pH dependent release of Sulfur

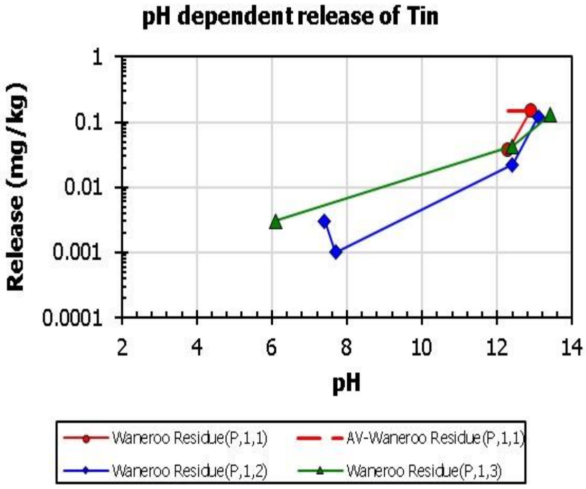

pH dependent concentration of Selenium

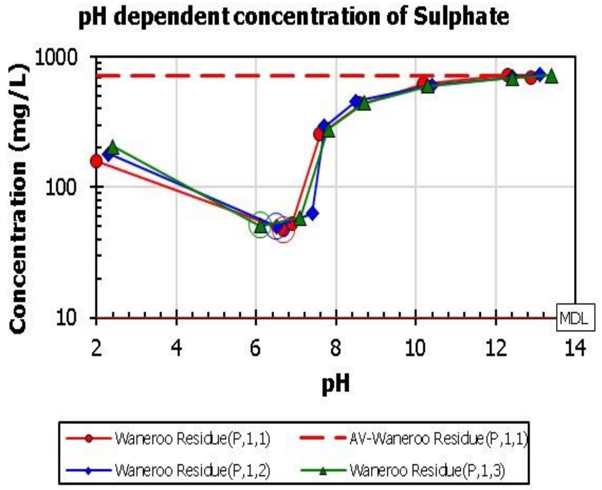

pH dependent release of Selenium

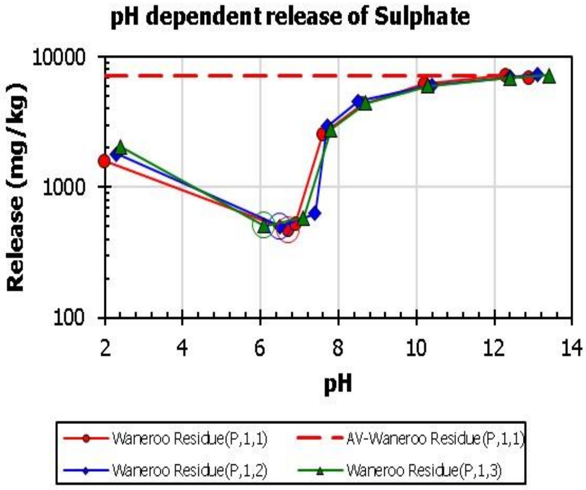

pH dependent concentration of Silicon

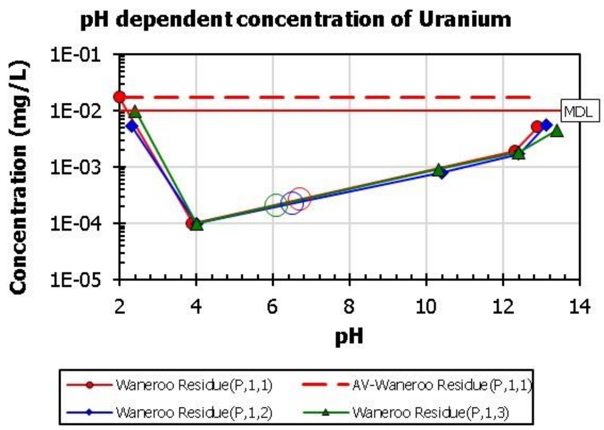

pH dependent release of Silicon

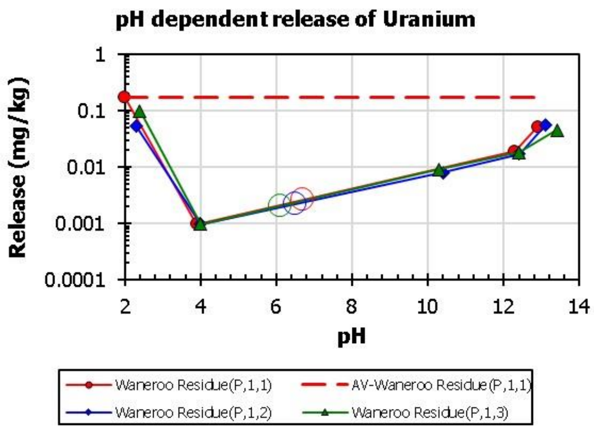

pH dependent concentration of Tin

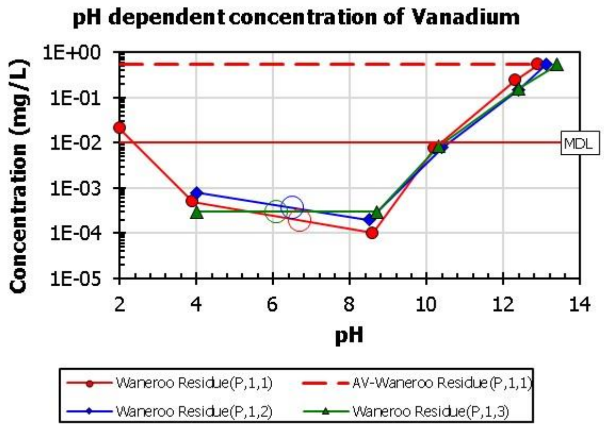

pH dependent release of Tin

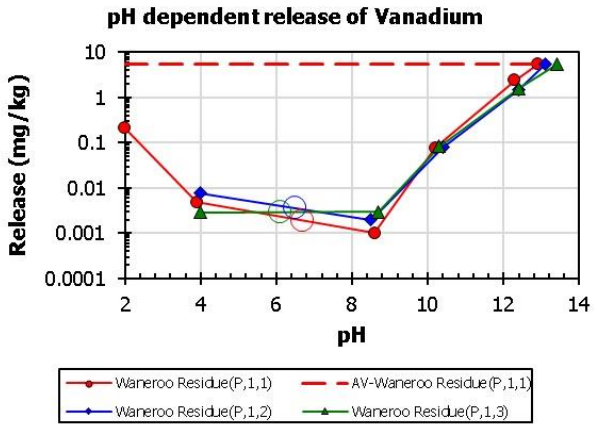

pH dependent concentration of Sulphate

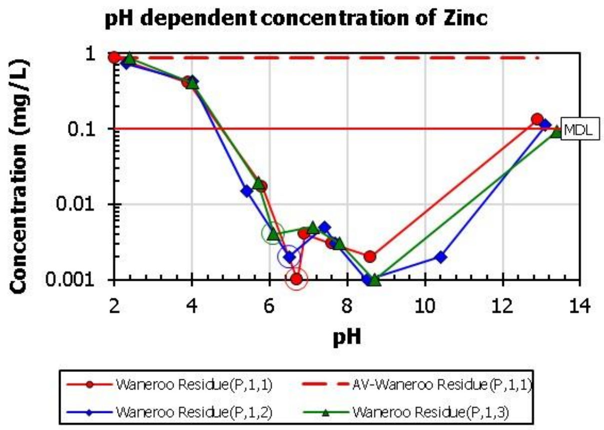

pH dependent release of Sulphate

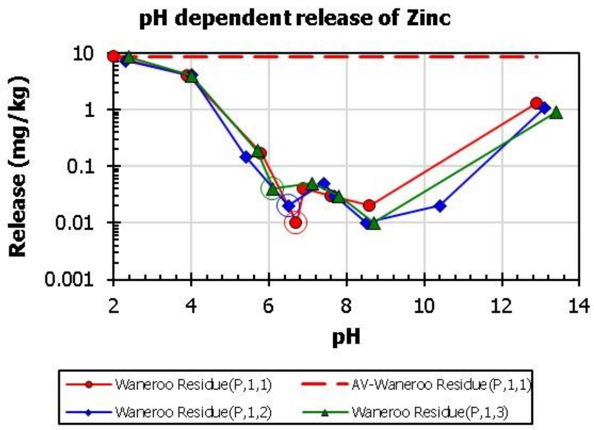

pH dependent concentration of Uranium


pH dependent release of Uranium


pH dependent concentration of Vanadium

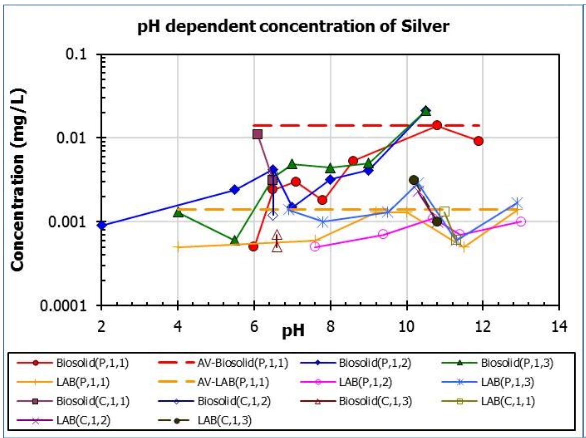

pH dependent release of Vanadium

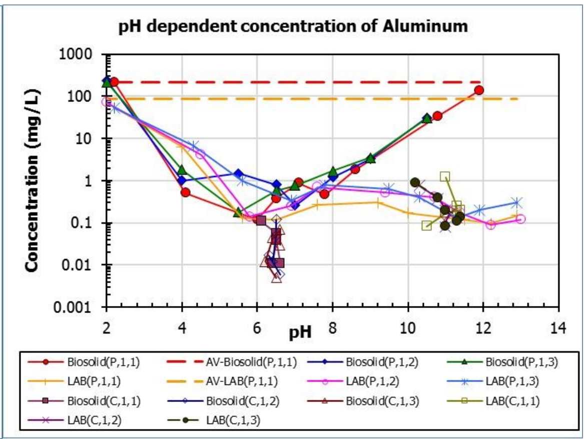

pH dependent concentration of Zinc

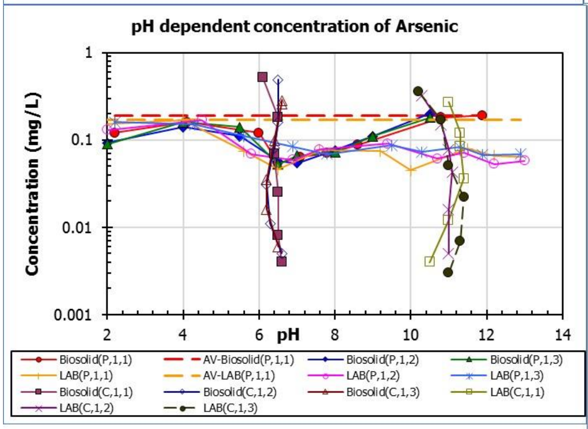

pH dependent release of Zinc

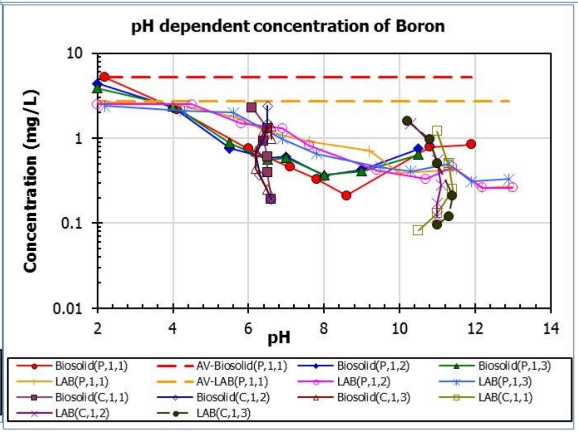
A5-6: Biosolids Cake and Lime amended biosolid (LAB)

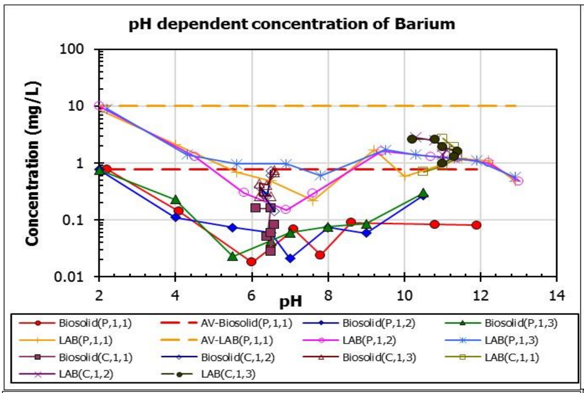
(Note: AV-Biosolid; Av-LAB- represents Method 1313 Availability; MDL – represents method of detection limit; Circles represents Natural pH points).

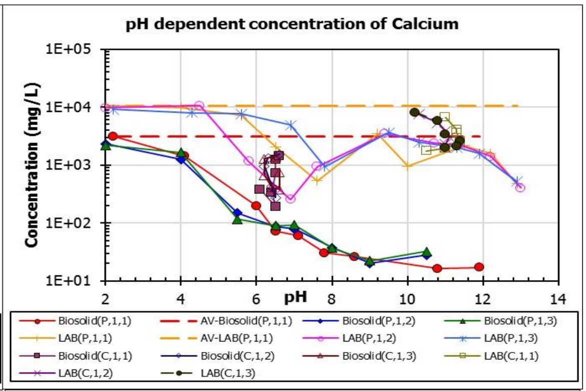


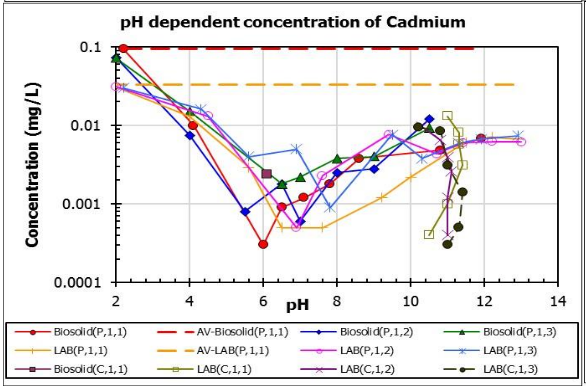


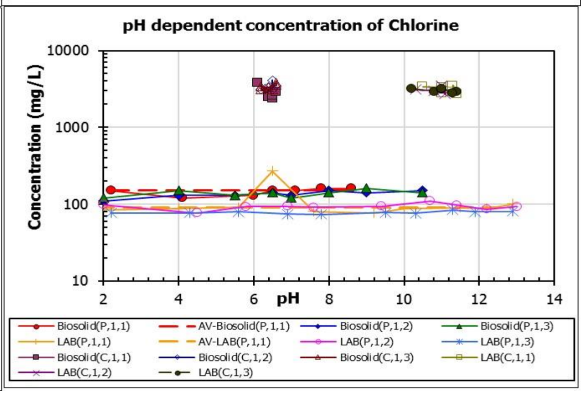


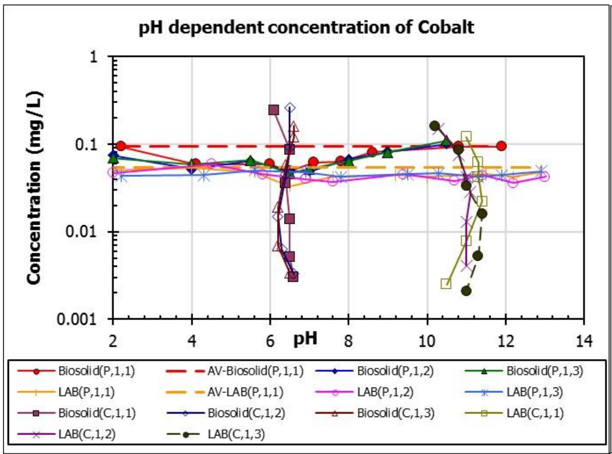


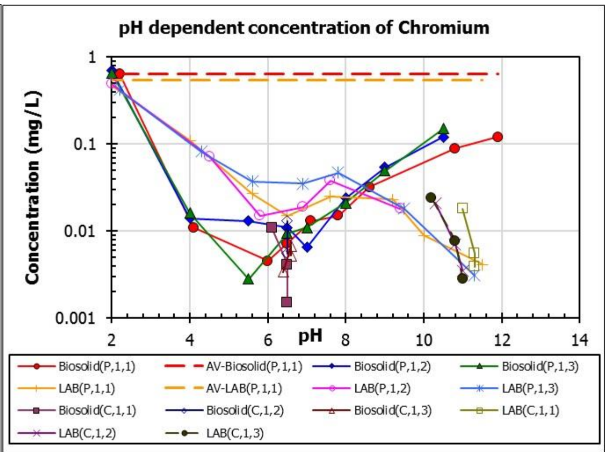


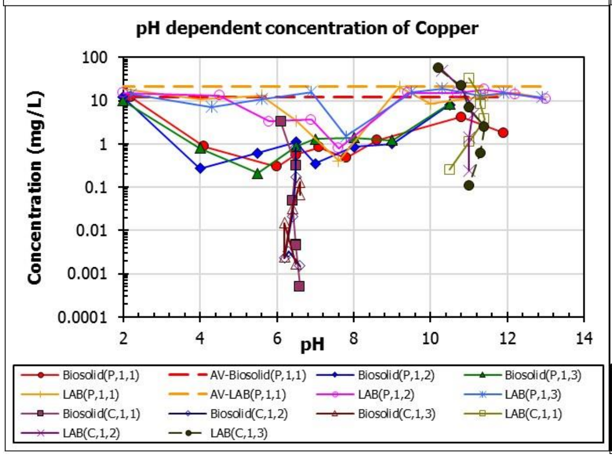


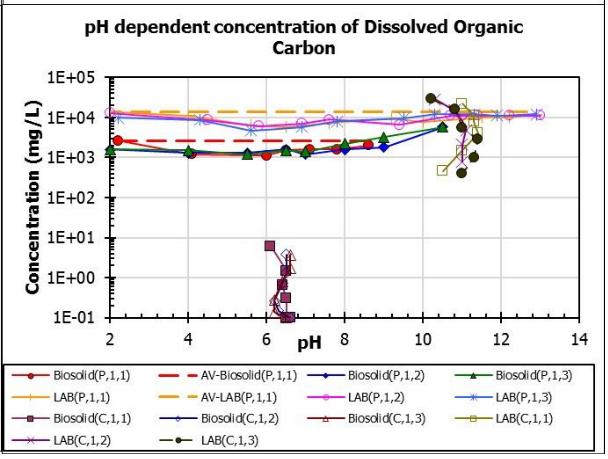


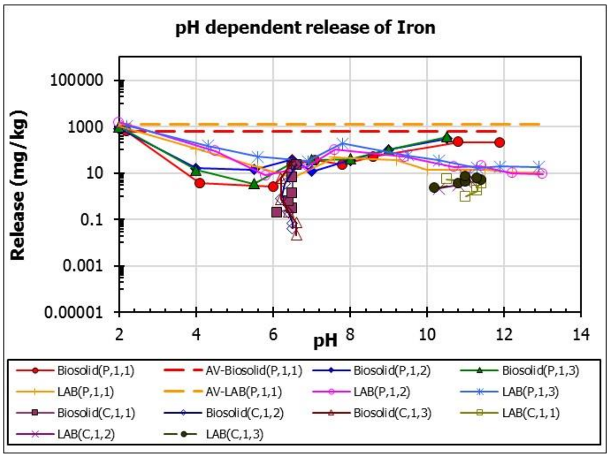


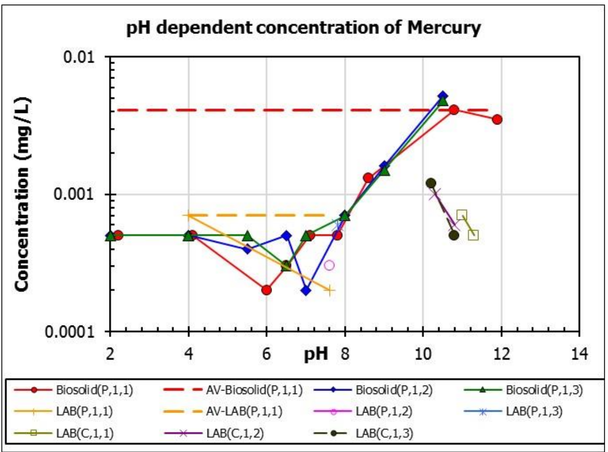

pH dependent concentration of Cobalt
Concentration (mg/L)
1
0.1
0.01
0.001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

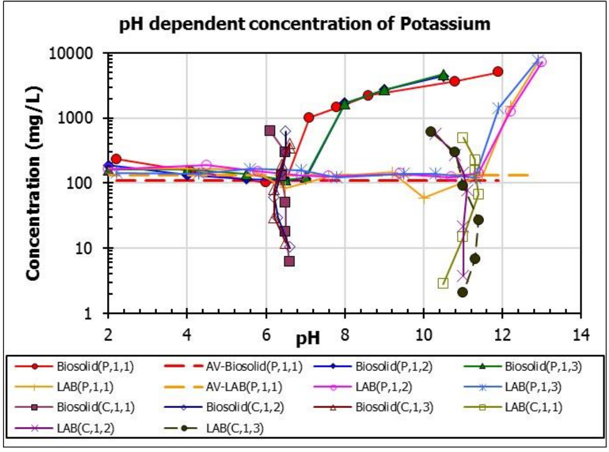

pH dependent concentration of Chromium
Concentration (mg/L)
1
0.1
0.01
0.001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

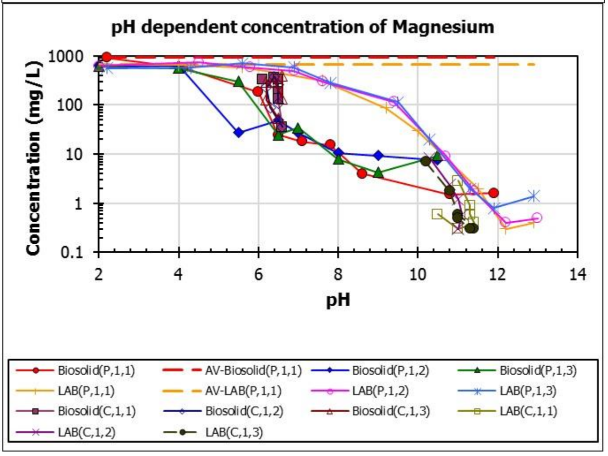

pH dependent concentration of Copper
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

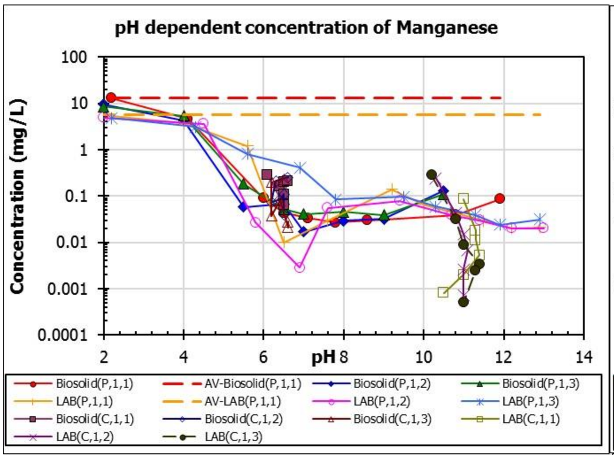

pH dependent concentration of Dissolved Organic Carbon
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

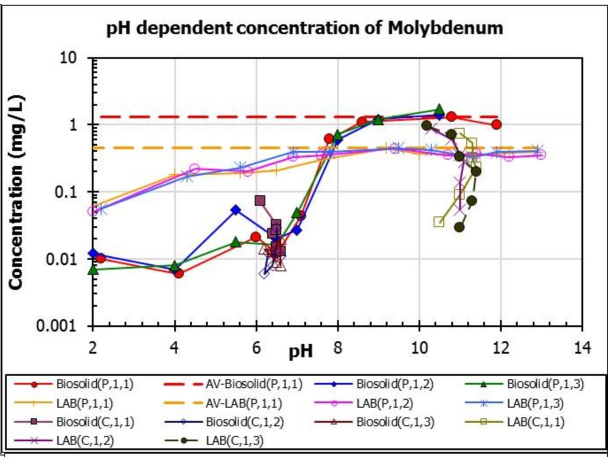

pH dependent release of Iron
Release (mg/kg)
100000
1000
10
0.1
0.001
0.00001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

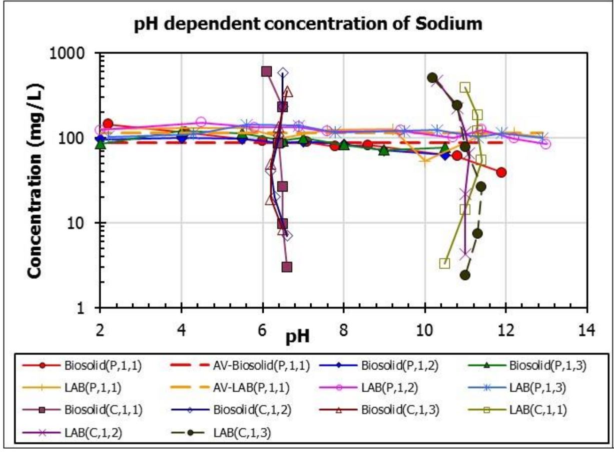

pH dependent concentration of Mercury
Concentration (mg/L)
0.01
0.001
0.0001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

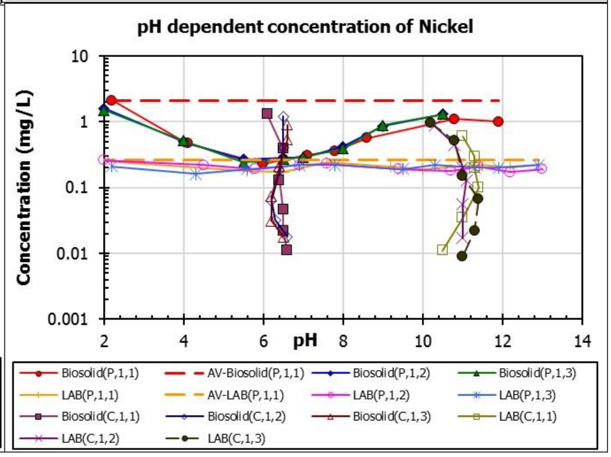

pH dependent concentration of Potassium
Concentration (mg/L)
10000
1000
100
10
1
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

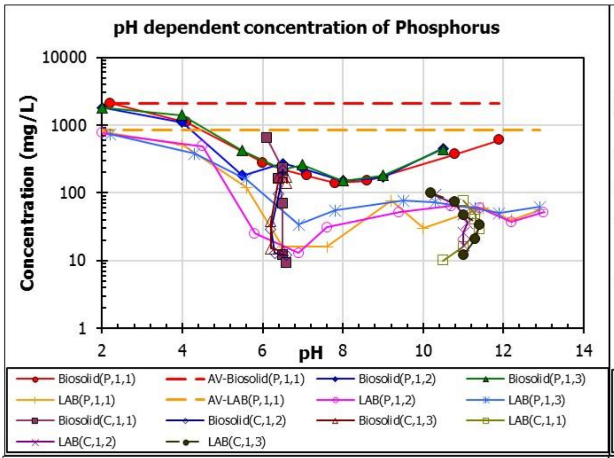

pH dependent concentration of Magnesium
Concentration (mg/L)
1000
100
10
1
0.1
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

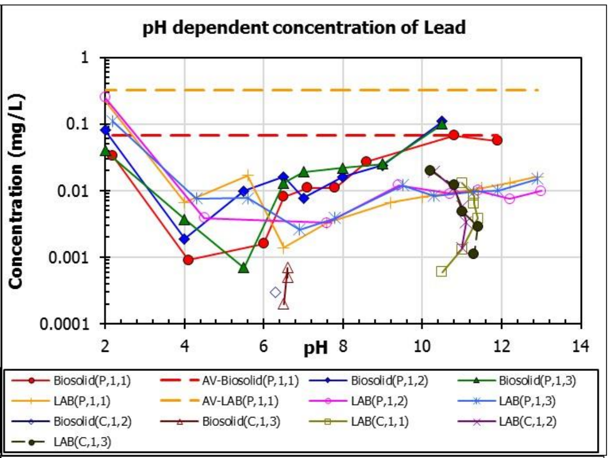

pH dependent concentration of Manganese

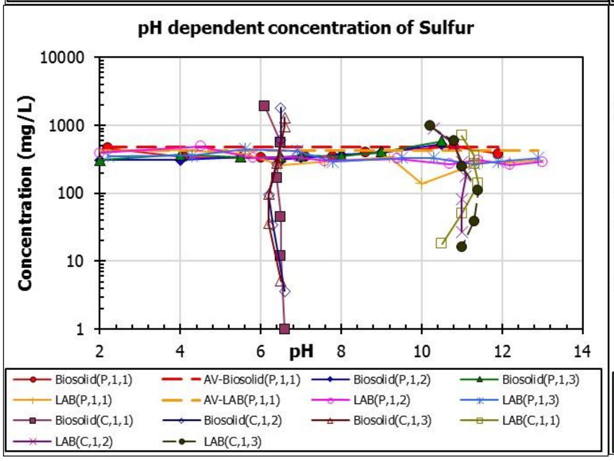

pH dependent concentration of Molybdenum

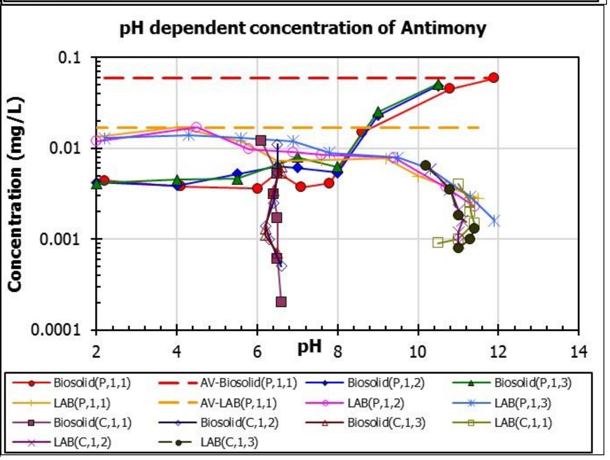

pH dependent concentration of Sodium

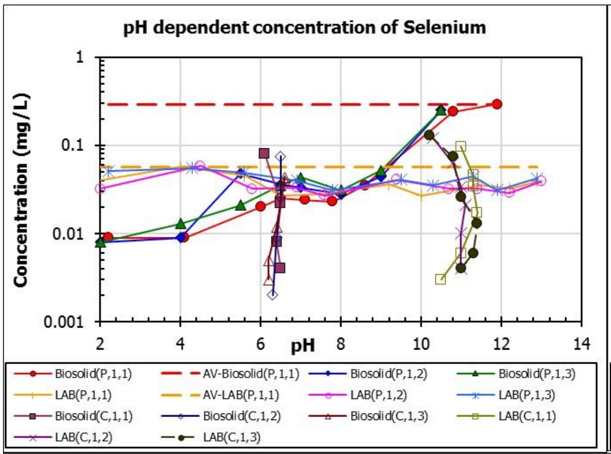

pH dependent concentration of Nickel

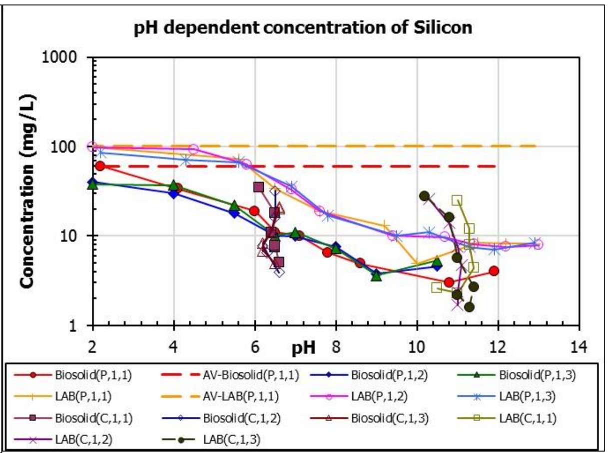

pH dependent concentration of Phosphorus

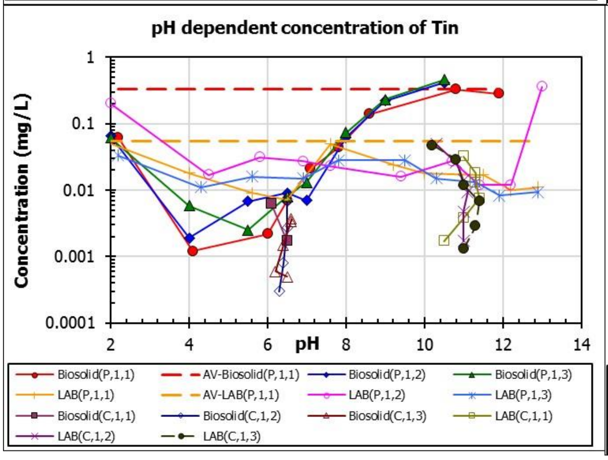

pH dependent concentration of Lead

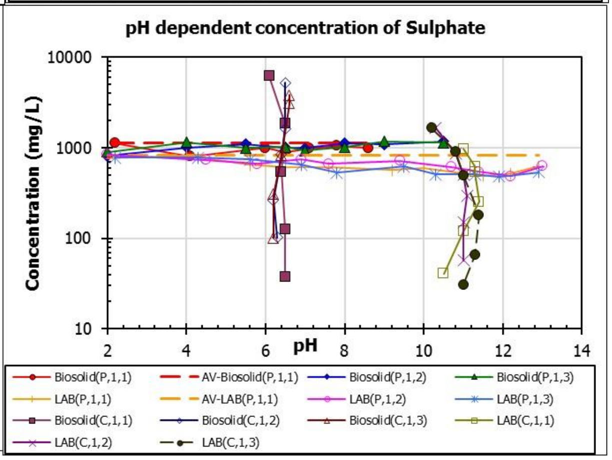

pH dependent concentration of Sulfur

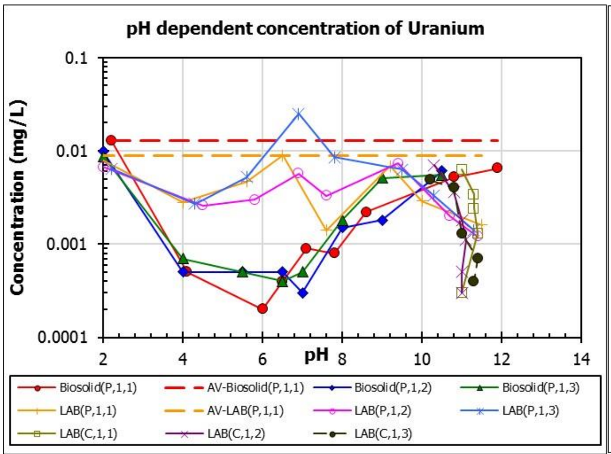

pH dependent concentration of Antimony

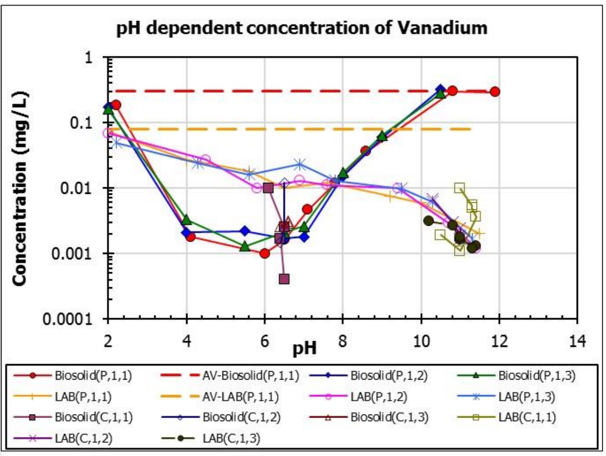

pH dependent concentration of Selenium
Concentration (mg/L)
1
0.1
0.01
0.001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

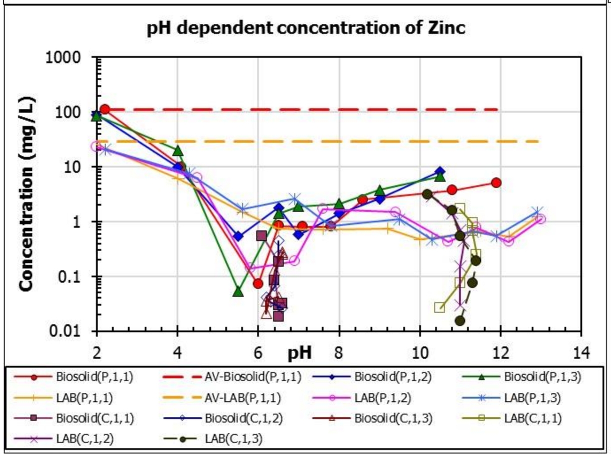

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


pH dependent concentration of Tin
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
10
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


pH dependent concentration of Uranium
Concentration (mg/L)
0.1
0.01
0.001
0.0001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

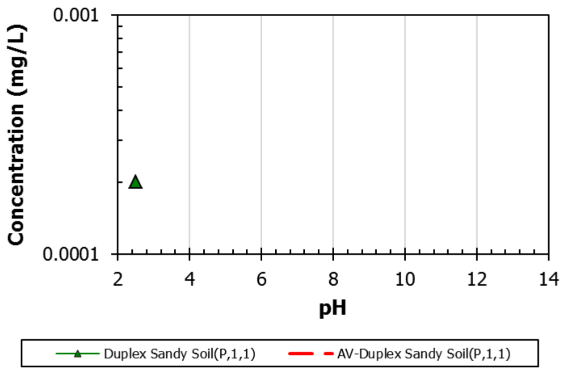

pH dependent concentration of Vanadium
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


pH dependent concentration of Zinc
Concentration (mg/L)
1000
100
10
1
0.1
0.01
pH
2
4
6
8
10
12
14
Biosolid(P,1,1)
AV-Biosolid(P,1,1)
Biosolid(P,1,2)
Biosolid(P,1,3)
LAB(P,1,1)
AV-LAB(P,1,1)
LAB(P,1,2)
LAB(P,1,3)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

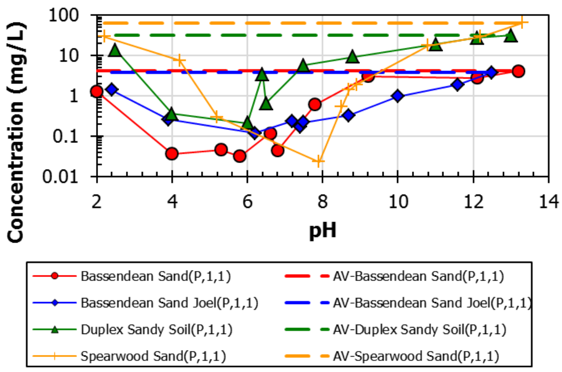
A5-7: Coastal Plain Soils

(Note: AV- represents Method 1313 Availability).

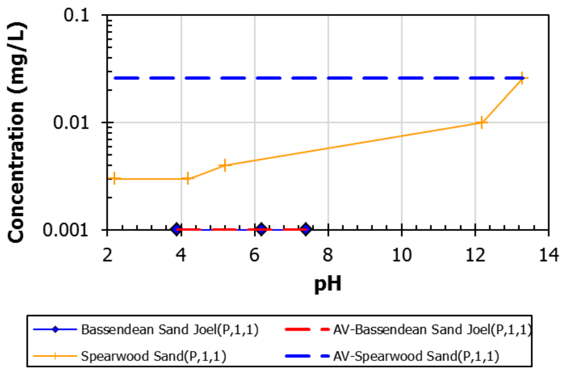
pH dependent concentration of Silver



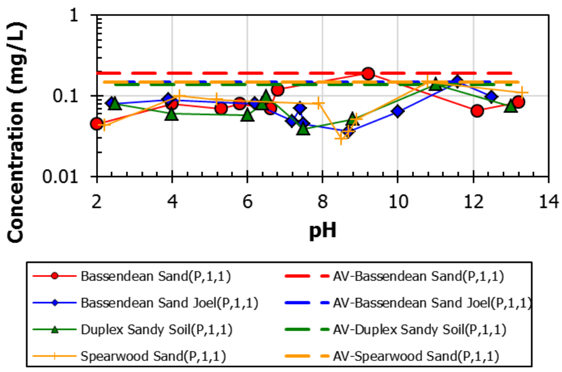
pH dependent concentration of Aluminum



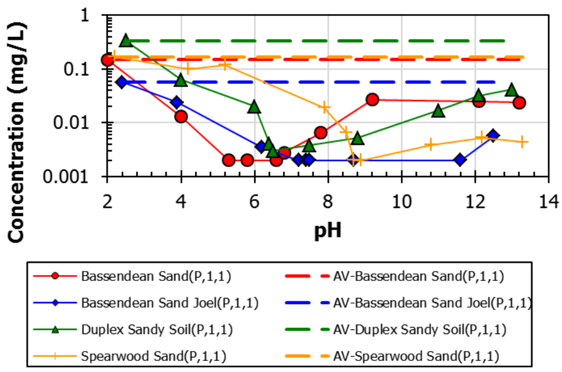
pH dependent concentration of Arsenic



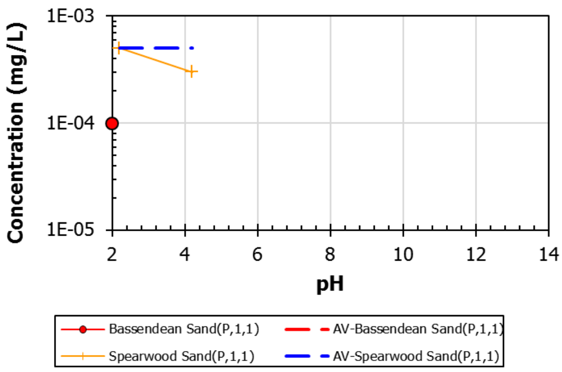
pH dependent concentration of Boron

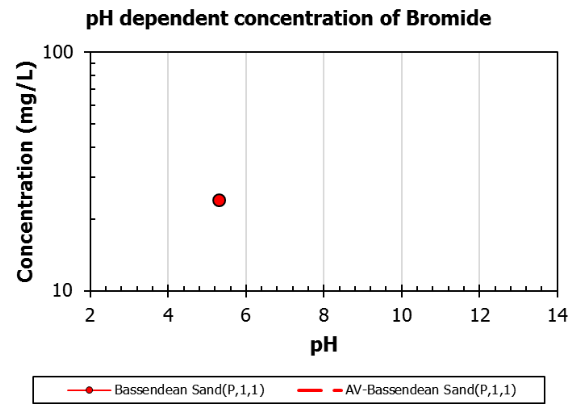


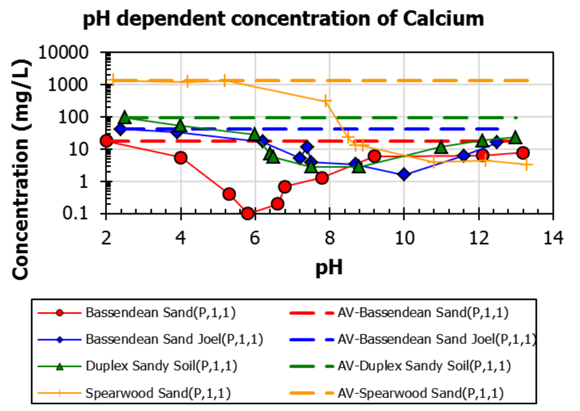
pH dependent concentration of Barium

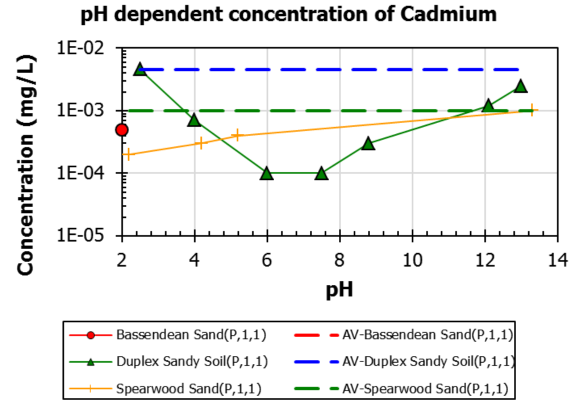


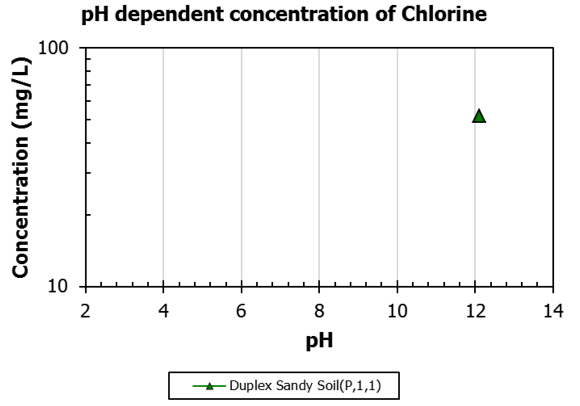
pH dependent concentration of Beryllium

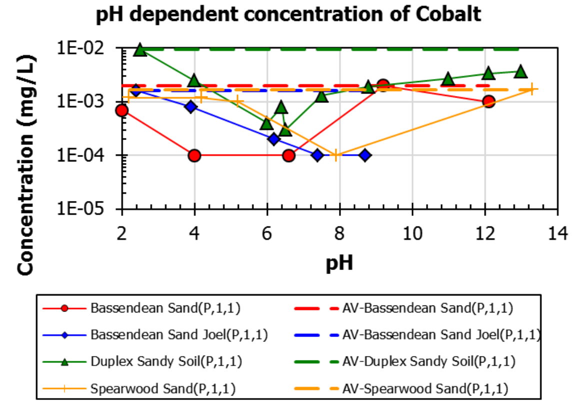


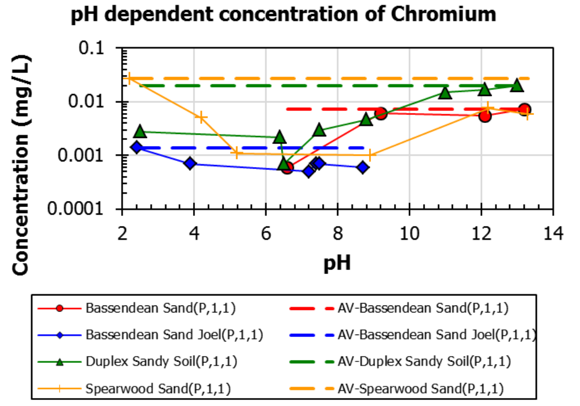

pH dependent concentration of Bromide

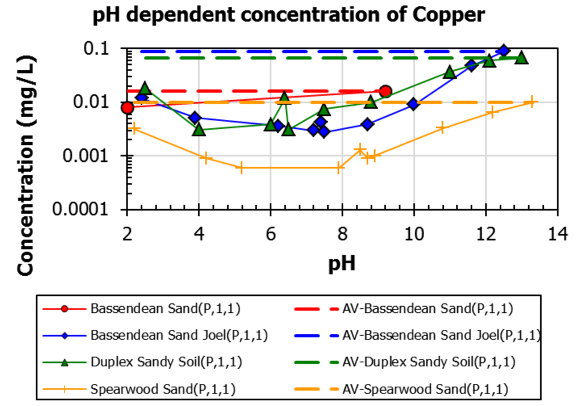

pH dependent concentration of Calcium

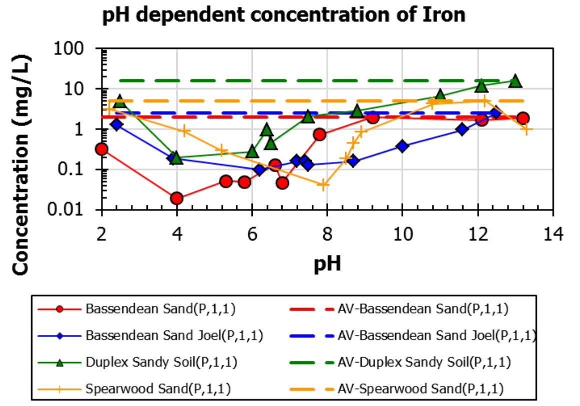

pH dependent concentration of Cadmium

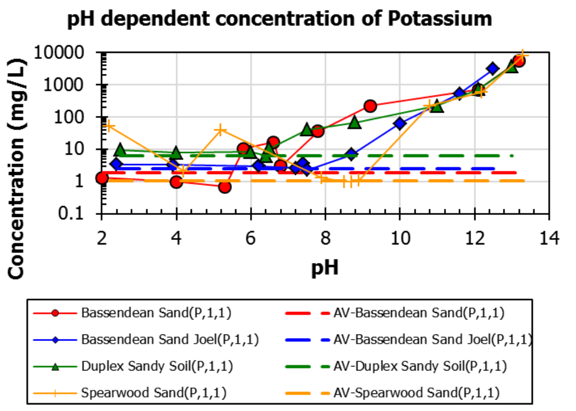

pH dependent concentration of Chlorine

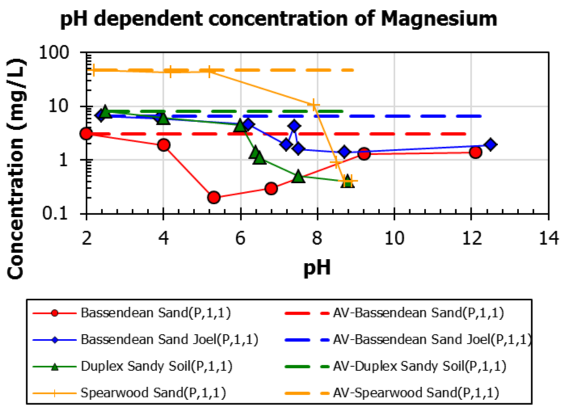

pH dependent concentration of Cobalt

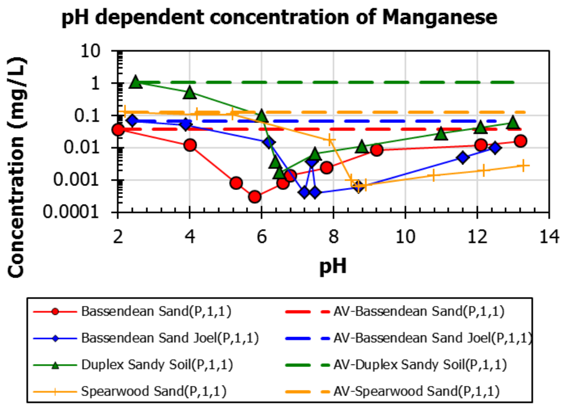

pH dependent concentration of Chromium

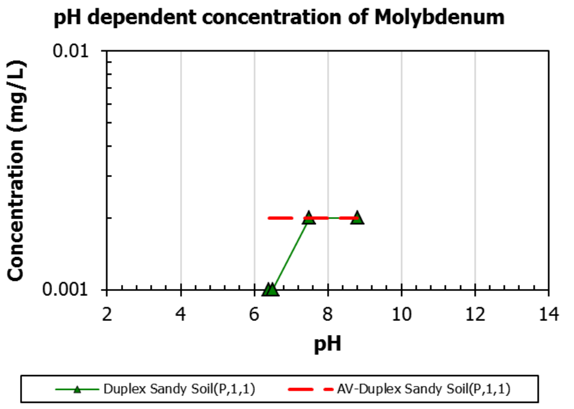

pH dependent concentration of Copper

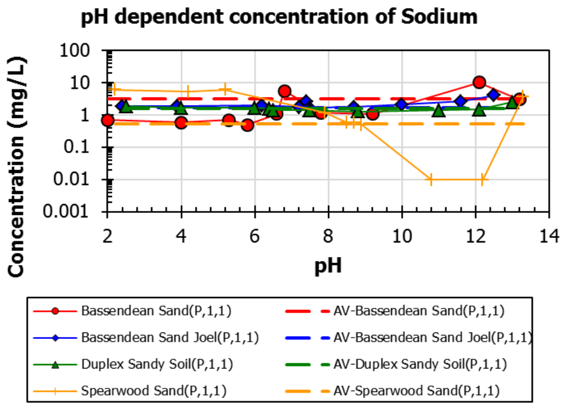

pH dependent concentration of Iron

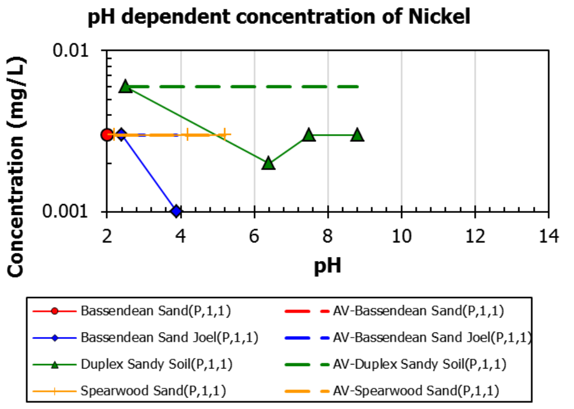

pH dependent concentration of Potassium

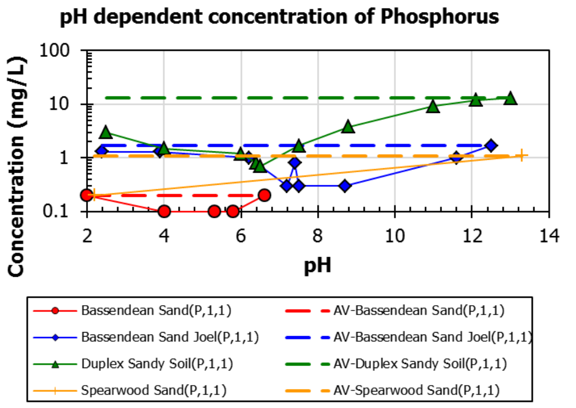

pH dependent concentration of Magnesium

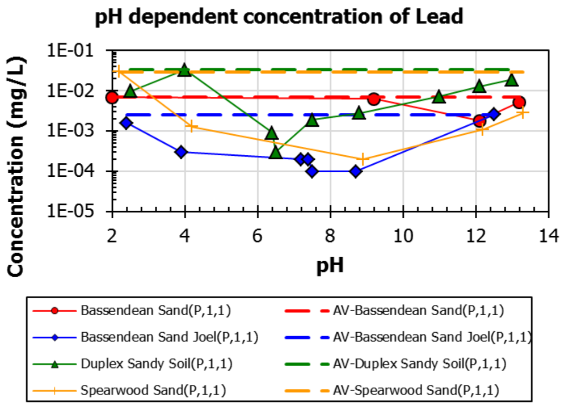

pH dependent concentration of Manganese

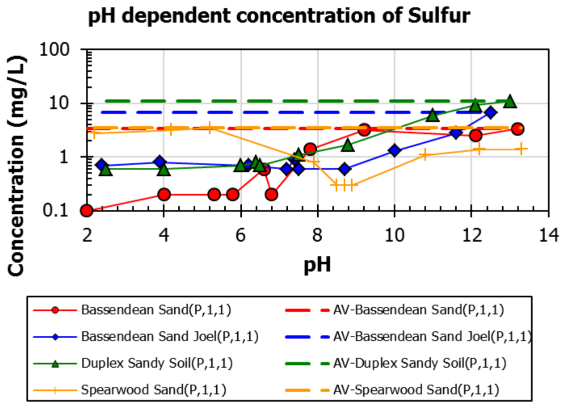

pH dependent concentration of Molybdenum

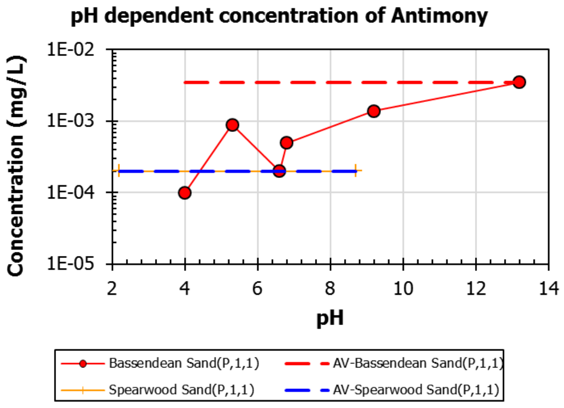

pH dependent concentration of Sodium

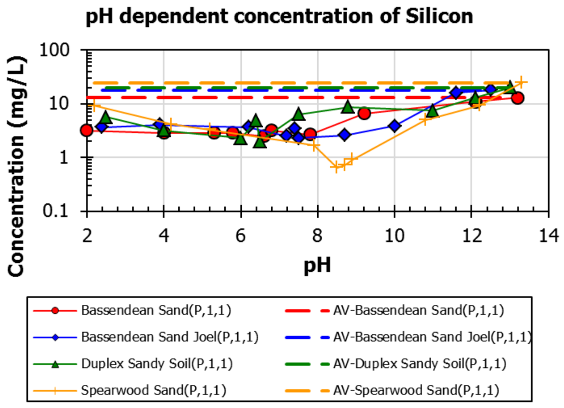

pH dependent concentration of Nickel

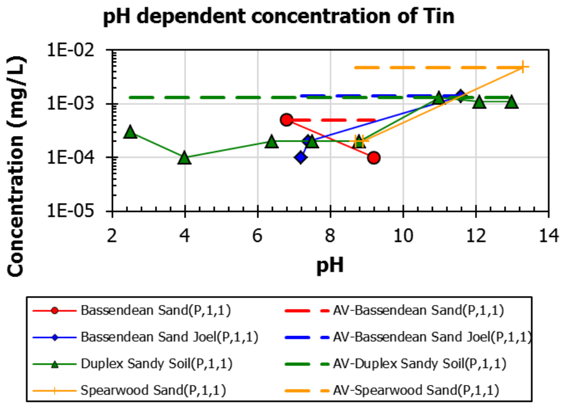

pH dependent concentration of Phosphorus

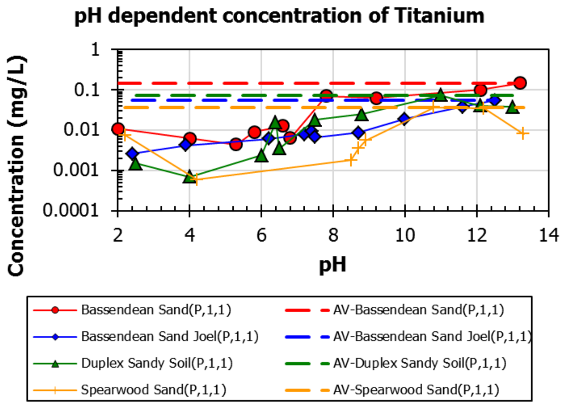

pH dependent concentration of Lead

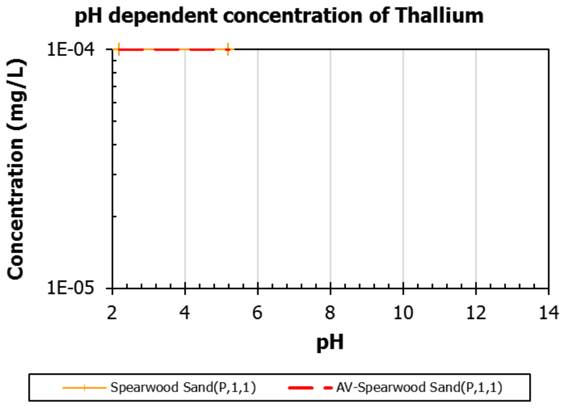

pH dependent concentration of Sulfur

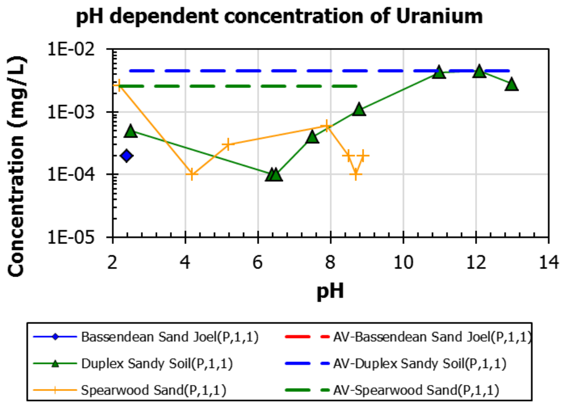

pH dependent concentration of Antimony

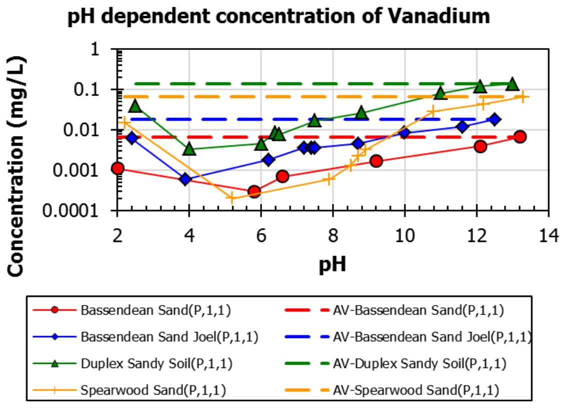

pH dependent concentration of Silicon

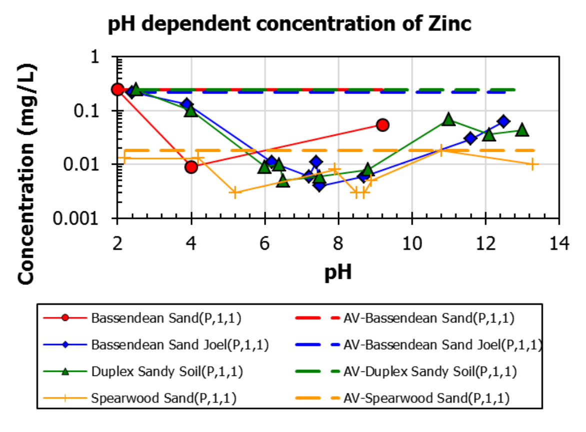

pH dependent concentration of Tin

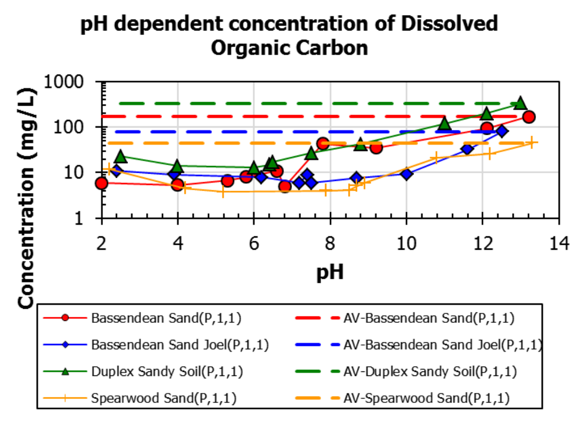

pH dependent concentration of Titanium


pH dependent concentration of Thallium


pH dependent concentration of Uranium

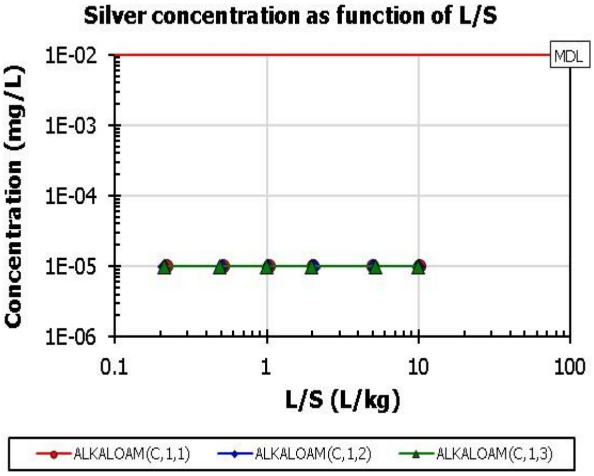

pH dependent concentration of Vanadium


pH dependent concentration of Zinc
Concentration (mg/L)
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH
Bassendean Sand(P,1,1)
AV-Bassendean Sand(P,1,1)
Bassendean Sand Joel(P,1,1)
AV-Bassendean Sand Joel(P,1,1)
Duplex Sandy Soil(P,1,1)
AV-Duplex Sandy Soil(P,1,1)
Spearwood Sand(P,1,1)
AV-Spearwood Sand(P,1,1)

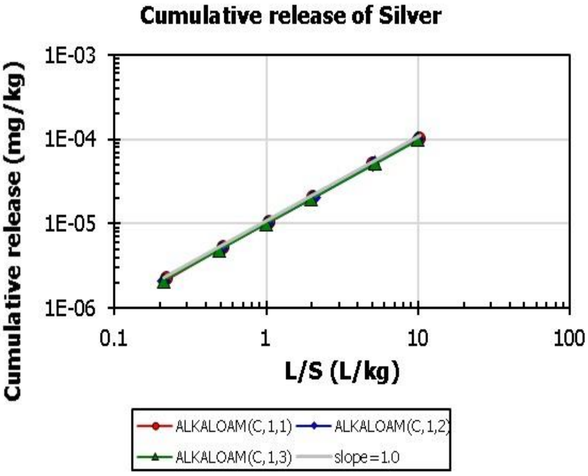

pH dependent concentration of Dissolved Organic Carbon
Concentration (mg/L)
1000
100
10
1
2
4
6
8
10
12
14
pH
Bassendean Sand(P,1,1)
AV-Bassendean Sand(P,1,1)
Bassendean Sand Joel(P,1,1)
AV-Bassendean Sand Joel(P,1,1)
Duplex Sandy Soil(P,1,1)
AV-Duplex Sandy Soil(P,1,1)
Spearwood Sand(P,1,1)
AV-Spearwood Sand(P,1,1)

Appendix A6: Graphical Presentation of L/S Analytical Data (Methods 1314)

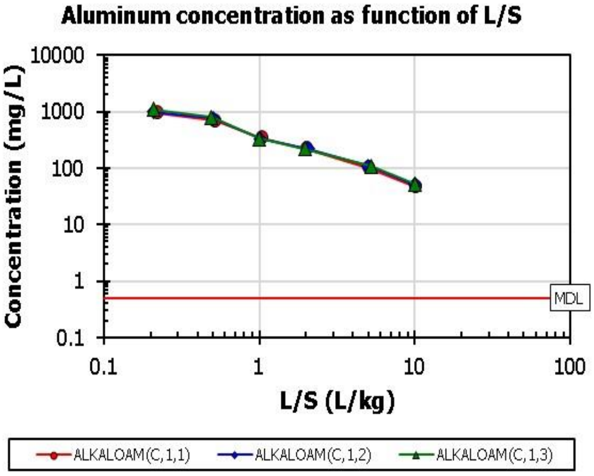
A6-1: By-product Alkaloam



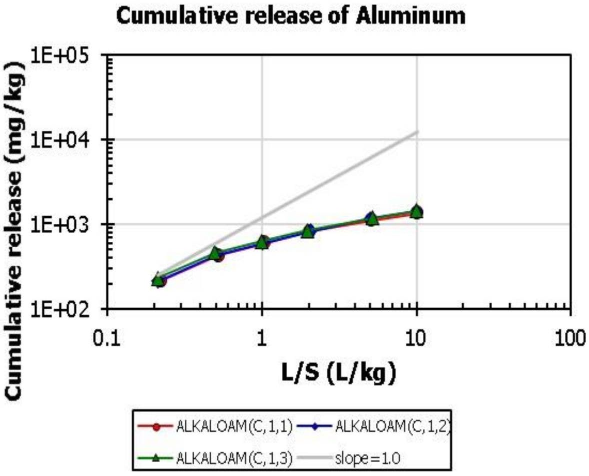
Silver concentration as function of L/S



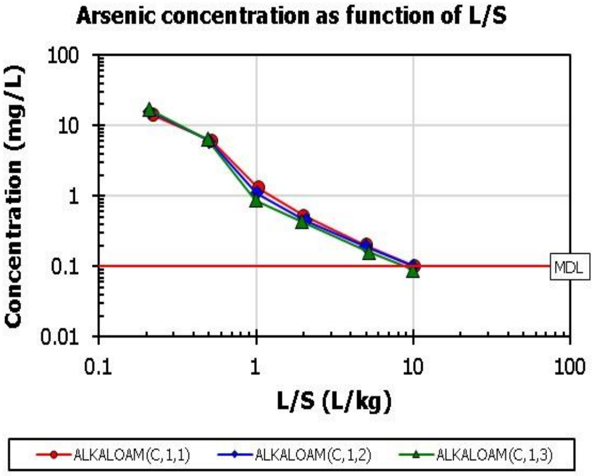
Cumulative release of Silver



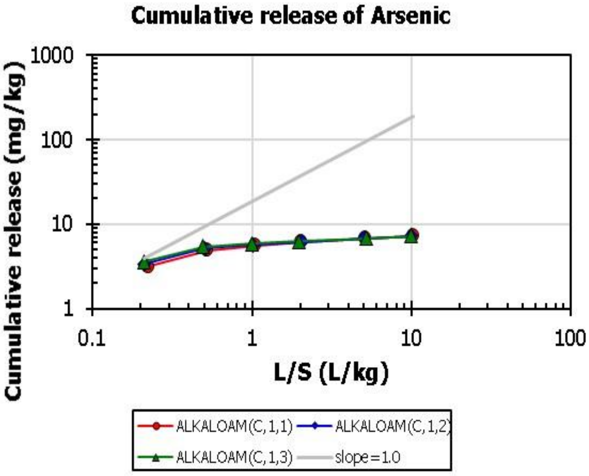
Aluminum concentration as function of L/S



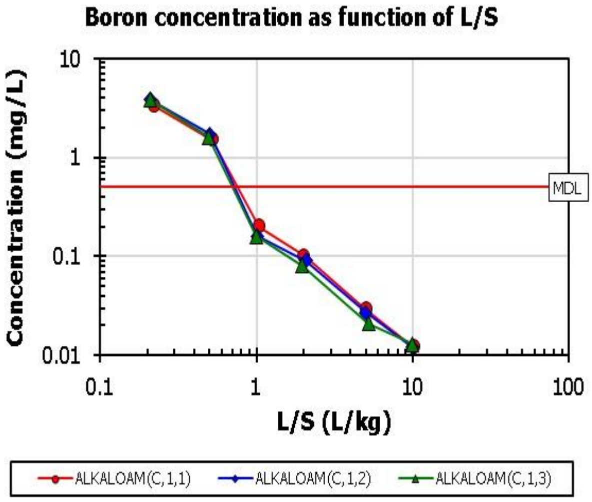
Cumulative release of Aluminum

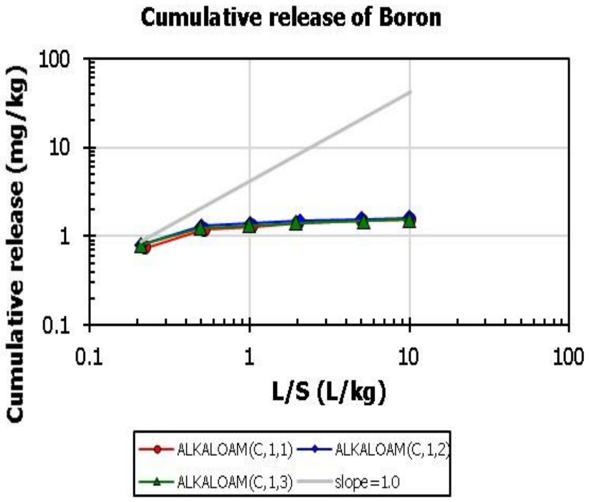


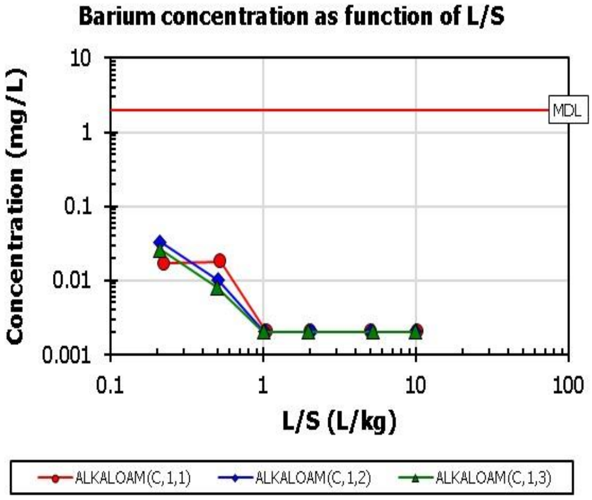
Arsenic concentration as function of L/S

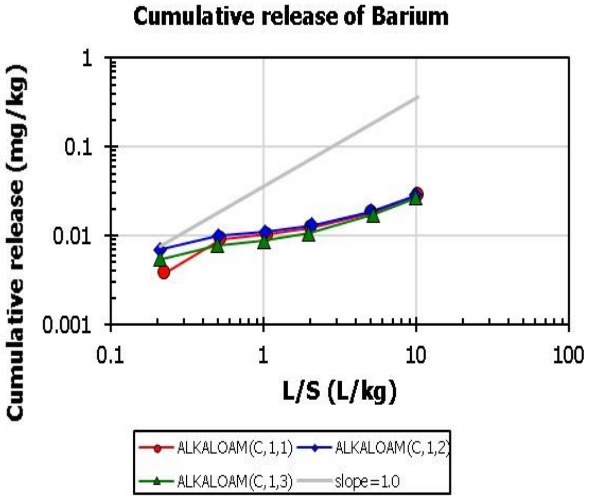


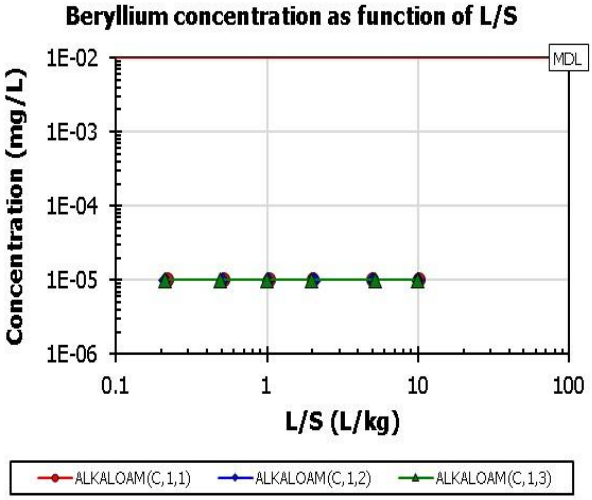
Cumulative release of Arsenic

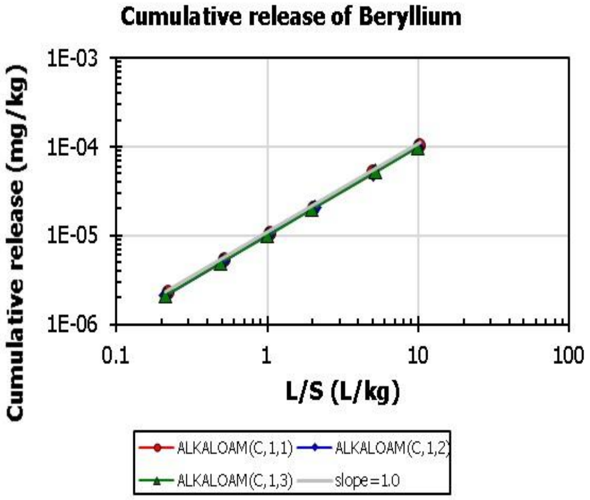

Boron concentration as function of L/S

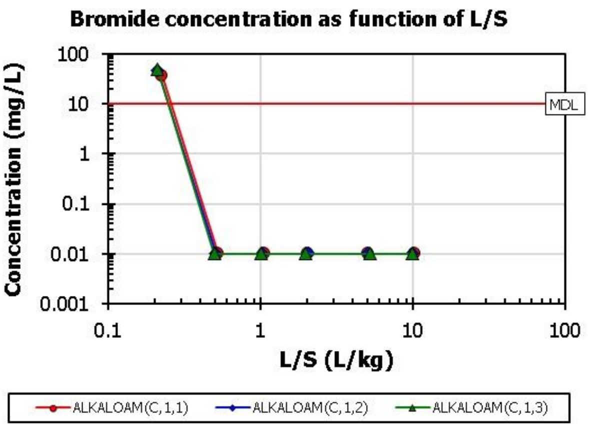

Cumulative release of Boron

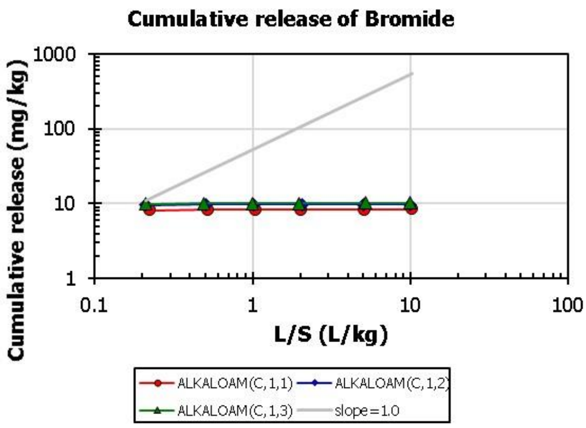

Barium concentration as function of L/S

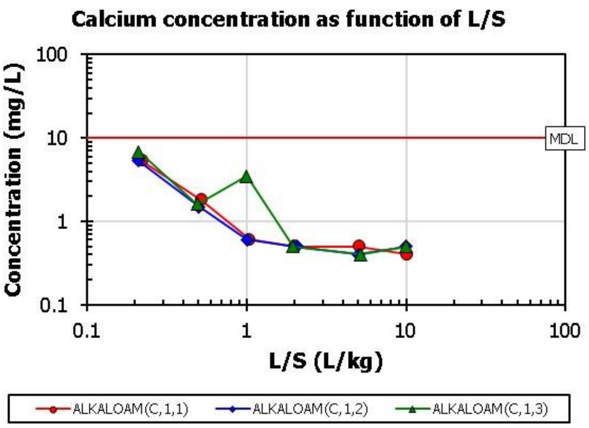

Cumulative release of Barium

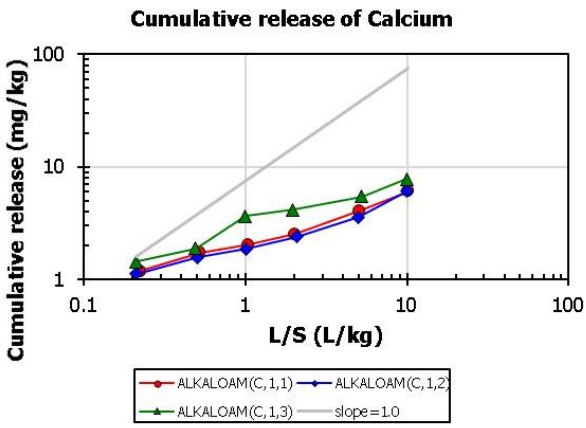

Beryllium concentration as function of L/S

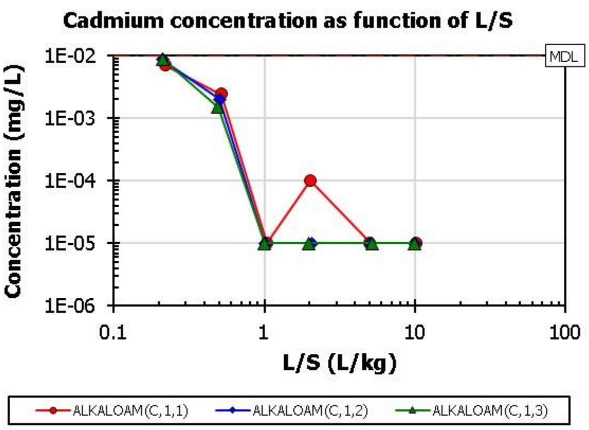

Cumulative release of Beryllium

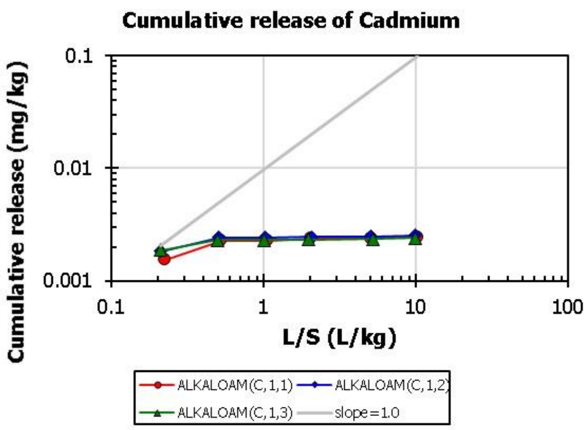

Bromide concentration as function of L/S

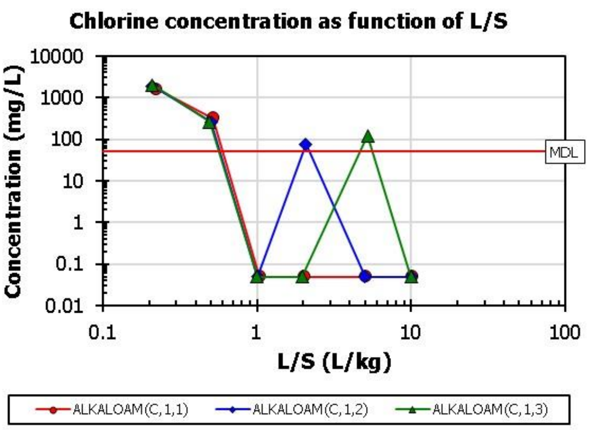

Cumulative release of Bromide

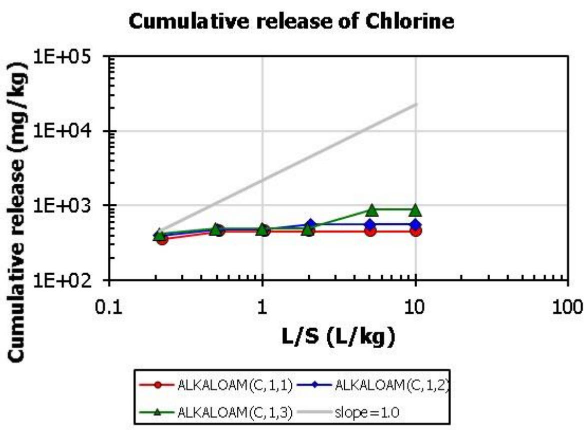

Calcium concentration as function of L/S

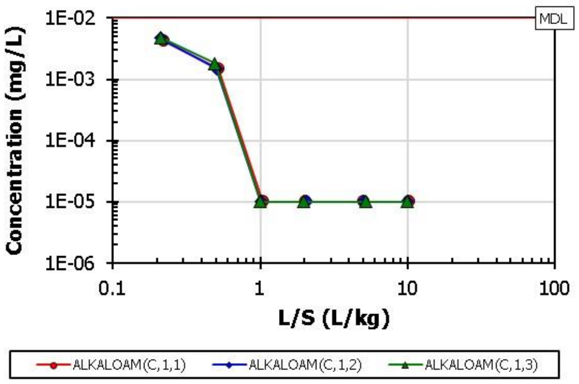

Cumulative release of Calcium

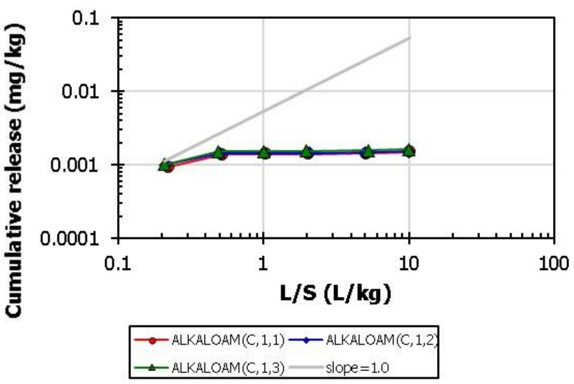

Cadmium concentration as function of L/S

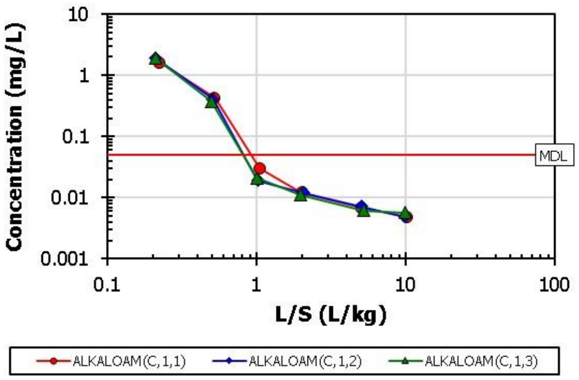

Cumulative release of Cadmium

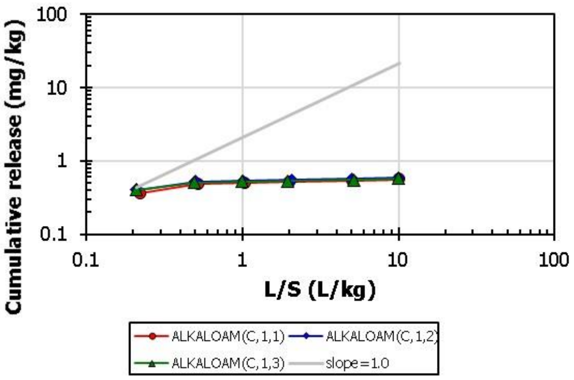

Chlorine concentration as function of L/S

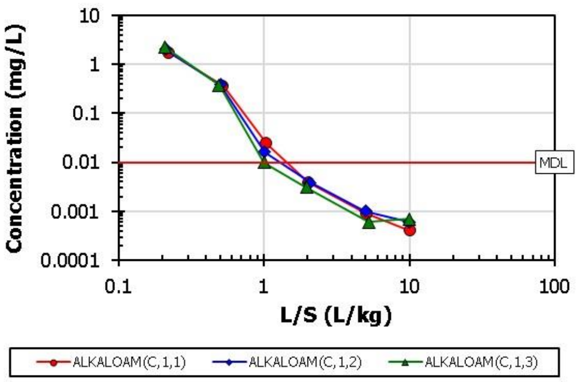

Cumulative release of Chlorine

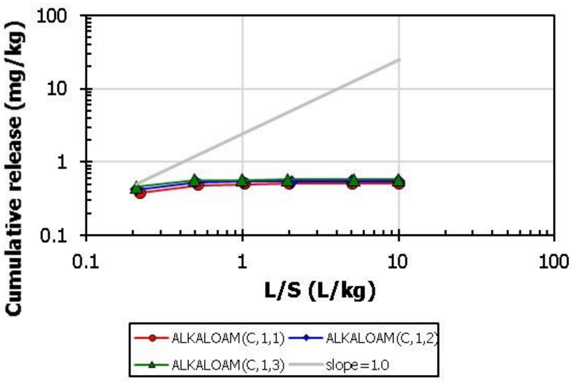

Cobalt concentration as function of L/S

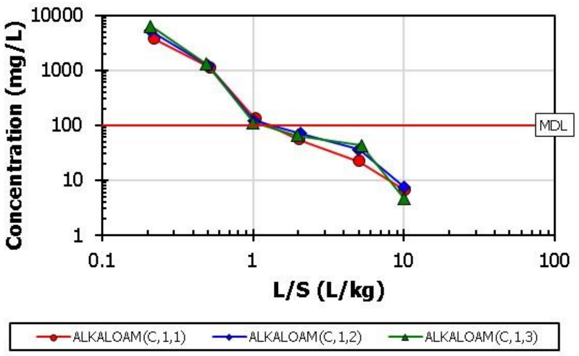

Cumulative release of Cobalt

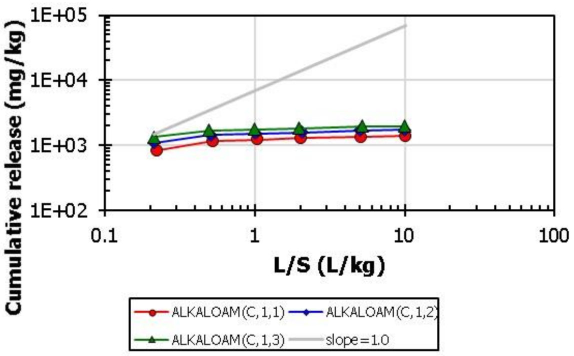

Chromium concentration as function of L/S

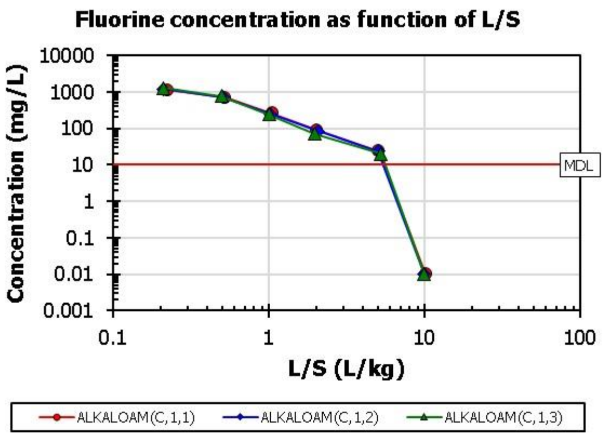

Cumulative release of Chromium

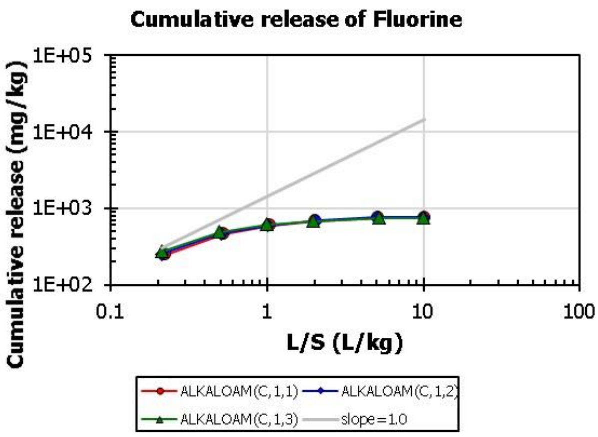

Copper concentration as function of L/S

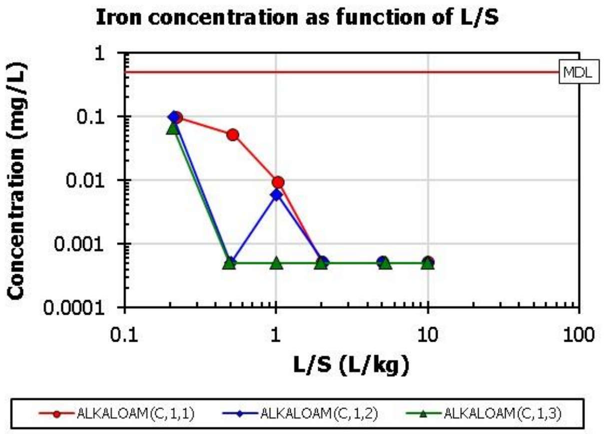

Cumulative release of Copper

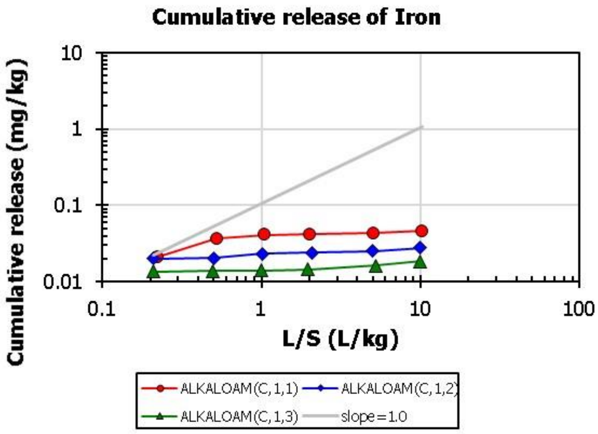

Dissolved Organic Carbon concentration as function of L/S

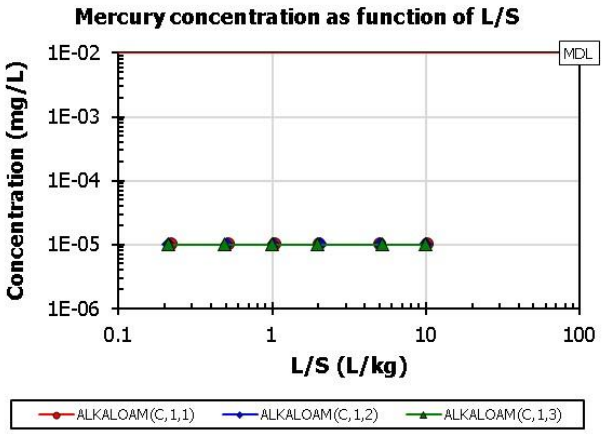

Cumulative release of Dissolved Organic Carbon

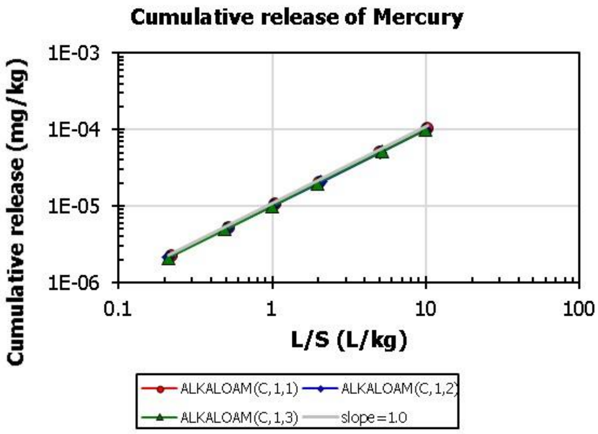

Fluorine concentration as function of L/S

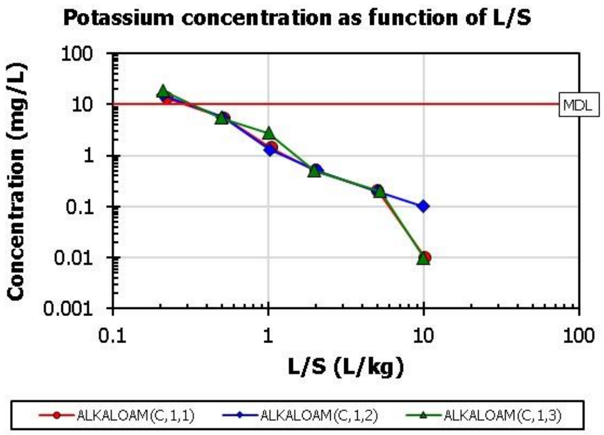

Cumulative release of Fluorine

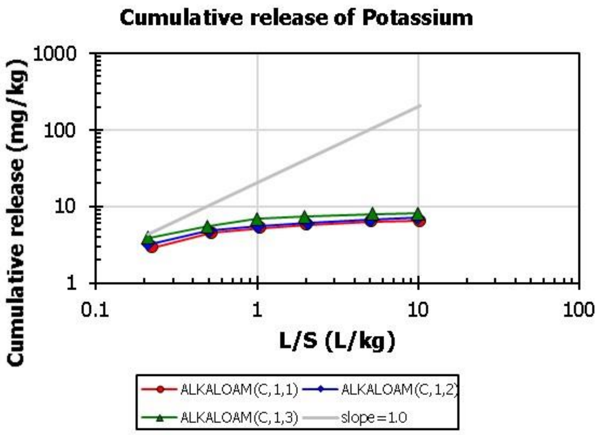

Iron concentration as function of L/S

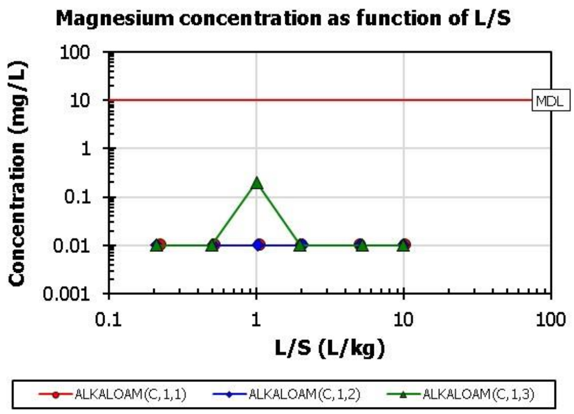

Cumulative release of Iron

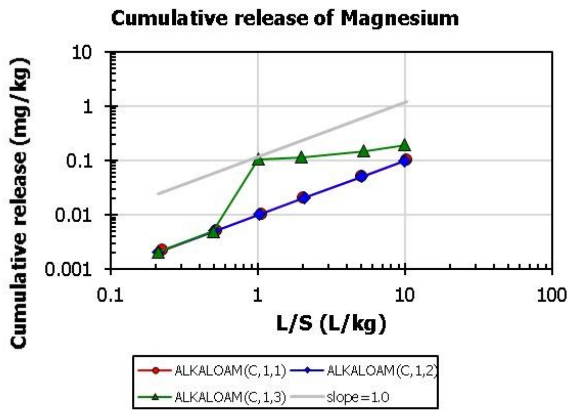

Mercury concentration as function of L/S

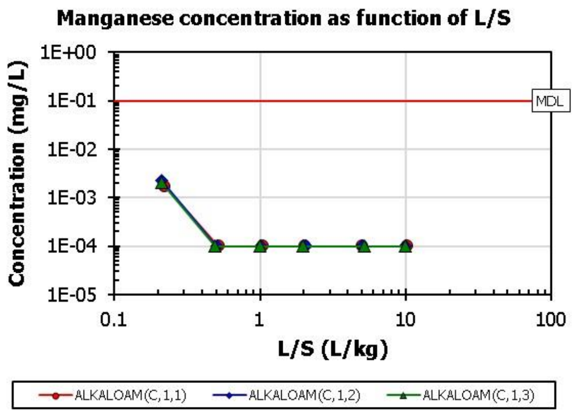

Cumulative release of Mercury

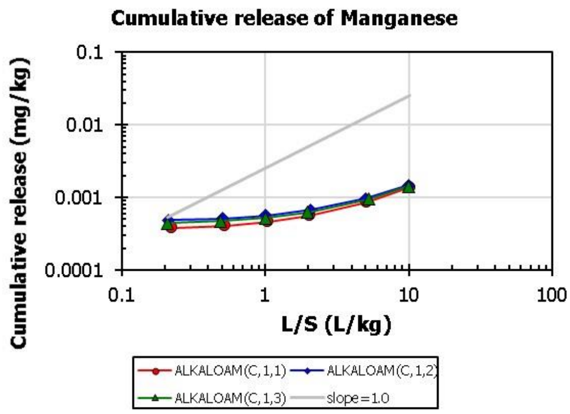

Potassium concentration as function of L/S

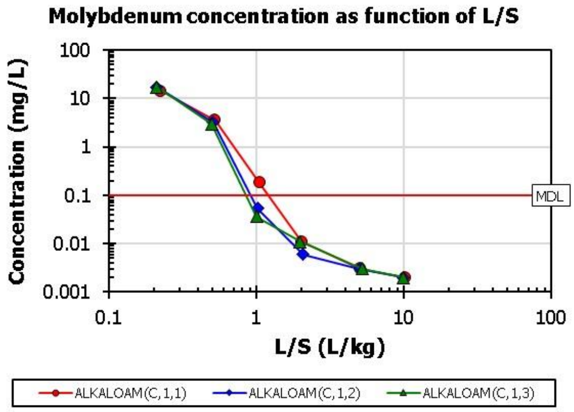

Cumulative release of Potassium

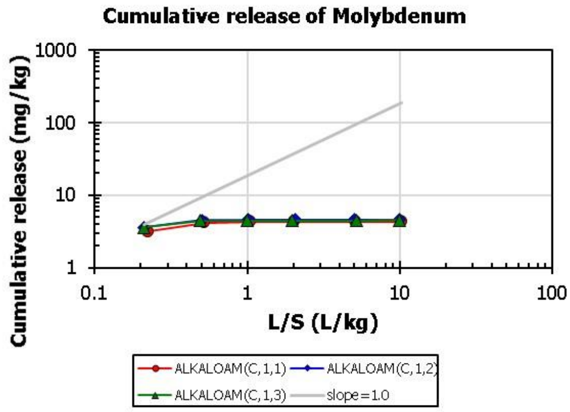

Magnesium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

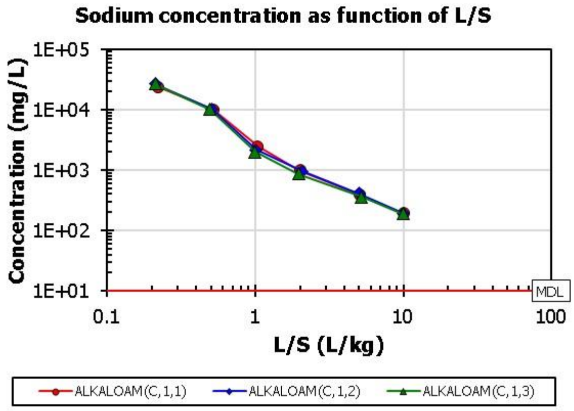

Cumulative release of Magnesium
Cumulative release (mg/kg)
10
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

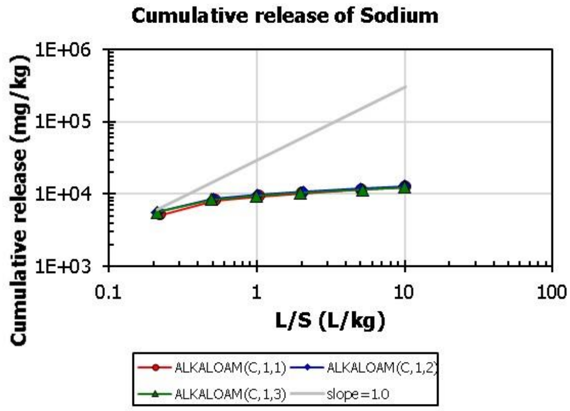

Manganese concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)


Cumulative release of Manganese
Cumulative release (mg/kg)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

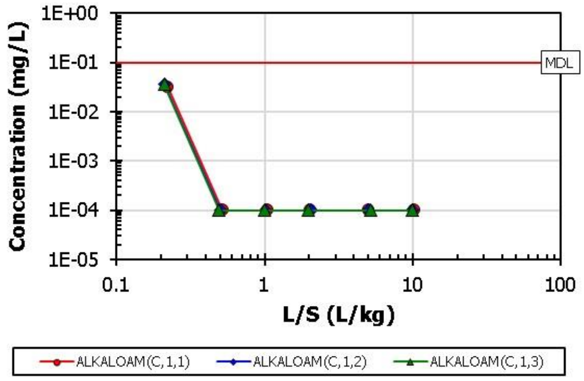

Molybdenum concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)


Cumulative release of Molybdenum
Cumulative release (mg/kg)
1000
100
10
1
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

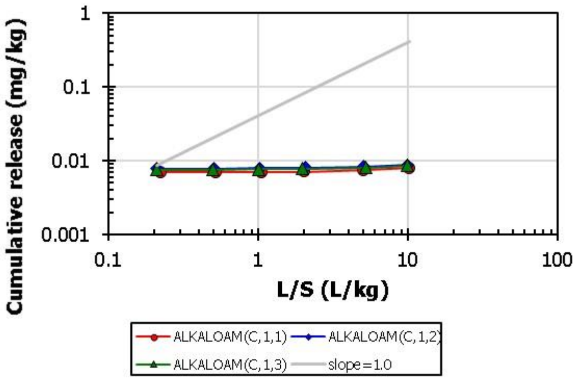

Sodium concentration as function of L/S
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)


Cumulative release of Sodium
Cumulative release (mg/kg)
1E+06
1E+05
1E+04
1E+03
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

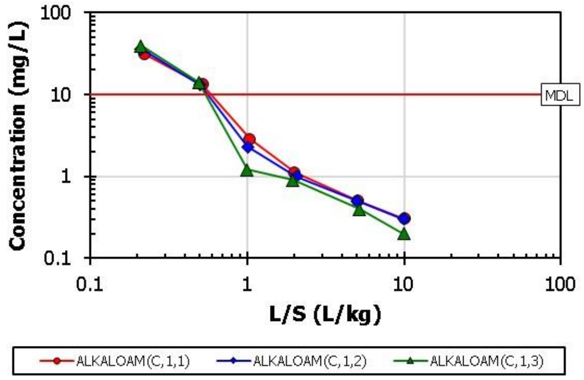
Nickel concentration as function of L/S



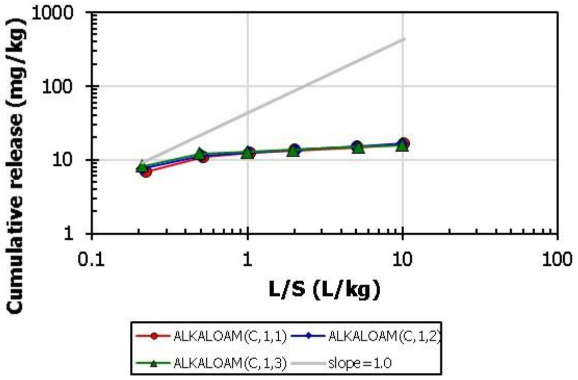
Cumulative release of Nickel



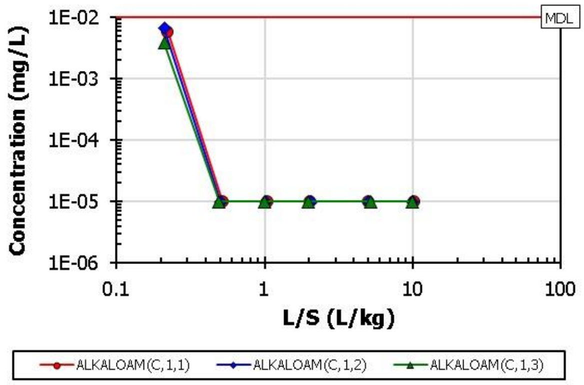
Phosphorus concentration as function of L/S



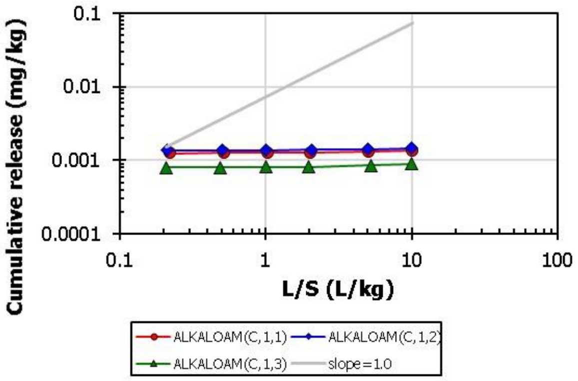
Cumulative release of Phosphorus



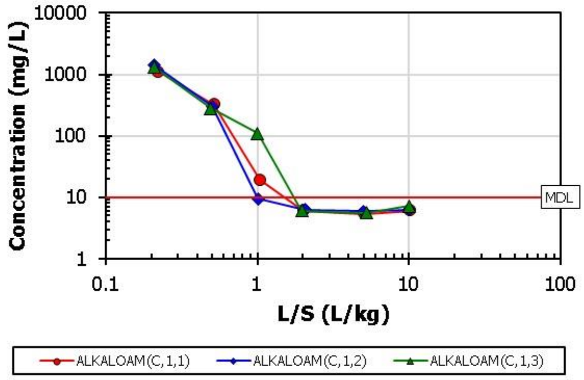
Lead concentration as function of L/S



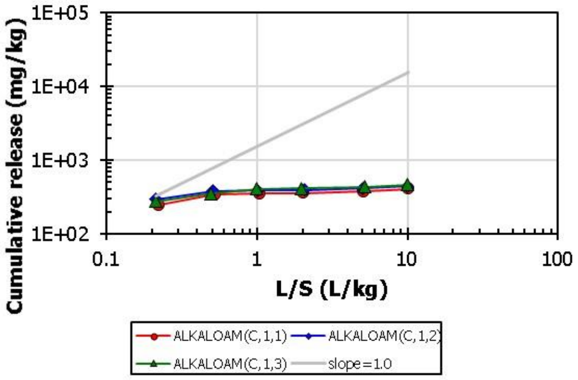
Cumulative release of Lead

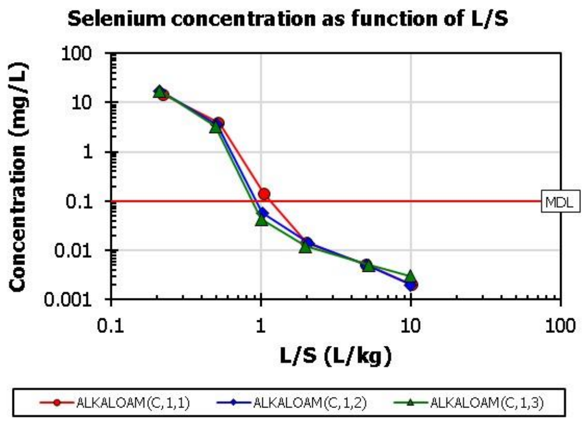


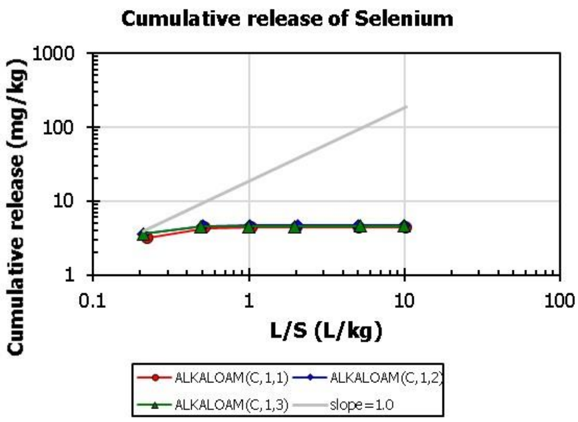
Sulfur concentration as function of L/S

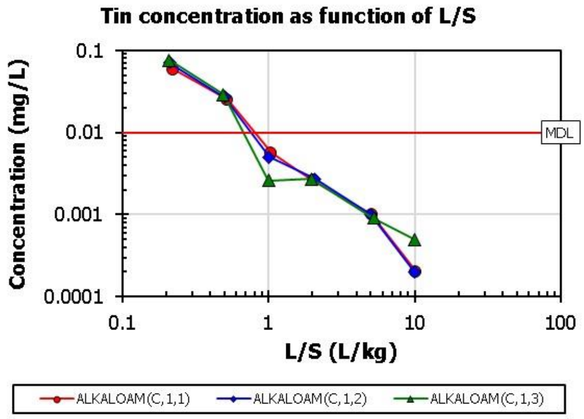


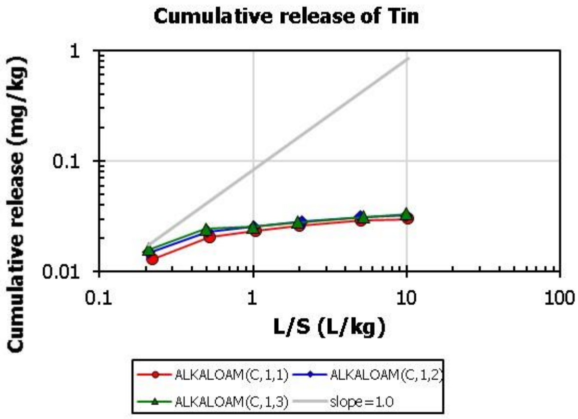
Cumulative release of Sulfur

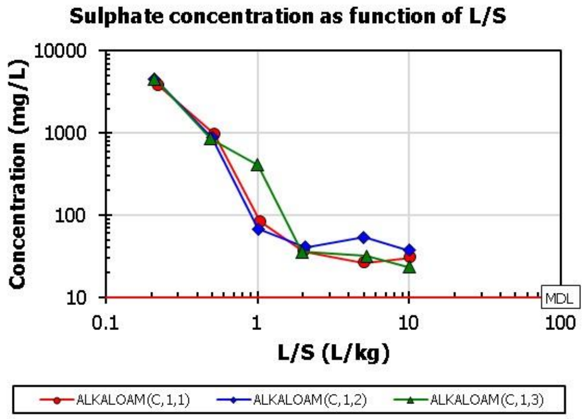


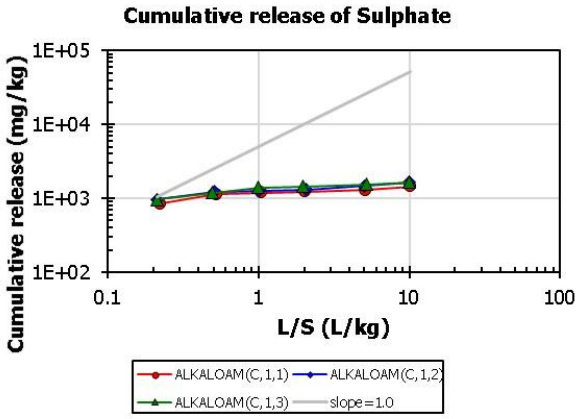

Selenium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
MDL
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

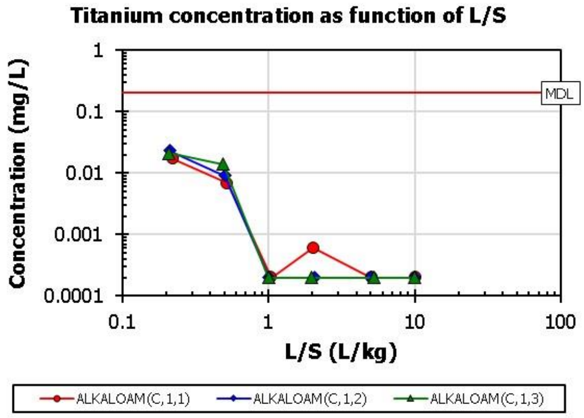

Cumulative release of Selenium
Cumulative release (mg/kg)
1000
100
10
1
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

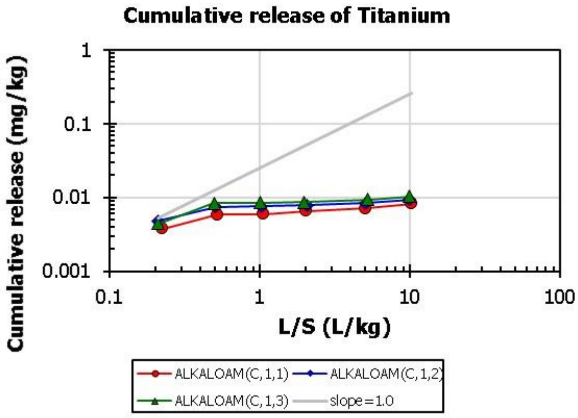

Tin concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
MDL
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

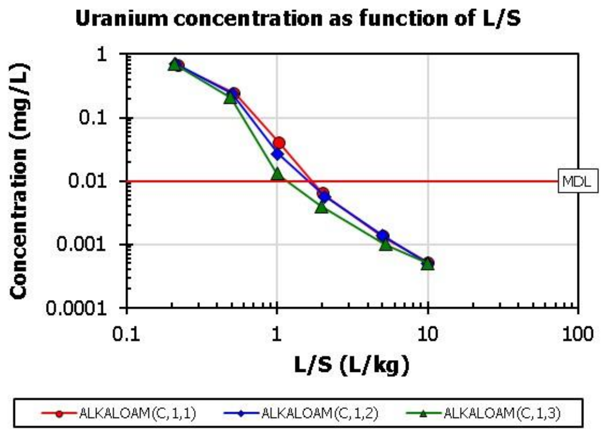

Cumulative release of Tin
Cumulative release (mg/kg)
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

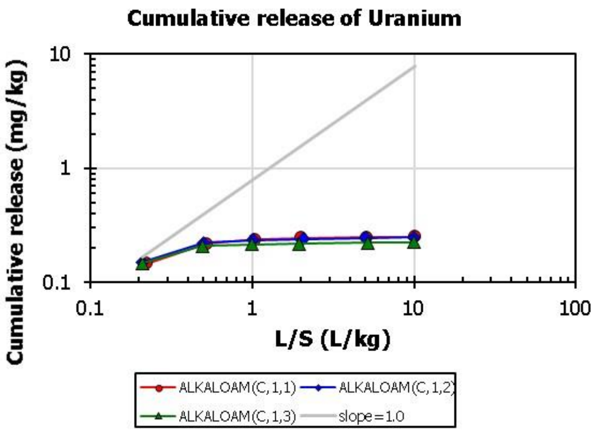

Sulphate concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
0.1
1
10
100
L/S (L/kg)
MDL
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

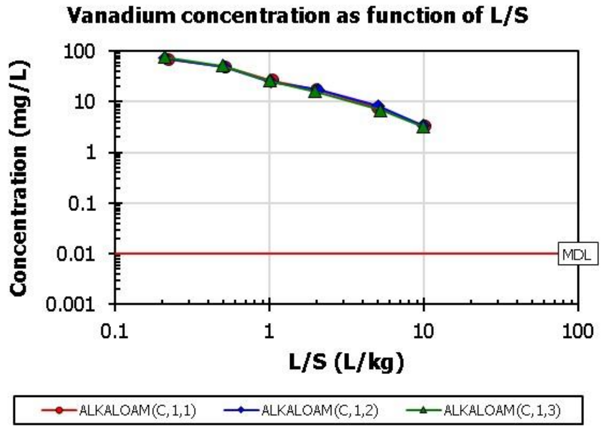

Cumulative release of Sulphate
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

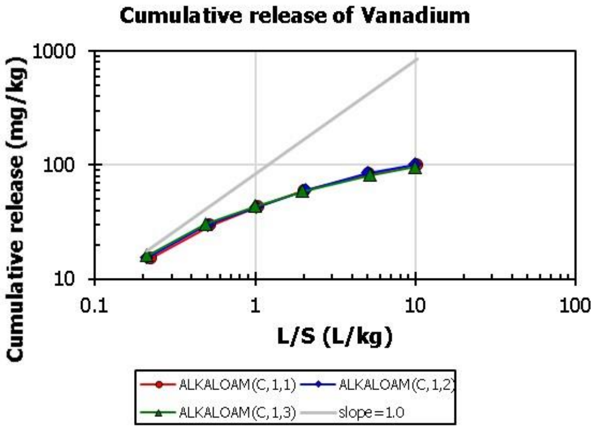

Titanium concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
MDL
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

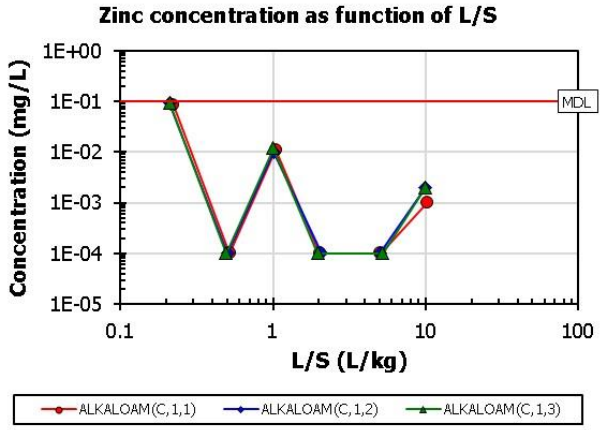

Cumulative release of Titanium
Cumulative release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

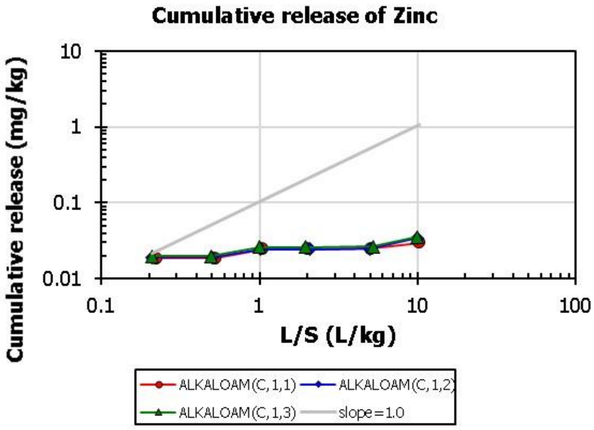

Uranium concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)


Cumulative release of Uranium
Cumulative release (mg/kg)
10
1
0.1
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

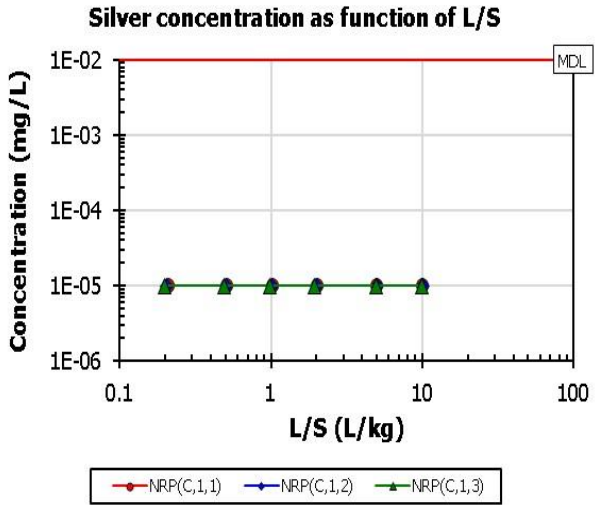

Vanadium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

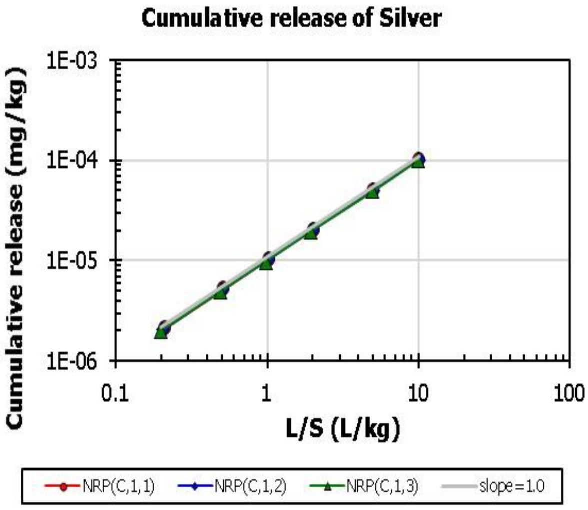

Cumulative release of Vanadium
Cumulative release (mg/kg)
1000
100
10
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

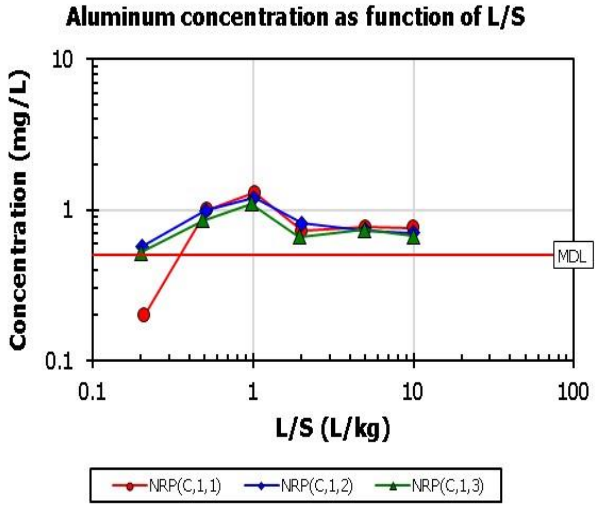

Zinc concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)

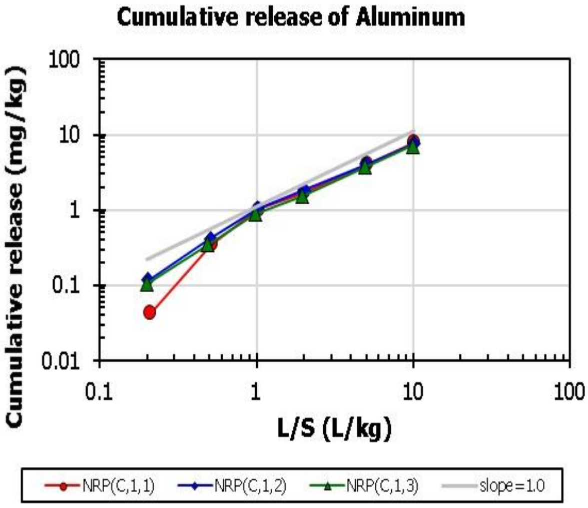

Cumulative release of Zinc
Cumulative release (mg/kg)
10
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
ALKALOAM(C,1,1)
ALKALOAM(C,1,2)
ALKALOAM(C,1,3)
slope=1.0

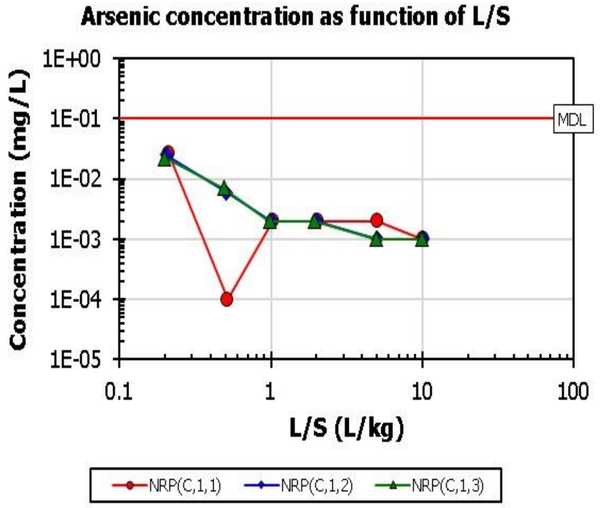
A6-2: By-product - NRP

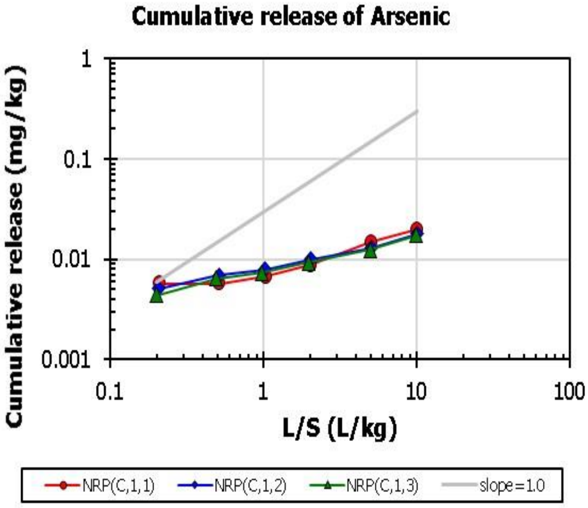

Silver concentration as function of L/S

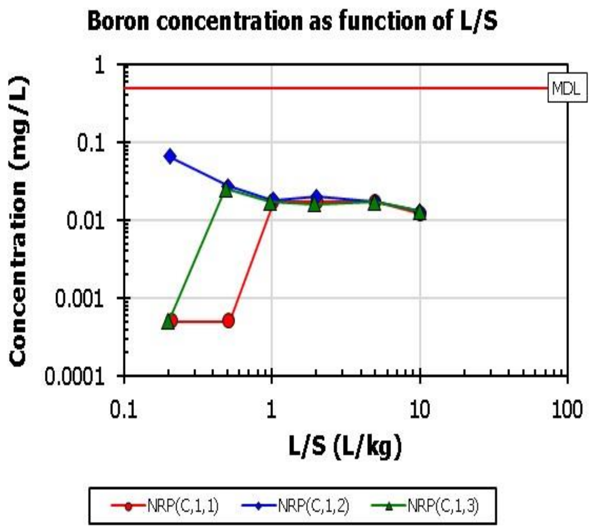

Cumulative release of Silver

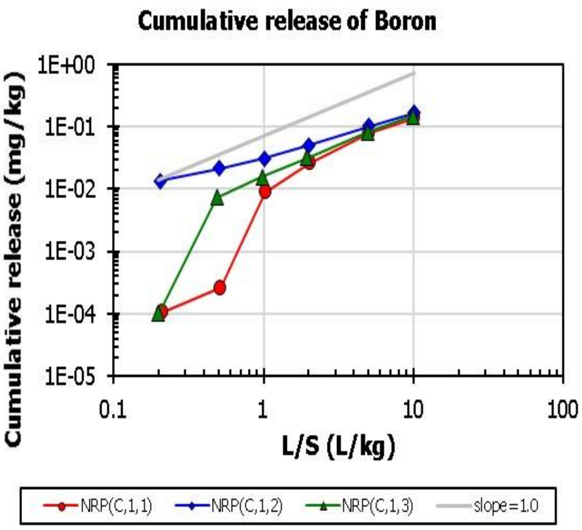

Aluminum concentration as function of L/S

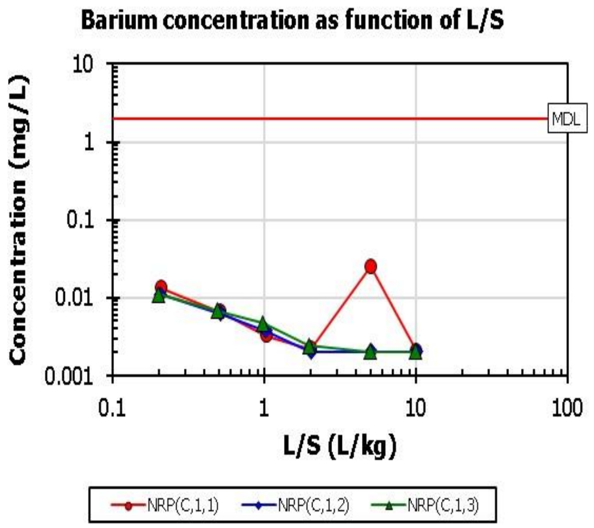

Cumulative release of Aluminum

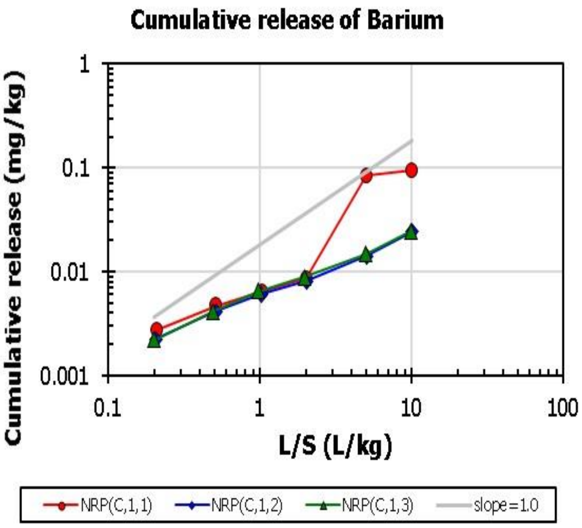

Arsenic concentration as function of L/S

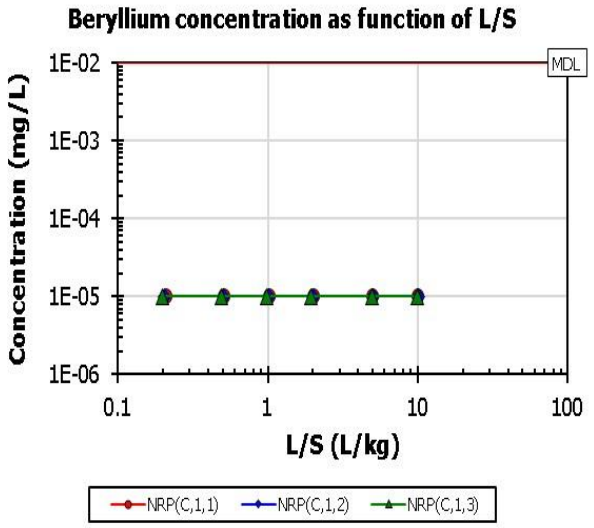

Cumulative release of Arsenic

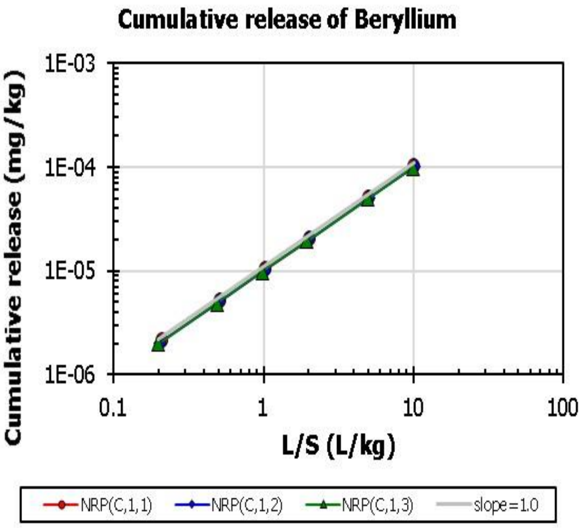

Boron concentration as function of L/S

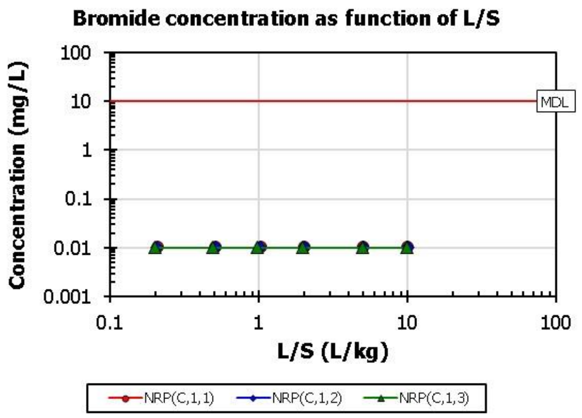

Cumulative release of Boron

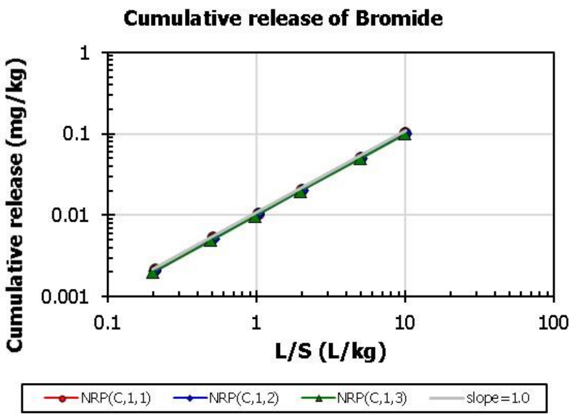

Barium concentration as function of L/S

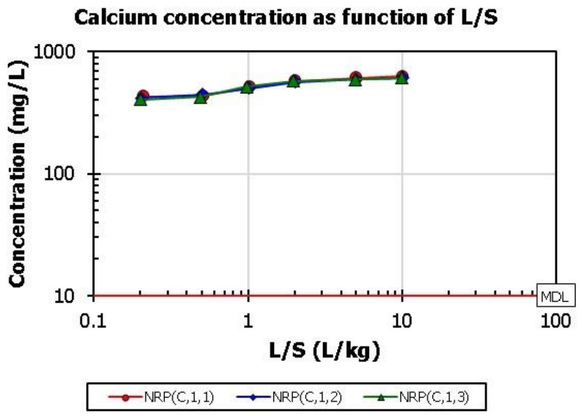

Cumulative release of Barium

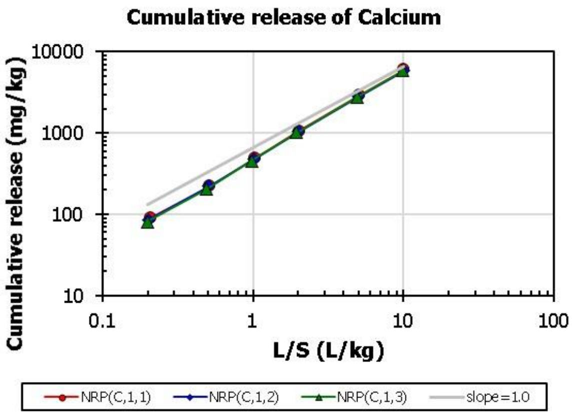

Beryllium concentration as function of L/S

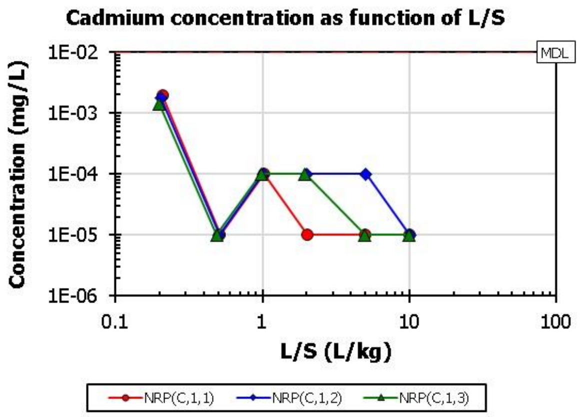

Cumulative release of Beryllium

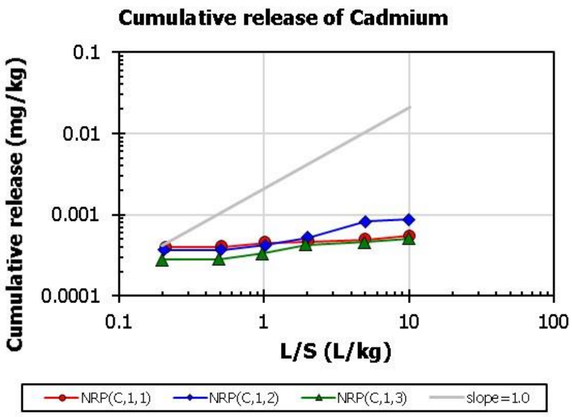

Bromide concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

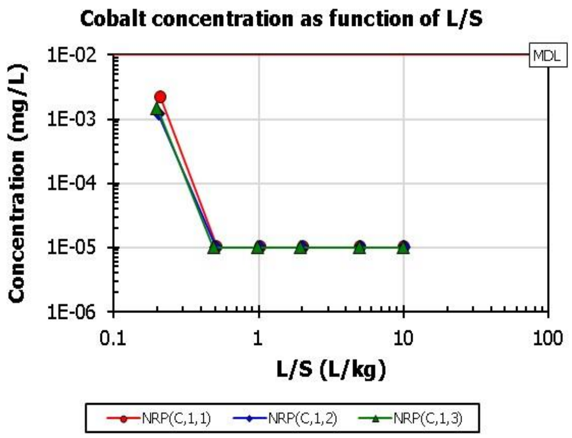

Cumulative release of Bromide
Cumulative release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

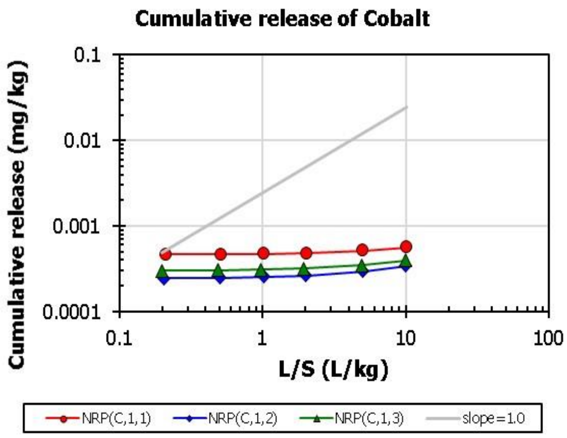

Calcium concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

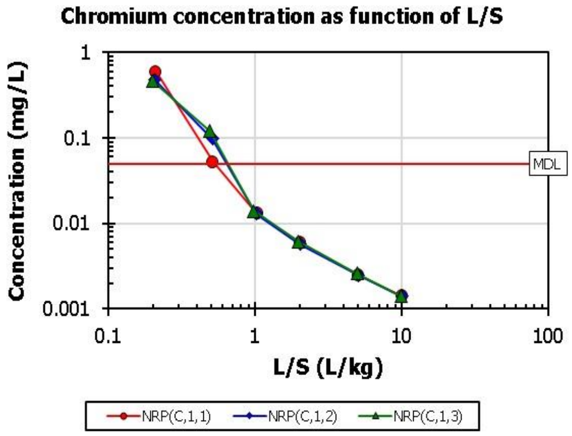

Cumulative release of Calcium
Cumulative release (mg/kg)
10000
1000
100
10
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

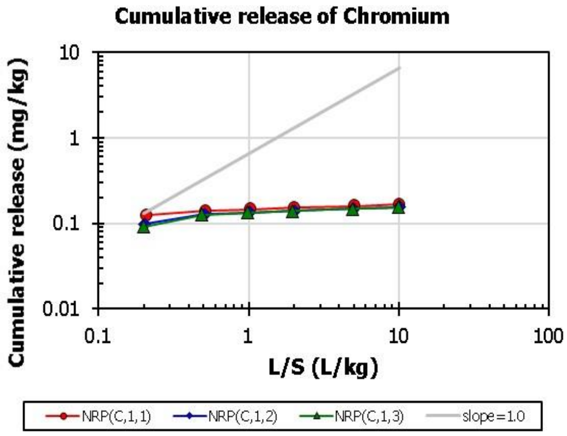

Cadmium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

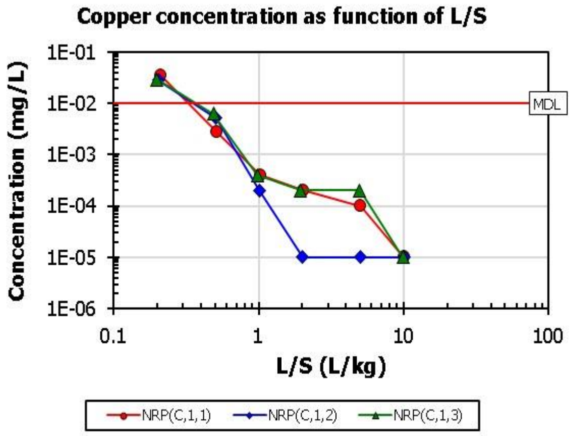

Cumulative release of Cadmium
Cumulative release (mg/kg)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

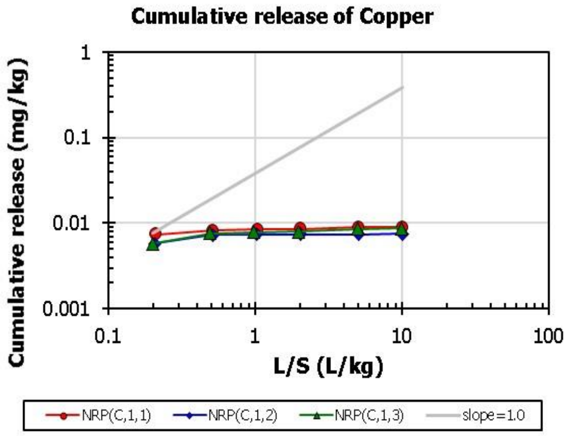

Cobalt concentration as function of L/S

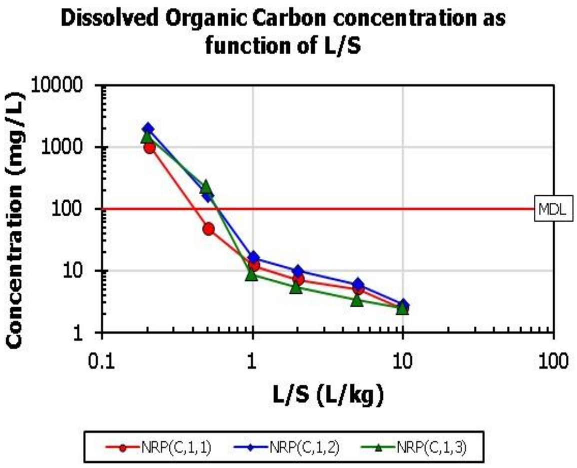

Cumulative release of Cobalt

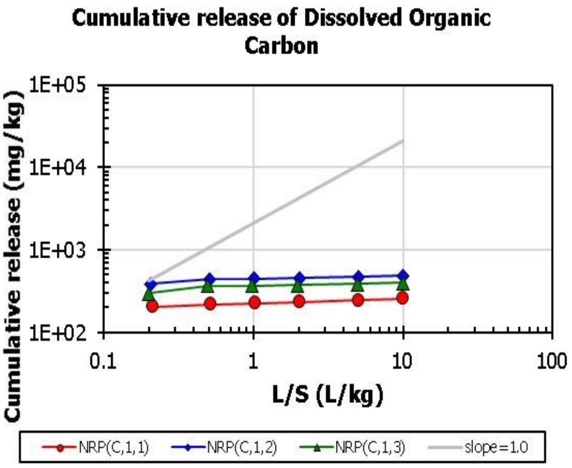

Chromium concentration as function of L/S

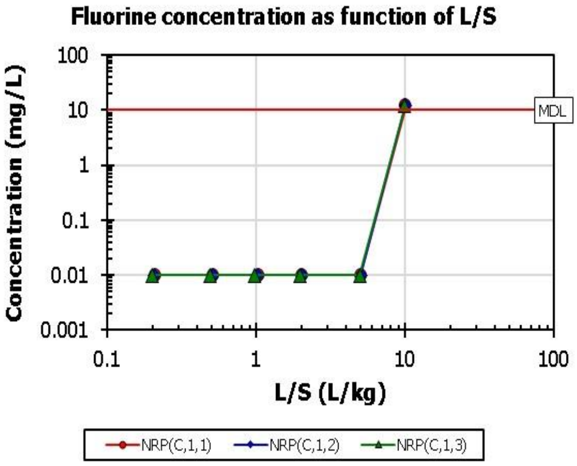

Cumulative release of Chromium

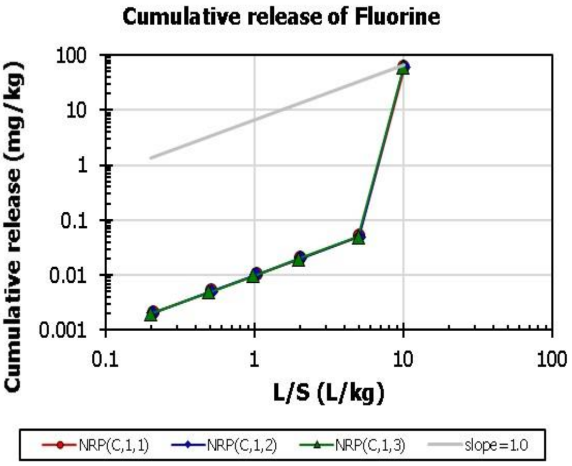

Copper concentration as function of L/S

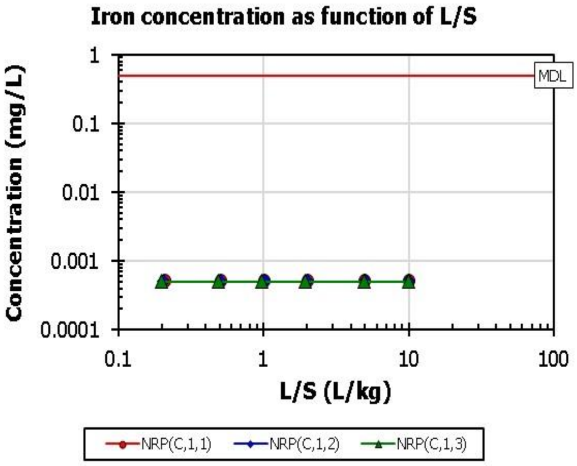

Cumulative release of Copper

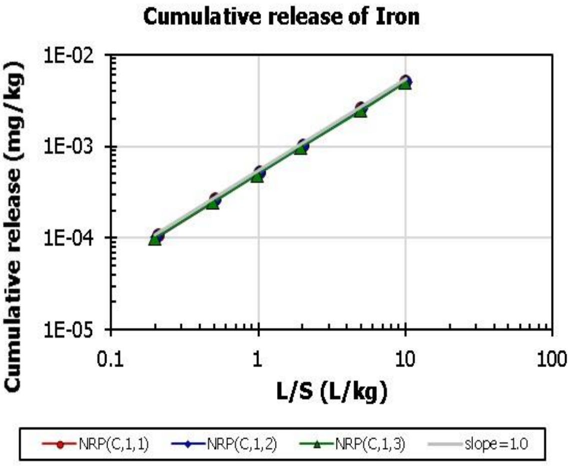

Dissolved Organic Carbon concentration as function of L/S

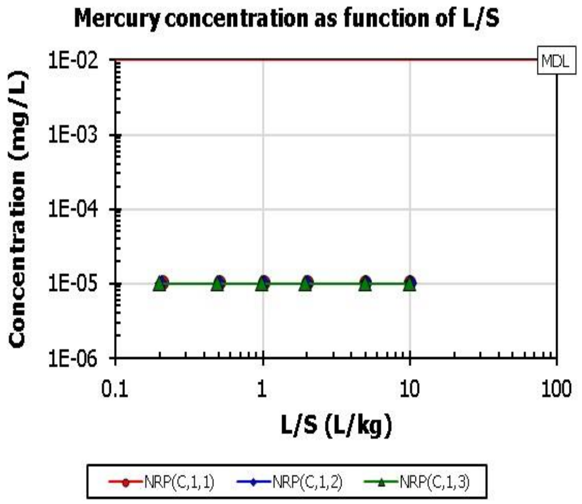

Cumulative release of Dissolved Organic Carbon

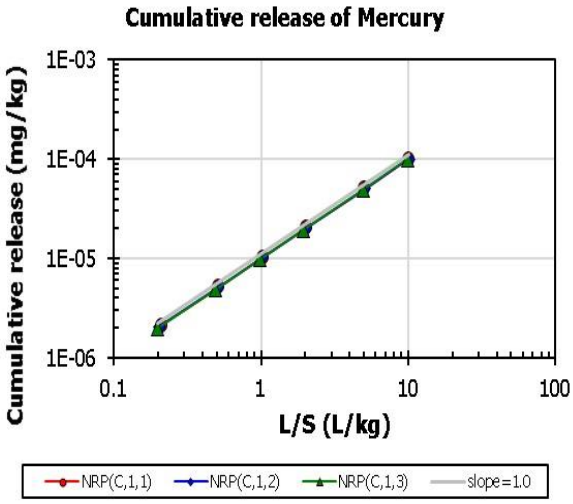

Fluorine concentration as function of L/S

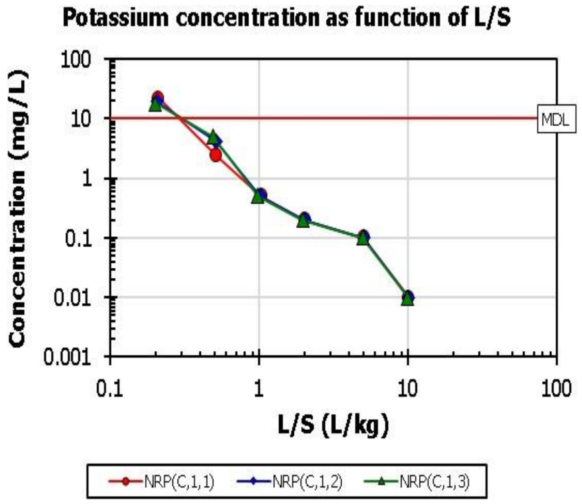

Cumulative release of Fluorine

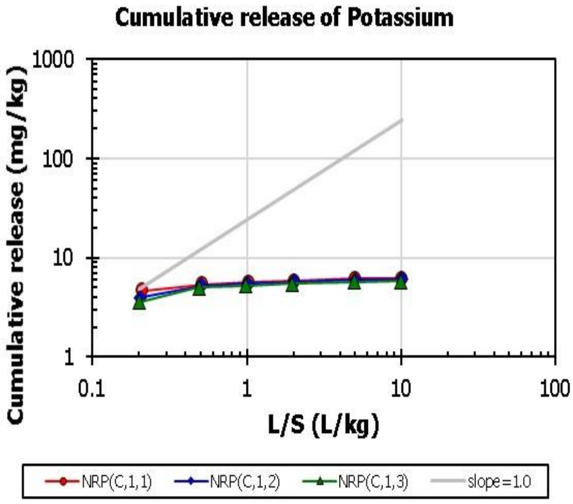

Iron concentration as function of L/S

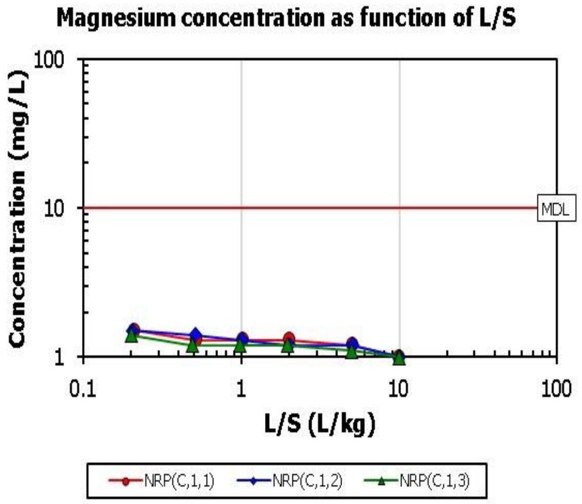

Cumulative release of Iron

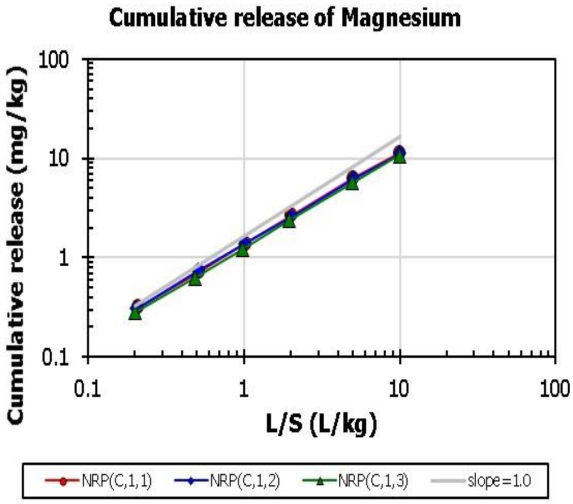

Mercury concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

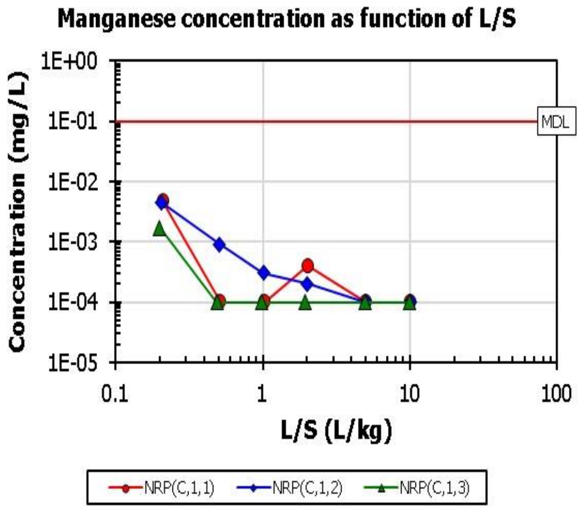

Cumulative release of Mercury
Cumulative release (mg/kg)
1E-03
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

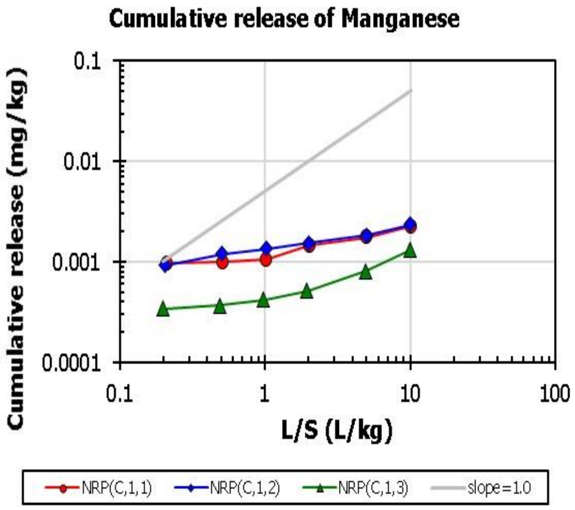

Potassium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

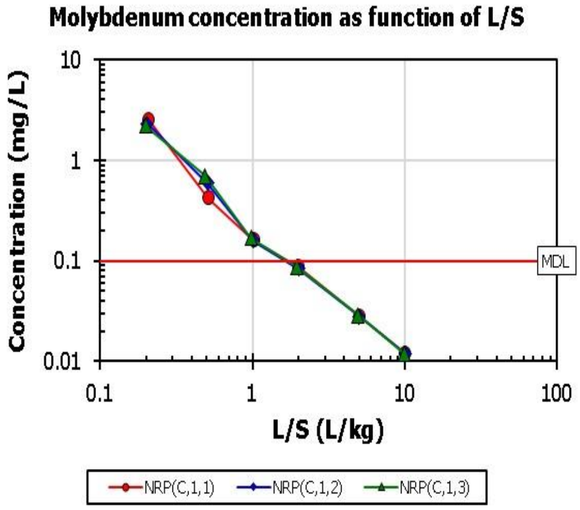

Cumulative release of Potassium
Cumulative release (mg/kg)
1000
100
10
1
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

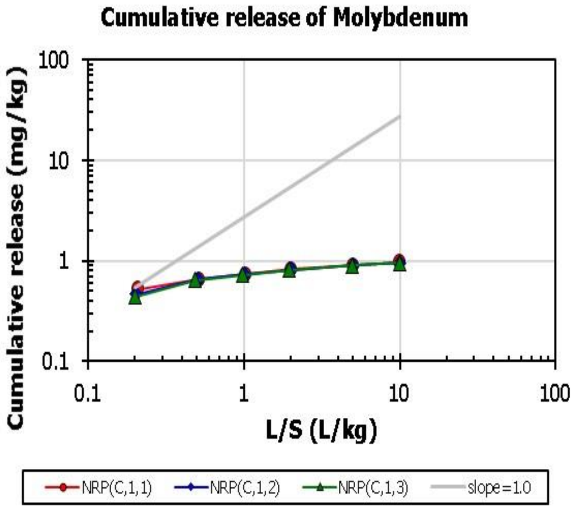

Magnesium concentration as function of L/S
Concentration (mg/L)
100
10
1
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

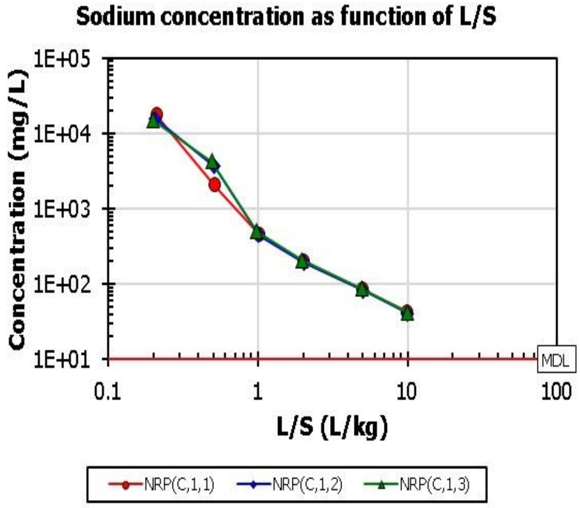

Cumulative release of Magnesium
Cumulative release (mg/kg)
100
10
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

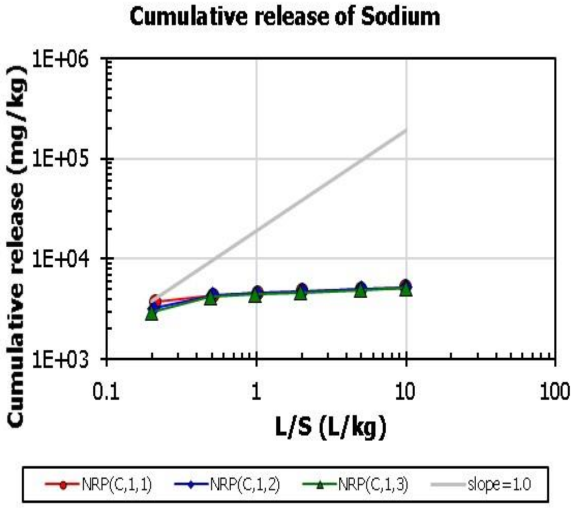

Manganese concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

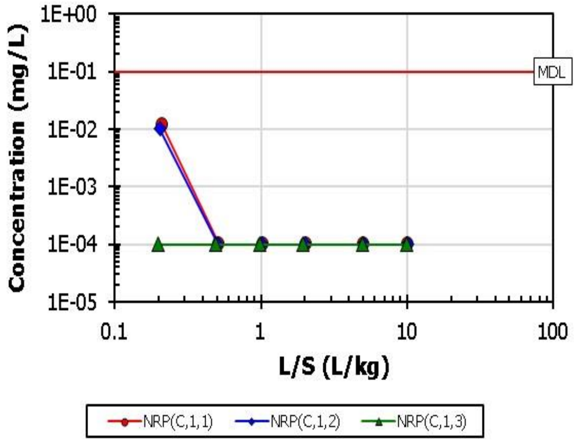

Cumulative release of Manganese
Cumulative release (mg/kg)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

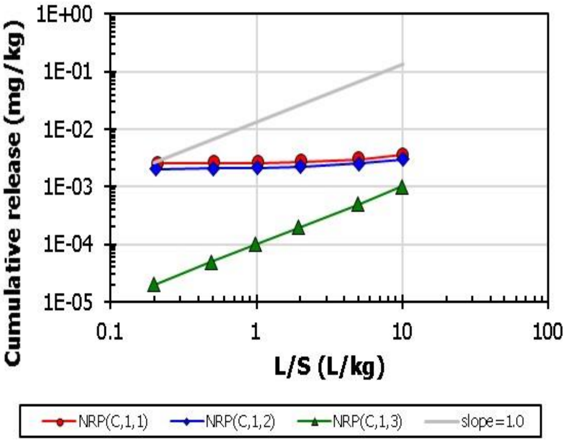

Molybdenum concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

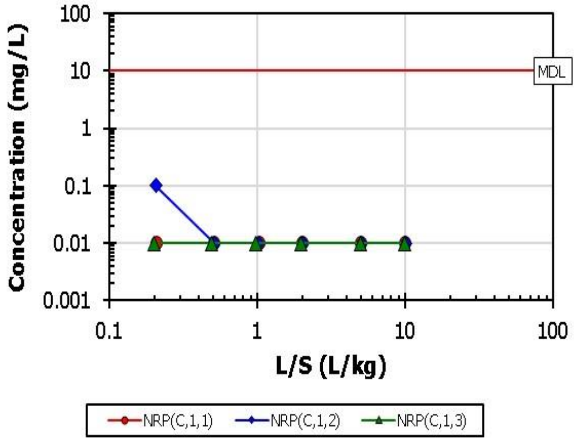

Cumulative release of Molybdenum
Cumulative release (mg/kg)
100
10
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

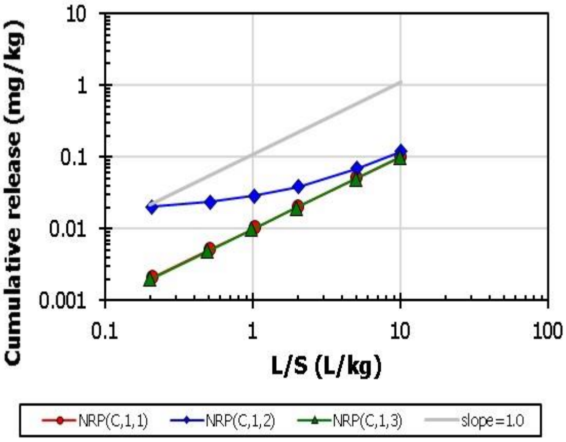

Sodium concentration as function of L/S
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

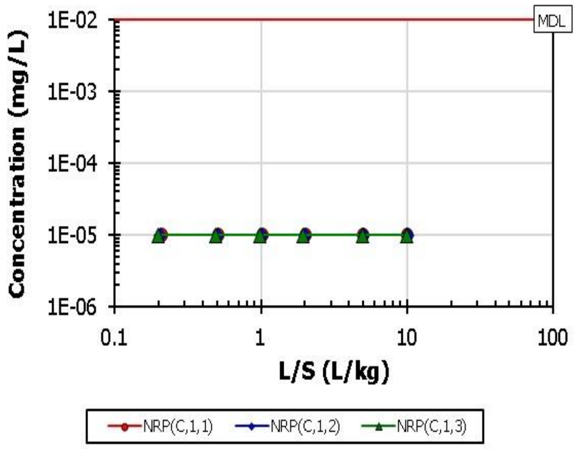

Cumulative release of Sodium
Cumulative release (mg/kg)
1E+06
1E+05
1E+04
1E+03
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

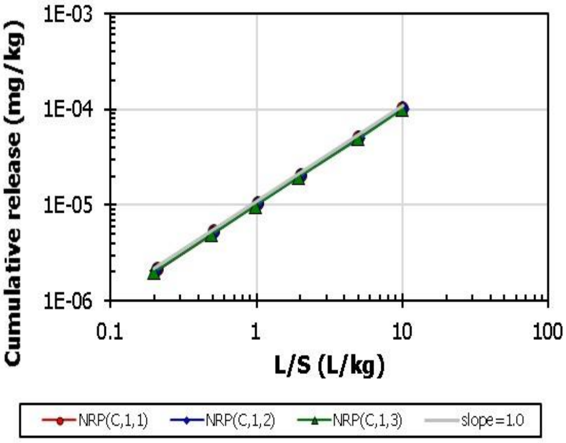

Nickel concentration as function of L/S

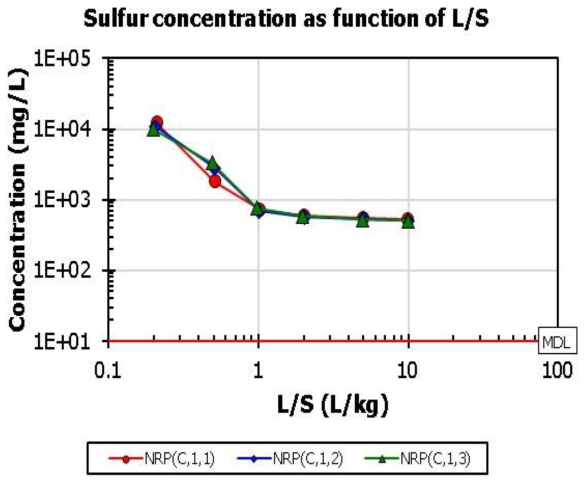

Cumulative release of Nickel

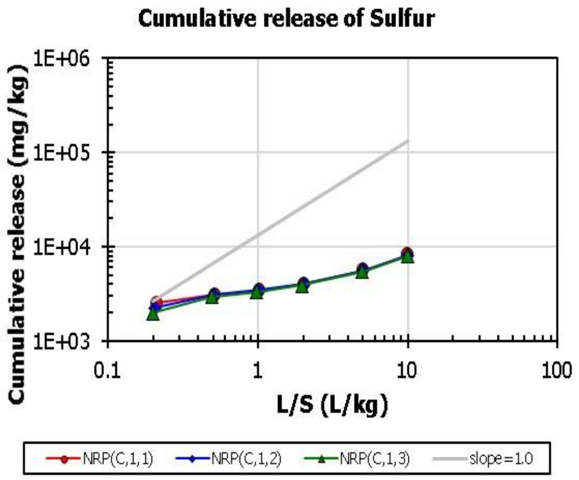

Phosphorus concentration as function of L/S

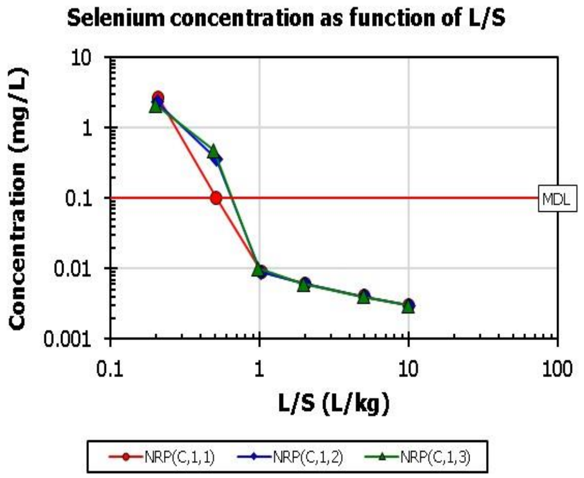

Cumulative release of Phosphorus

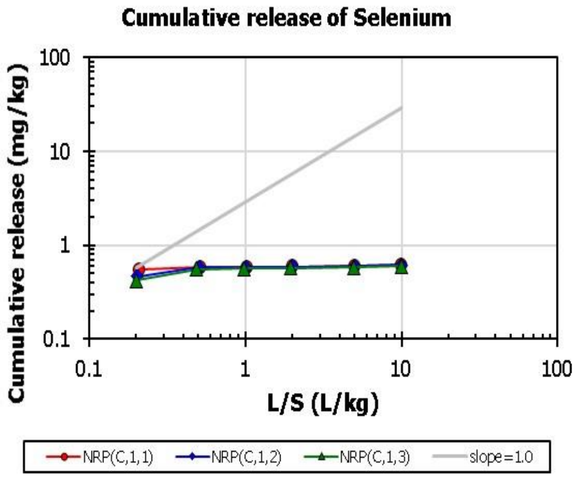

Lead concentration as function of L/S

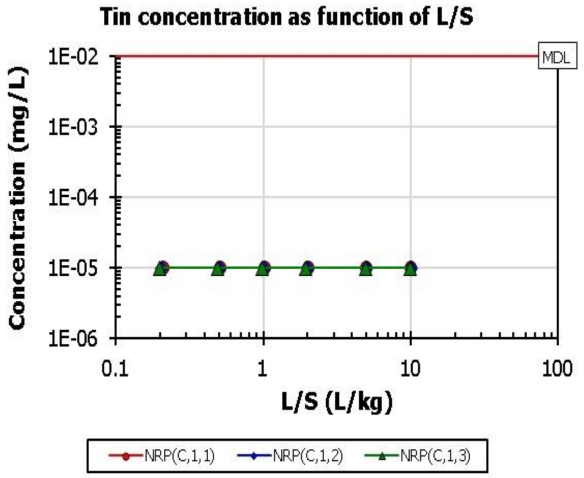

Cumulative release of Lead

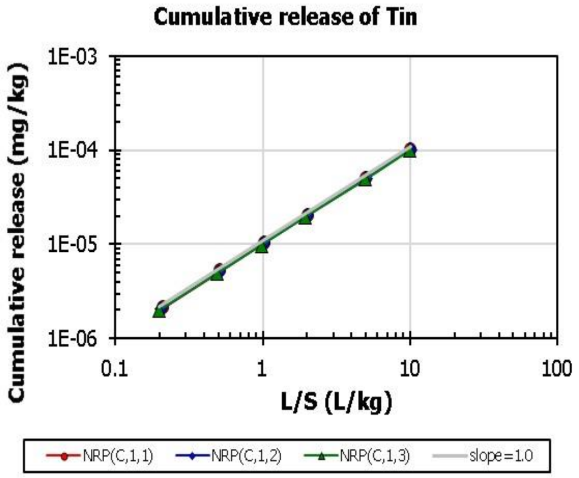

Sulfur concentration as function of L/S

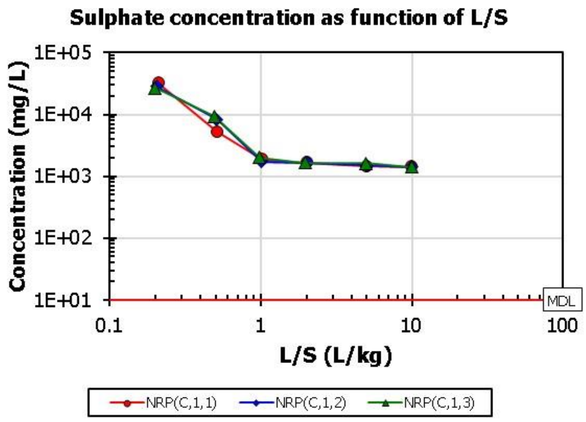

Cumulative release of Sulfur

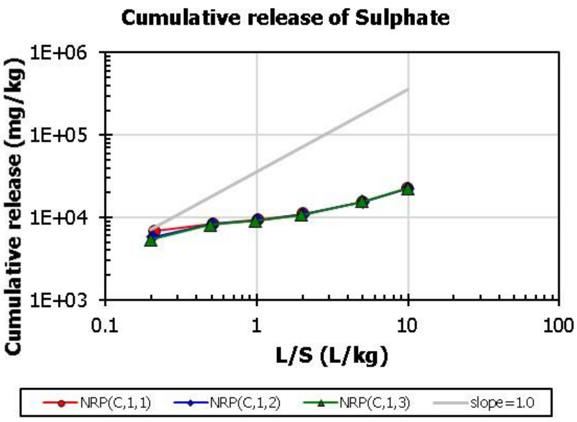

Selenium concentration as function of L/S

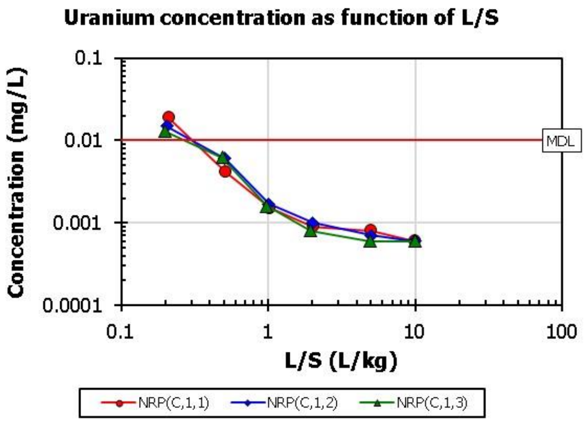

Cumulative release of Selenium

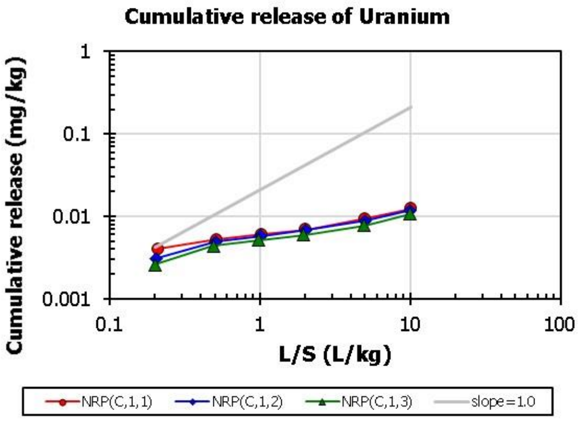

Tin concentration as function of L/S

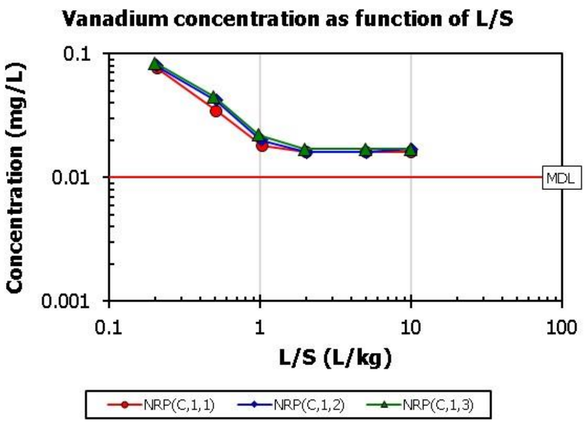

Cumulative release of Tin

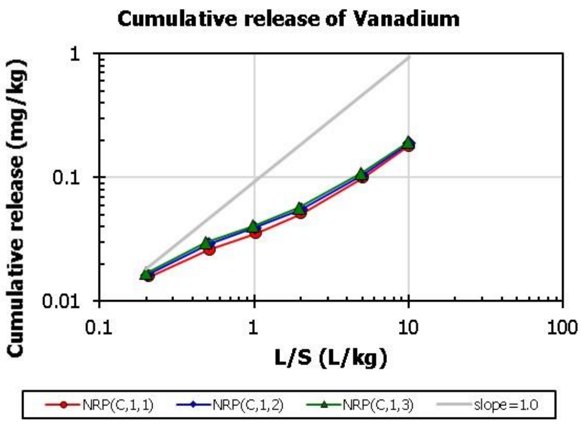

Sulphate concentration as function of L/S
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

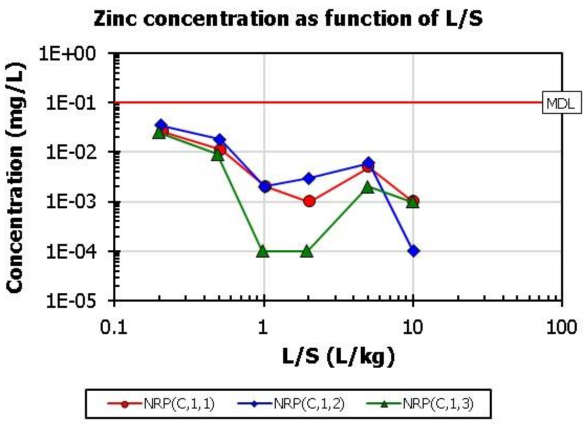

Cumulative release of Sulphate
Cumulative release (mg/kg)
1E+06
1E+05
1E+04
1E+03
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

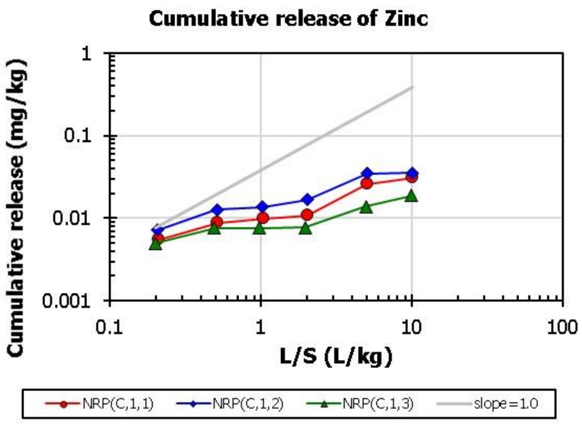

Uranium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)


Cumulative release of Uranium
Cumulative release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

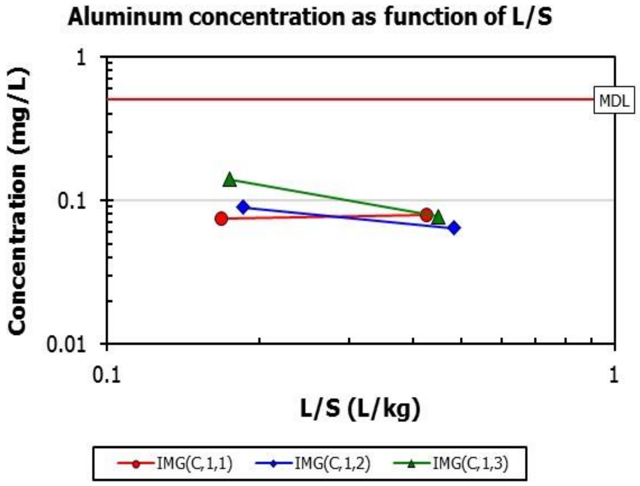

Vanadium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

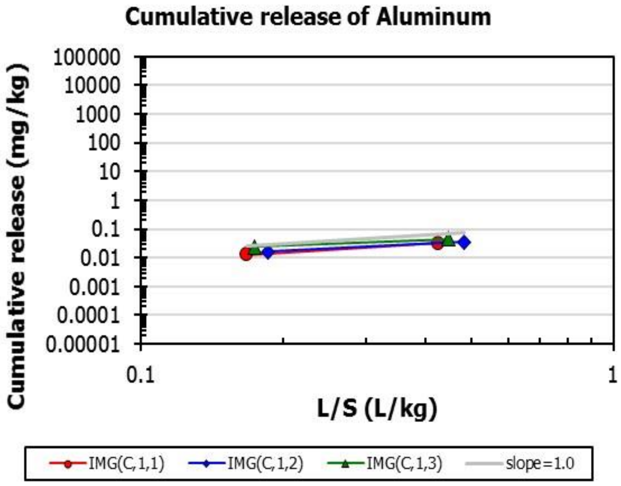

Cumulative release of Vanadium
Cumulative release (mg/kg)
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

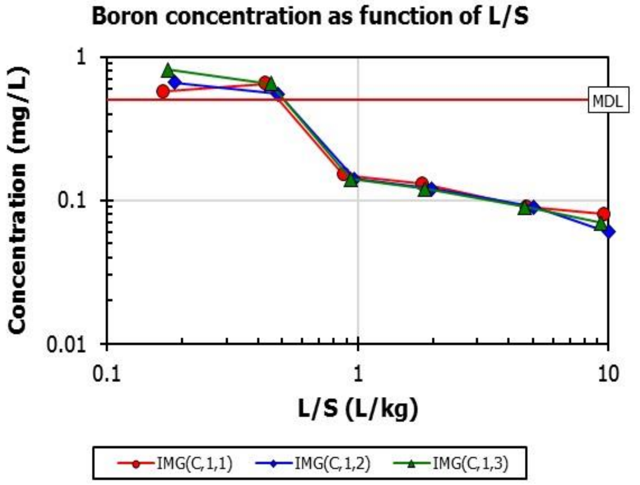

Zinc concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)

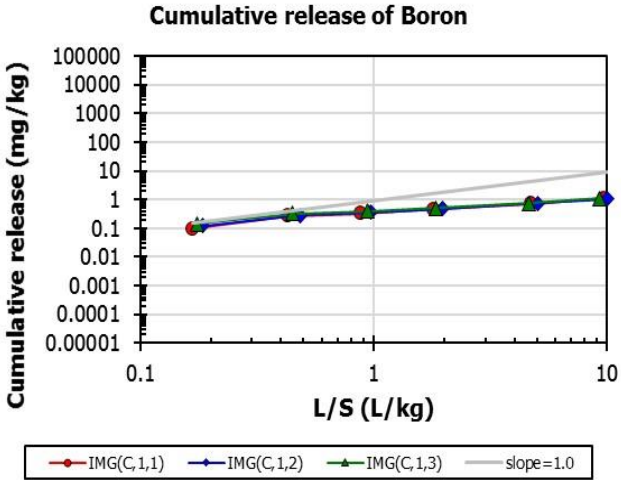

Cumulative release of Zinc
Cumulative release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(C,1,1)
NRP(C,1,2)
NRP(C,1,3)
slope=1.0

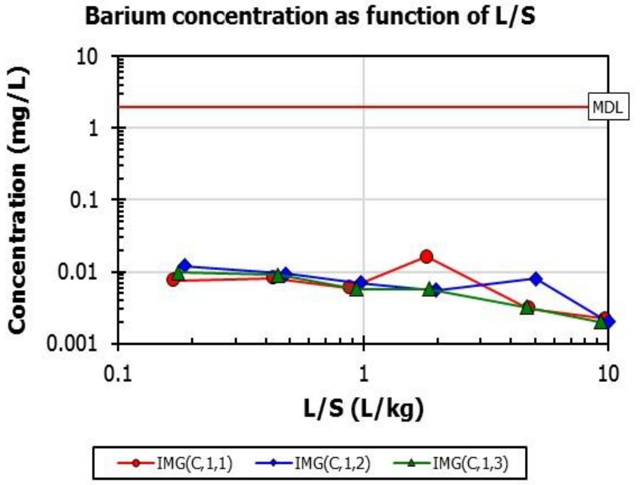
A6-3: By-product – Ironman Gypsum (IMG)

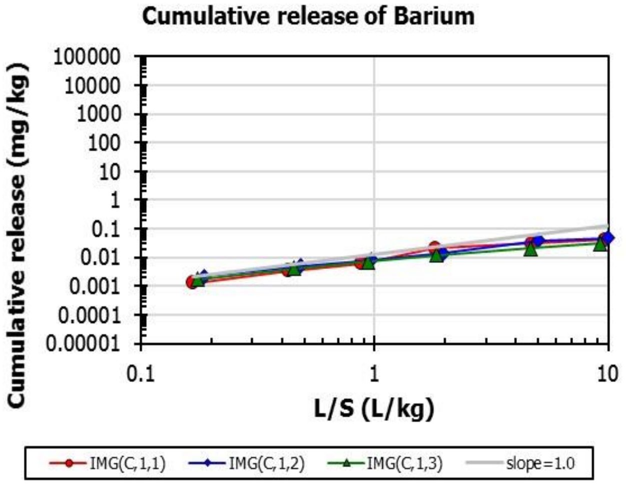


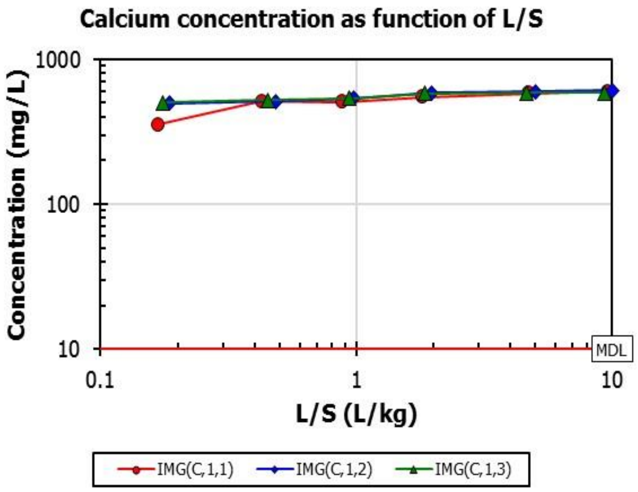


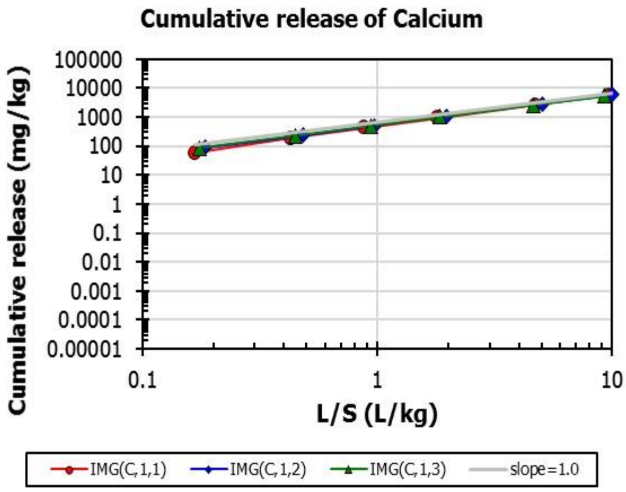


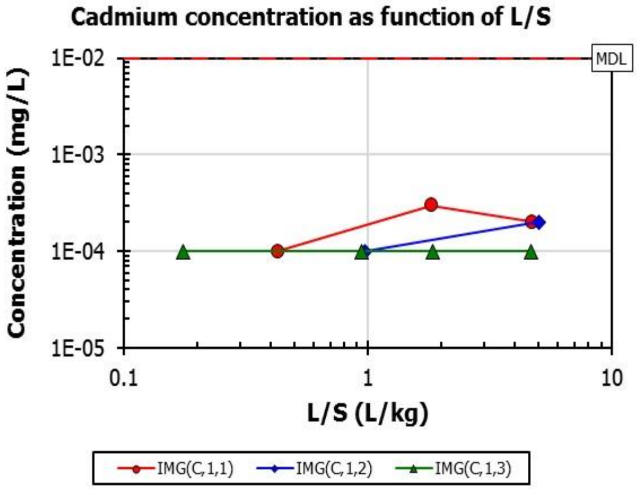


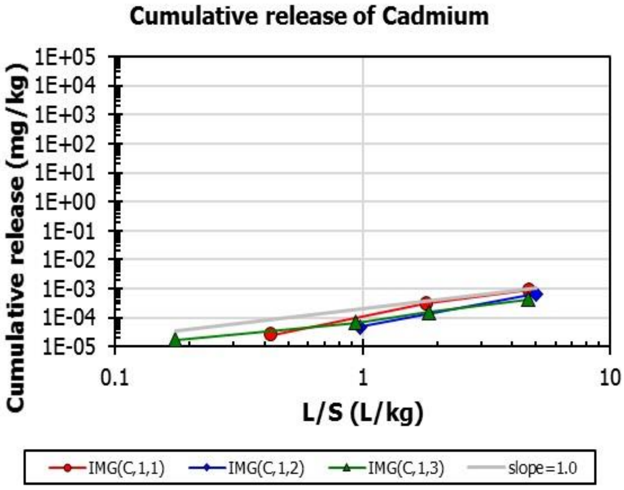


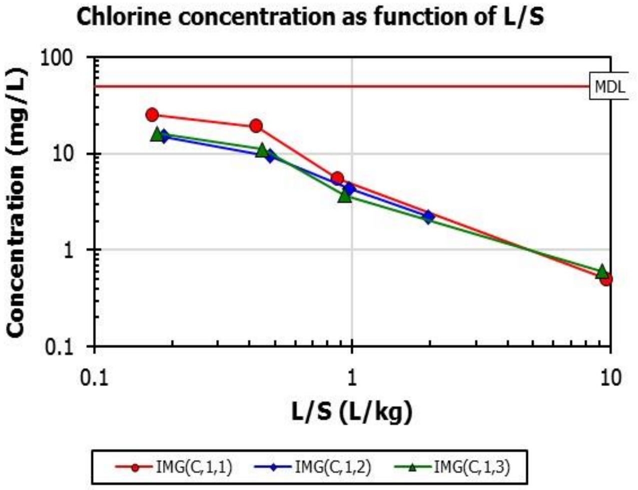


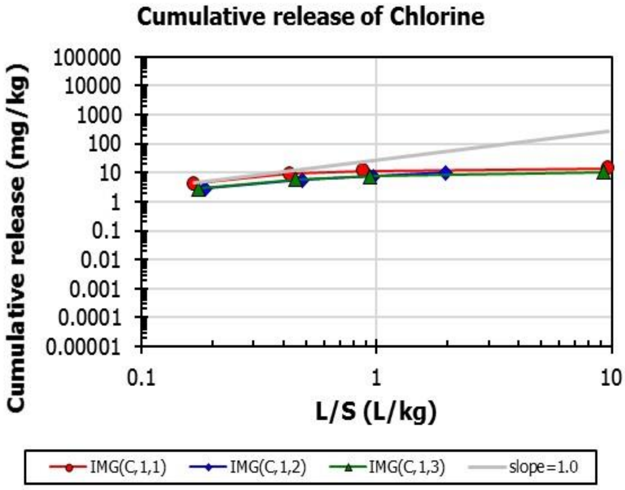

Calcium concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

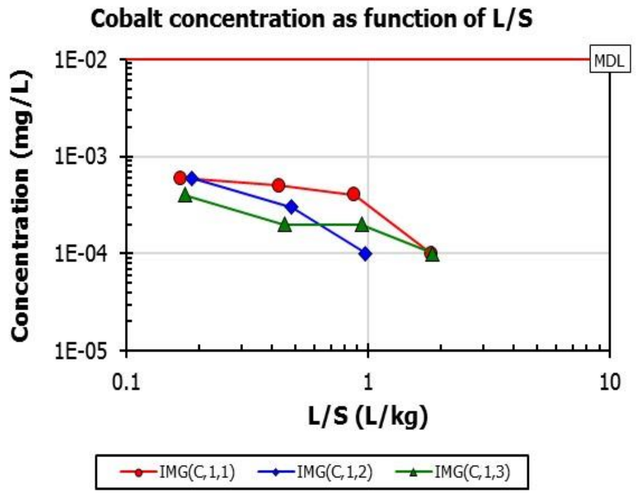

Cumulative release of Calcium
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

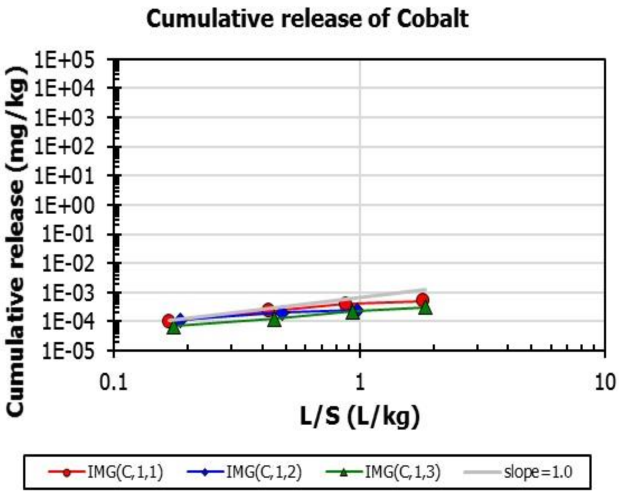

Cadmium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

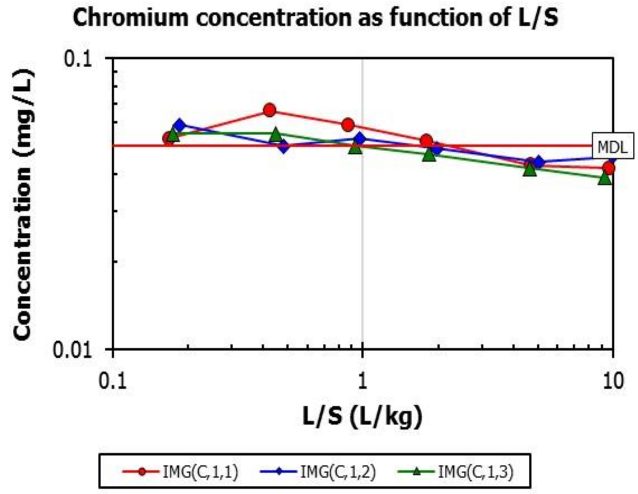

Cumulative release of Cadmium
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

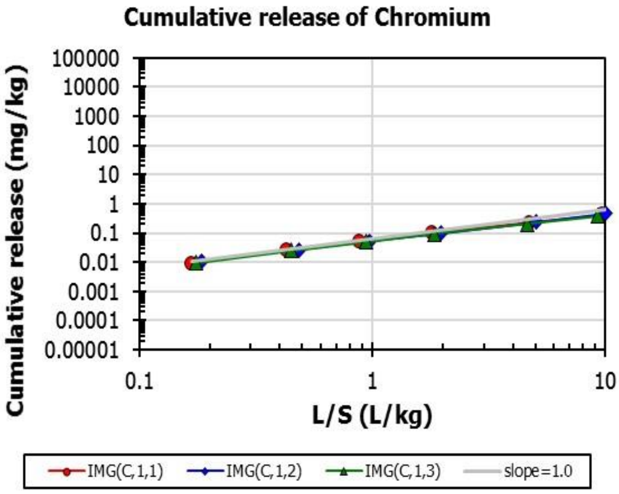

Chlorine concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

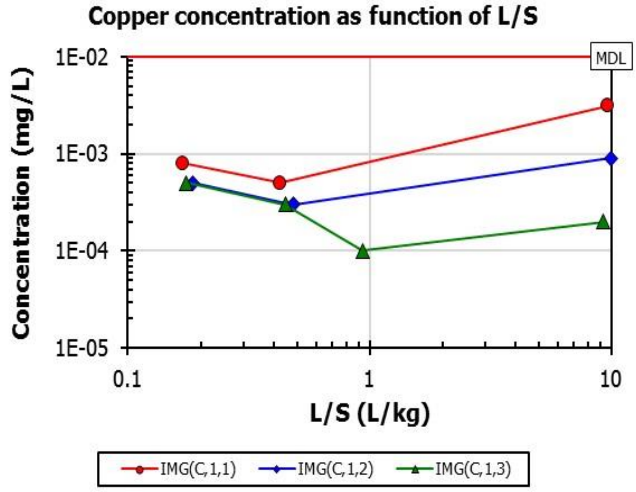

Cumulative release of Chlorine
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

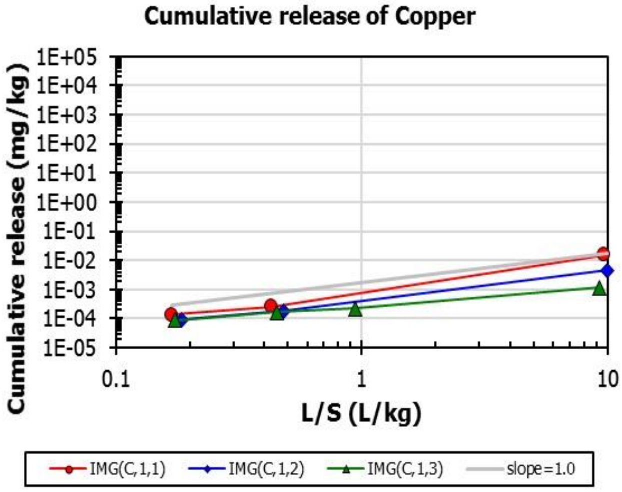

Cobalt concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

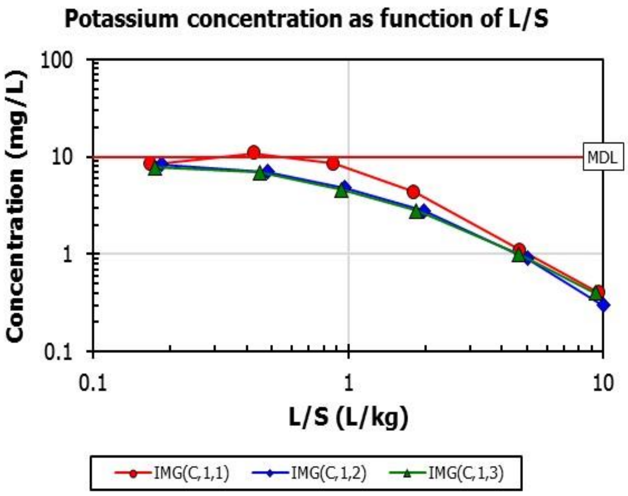

Cumulative release of Cobalt
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

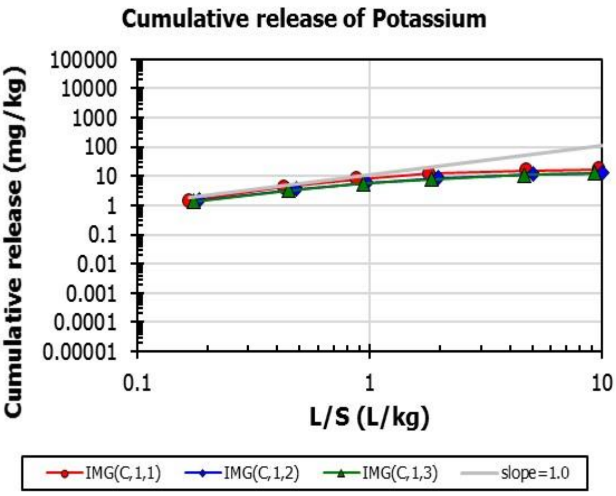

Chromium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

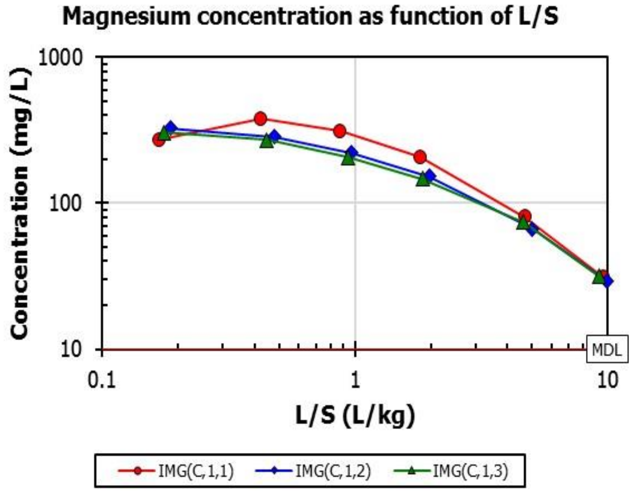

Cumulative release of Chromium
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

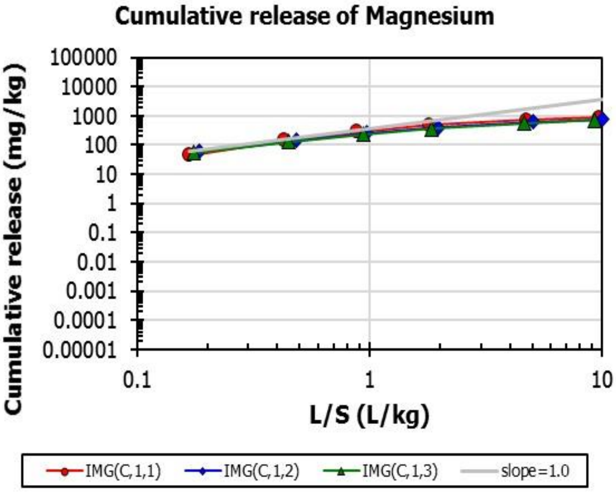

Copper concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)

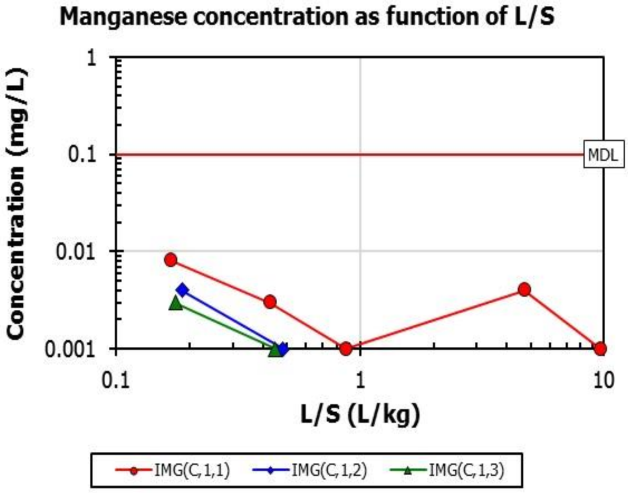

Cumulative release of Copper
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

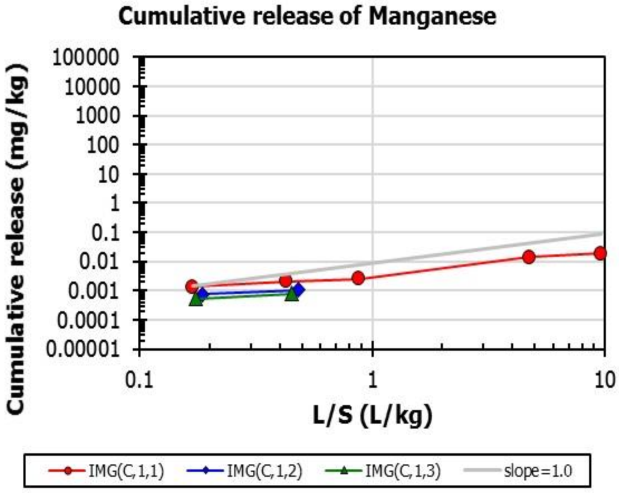

Potassium concentration as function of L/S

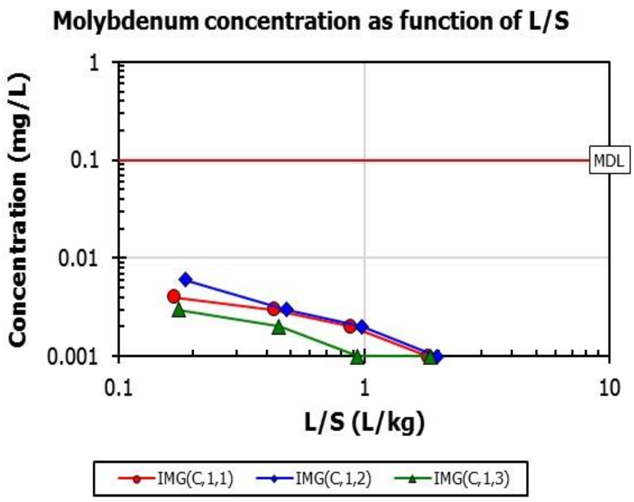

Cumulative release of Potassium

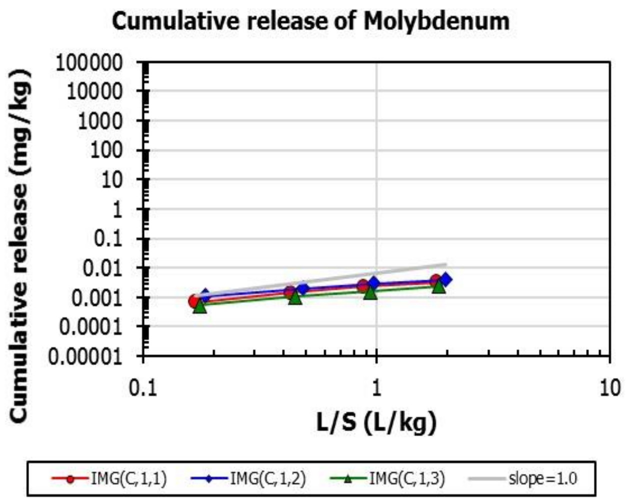

Magnesium concentration as function of L/S

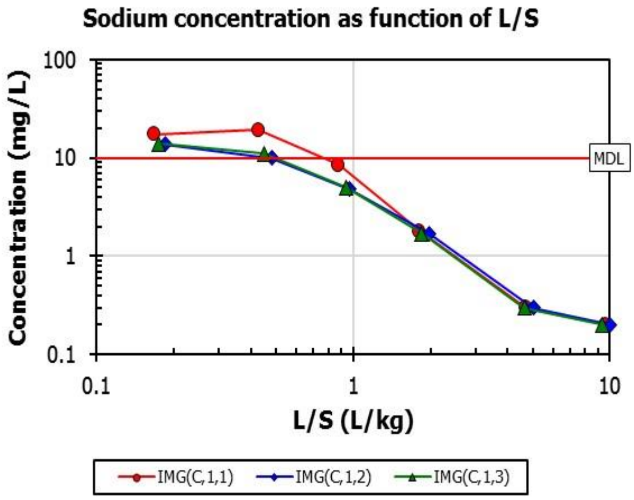

Cumulative release of Magnesium

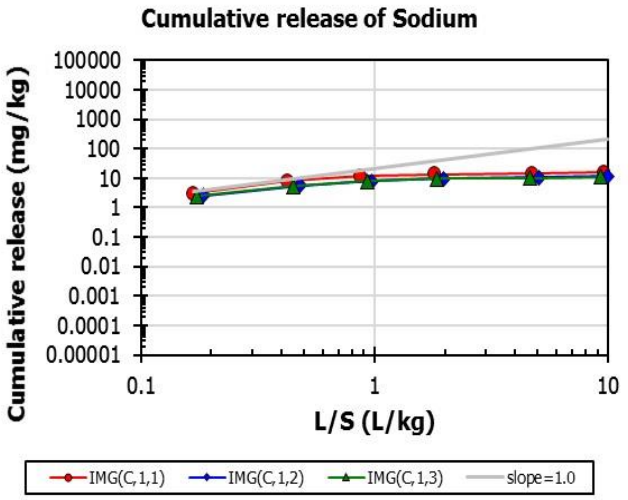

Manganese concentration as function of L/S

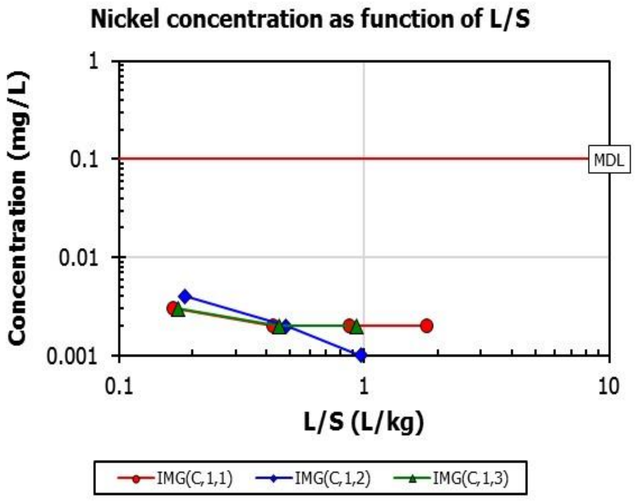

Cumulative release of Manganese

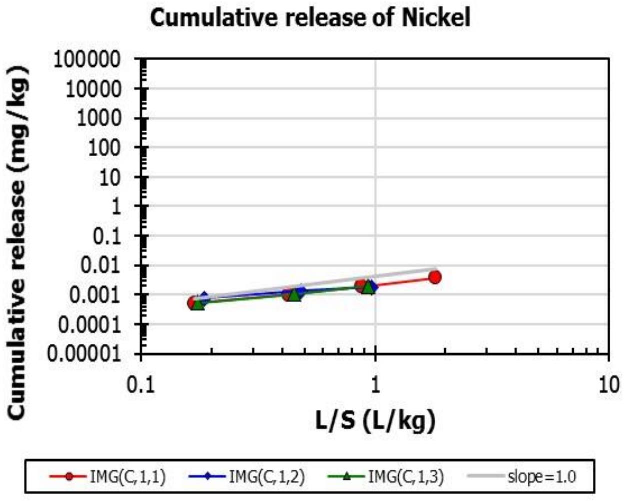

Molybdenum concentration as function of L/S

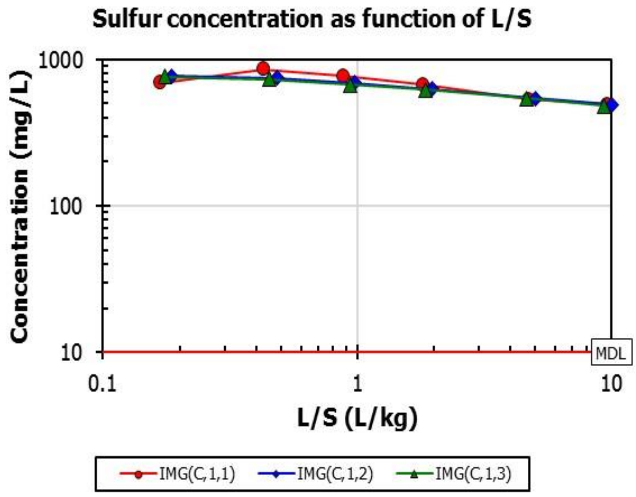

Cumulative release of Molybdenum

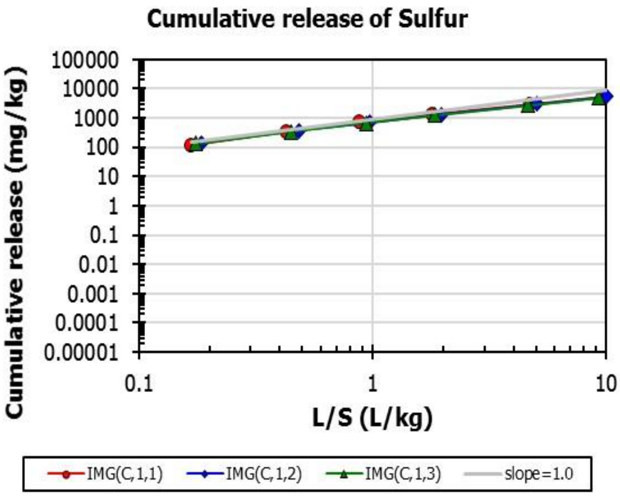

Sodium concentration as function of L/S

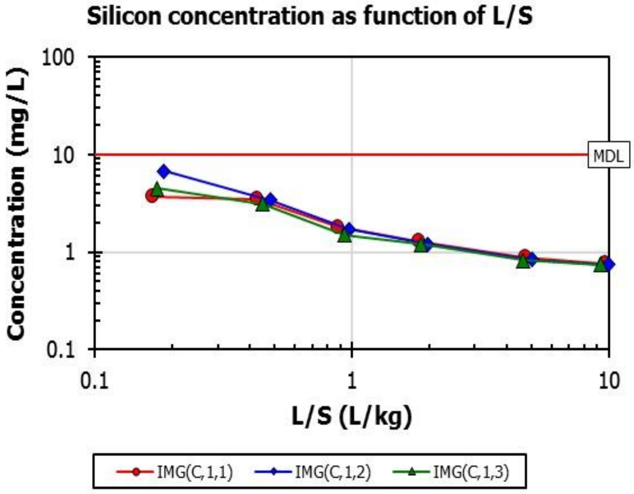

Cumulative release of Sodium

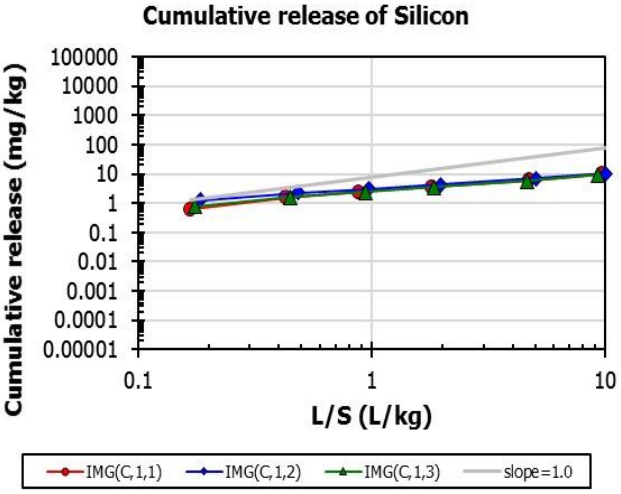

Nickel concentration as function of L/S

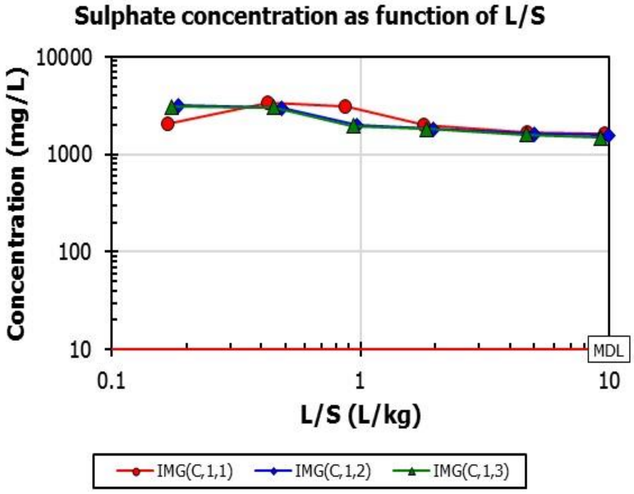

Cumulative release of Nickel

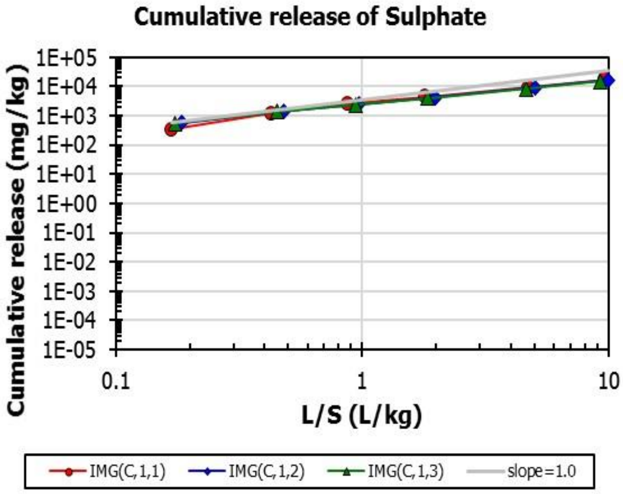

Sulfur concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)


Cumulative release of Sulfur
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

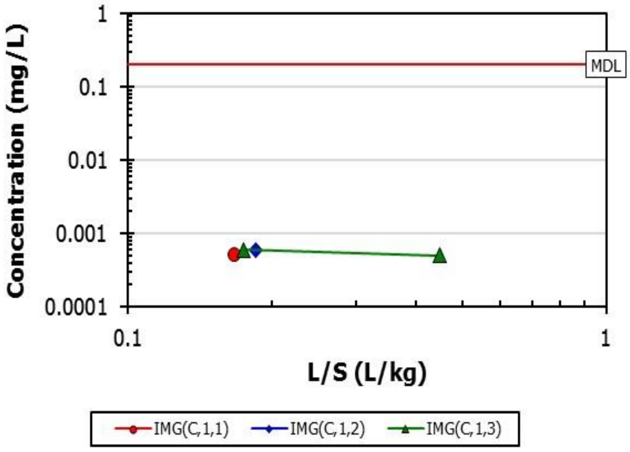

Silicon concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)


Cumulative release of Silicon
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

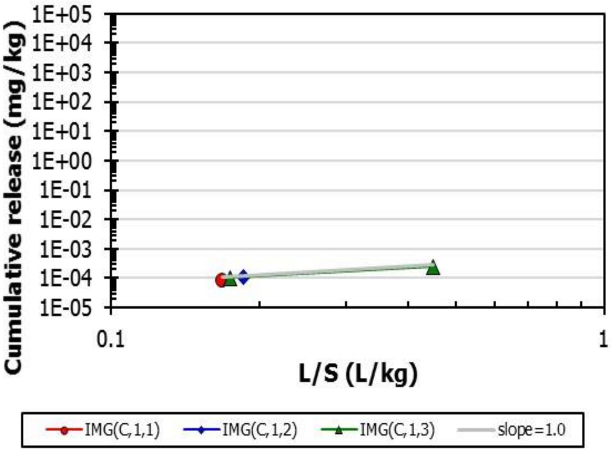

Sulphate concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
MDL
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)


Cumulative release of Sulphate
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
L/S (L/kg)
IMG(C,1,1)
IMG(C,1,2)
IMG(C,1,3)
slope=1.0

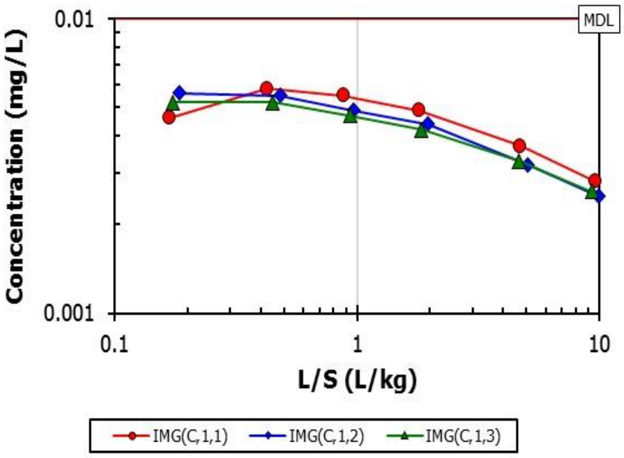
Titanium concentration as function of L/S



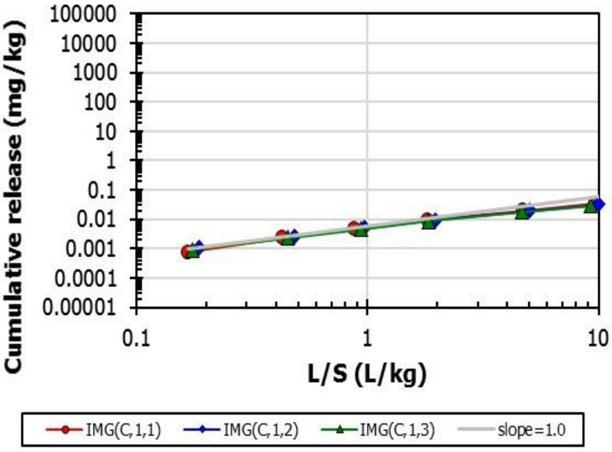
Cumulative release of Titanium



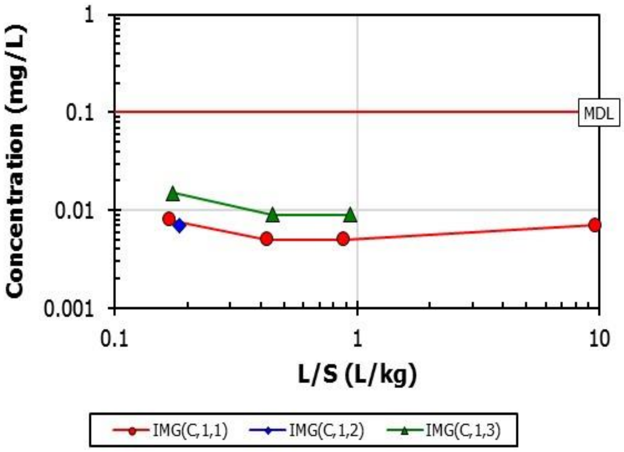
Uranium concentration as function of L/S



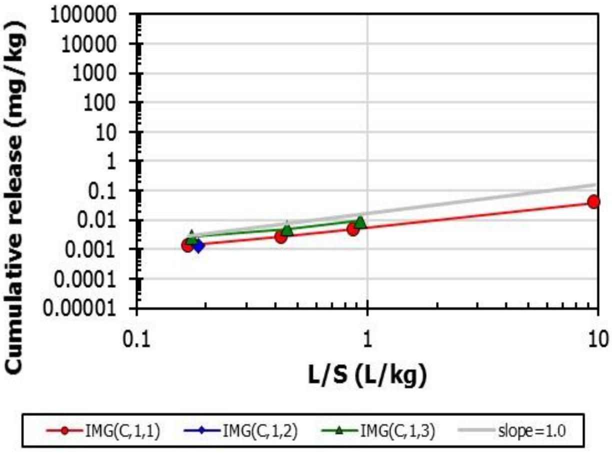
Cumulative release of Uranium



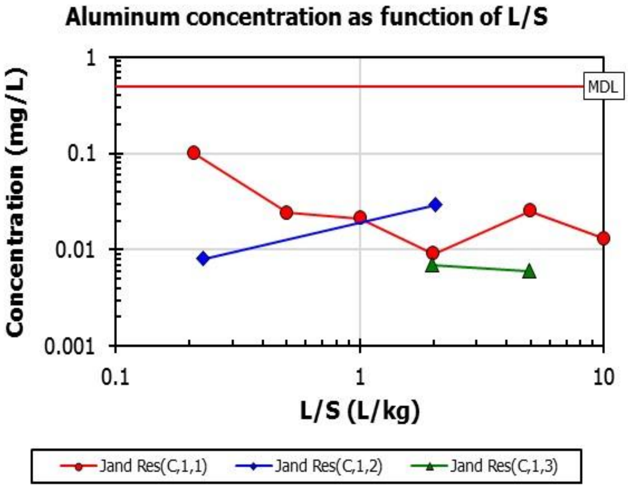
Zinc concentration as function of L/S

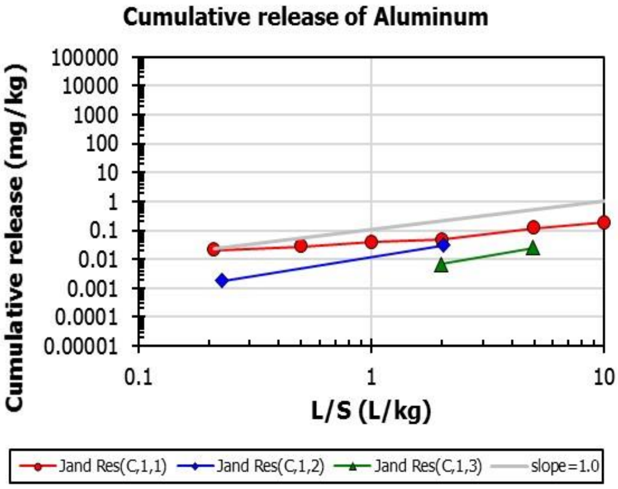


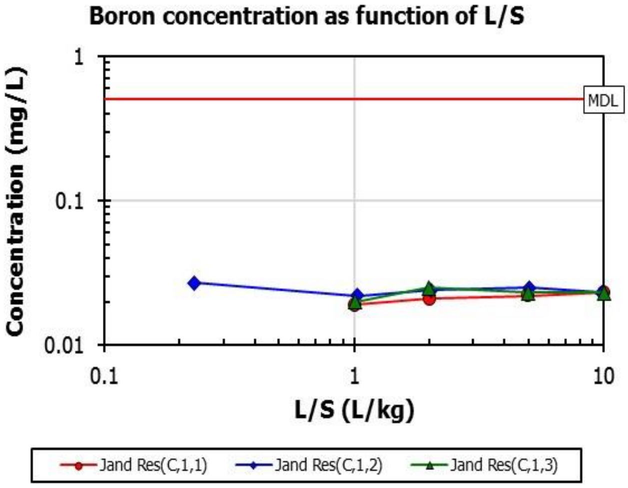
Cumulative release of Zinc

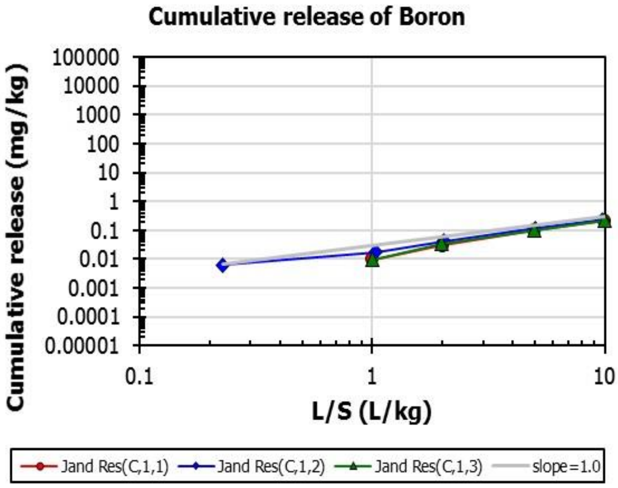


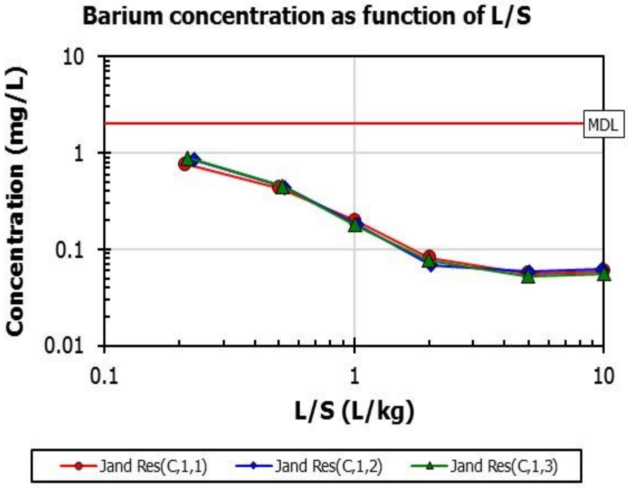
A6-4: Groundwater Residues - Jandakot

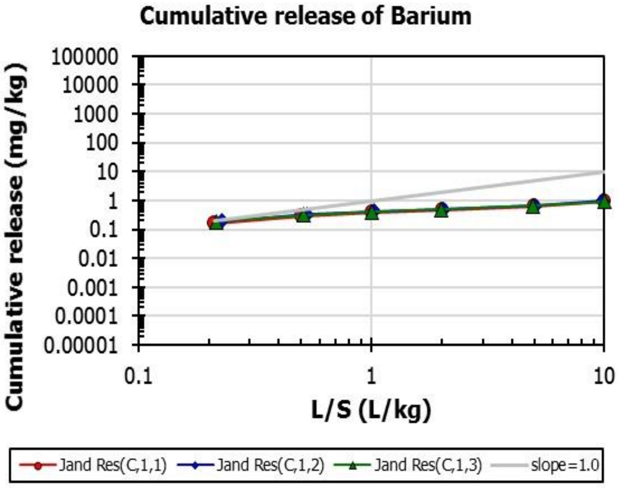


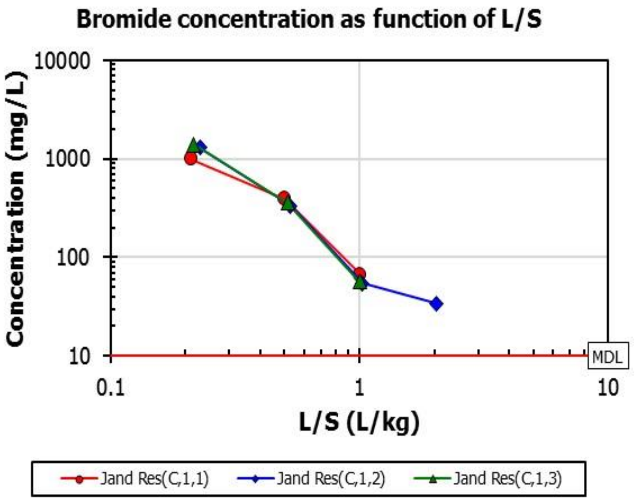


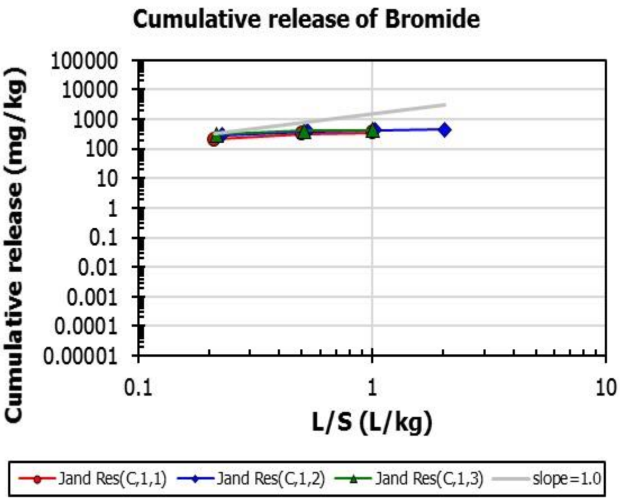


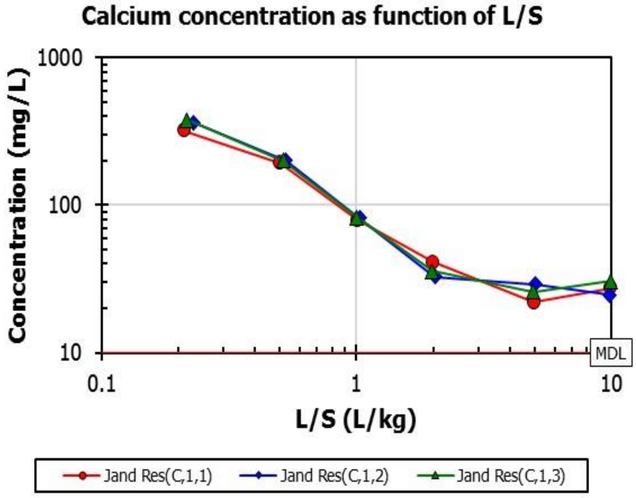


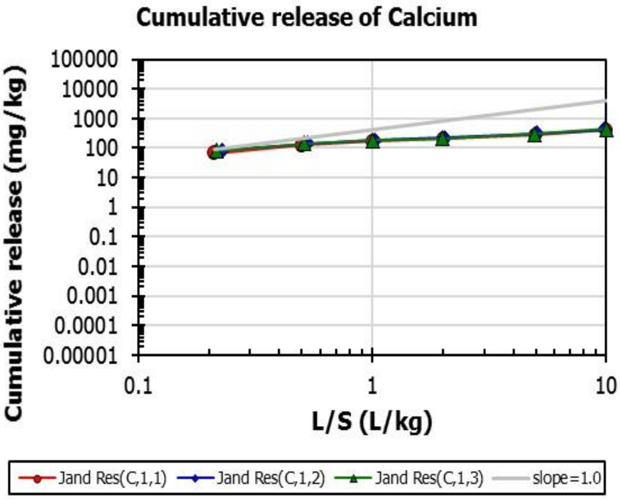


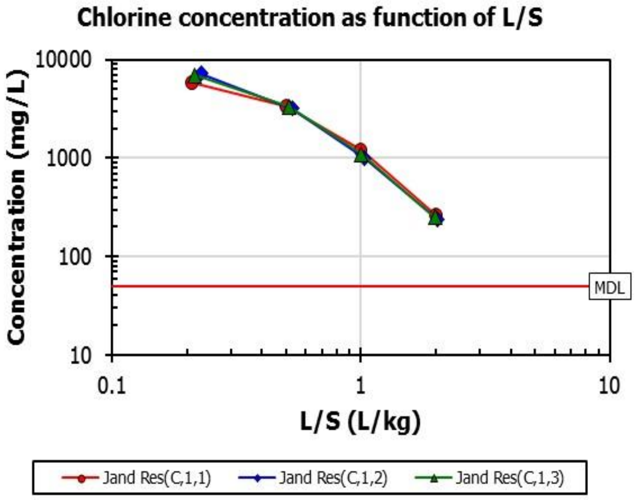


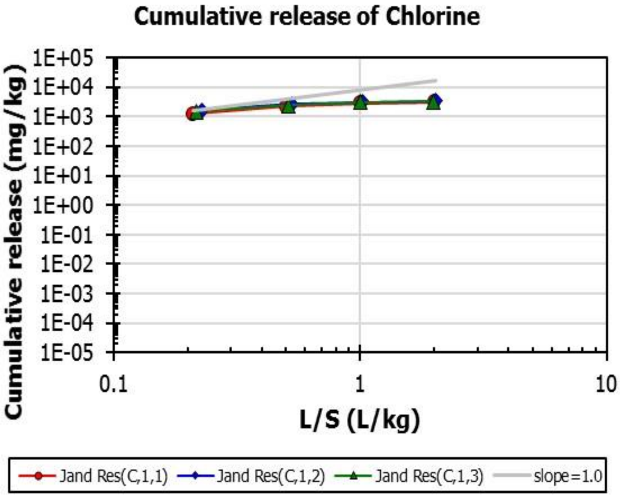

Bromide concentration as function of L/S

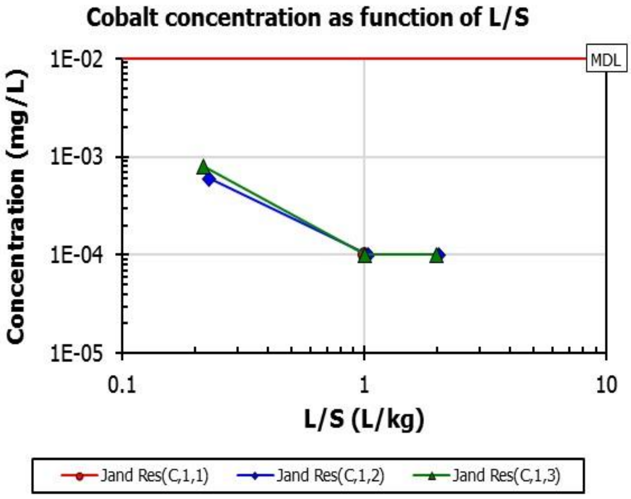

Cumulative release of Bromide

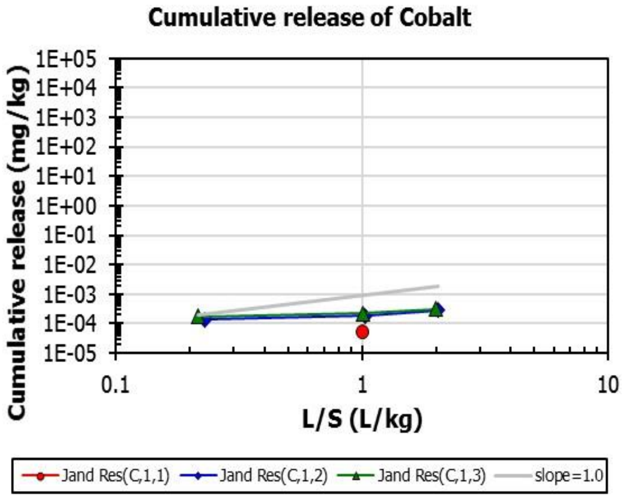

Calcium concentration as function of L/S

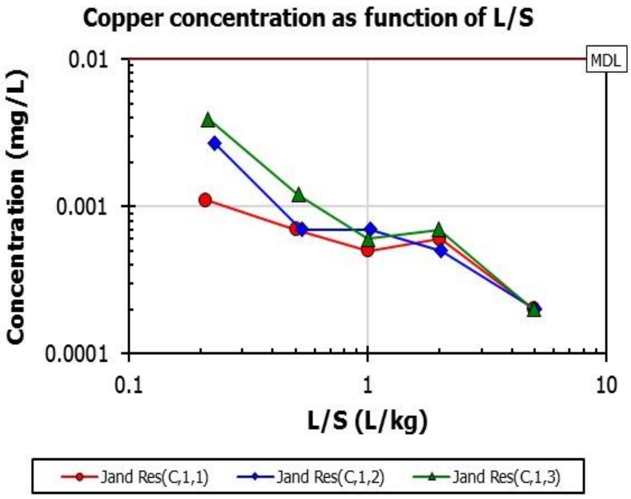

Cumulative release of Calcium

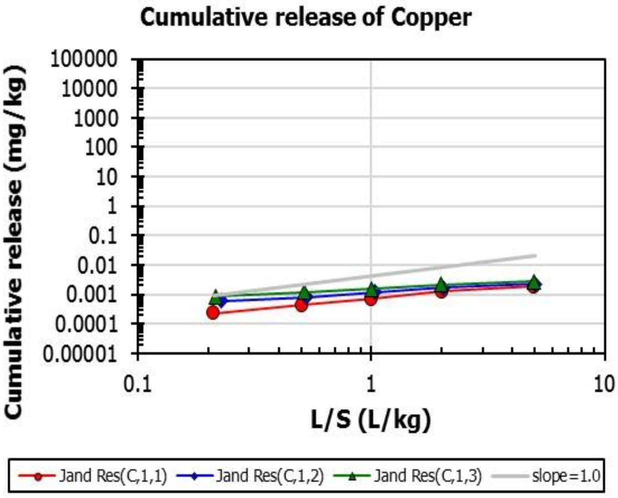

Chlorine concentration as function of L/S

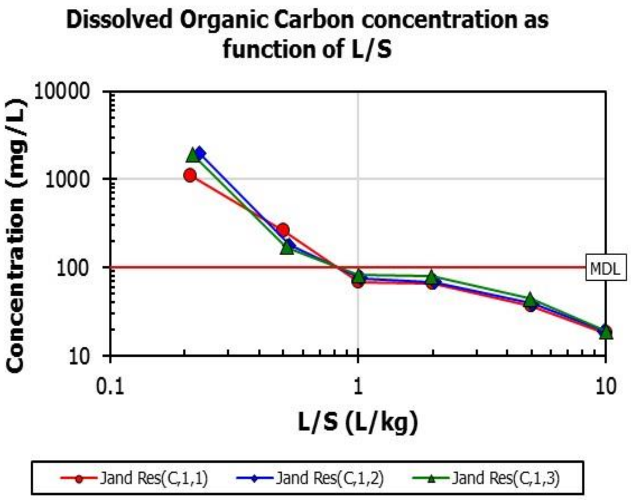

Cumulative release of Chlorine

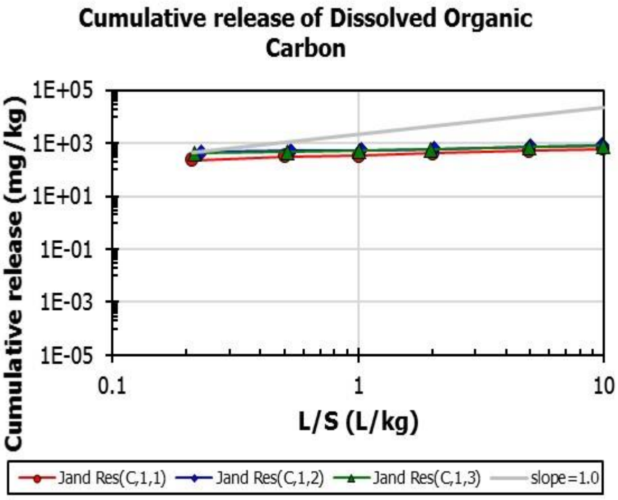

Cobalt concentration as function of L/S

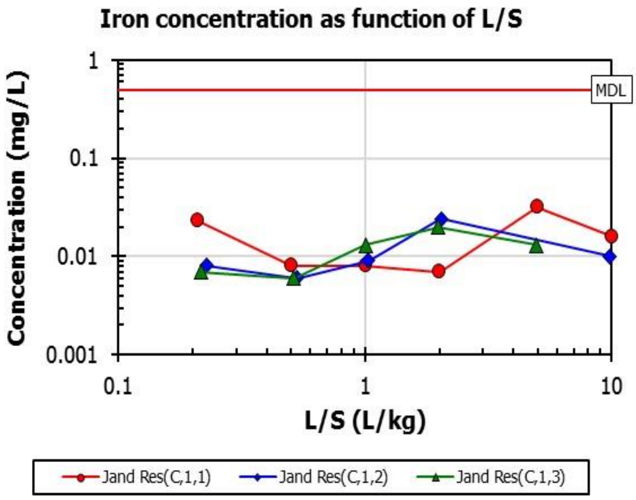

Cumulative release of Cobalt

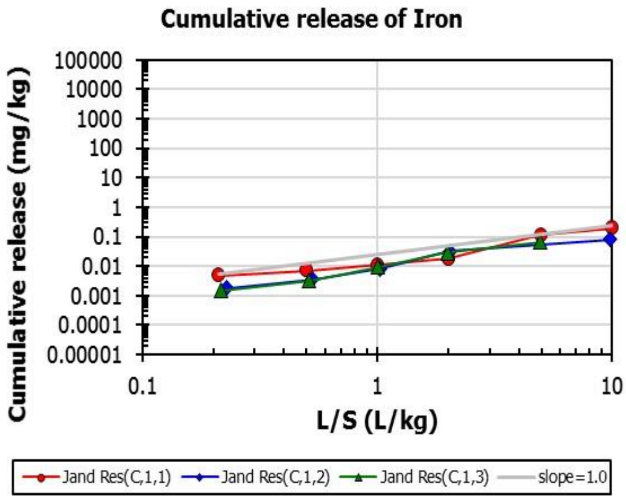

Copper concentration as function of L/S

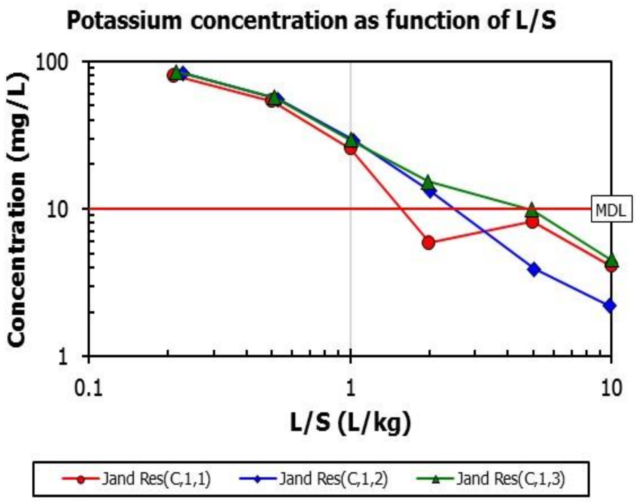

Cumulative release of Copper

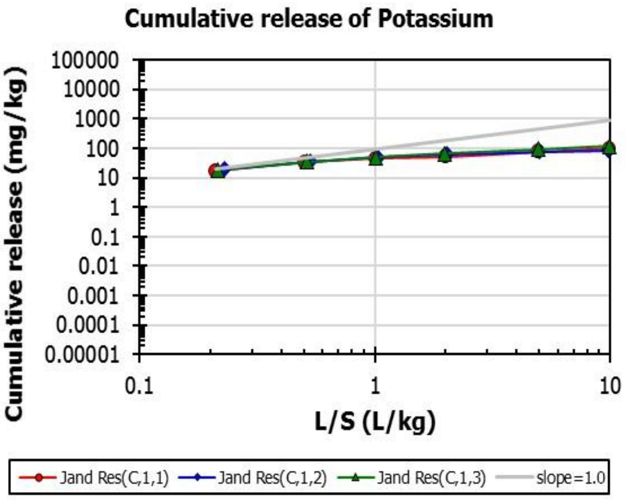

Dissolved Organic Carbon concentration as function of L/S

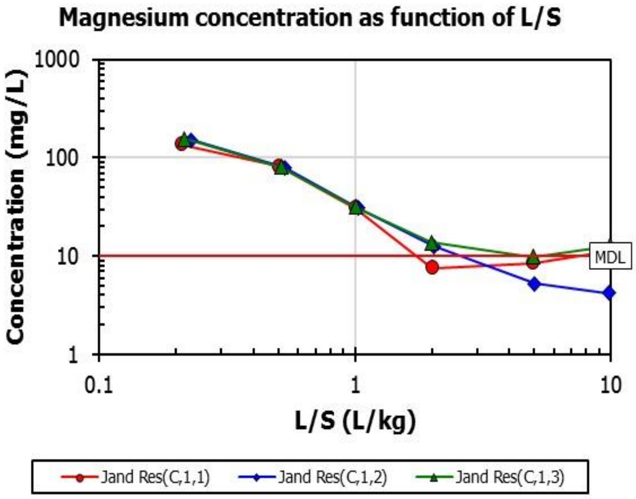

Cumulative release of Dissolved Organic Carbon

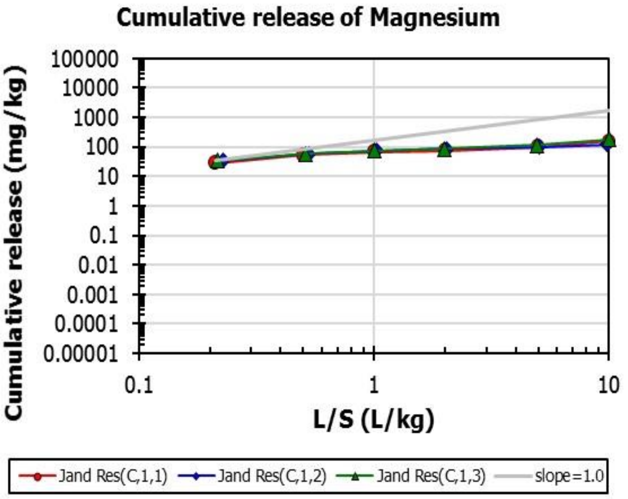

Iron concentration as function of L/S

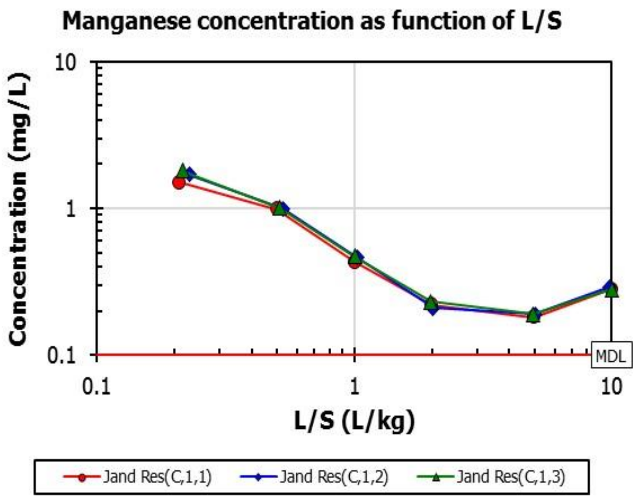

Cumulative release of Iron

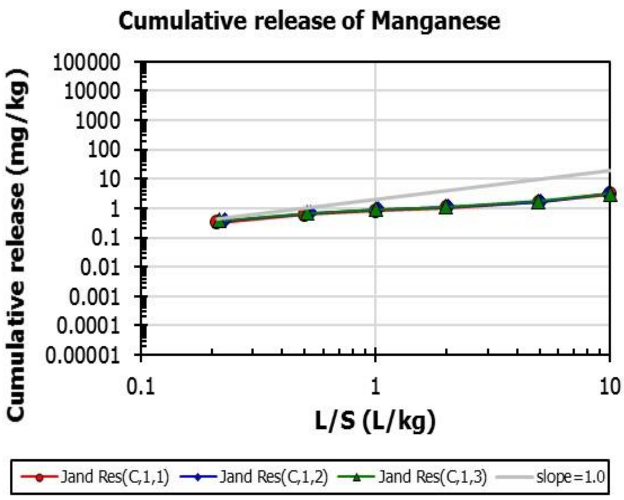

Potassium concentration as function of L/S

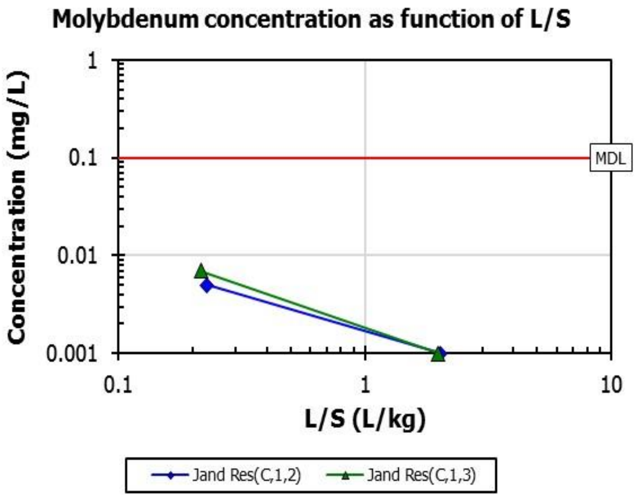

Cumulative release of Potassium

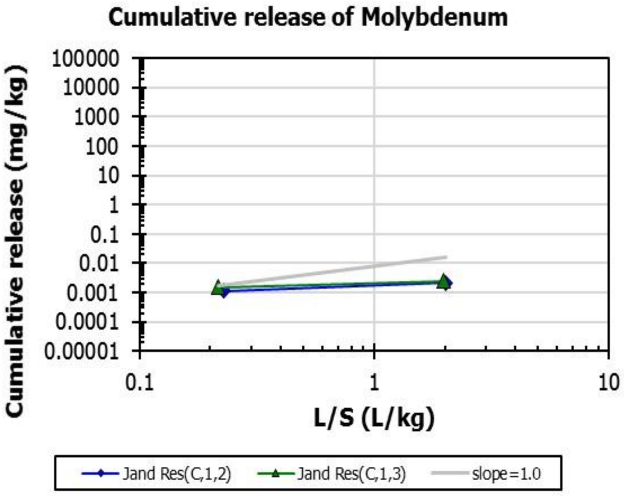

Magnesium concentration as function of L/S

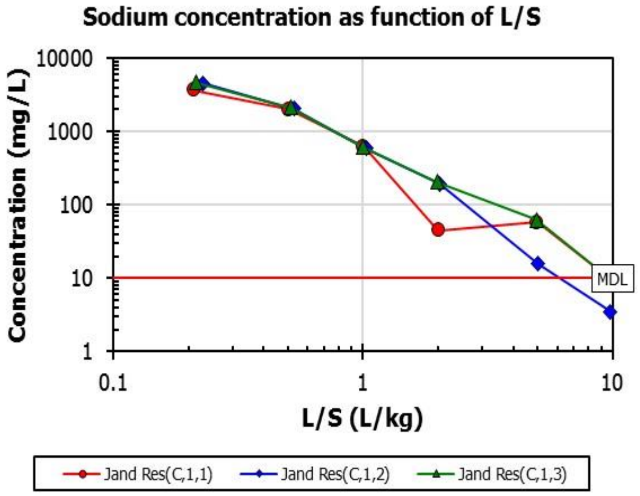

Cumulative release of Magnesium

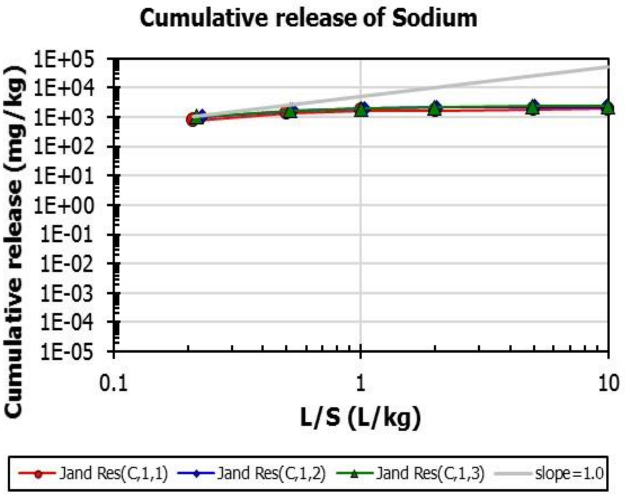

Manganese concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.1
1
10
L/S (L/kg)
MDL
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)


Cumulative release of Manganese
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)
slope=1.0

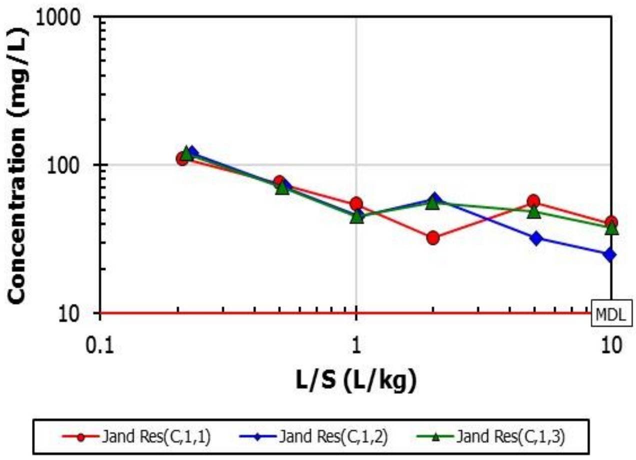

Molybdenum concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
0.1
1
10
L/S (L/kg)
MDL
Jand Res(C,1,2)
Jand Res(C,1,3)


Cumulative release of Molybdenum
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Jand Res(C,1,2)
Jand Res(C,1,3)
slope=1.0

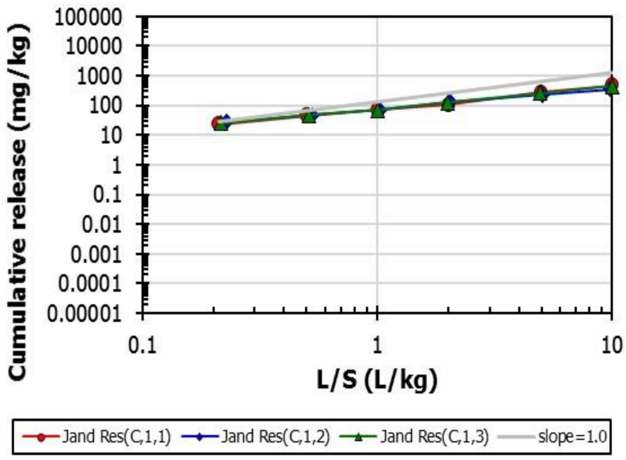

Sodium concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
1
0.1
1
10
L/S (L/kg)
MDL
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)


Cumulative release of Sodium
Cumulative release (mg/kg)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)
slope=1.0

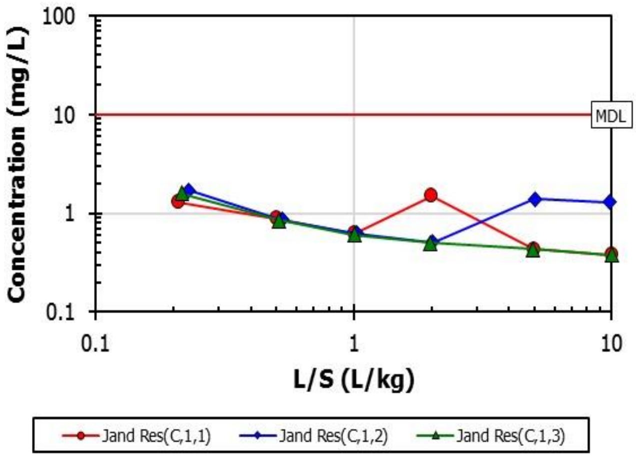
Sulfur concentration as function of L/S



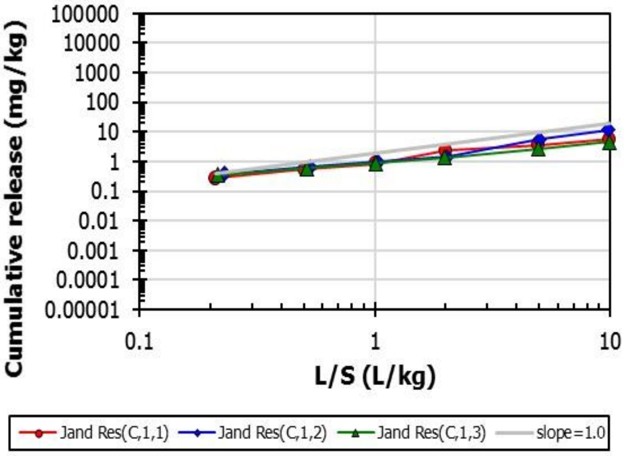
Cumulative release of Sulfur



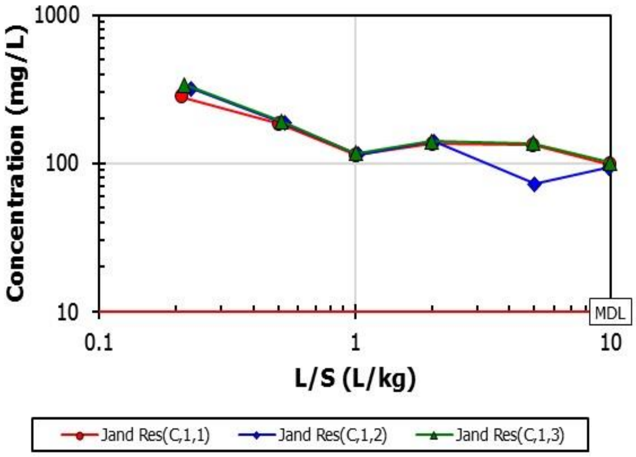
Silicon concentration as function of L/S



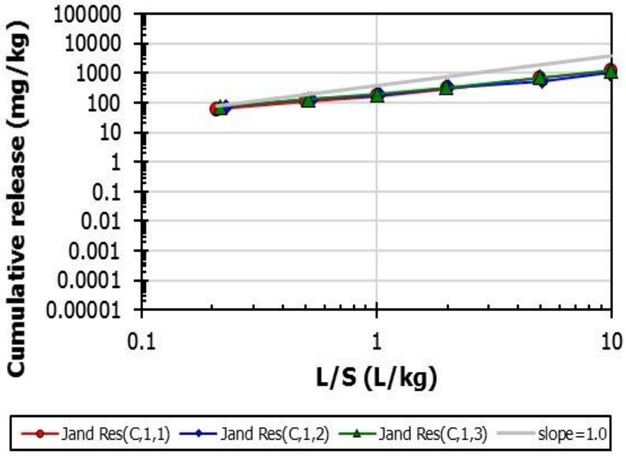
Cumulative release of Silicon

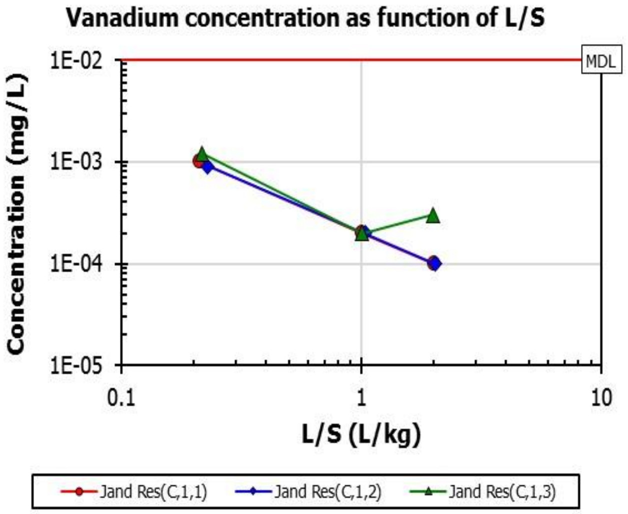


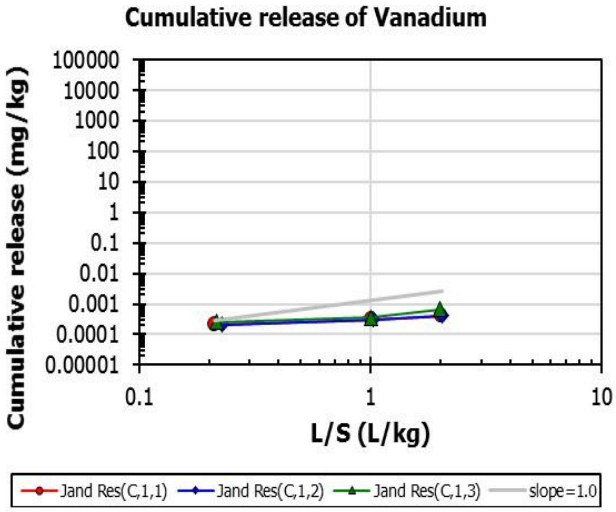
Sulphate concentration as function of L/S

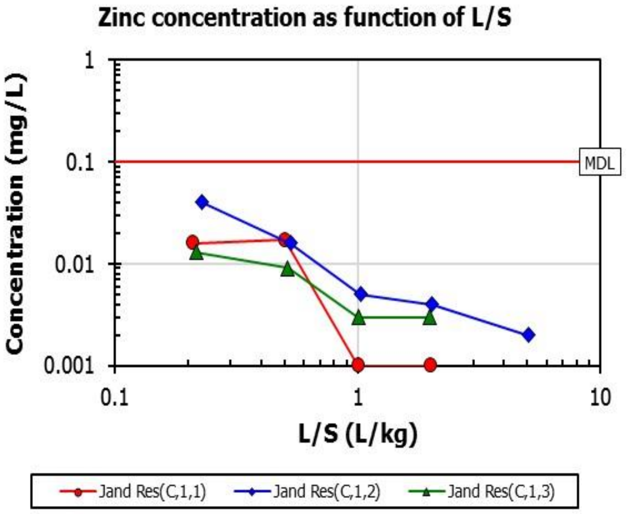


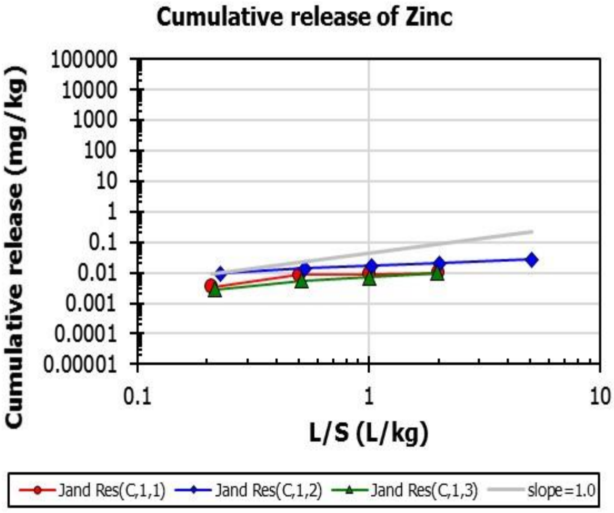
Cumulative release of Sulphate



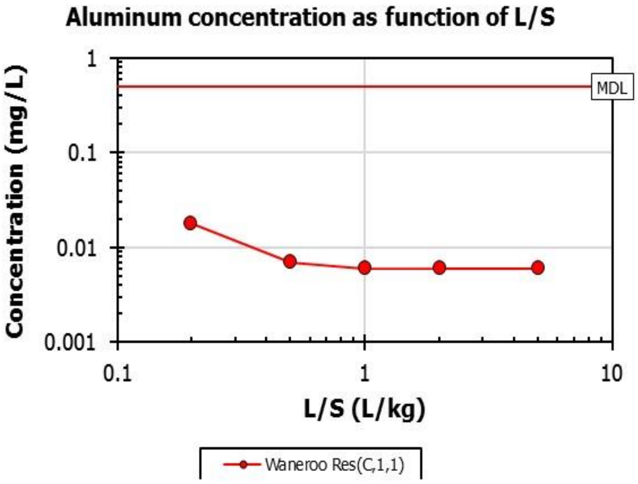

Vanadium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)

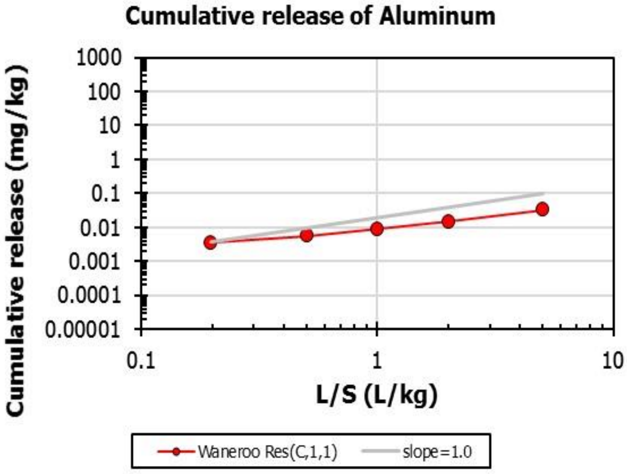

Cumulative release of Vanadium
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)
slope=1.0

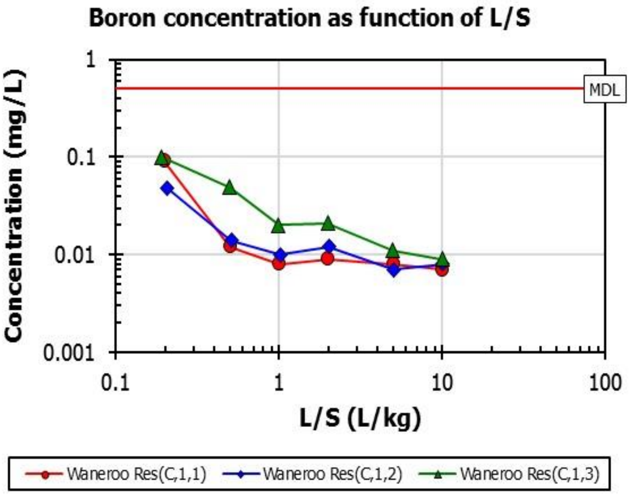

Zinc concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)

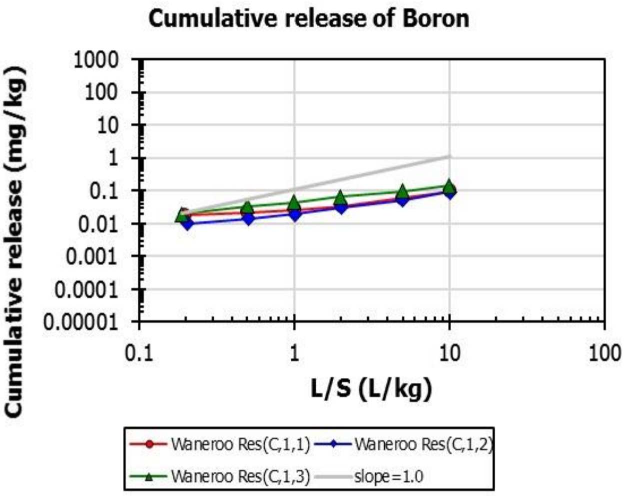

Cumulative release of Zinc
Cumulative release (mg/kg)
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Jand Res(C,1,1)
Jand Res(C,1,2)
Jand Res(C,1,3)
slope=1.0

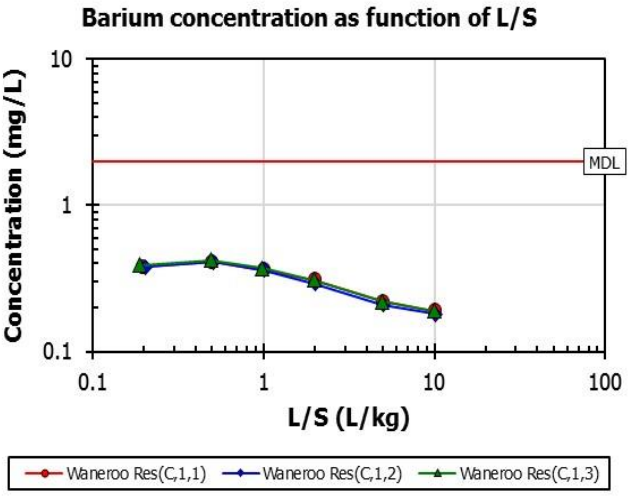
A6-5: Groundwater Residues - Wanneroo

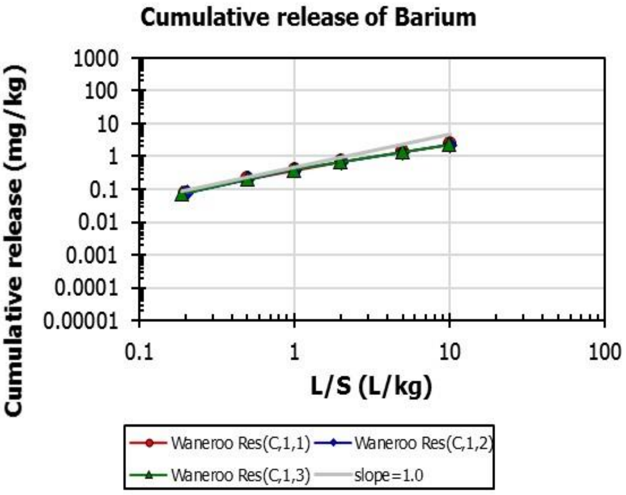


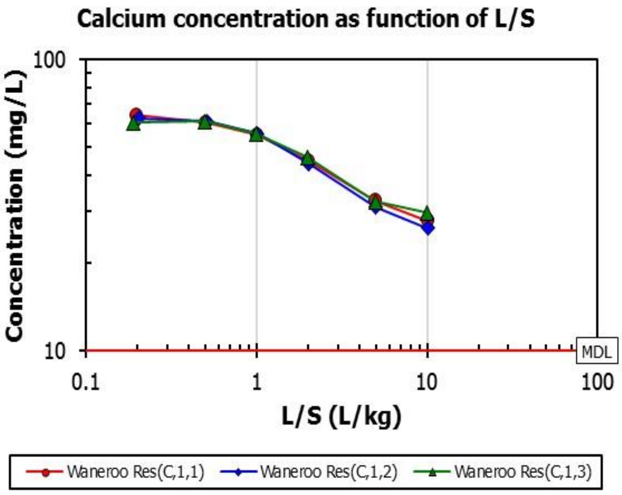


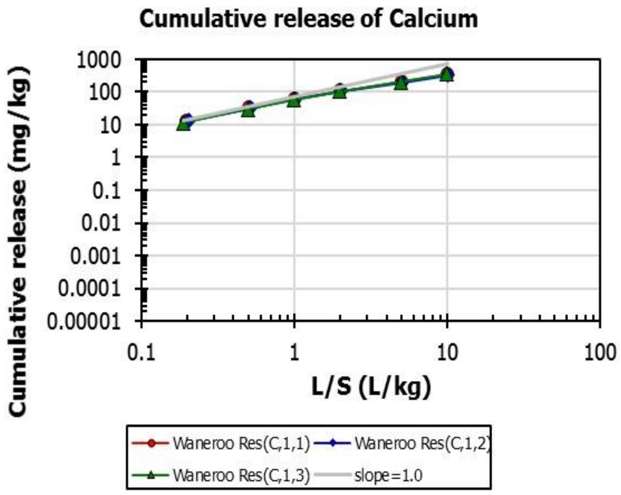


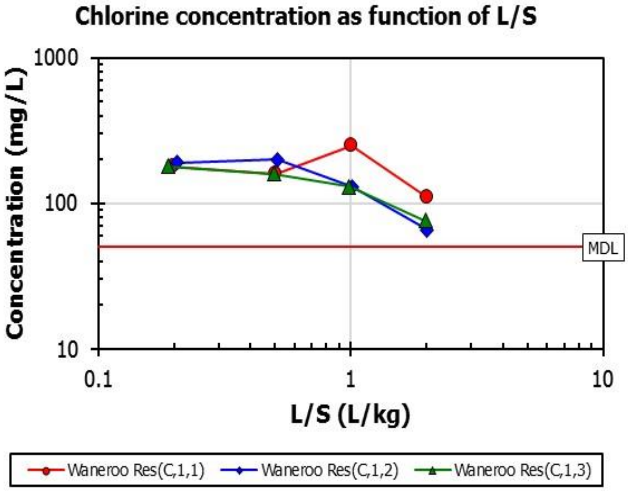


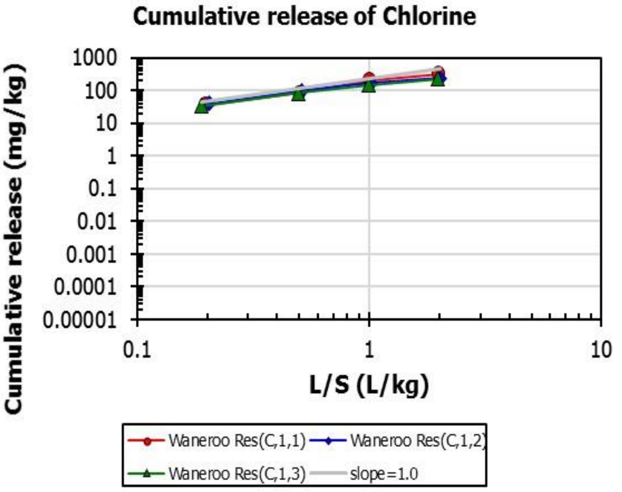


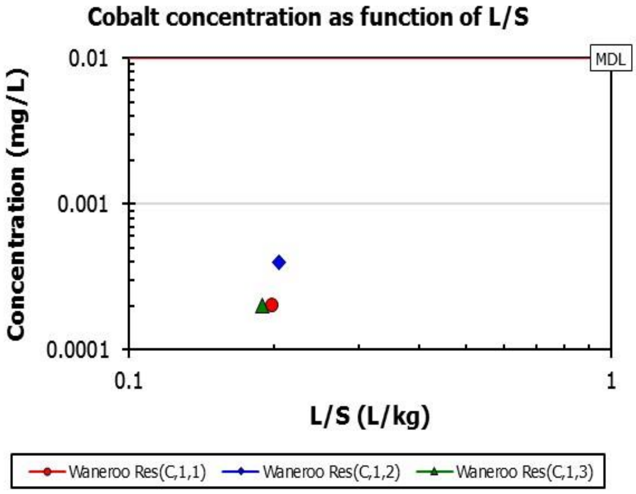


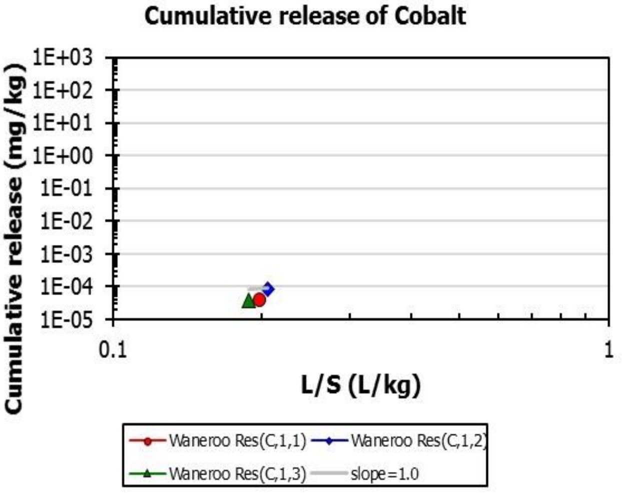

Calcium concentration as function of L/S
Concentration (mg/L)
100
10
MDL
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

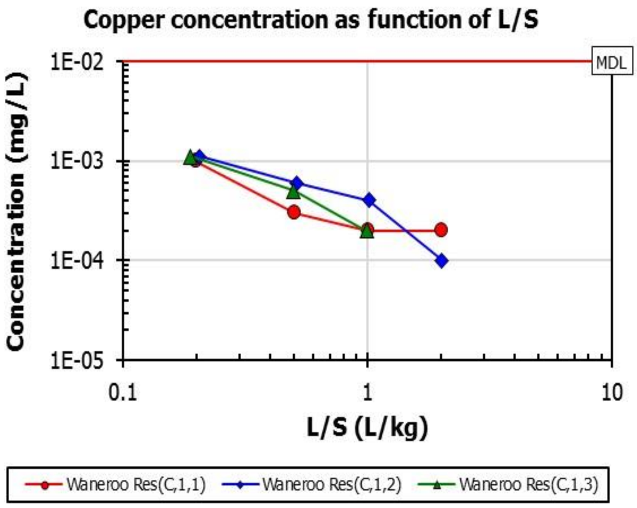

Cumulative release of Calcium
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

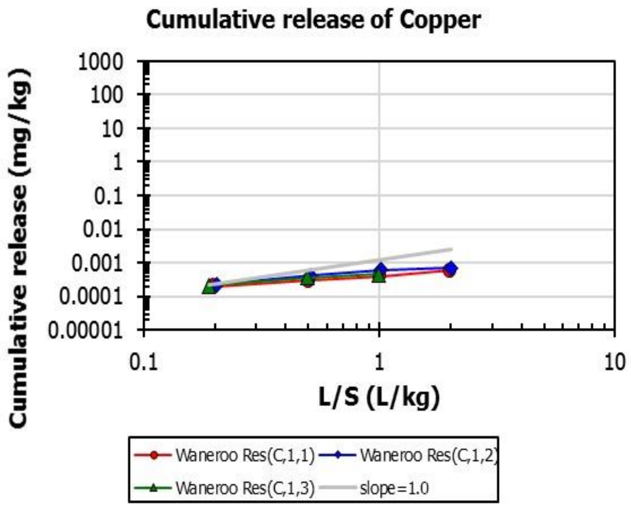

Chlorine concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

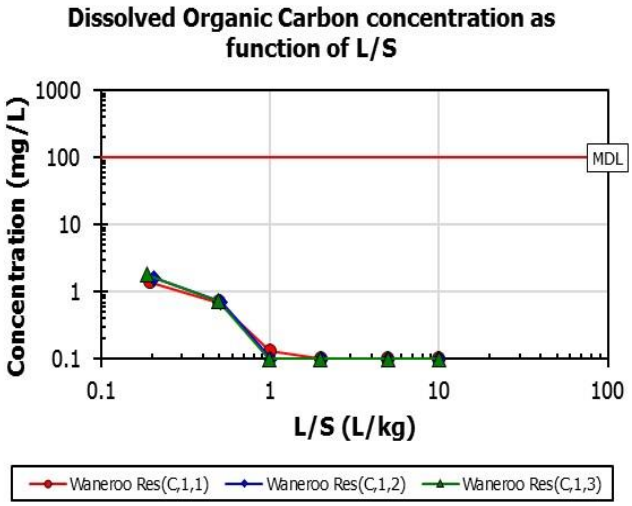

Cumulative release of Chlorine
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

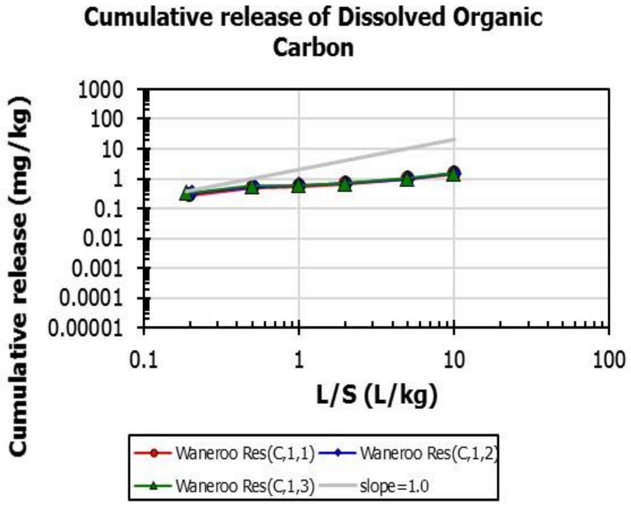

Cobalt concentration as function of L/S
Concentration (mg/L)
0.01
0.001
0.0001
MDL
0.1
1
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

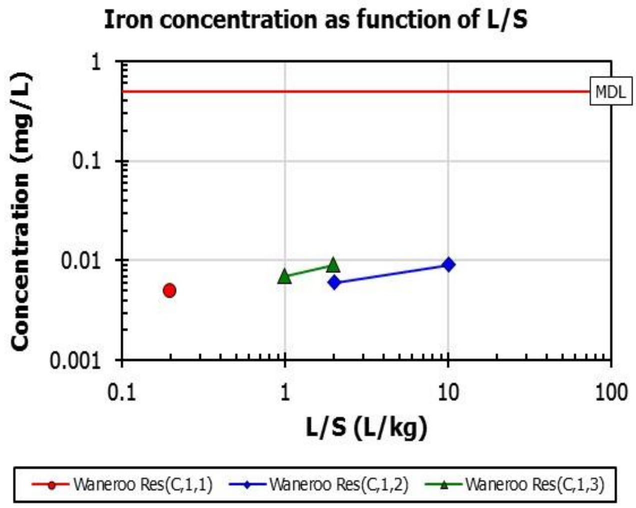

Cumulative release of Cobalt
Cumulative release (mg/kg)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

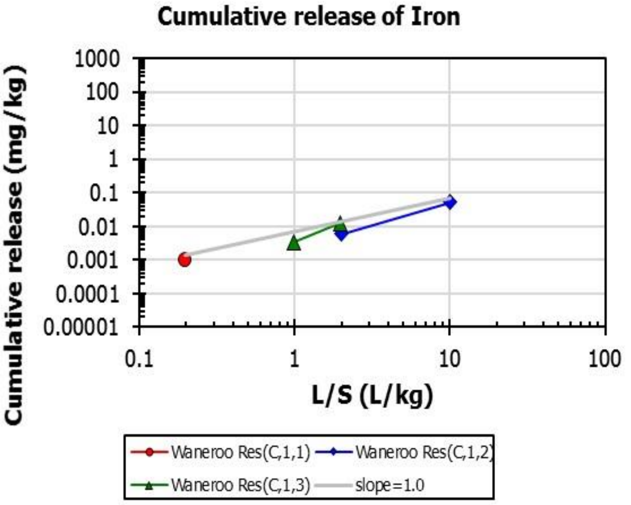

Copper concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)


Cumulative release of Copper
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

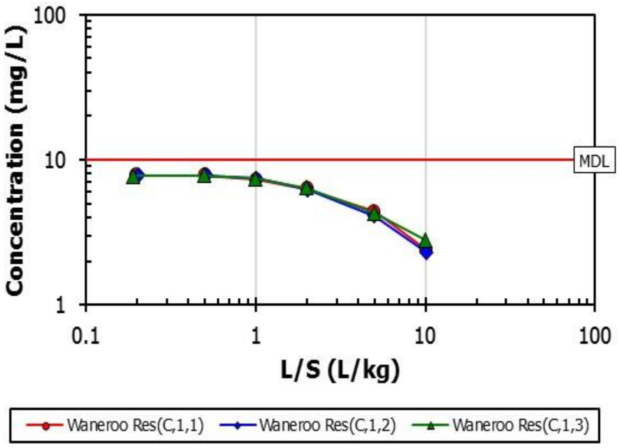

Dissolved Organic Carbon concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
0.1
MDL
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)


Cumulative release of Dissolved Organic Carbon
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

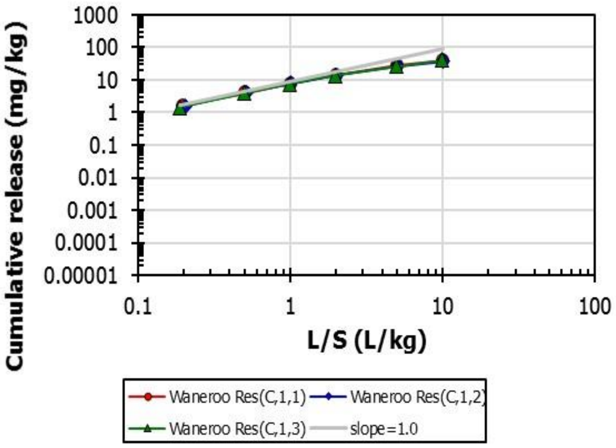

Iron concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)


Cumulative release of Iron
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

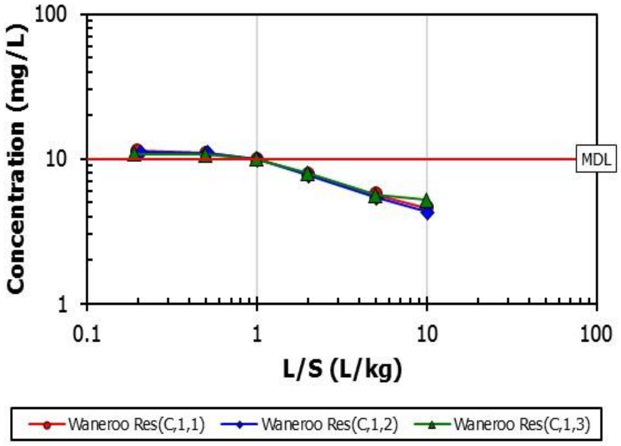
Potassium concentration as function of L/S



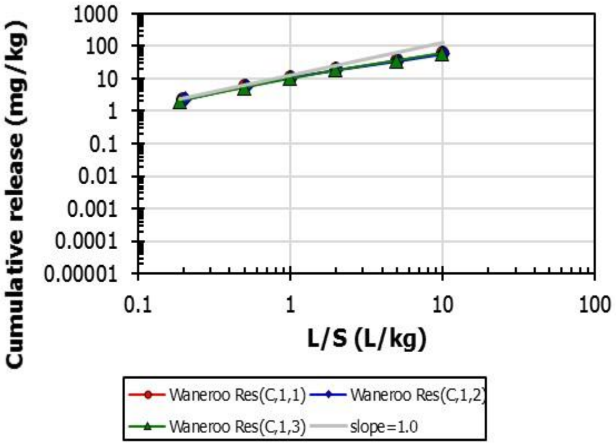
Cumulative release of Potassium



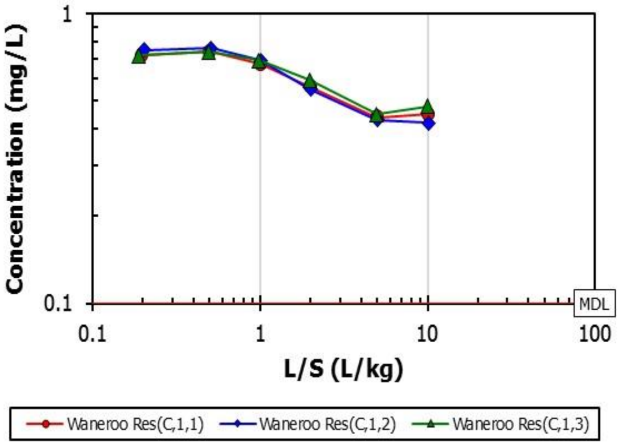
Magnesium concentration as function of L/S



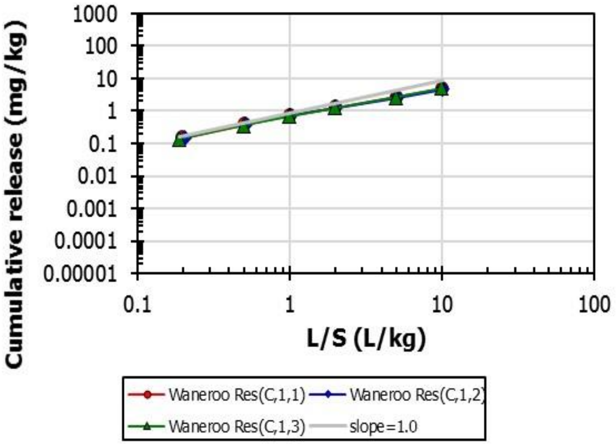
Cumulative release of Magnesium

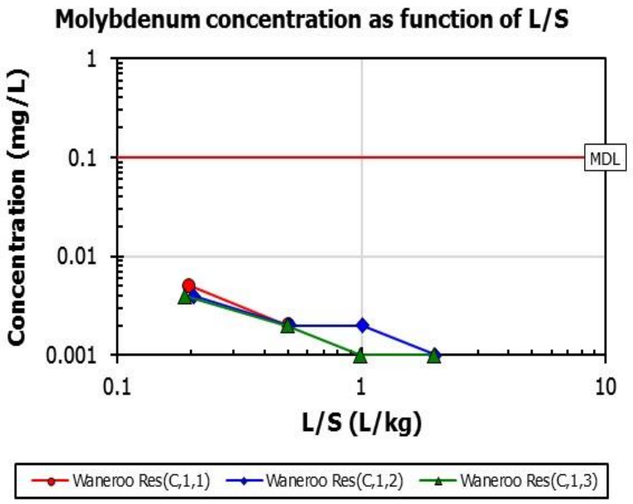


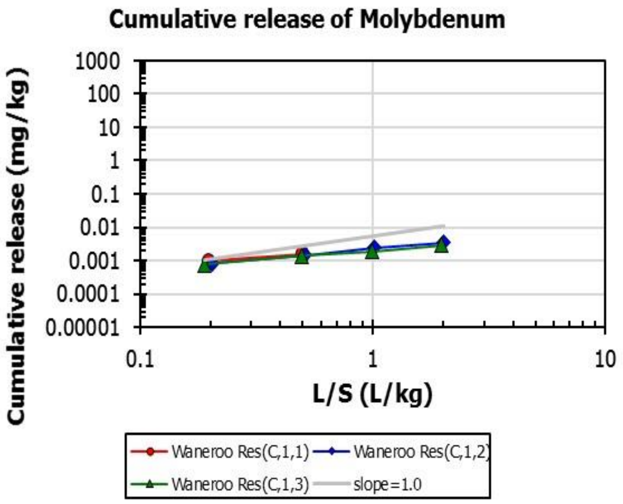
Manganese concentration as function of L/S

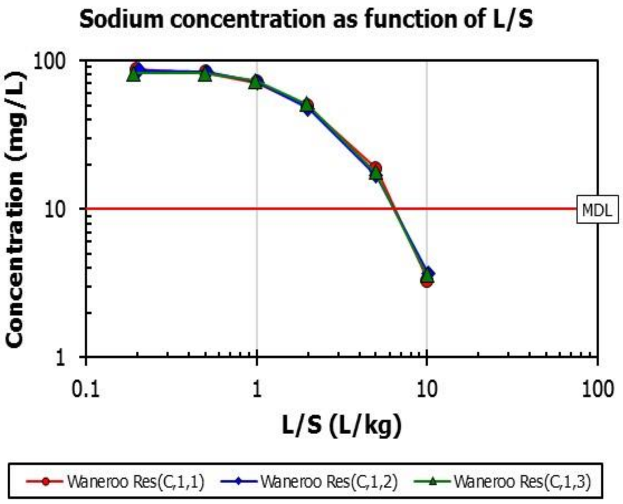


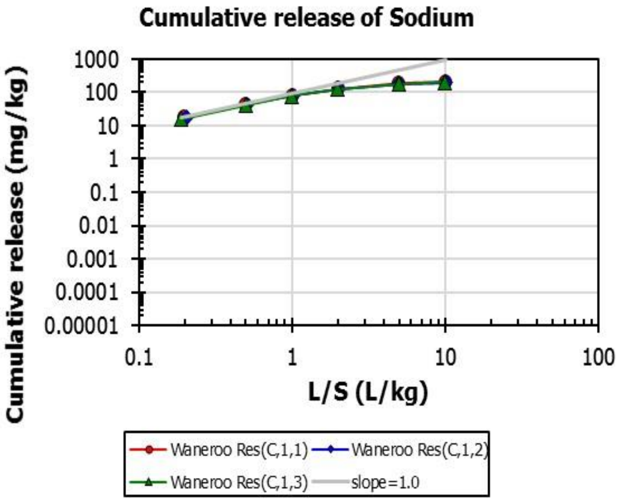
Cumulative release of Manganese

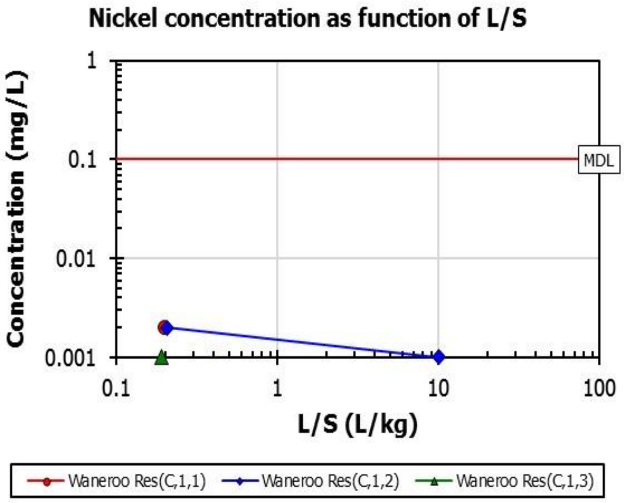


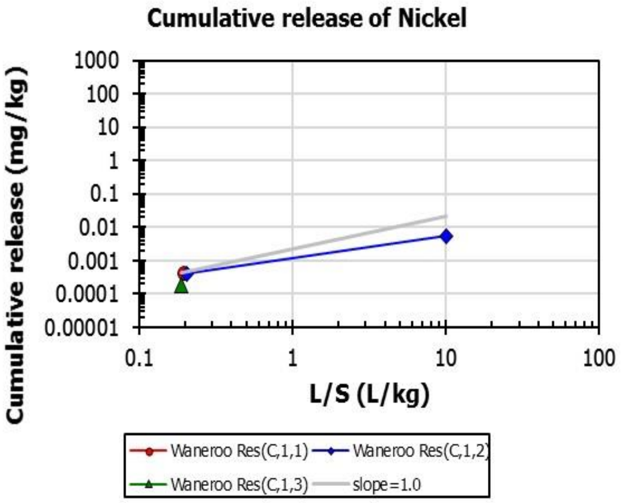

Molybdenum concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

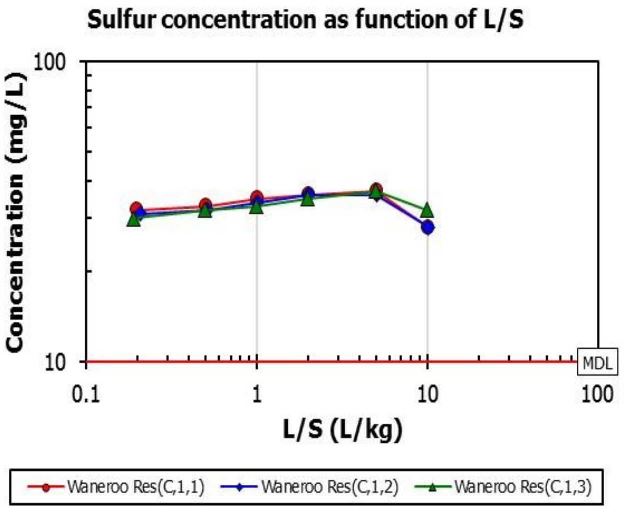

Cumulative release of Molybdenum
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

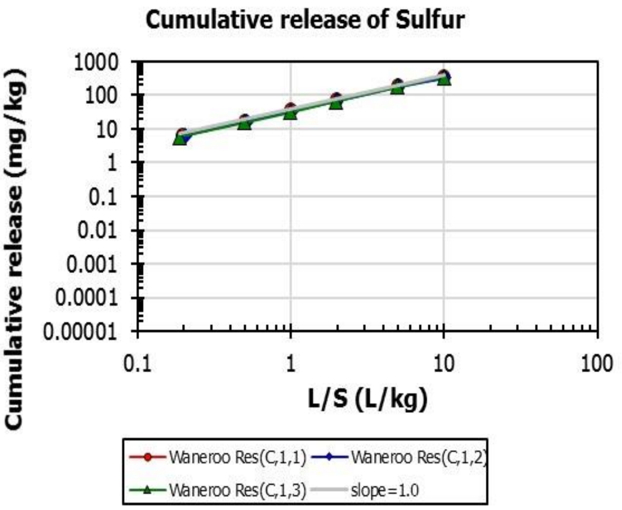

Sodium concentration as function of L/S
Concentration (mg/L)
100
10
1
MDL
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

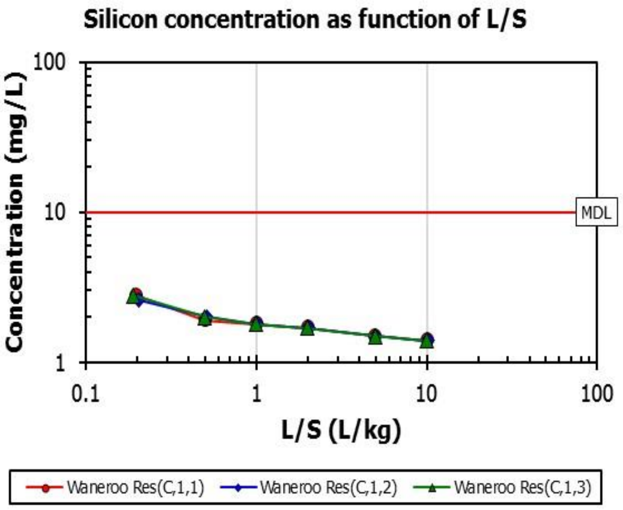

Cumulative release of Sodium
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

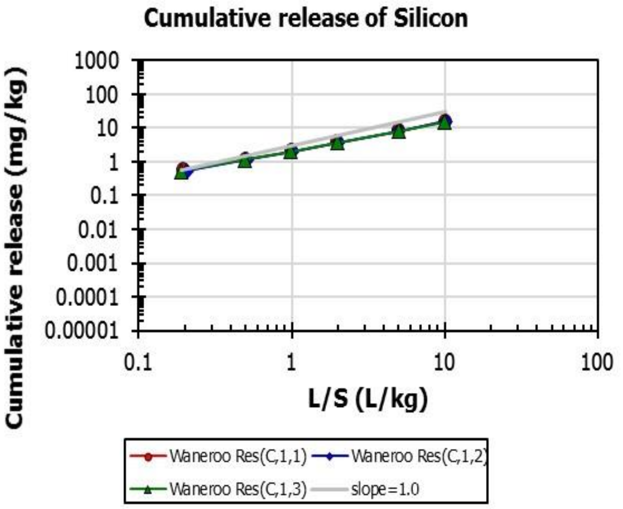

Nickel concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)

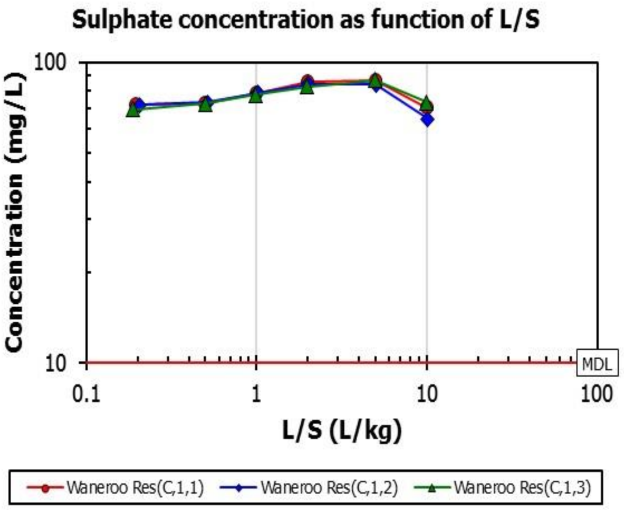

Cumulative release of Nickel
Cumulative release (mg/kg)
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
L/S (L/kg)
Waneroo Res(C,1,1)
Waneroo Res(C,1,2)
Waneroo Res(C,1,3)
slope=1.0

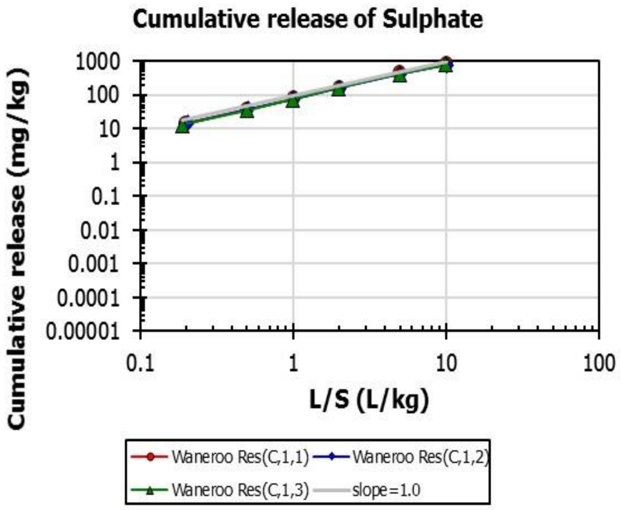

Sulfur concentration as function of L/S

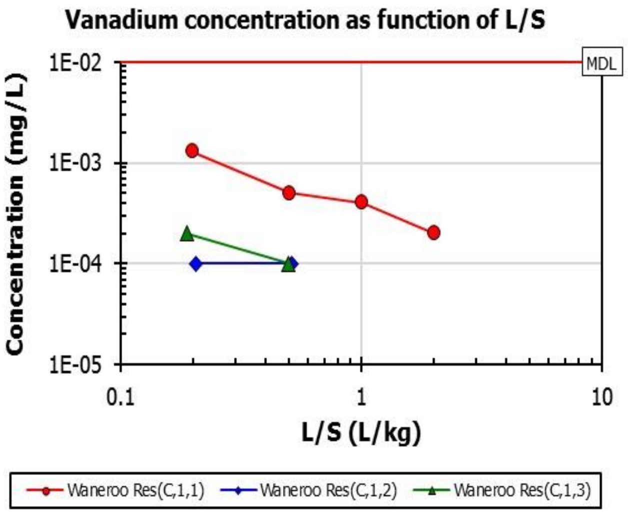

Cumulative release of Sulfur

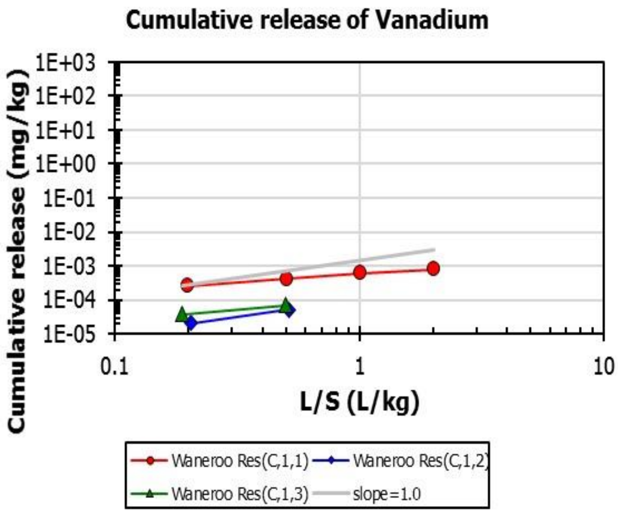

Silicon concentration as function of L/S

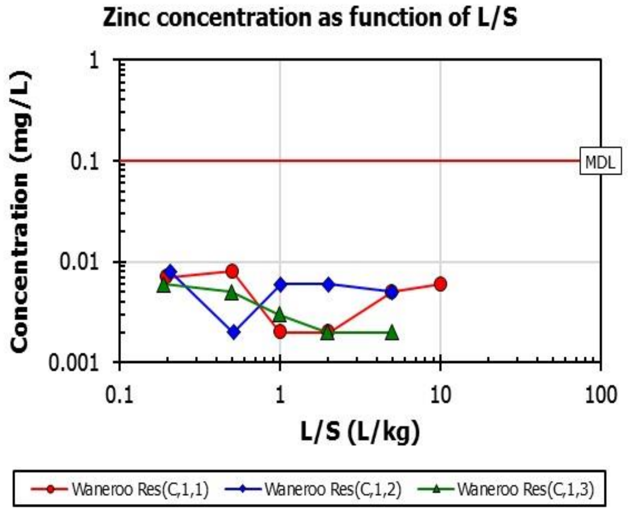

Cumulative release of Silicon

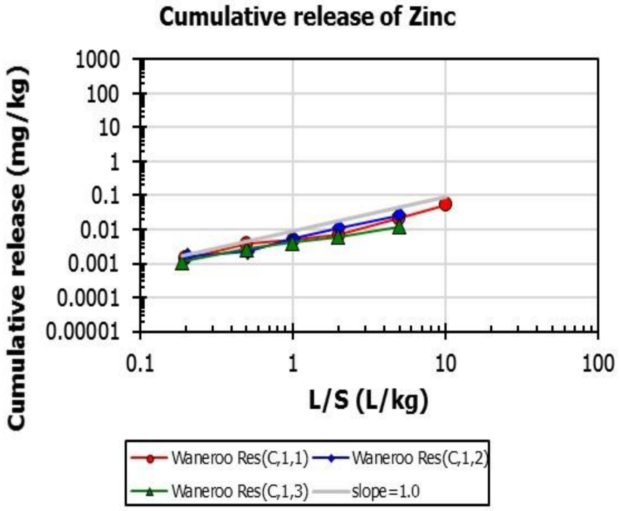

Sulphate concentration as function of L/S


Cumulative release of Sulphate

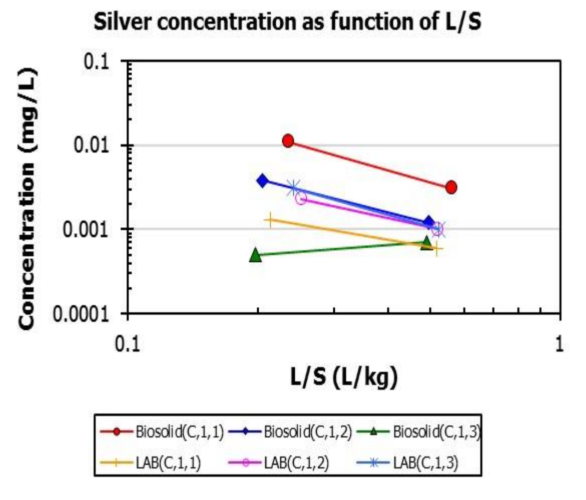

Vanadium concentration as function of L/S

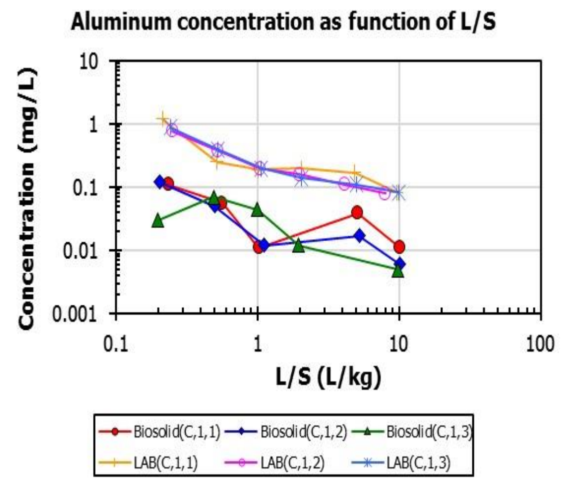

Cumulative release of Vanadium

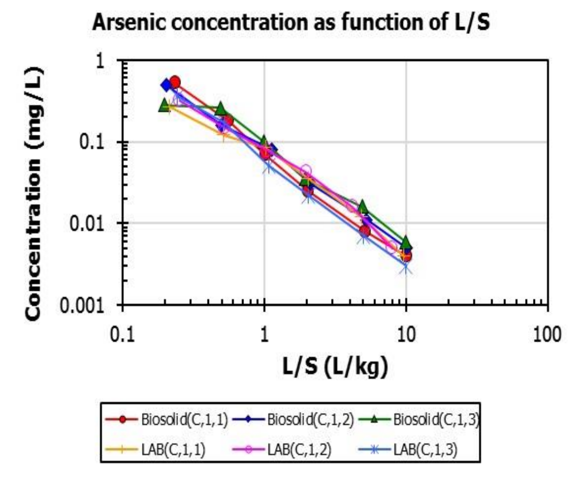

Zinc concentration as function of L/S

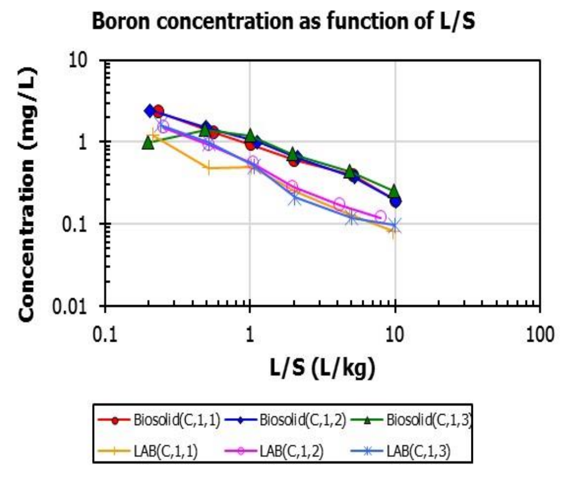

Cumulative release of Zinc

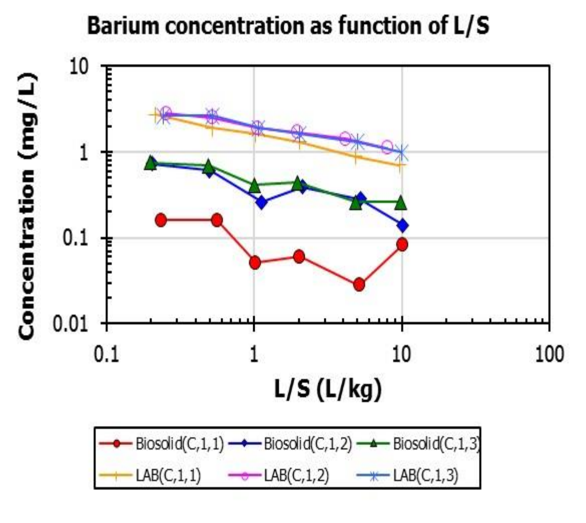
A6-6: Biosolids Cake and Lime Amended Biosolid (LAB)

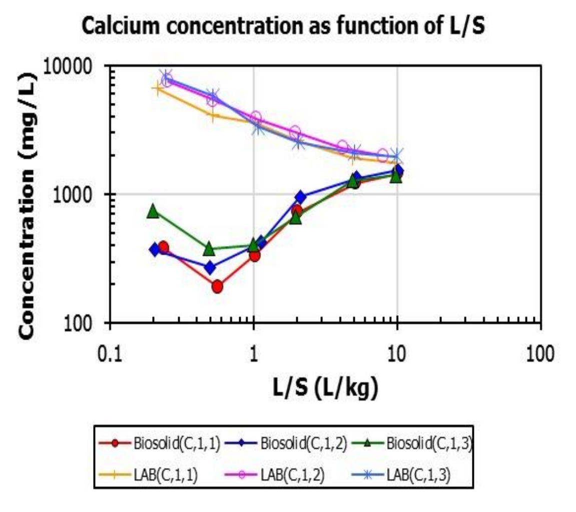


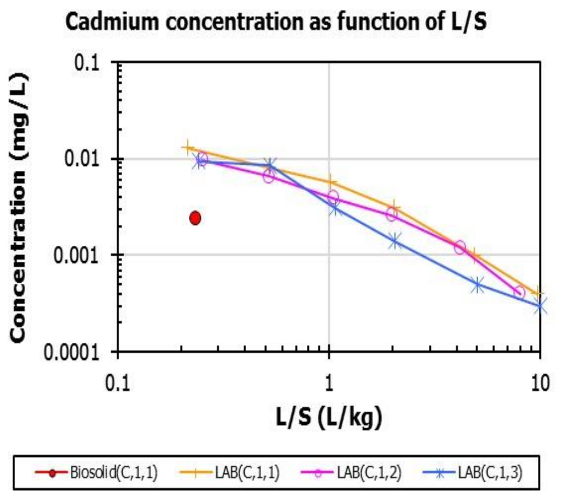


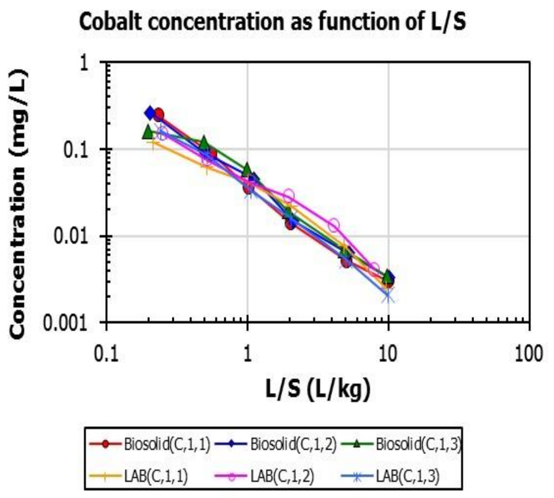


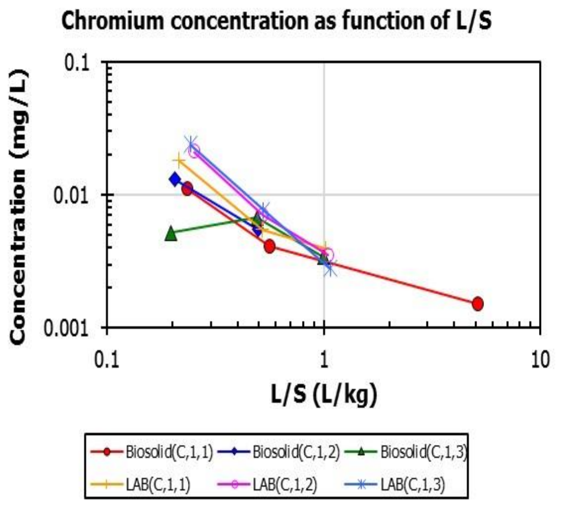


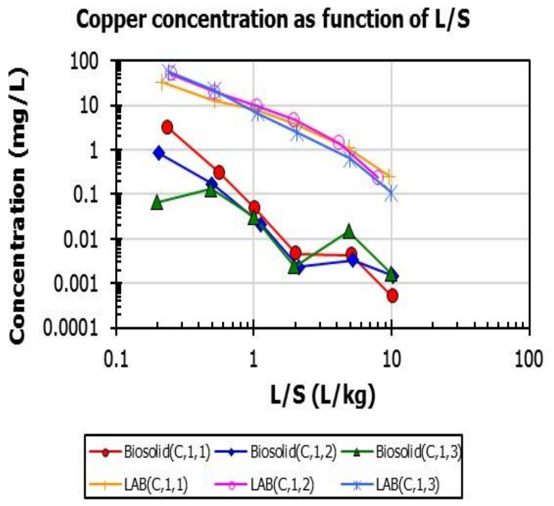


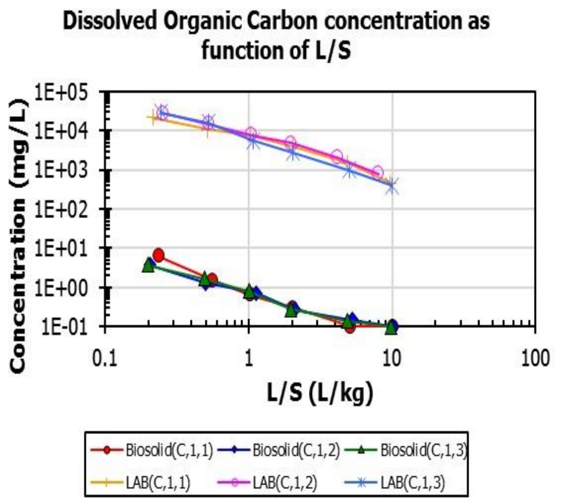


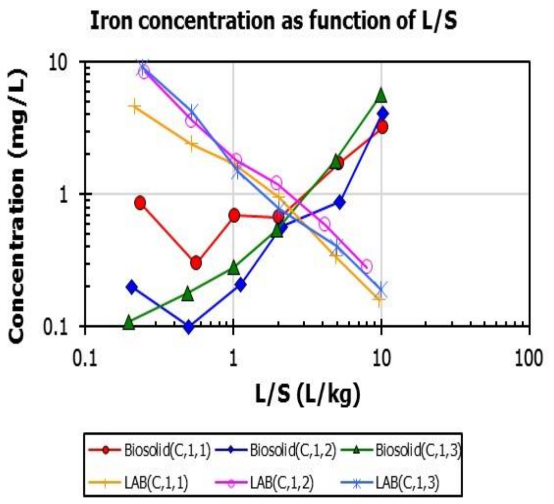

Cadmium concentration as function of L/S

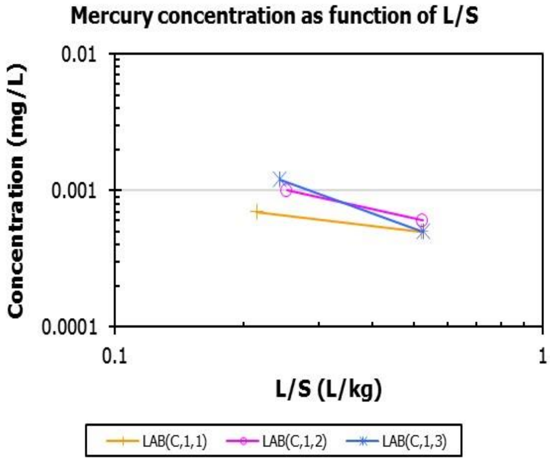

Cobalt concentration as function of L/S

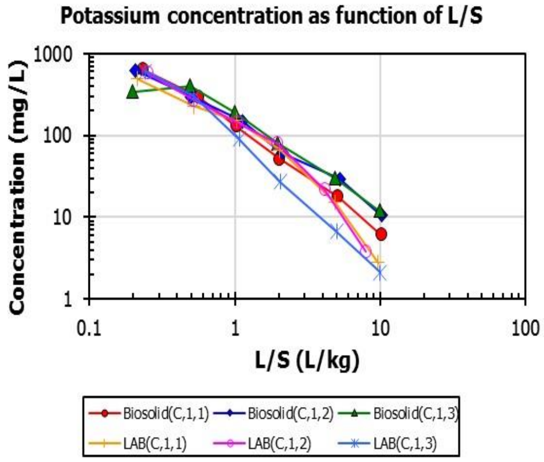

Chromium concentration as function of L/S

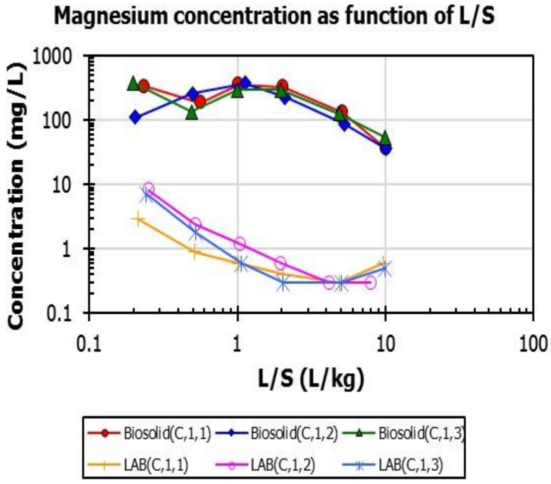

Copper concentration as function of L/S

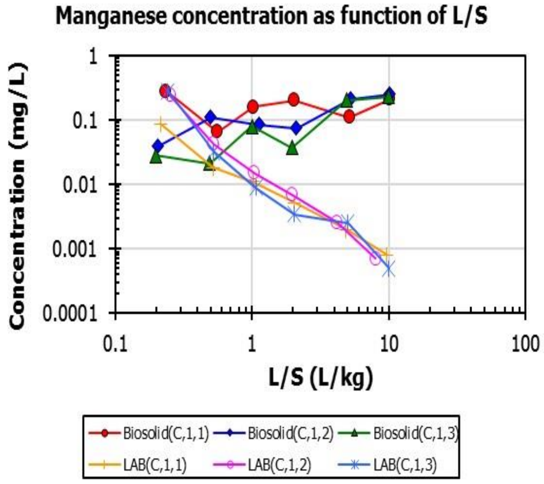

Dissolved Organic Carbon concentration as function of L/S

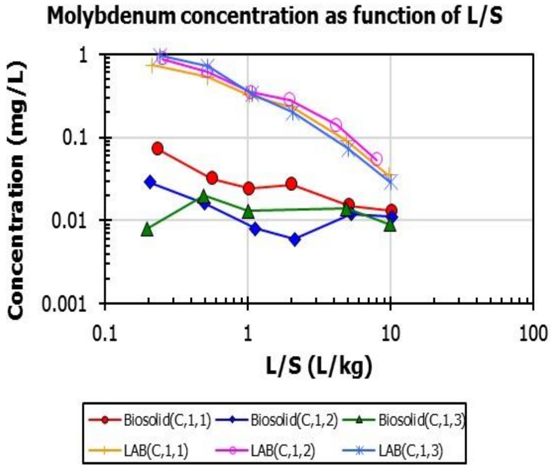

Iron concentration as function of L/S

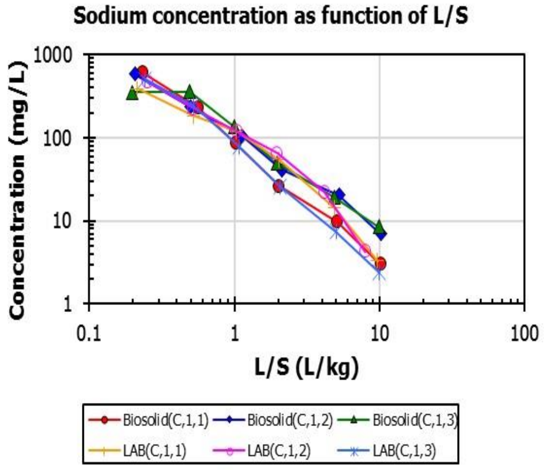

Mercury concentration as function of L/S

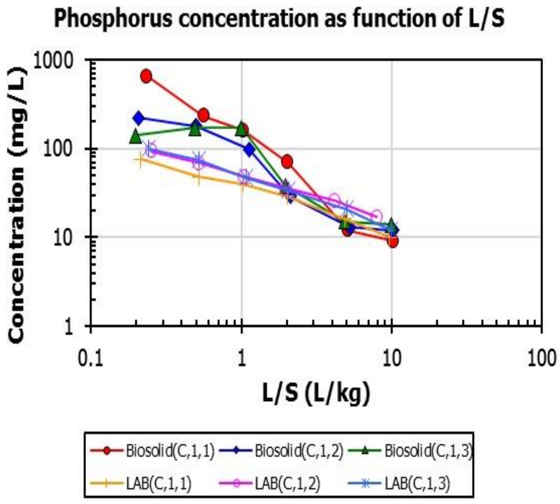

Potassium concentration as function of L/S

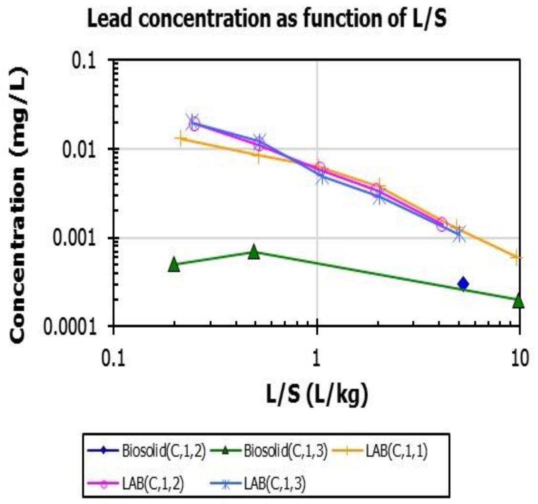

Magnesium concentration as function of L/S

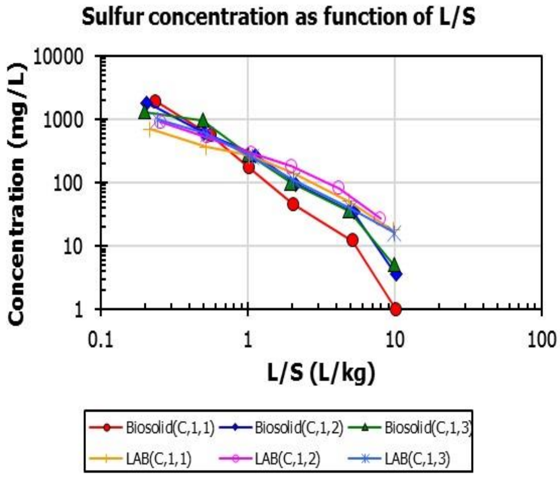

Manganese concentration as function of L/S

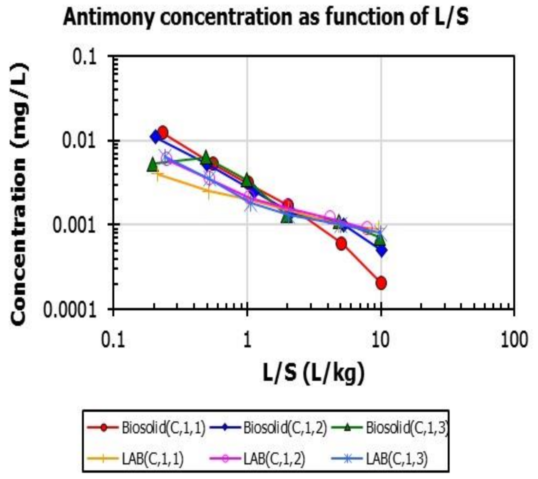

Molybdenum concentration as function of L/S

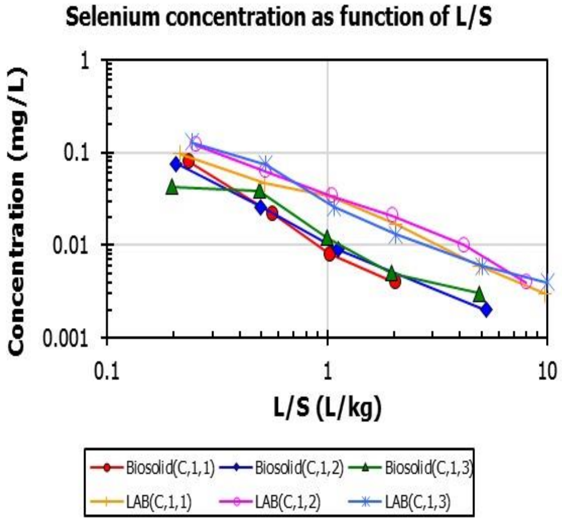

Sodium concentration as function of L/S

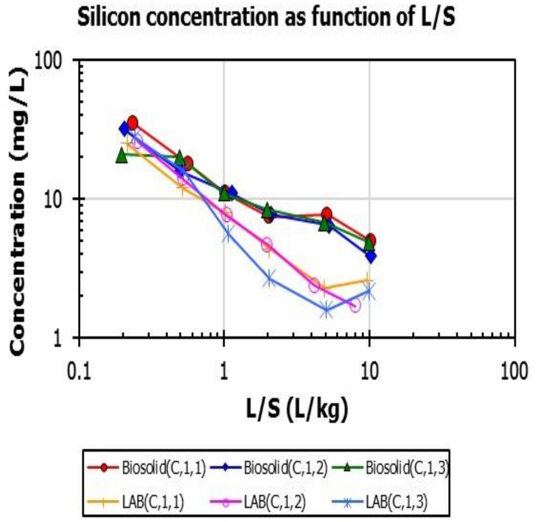

Phosphorus concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

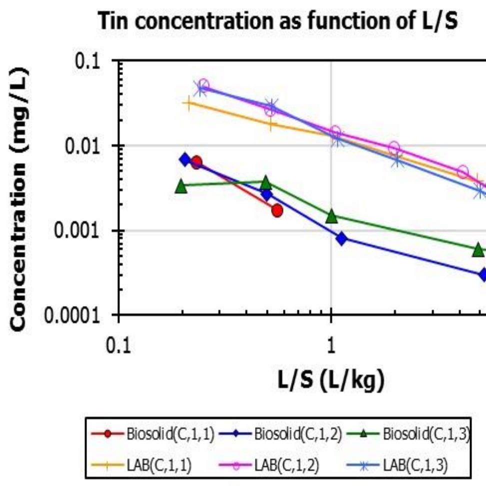

Lead concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.1
1
10
L/S (L/kg)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


Sulfur concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

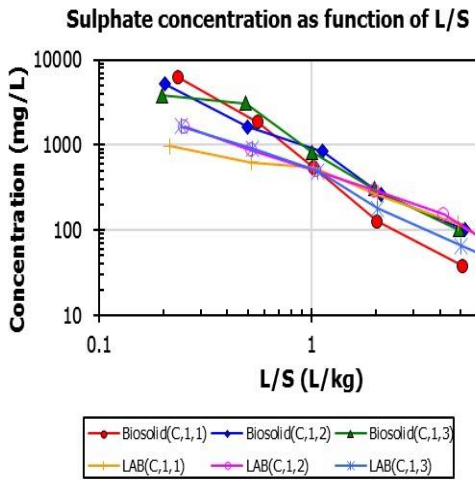

Antimony concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)


Selenium concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
0.1
1
10
L/S (L/kg)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)

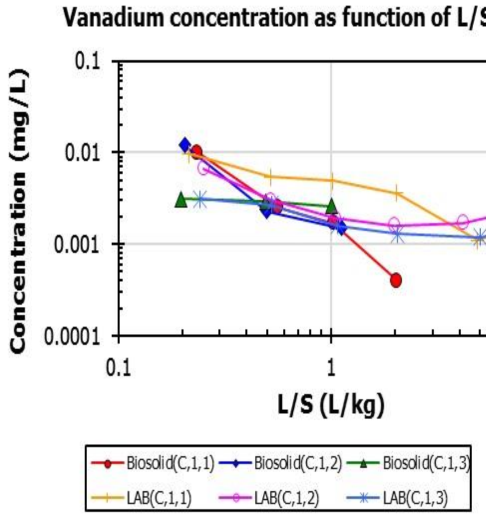

Silicon concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(C,1,1)
Biosolid(C,1,2)
Biosolid(C,1,3)
LAB(C,1,1)
LAB(C,1,2)
LAB(C,1,3)



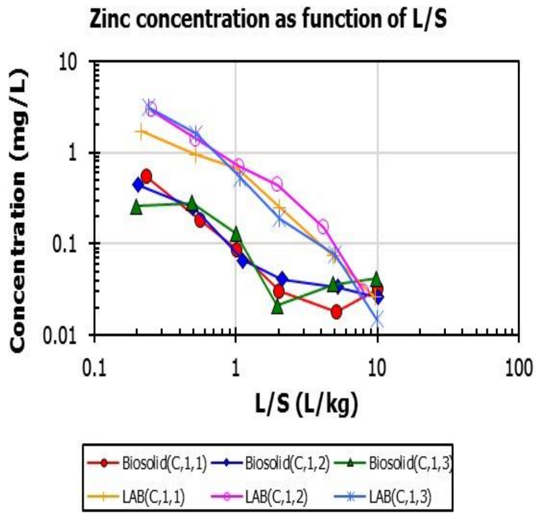
Tin concentration as function of L/S



Sulphate concentration as function of L/S



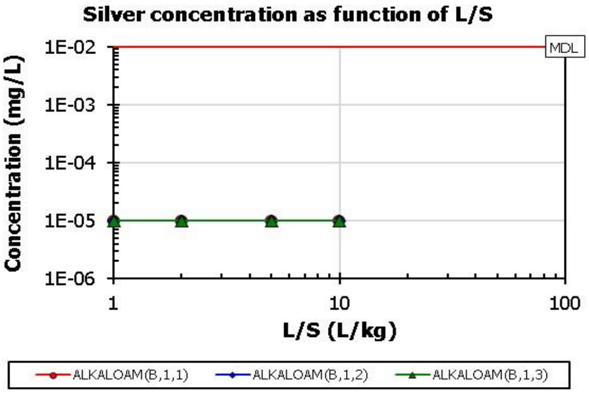
Vanadium concentration as function of L/S

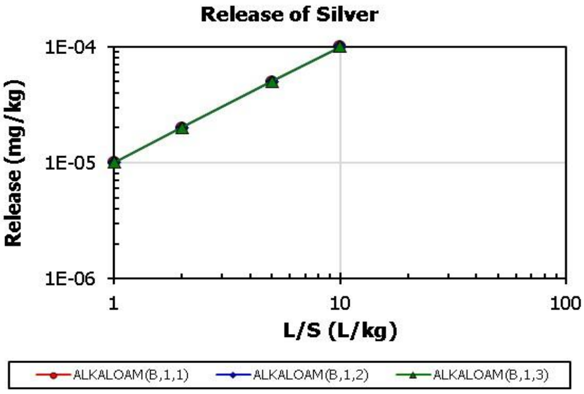


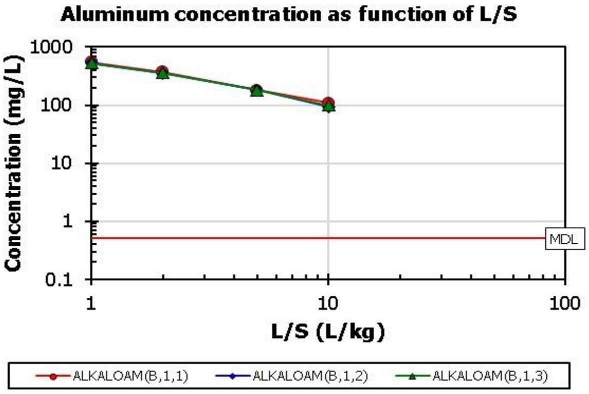
Zinc concentration as function of L/S

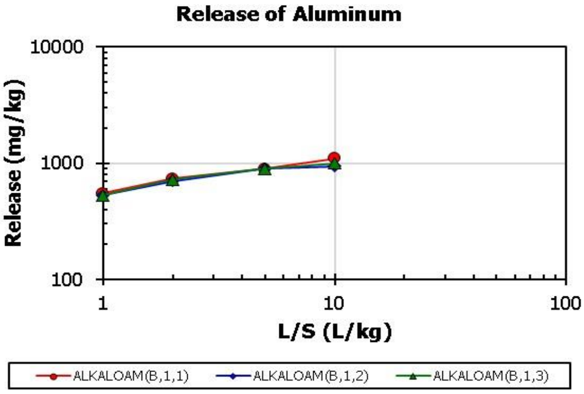
Appendix A7: Graphical Presentation of Analytical Data for Method 1316

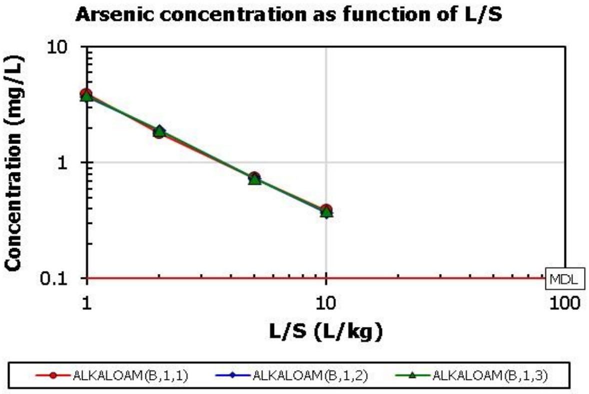
A7-1: By-product Alkaloam

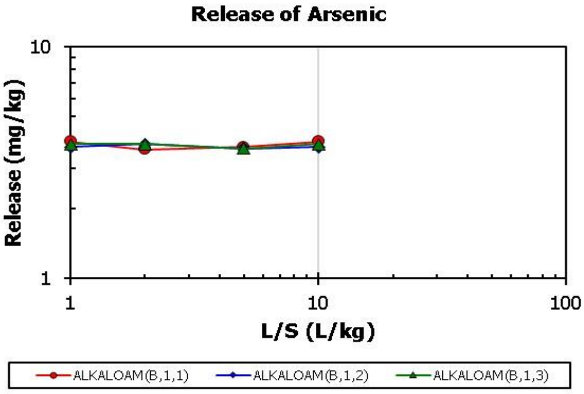


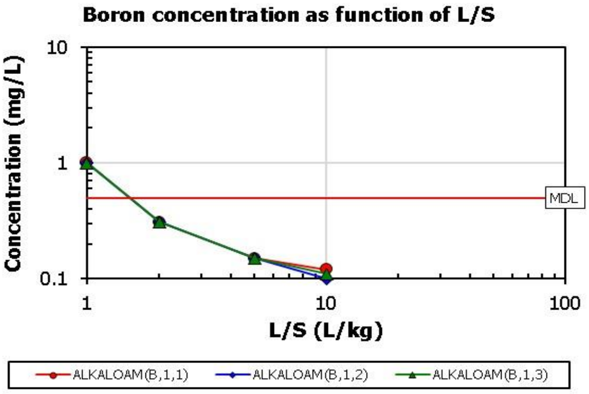


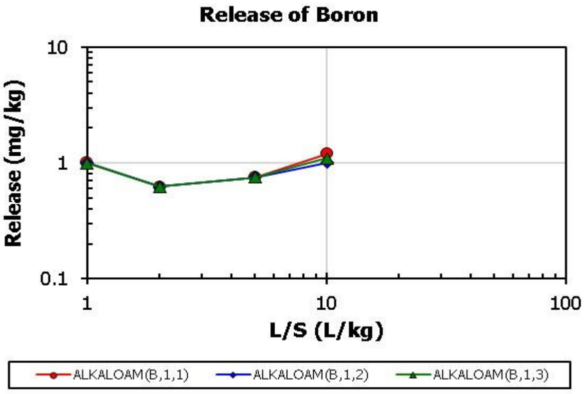


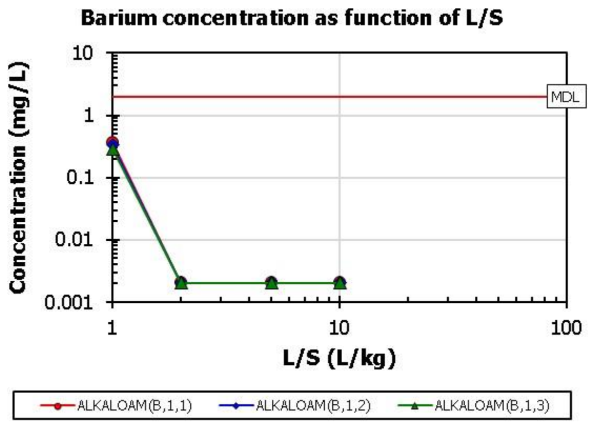


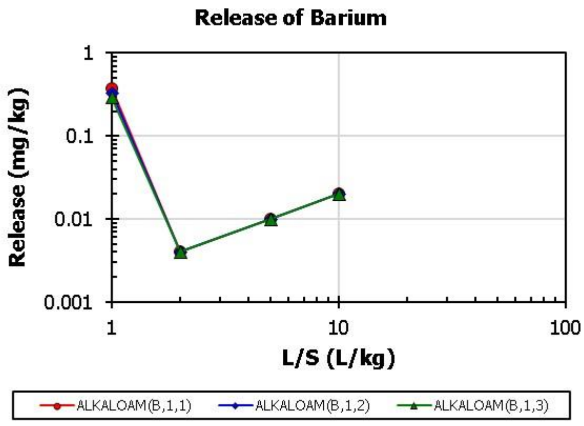


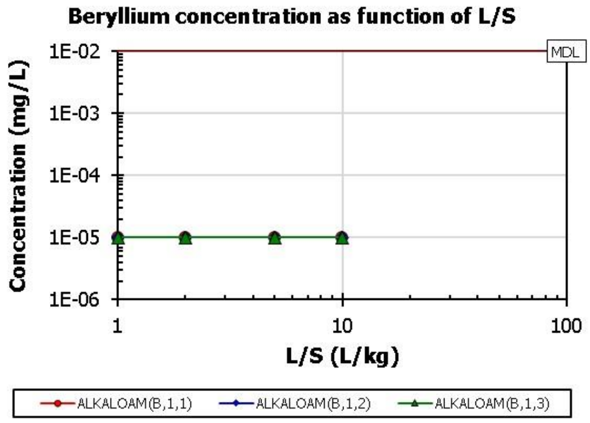


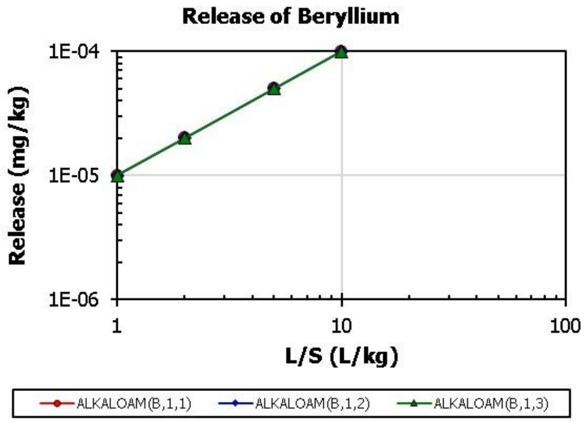


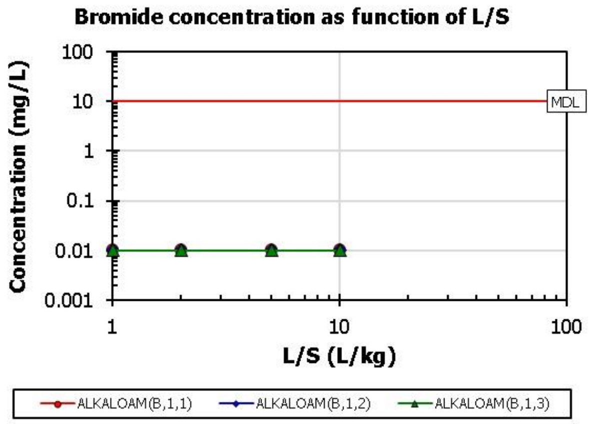


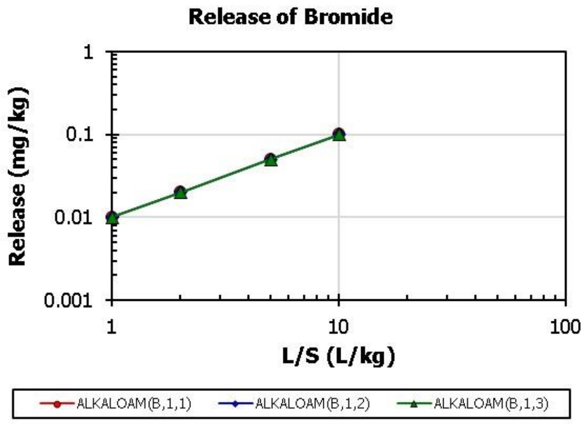

Barium concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.01
0.001
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

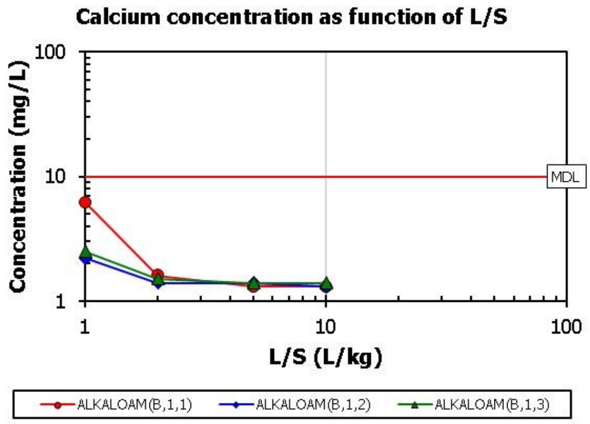

Release of Barium
Release (mg/kg)
1
0.1
0.01
0.001
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

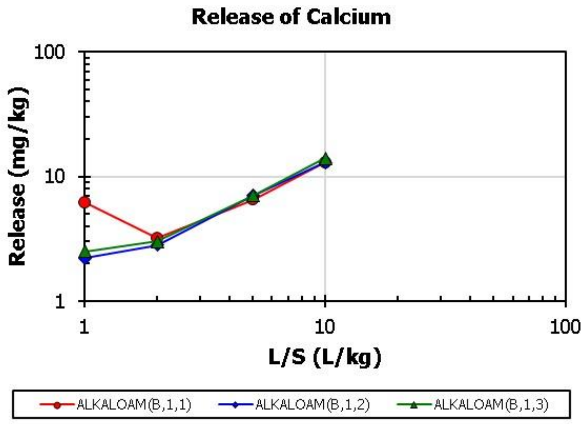

Beryllium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)


Release of Beryllium
Release (mg/kg)
1E-04
1E-05
1E-06
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

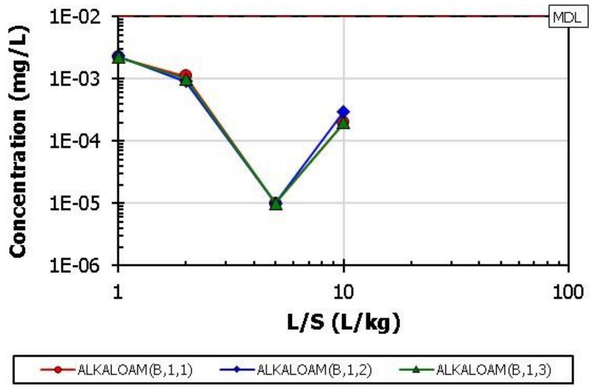

Bromide concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)


Release of Bromide
Release (mg/kg)
1
0.1
0.01
0.001
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

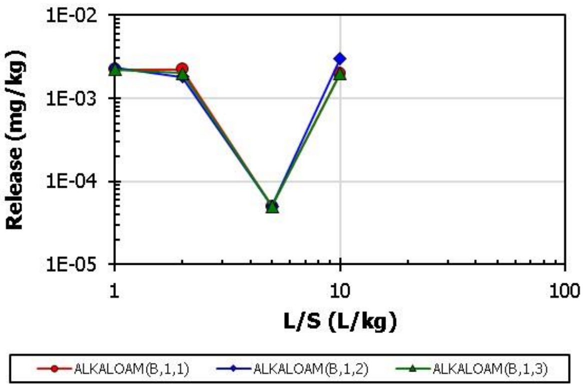

Calcium concentration as function of L/S
Concentration (mg/L)
100
10
1
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)


Release of Calcium
Release (mg/kg)
100
10
1
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

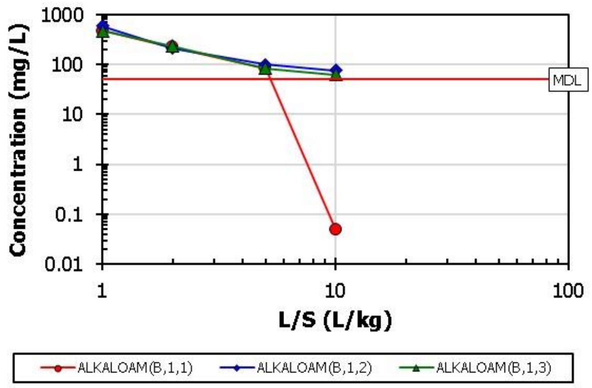
Cadmium concentration as function of L/S



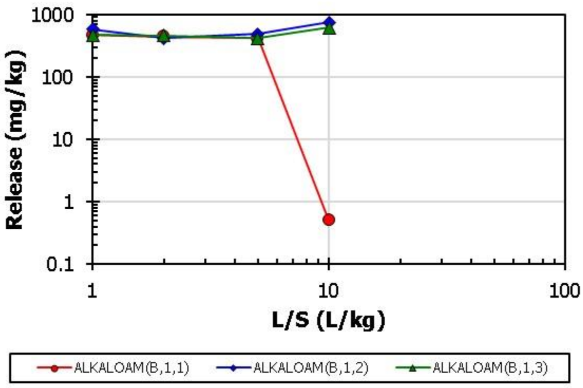
Release of Cadmium



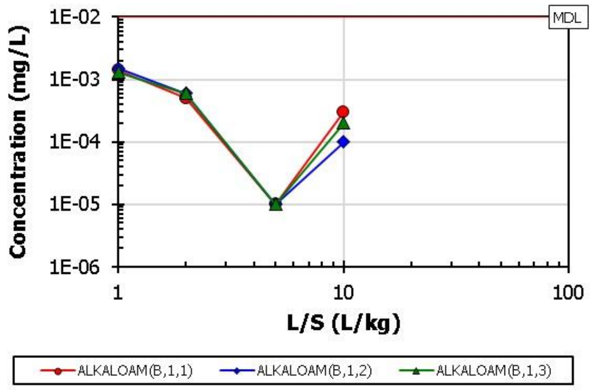
Chlorine concentration as function of L/S



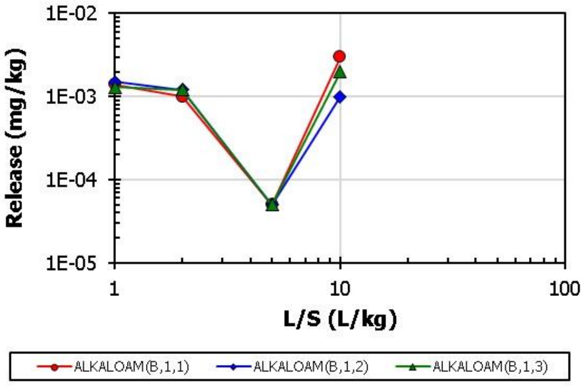
Release of Chlorine



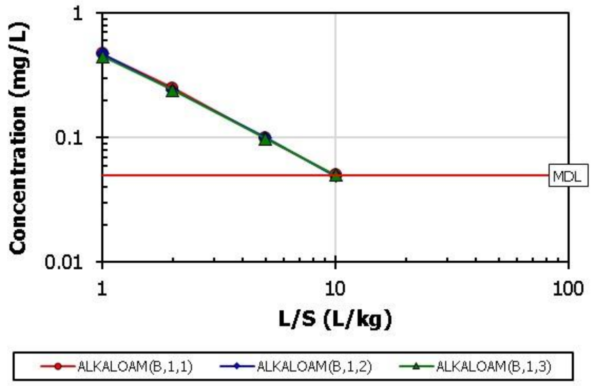
Cobalt concentration as function of L/S



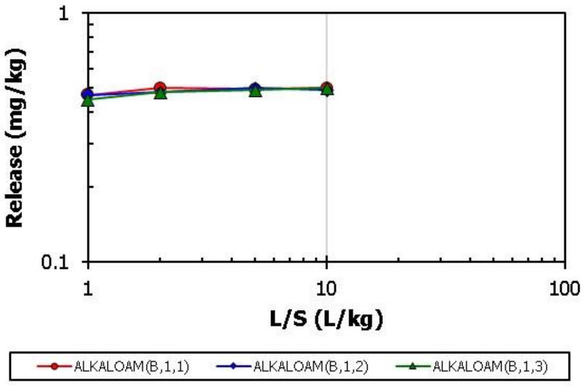
Release of Cobalt



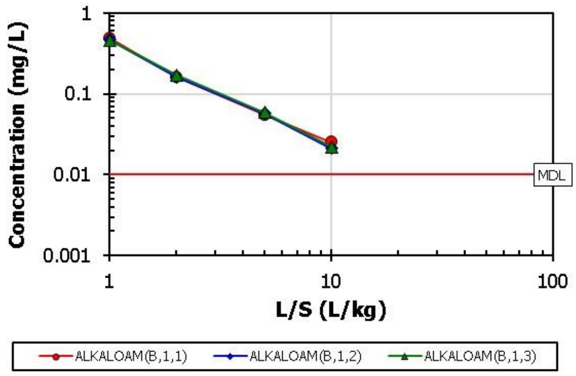
Chromium concentration as function of L/S



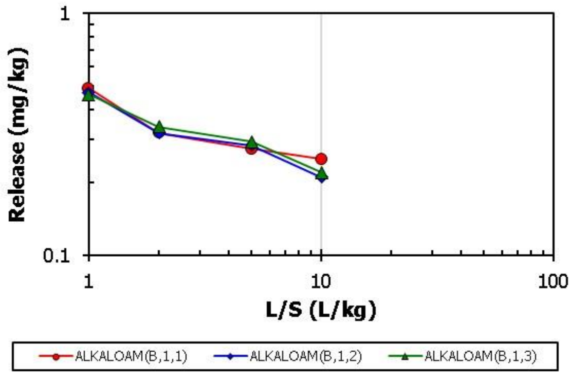
Release of Chromium



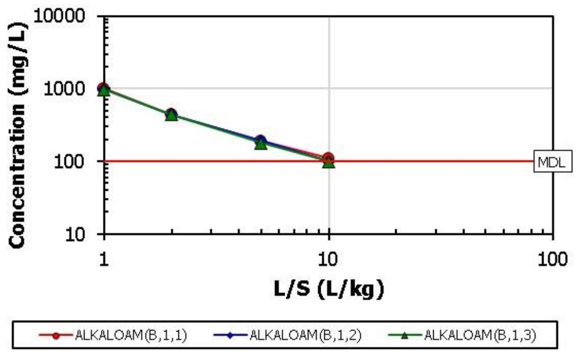
Copper concentration as function of L/S



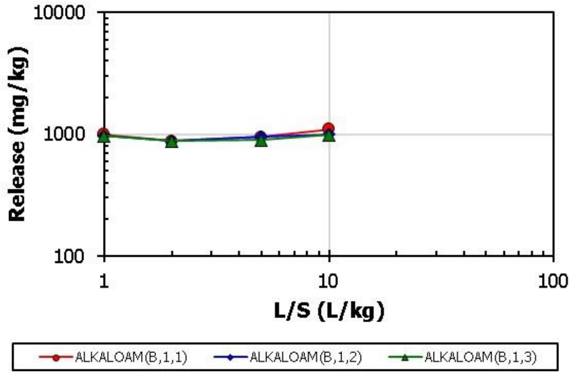
Release of Copper



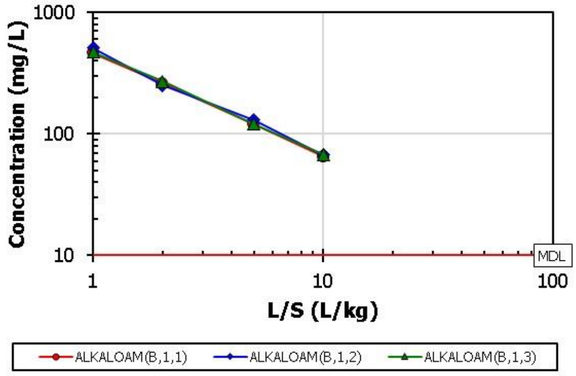
Dissolved Organic Carbon concentration as function of L/S



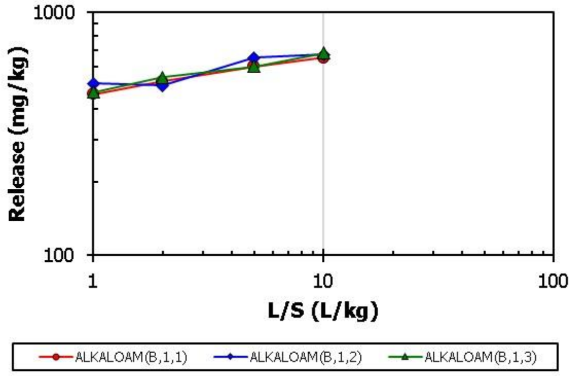
Release of Dissolved Organic Carbon



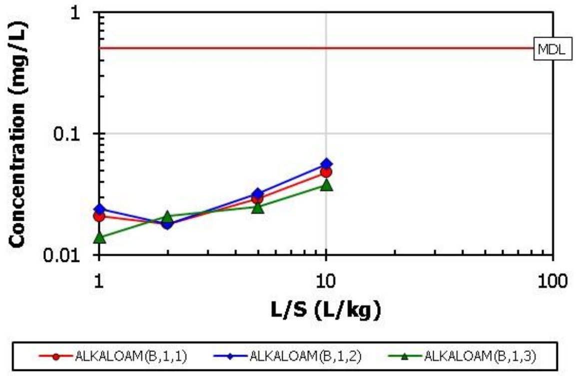
Fluorine concentration as function of L/S



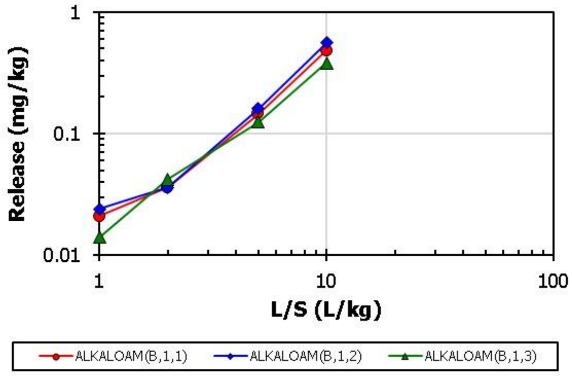
Release of Fluorine



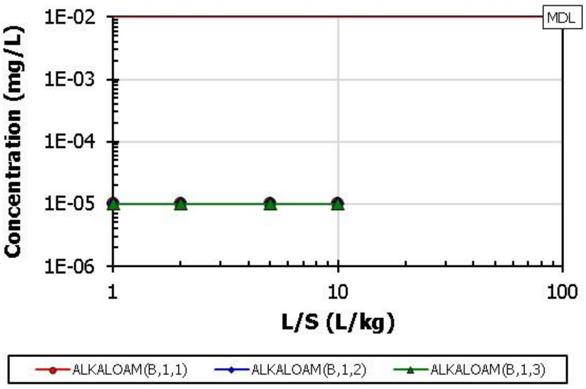
Iron concentration as function of L/S



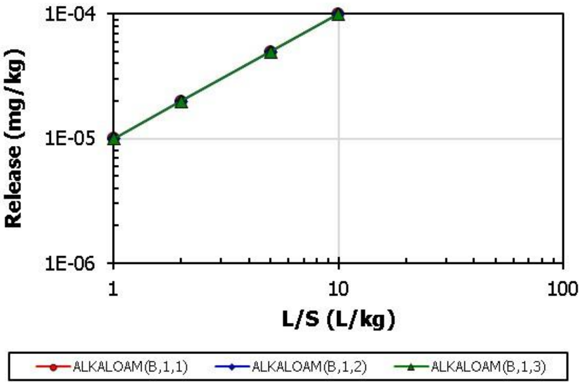
Release of Iron



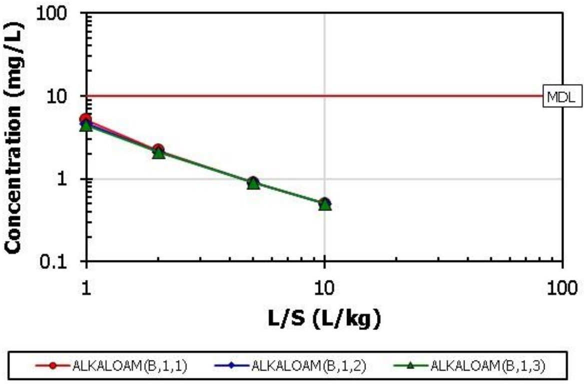
Mercury concentration as function of L/S



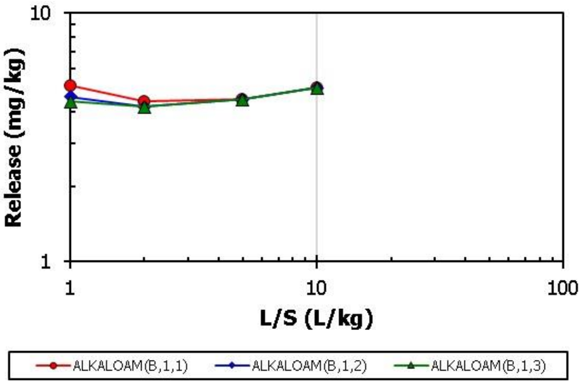
Release of Mercury



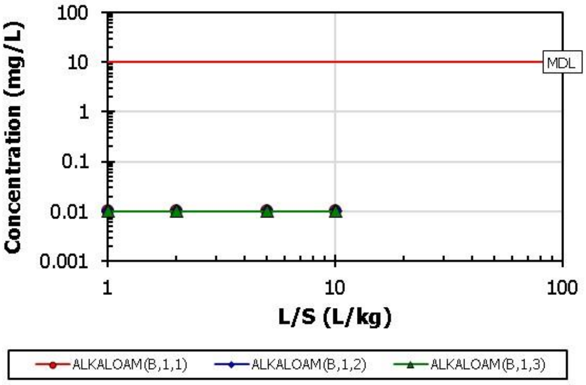
Potassium concentration as function of L/S



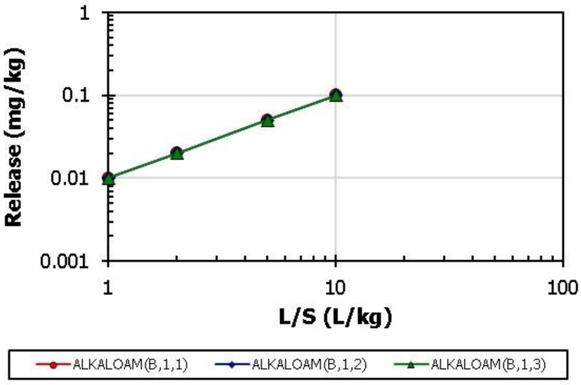
Release of Potassium



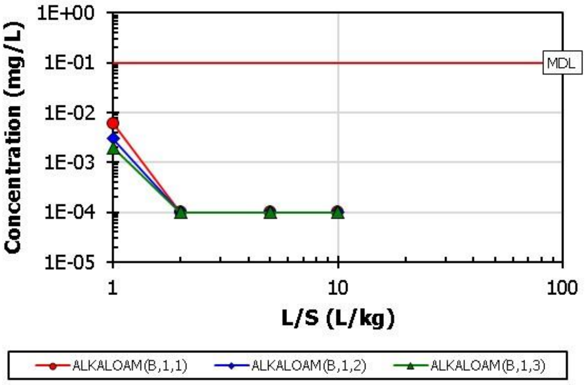
Magnesium concentration as function of L/S



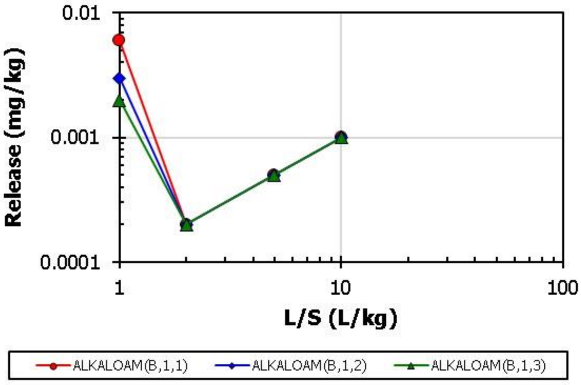
Release of Magnesium

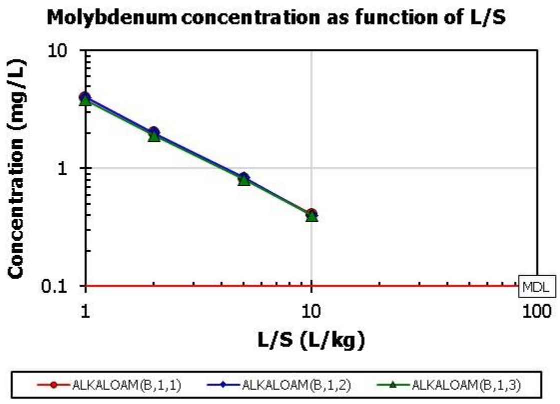


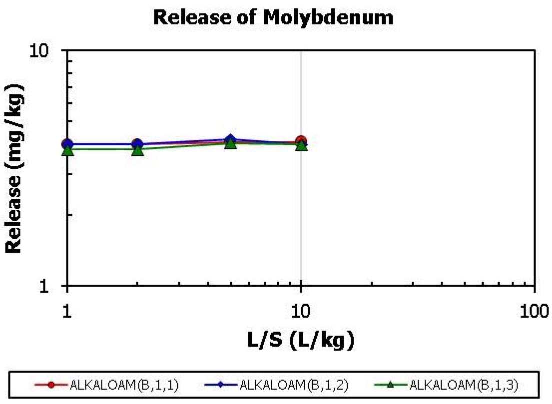
Manganese concentration as function of L/S

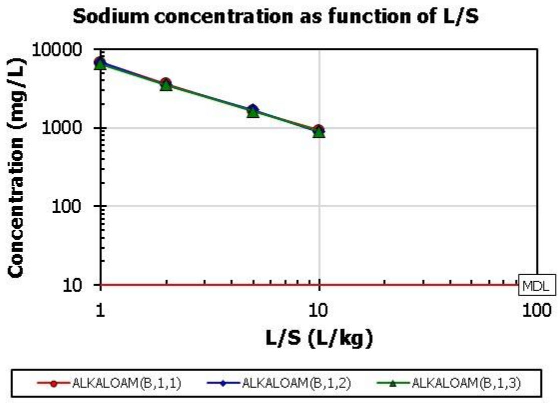


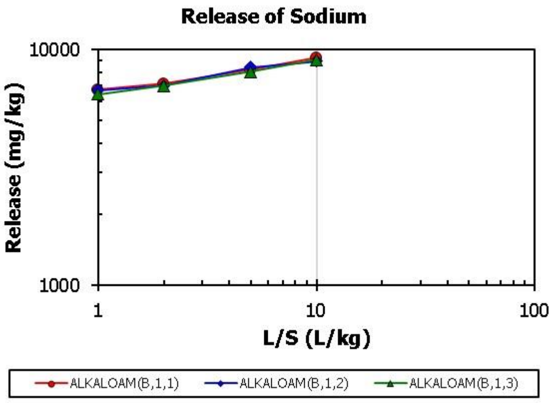
Release of Manganese

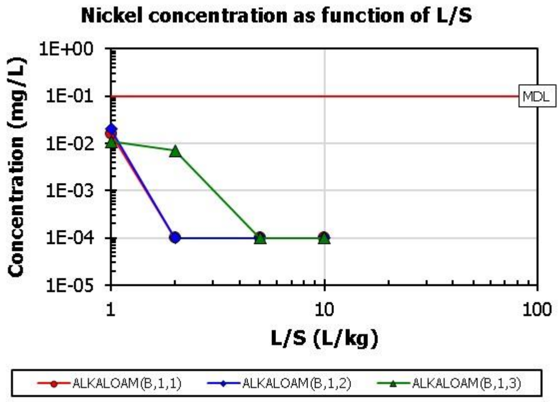


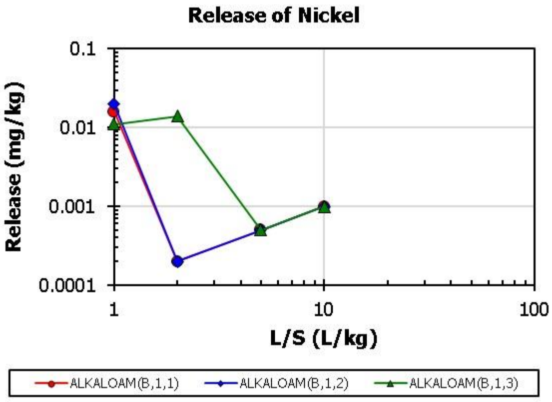

Molybdenum concentration as function of L/S
Concentration (mg/L)
10
1
0.1
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

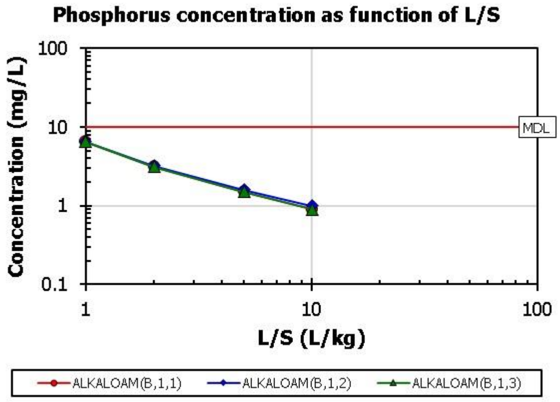

Release of Molybdenum
Release (mg/kg)
10
1
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

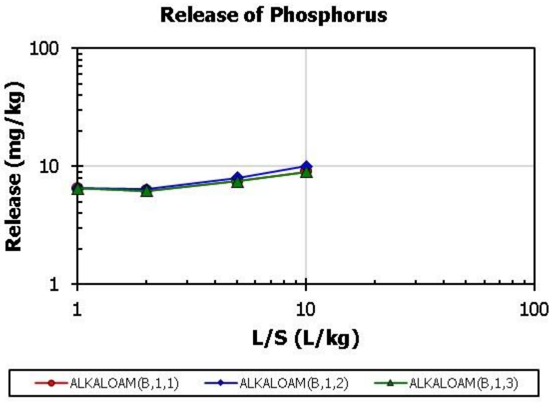

Sodium concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

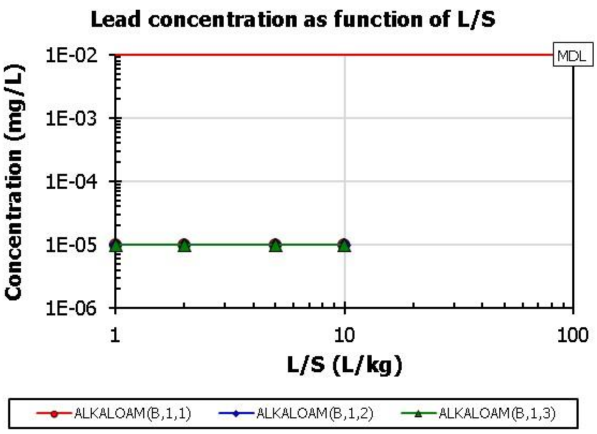

Release of Sodium
Release (mg/kg)
10000
1000
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

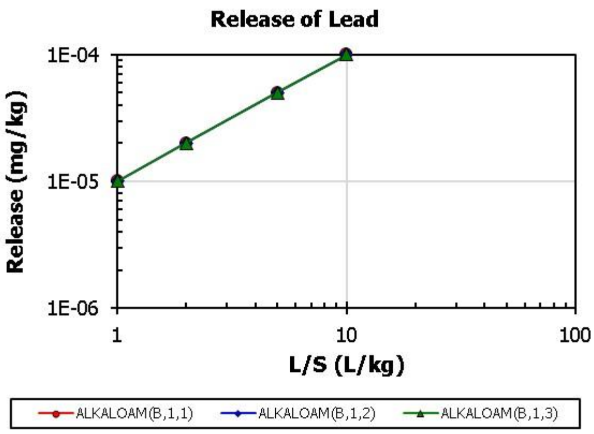

Nickel concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

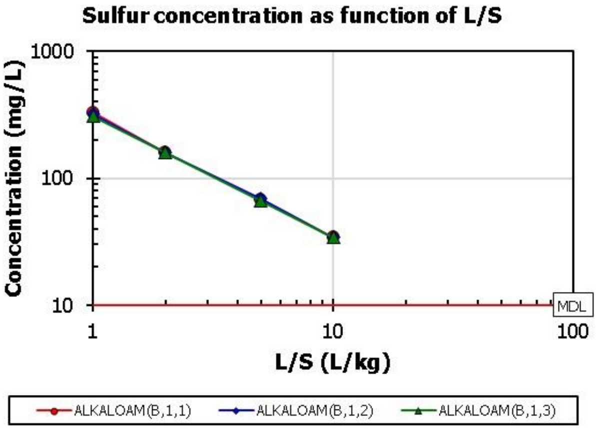

Release of Nickel
Release (mg/kg)
0.1
0.01
0.001
0.0001
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

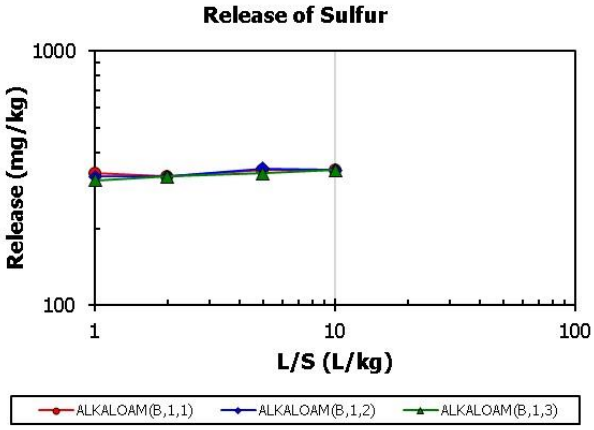

Phosphorus concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

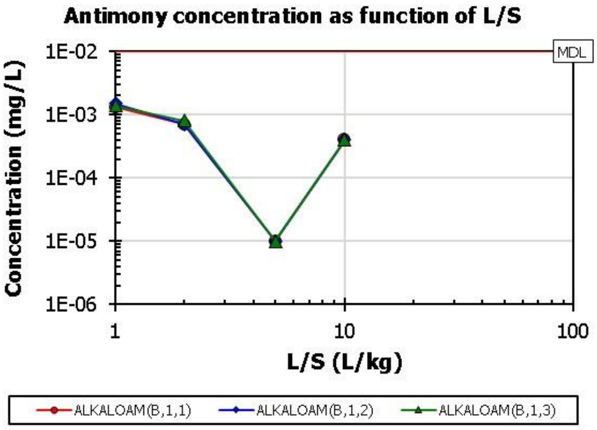

Release of Phosphorus
Release (mg/kg)
100
10
1
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

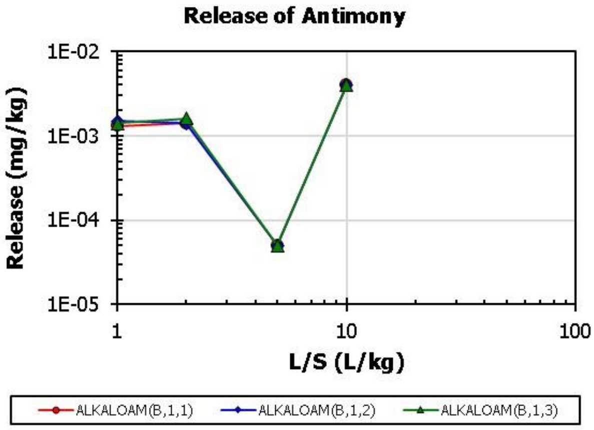

Lead concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

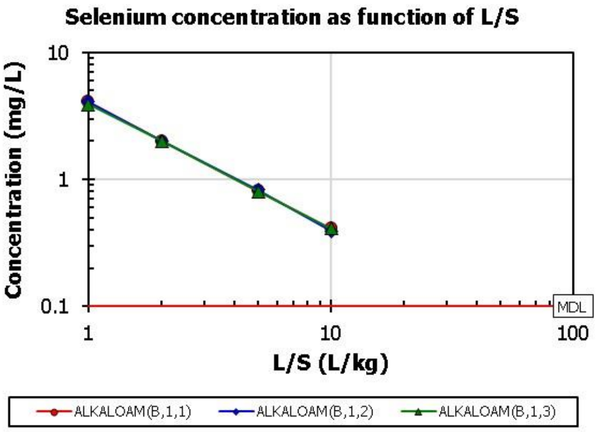

Release of Lead
Release (mg/kg)
1E-04
1E-05
1E-06
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

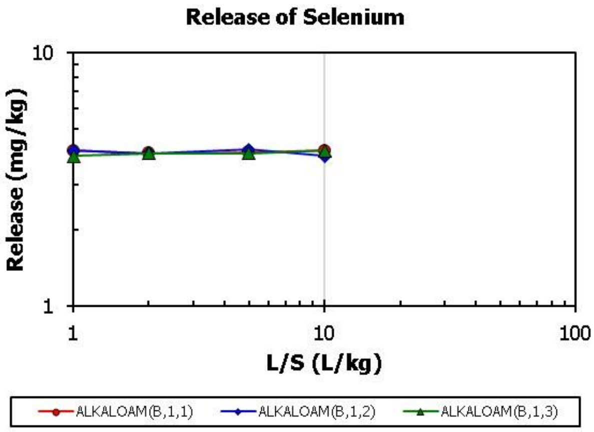

Sulfur concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

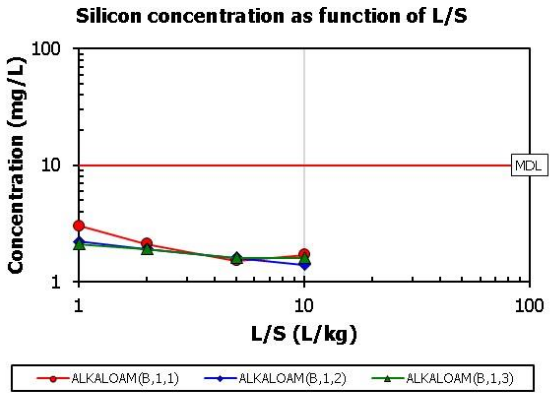

Release of Sulfur
Release (mg/kg)
1000
100
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

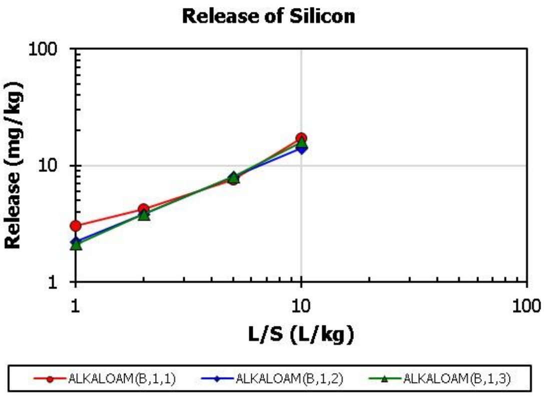

Antimony concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

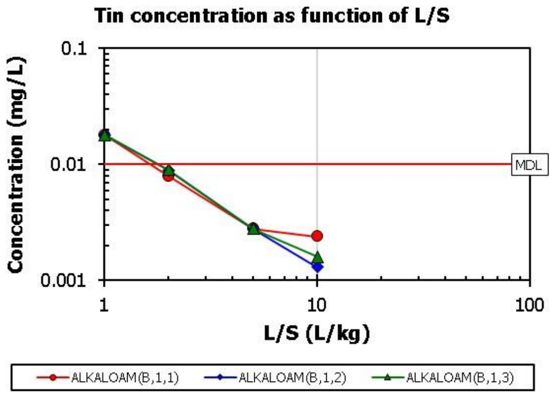

Release of Antimony
Release (mg/kg)
1E-02
1E-03
1E-04
1E-05
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

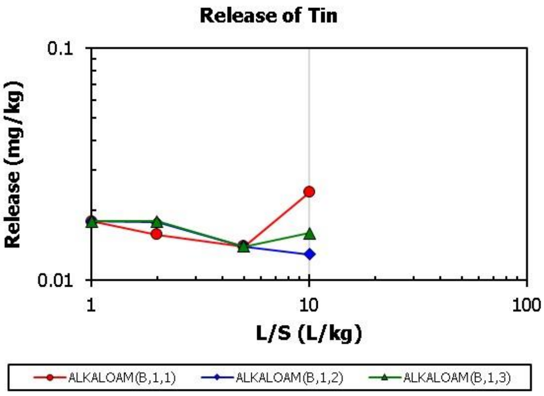

Selenium concentration as function of L/S
Concentration (mg/L)
10
1
0.1
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

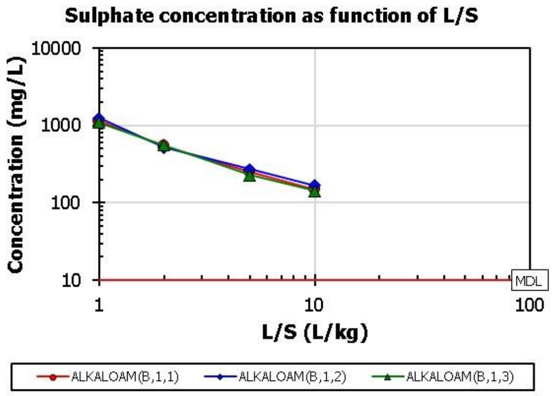

Release of Selenium
Release (mg/kg)
10
1
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

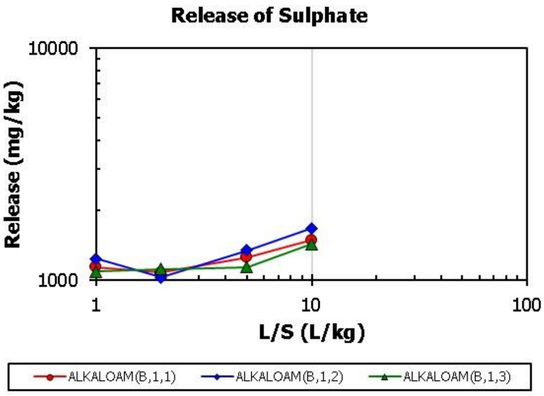

Silicon concentration as function of L/S
Concentration (mg/L)
100
10
1
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

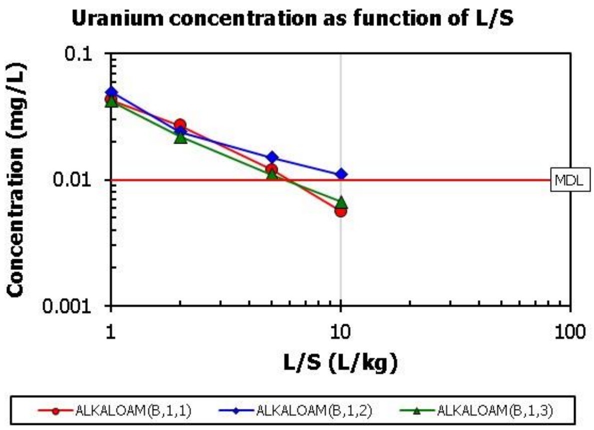

Release of Silicon
Release (mg/kg)
100
10
1
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

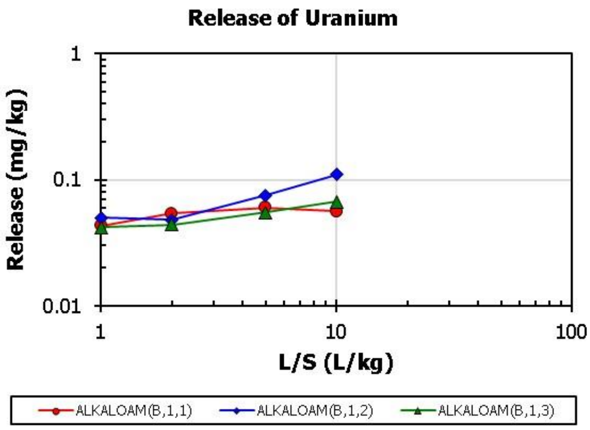

Tin concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

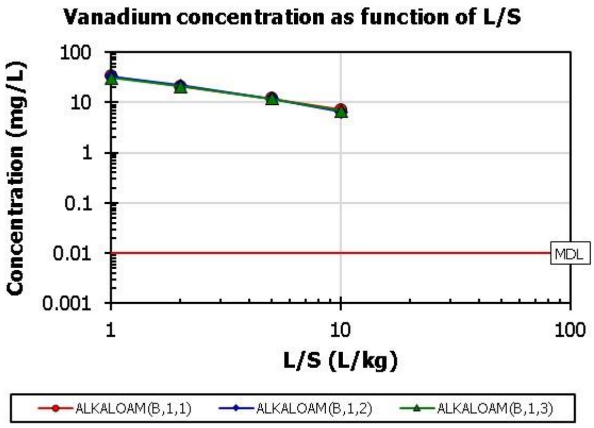

Release of Tin
Release (mg/kg)
0.1
0.01
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

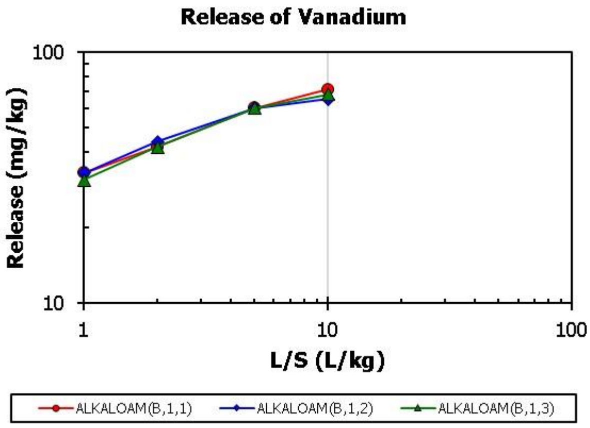

Sulphate concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

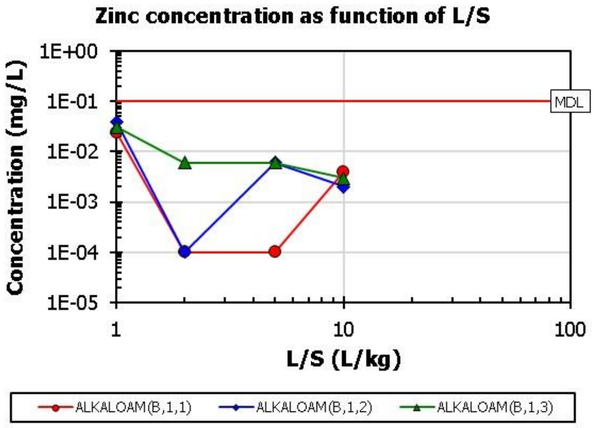

Release of Sulphate
Release (mg/kg)
10000
1000
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

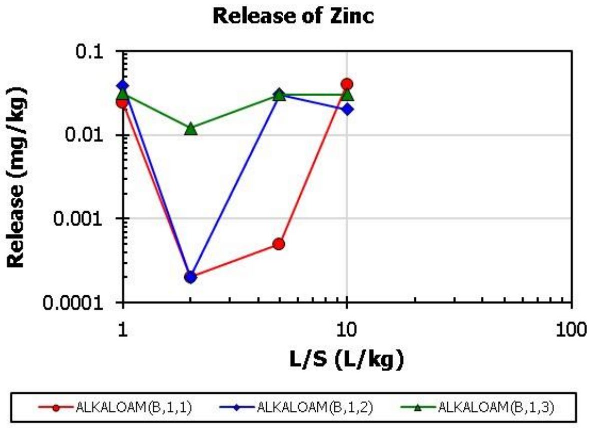

Uranium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)


Release of Uranium
Release (mg/kg)
1
0.1
0.01
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

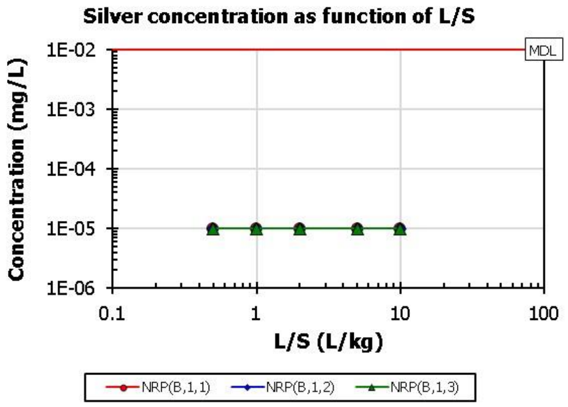

Vanadium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

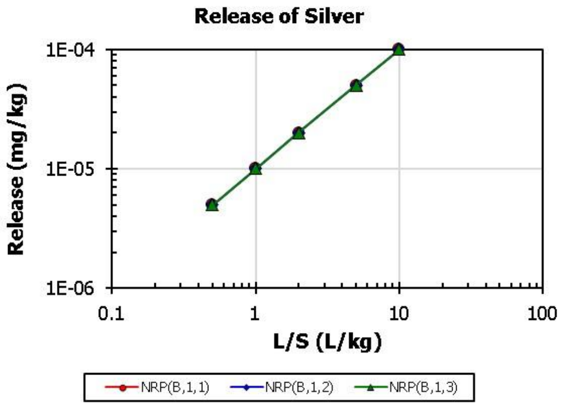

Release of Vanadium
Release (mg/kg)
100
10
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

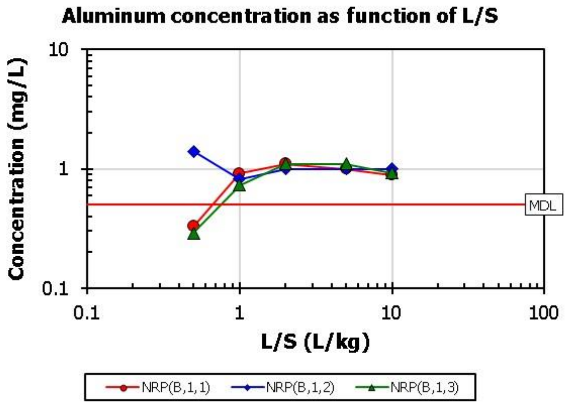

Zinc concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

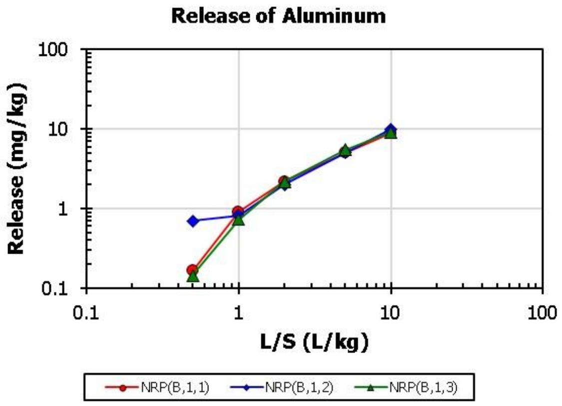

Release of Zinc
Release (mg/kg)
0.1
0.01
0.001
0.0001
1
10
100
L/S (L/kg)
ALKALOAM(B,1,1)
ALKALOAM(B,1,2)
ALKALOAM(B,1,3)

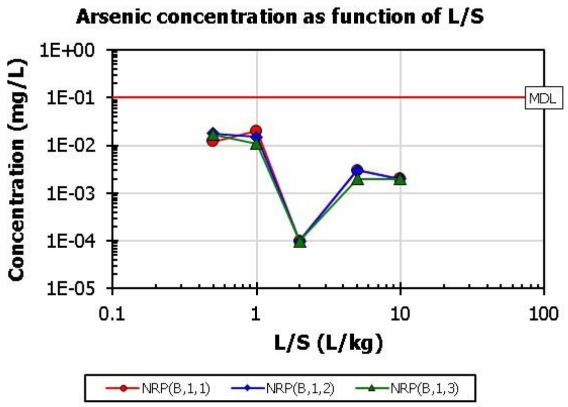
A7-2: By-product NRP

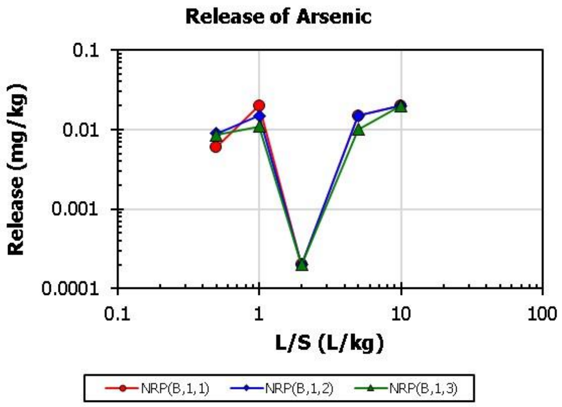


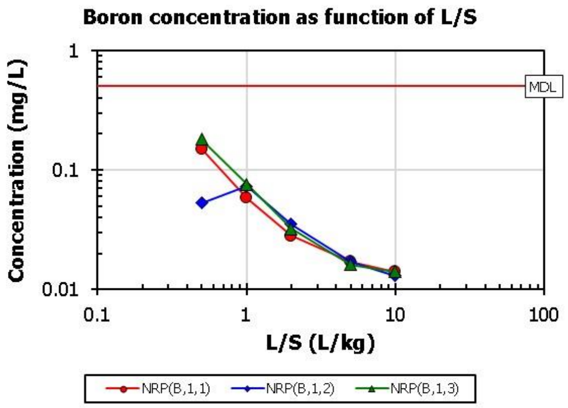


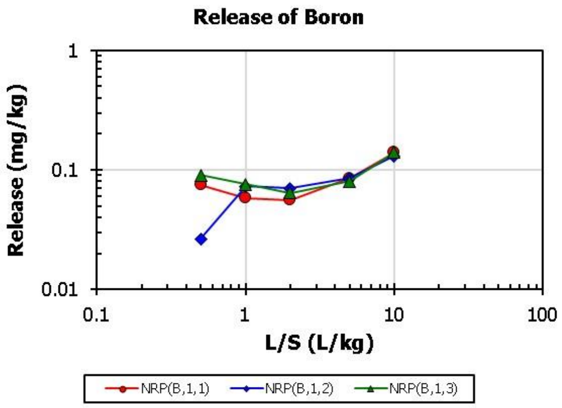


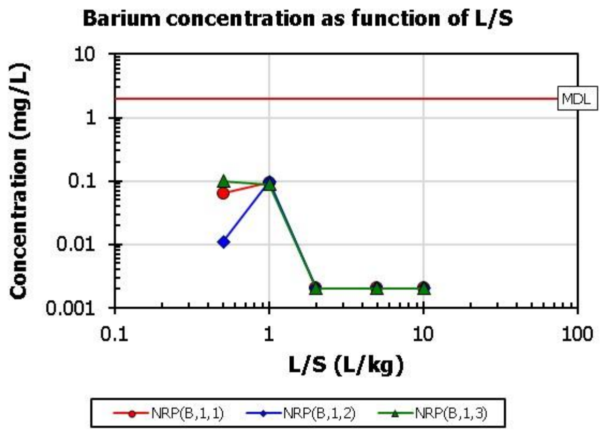


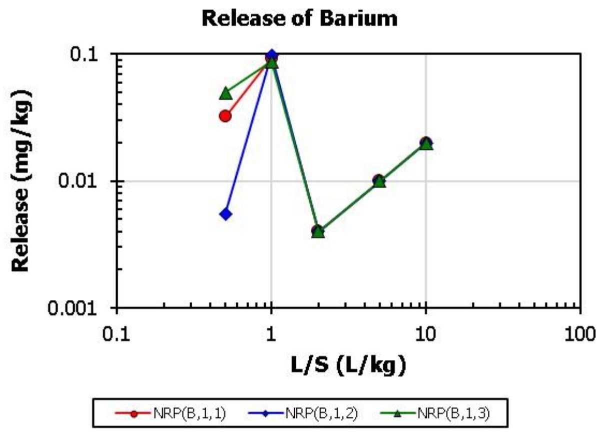


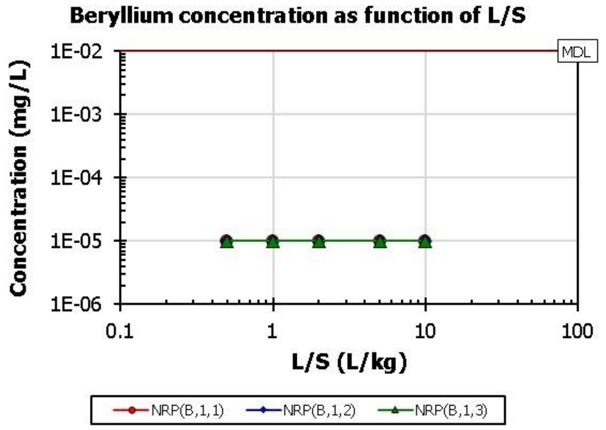


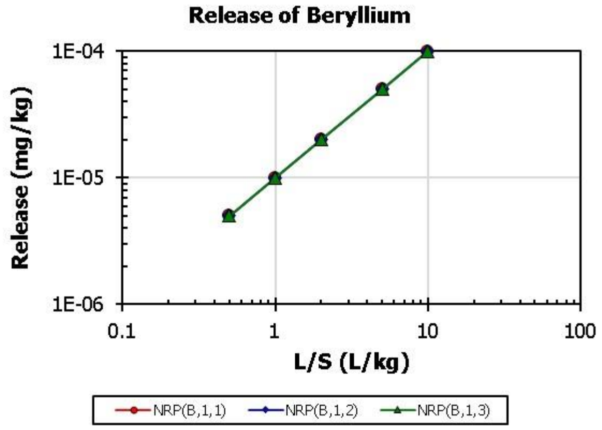


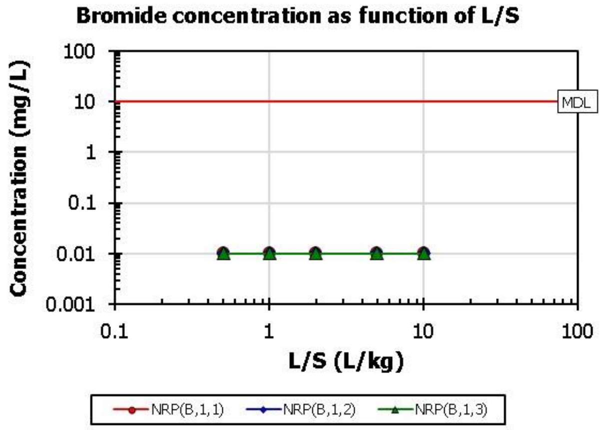


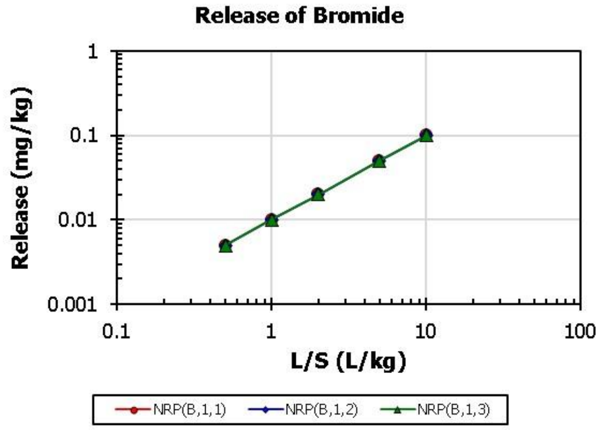

Barium concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

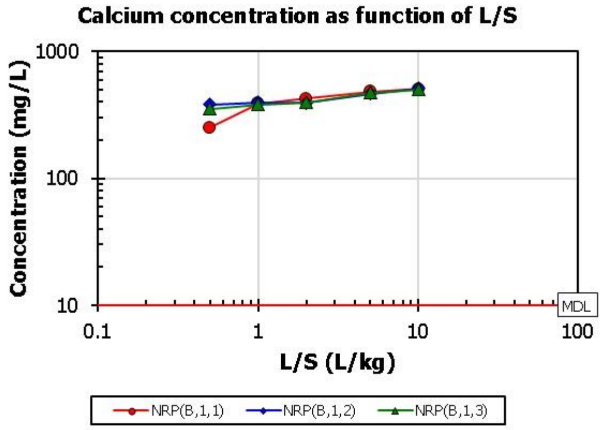

Release of Barium
Release (mg/kg)
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

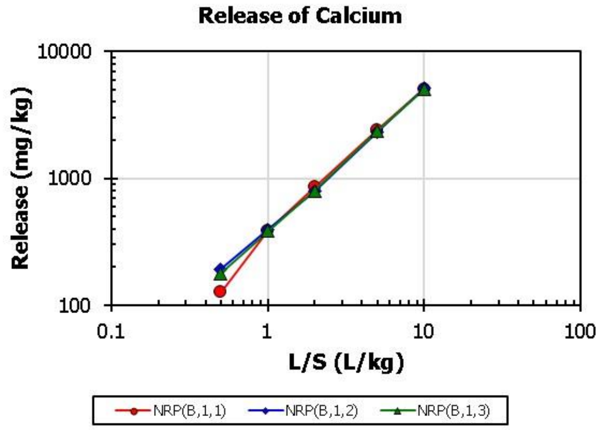

Beryllium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

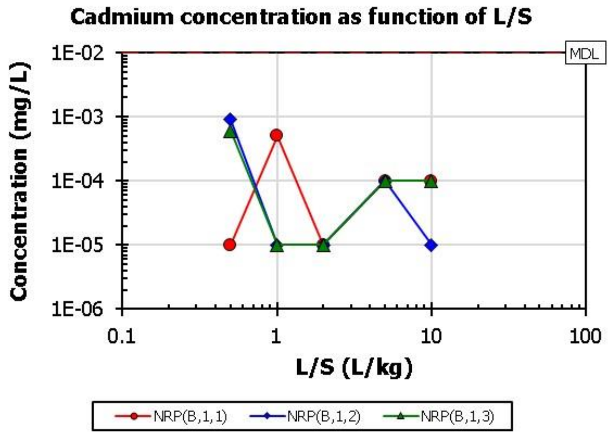

Release of Beryllium
Release (mg/kg)
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

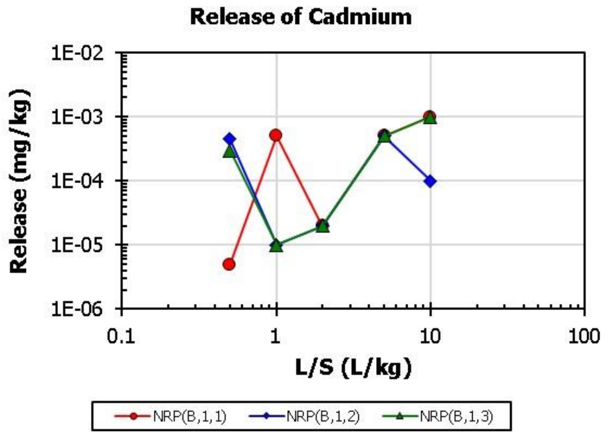

Bromide concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

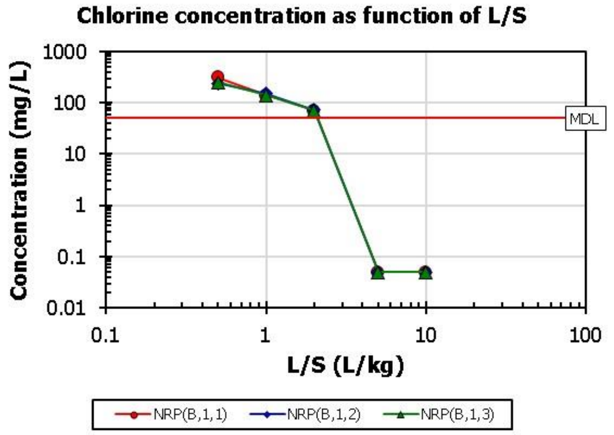

Release of Bromide
Release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

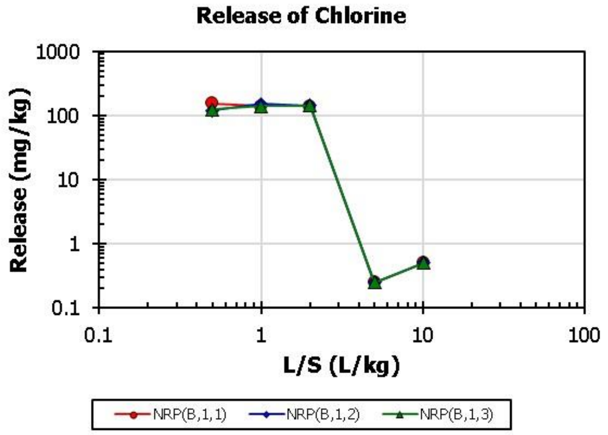

Calcium concentration as function of L/S
Concentration (mg/L)
1000
100
10
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

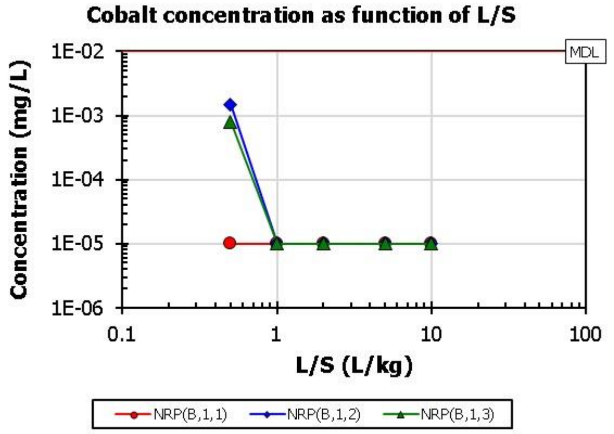

Release of Calcium
Release (mg/kg)
10000
1000
100
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

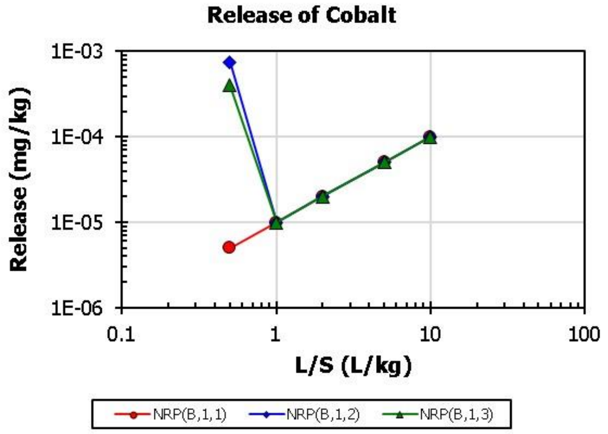

Cadmium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

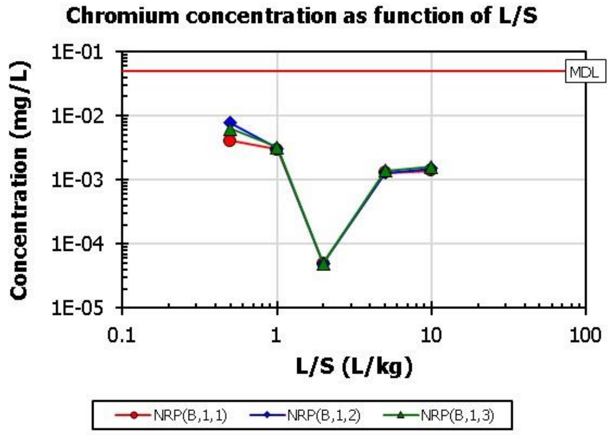

Release of Cadmium
Release (mg/kg)
1E-02
1E-03
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

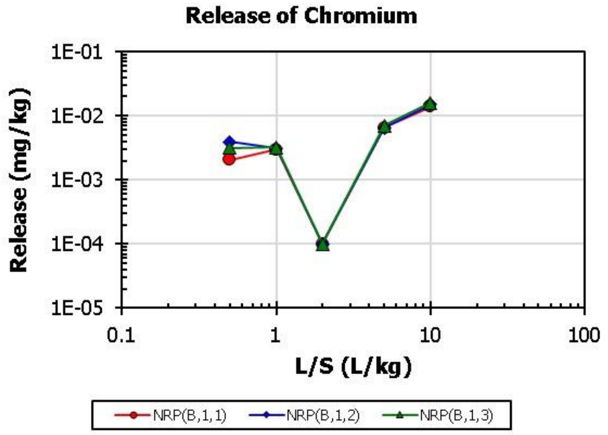

Chlorine concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
0.1
0.01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

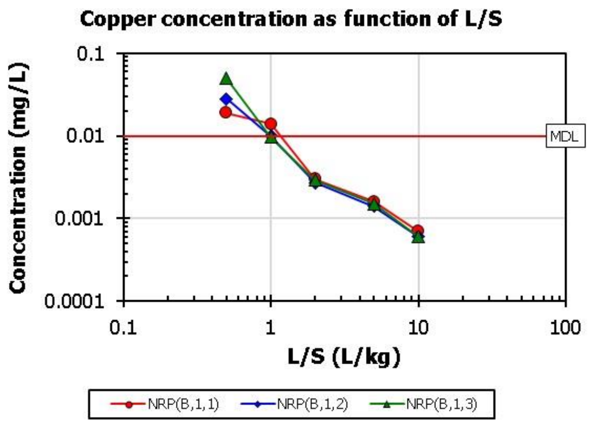

Release of Chlorine
Release (mg/kg)
1000
100
10
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

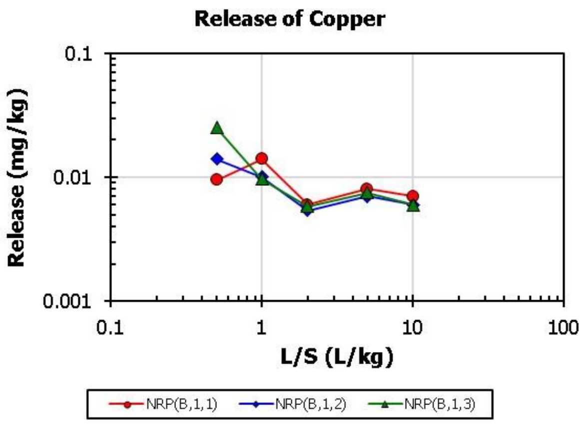

Cobalt concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

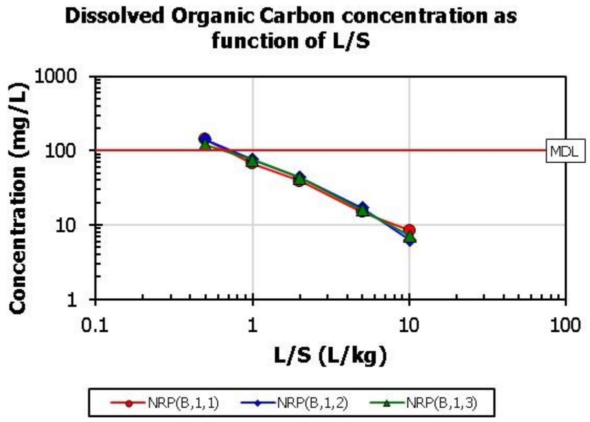

Release of Cobalt
Release (mg/kg)
1E-03
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

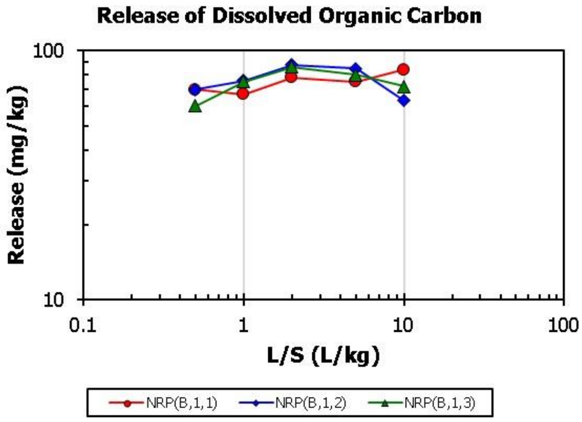

Chromium concentration as function of L/S
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

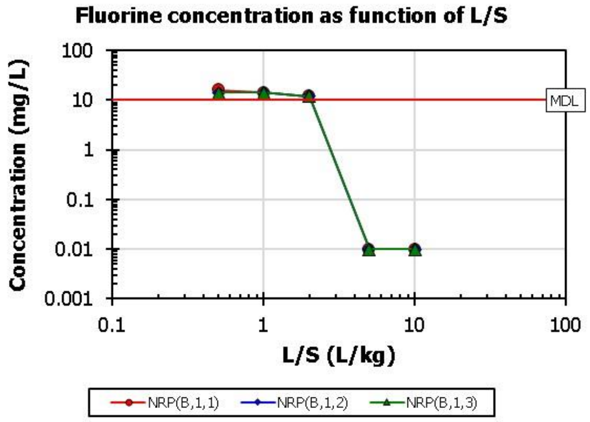

Release of Chromium
Release (mg/kg)
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

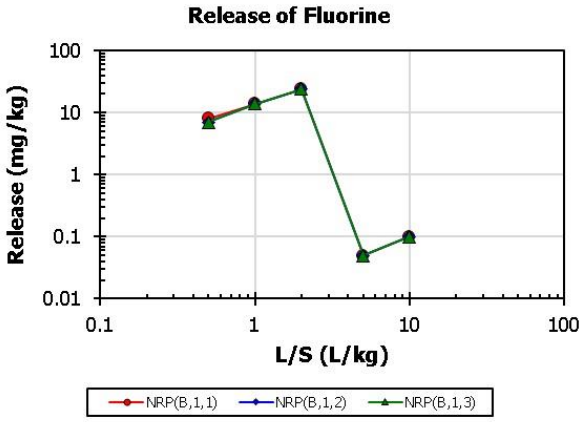

Copper concentration as function of L/S

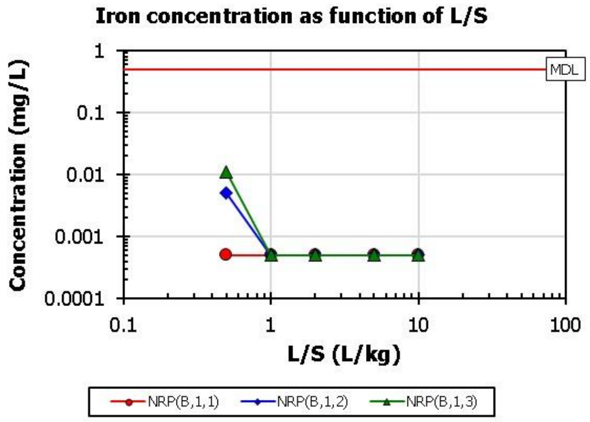

Release of Copper

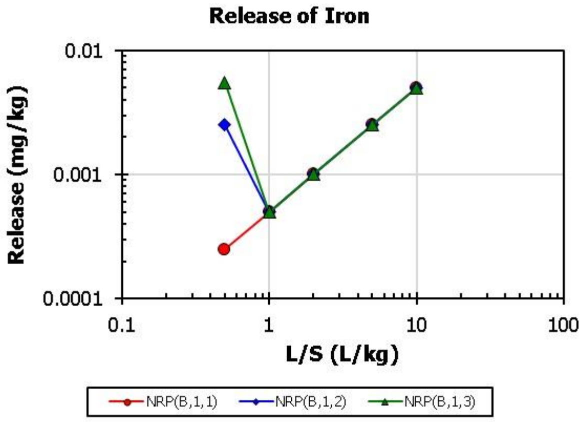

Dissolved Organic Carbon concentration as function of L/S

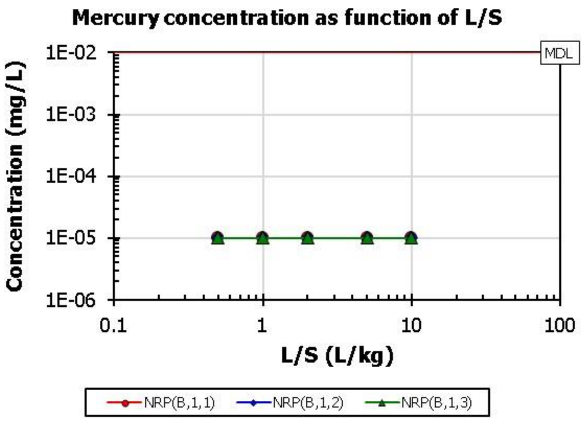

Release of Dissolved Organic Carbon

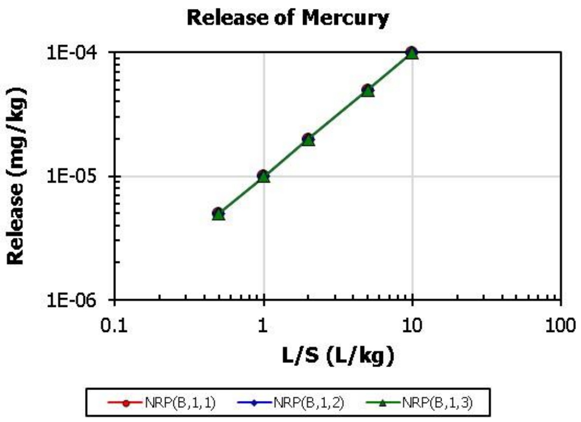

Fluorine concentration as function of L/S

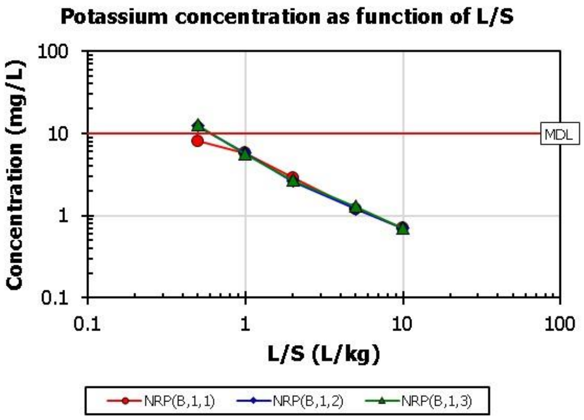

Release of Fluorine

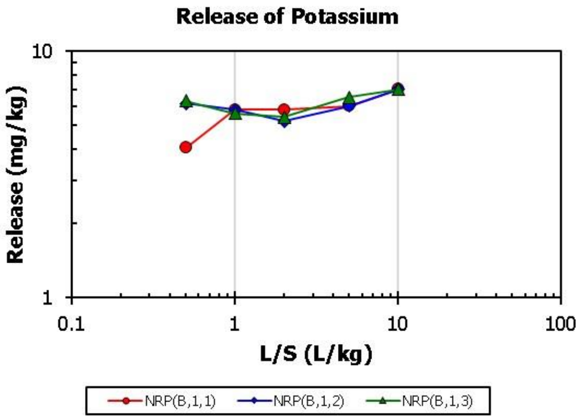

Iron concentration as function of L/S

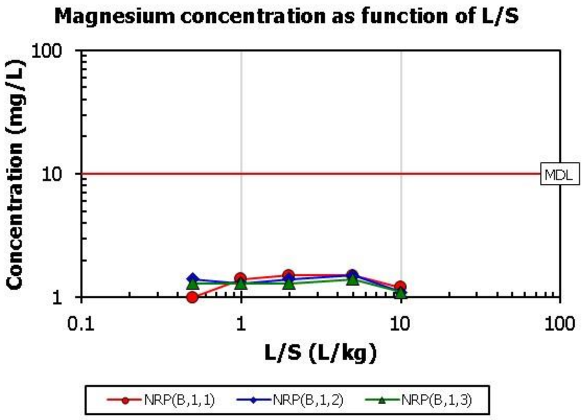

Release of Iron

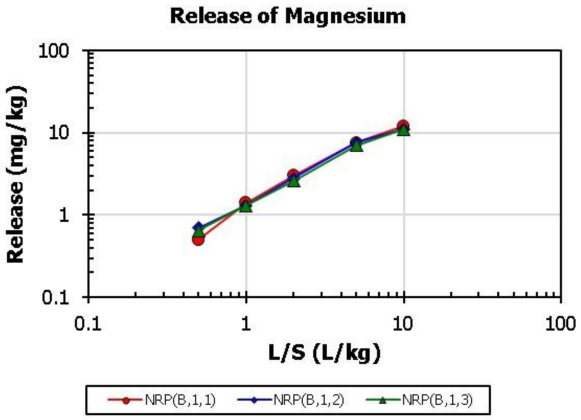

Mercury concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

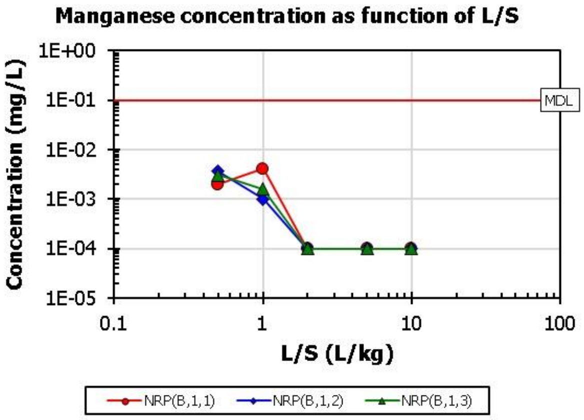

Release of Mercury
Release (mg/kg)
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

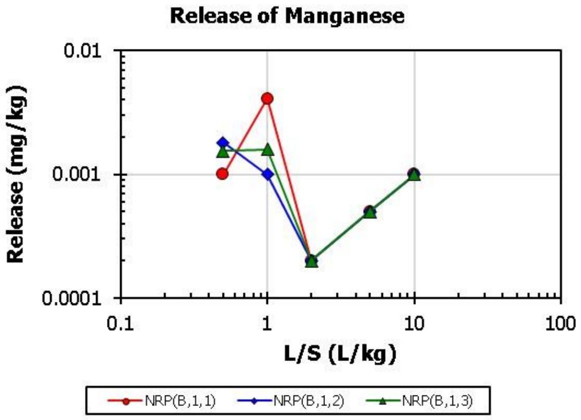

Potassium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

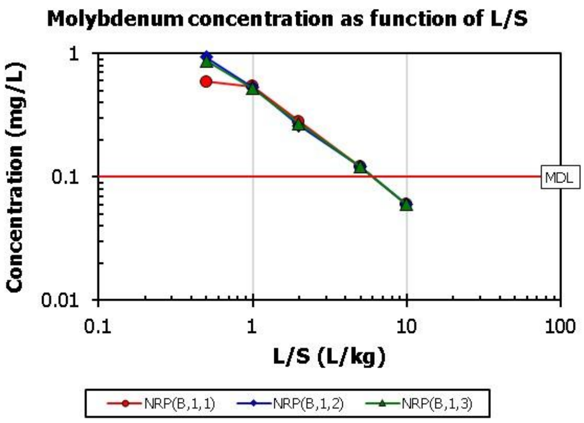

Release of Potassium
Release (mg/kg)
10
1
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

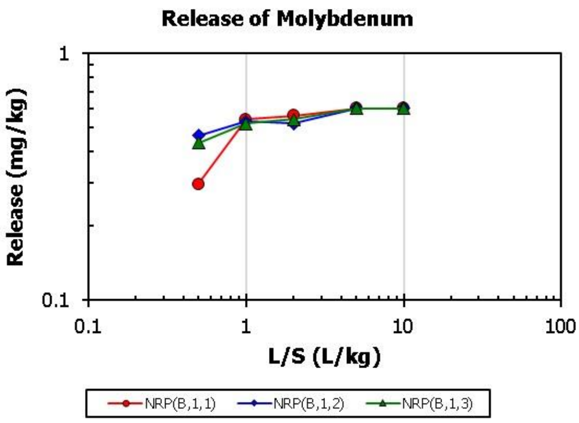

Magnesium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

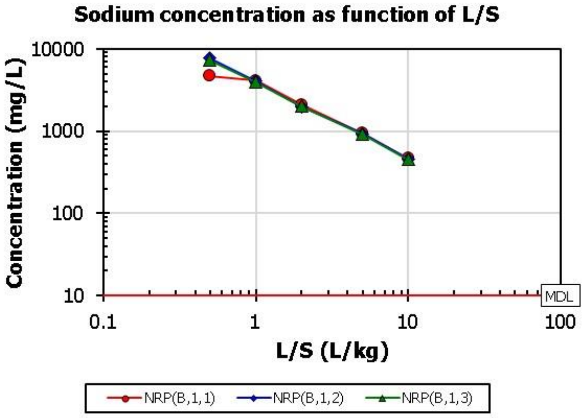

Release of Magnesium
Release (mg/kg)
100
10
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

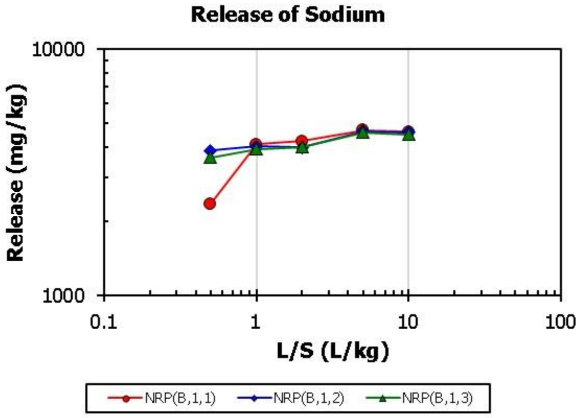

Manganese concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

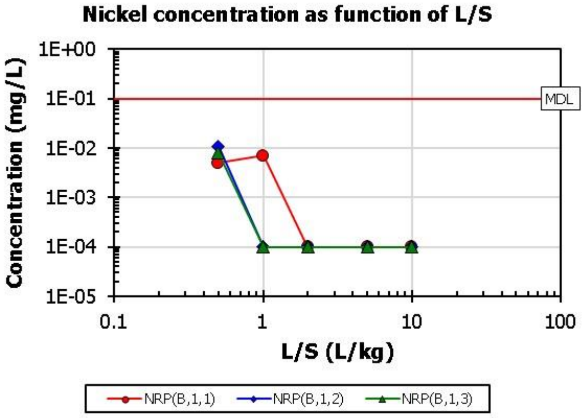

Release of Manganese
Release (mg/kg)
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

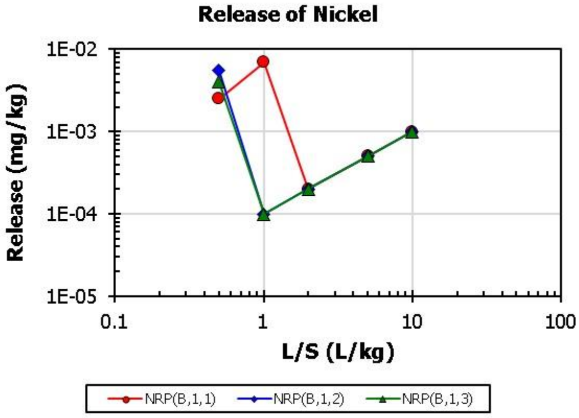

Molybdenum concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

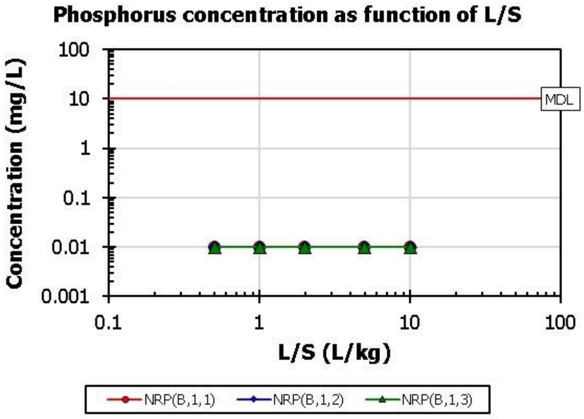

Release of Molybdenum
Release (mg/kg)
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

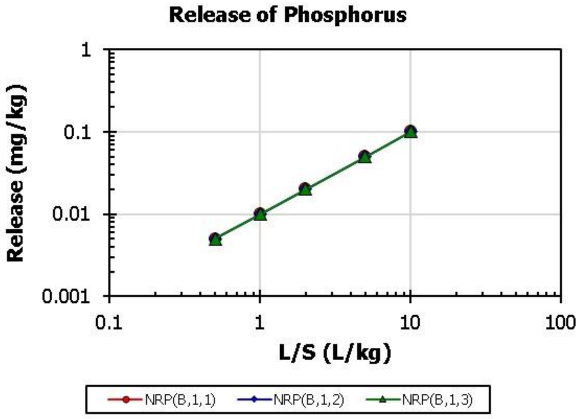

Sodium concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

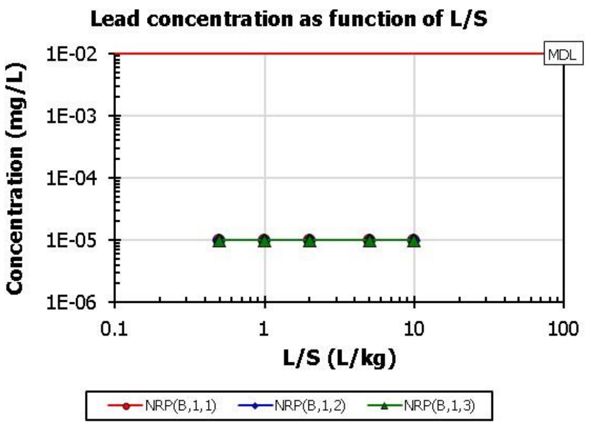

Release of Sodium
Release (mg/kg)
10000
1000
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

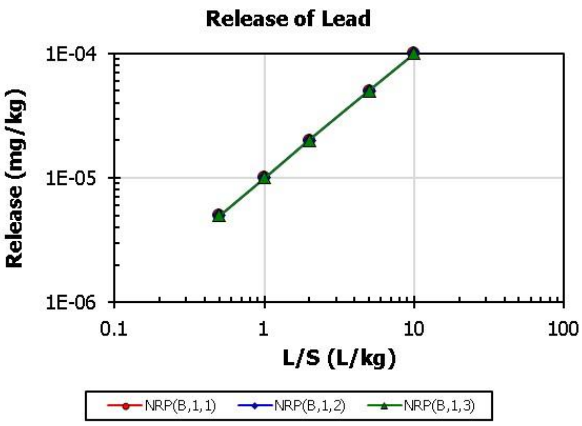

Nickel concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

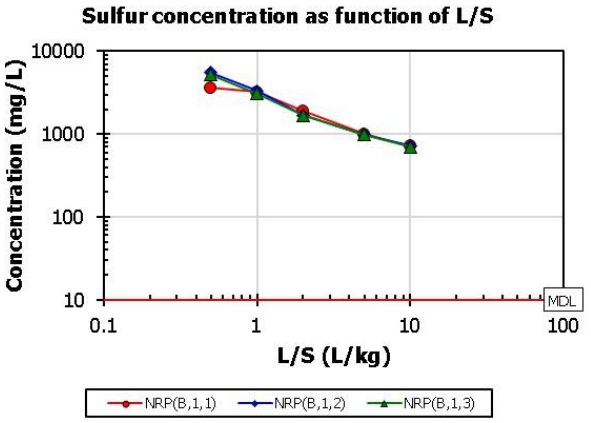

Release of Nickel
Release (mg/kg)
1E-02
1E-03
1E-04
1E-05
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

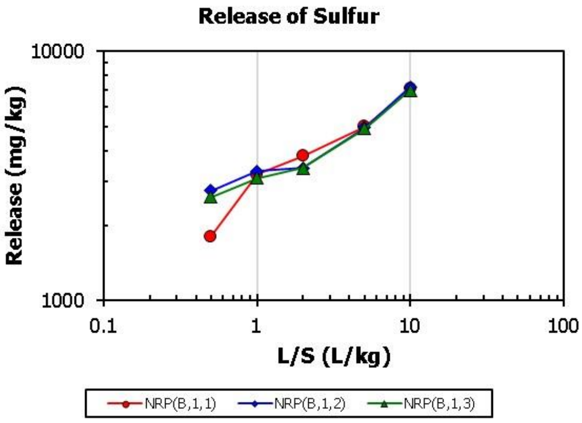

Phosphorus concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
MDL
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

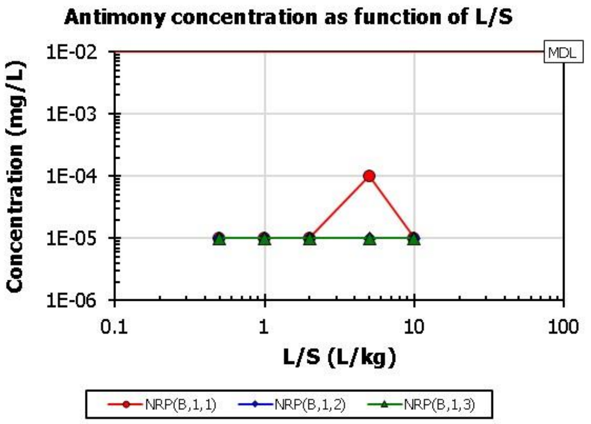

Release of Phosphorus
Release (mg/kg)
1
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

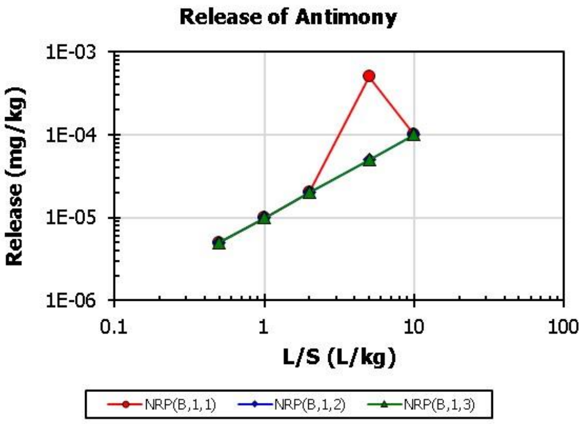

Lead concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

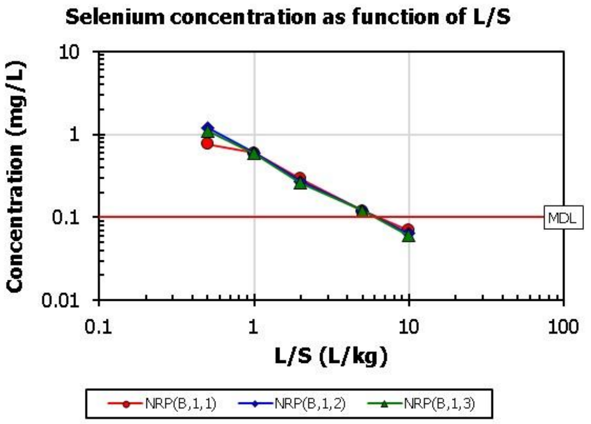

Release of Lead
Release (mg/kg)
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

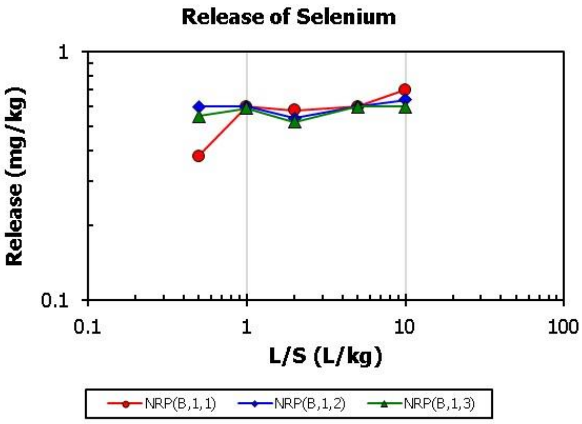

Sulfur concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

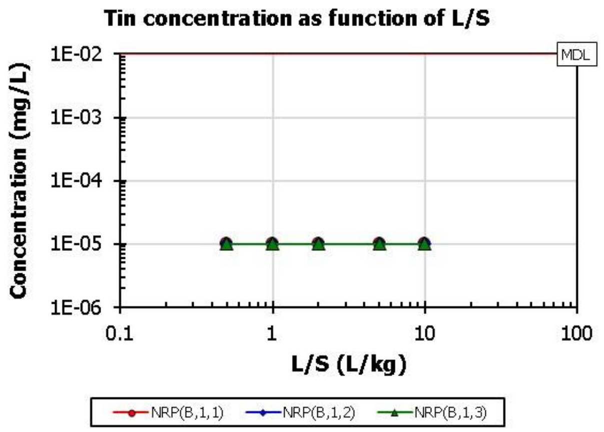

Release of Sulfur
Release (mg/kg)
10000
1000
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

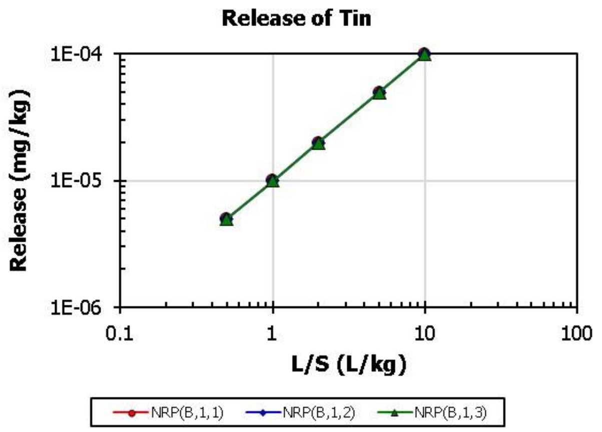

Antimony concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

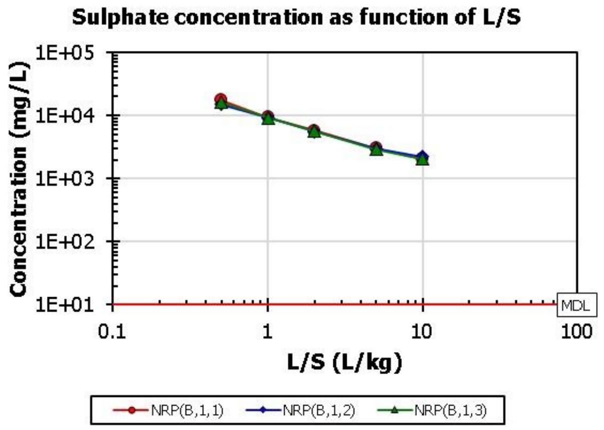

Release of Antimony
Release (mg/kg)
1E-03
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

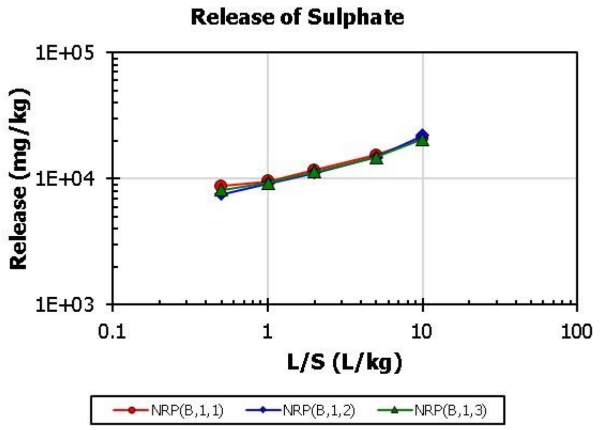

Selenium concentration as function of L/S
Concentration (mg/L)
10
1
0.1
0.01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

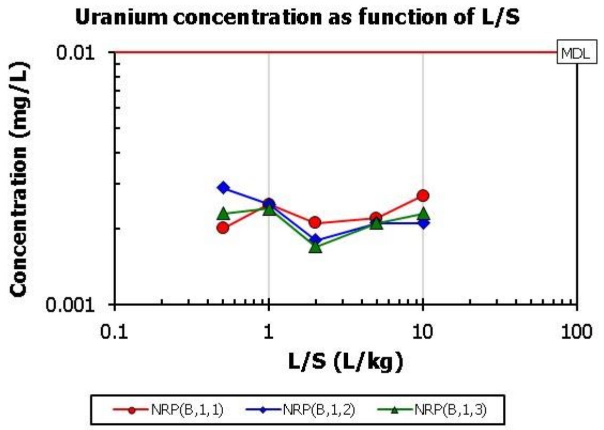

Release of Selenium
Release (mg/kg)
1
0.1
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

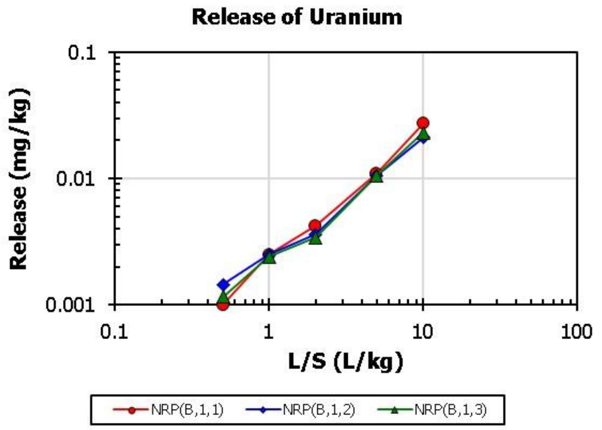

Tin concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

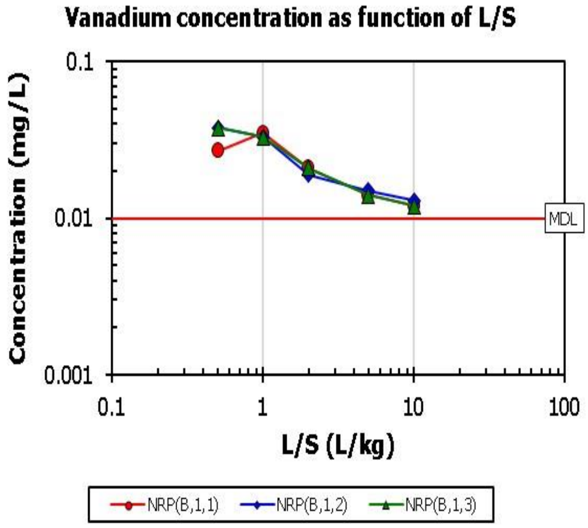

Release of Tin
Release (mg/kg)
1E-04
1E-05
1E-06
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

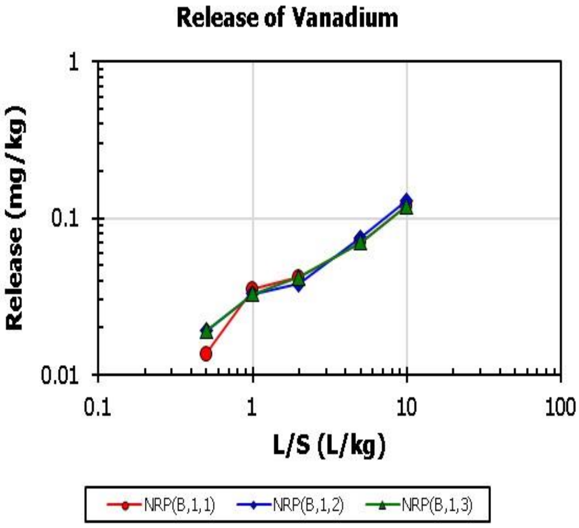

Sulphate concentration as function of L/S
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

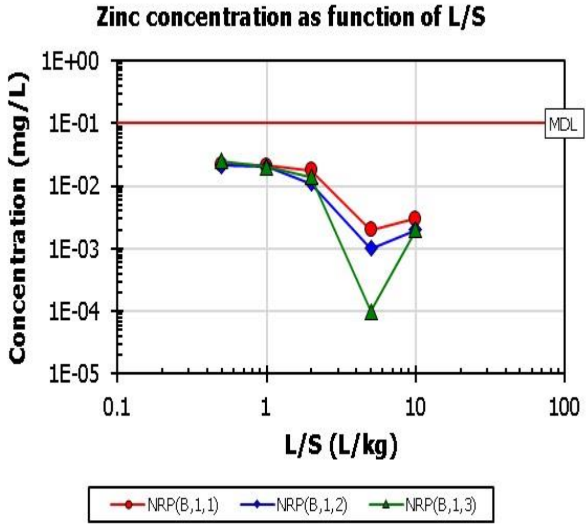

Release of Sulphate
Release (mg/kg)
1E+05
1E+04
1E+03
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

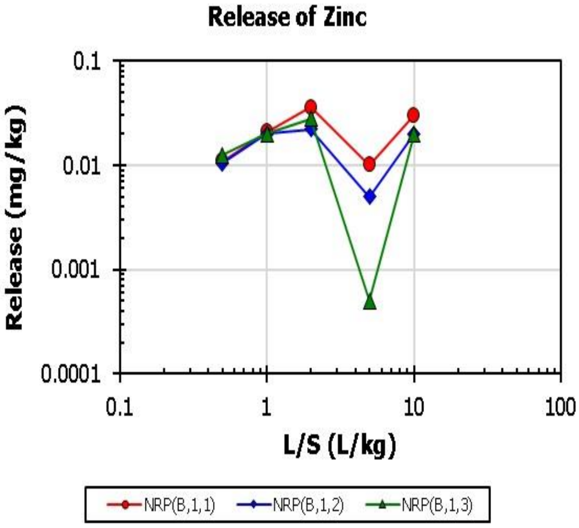

Uranium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)


Release of Uranium
Release (mg/kg)
0.1
0.01
0.001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

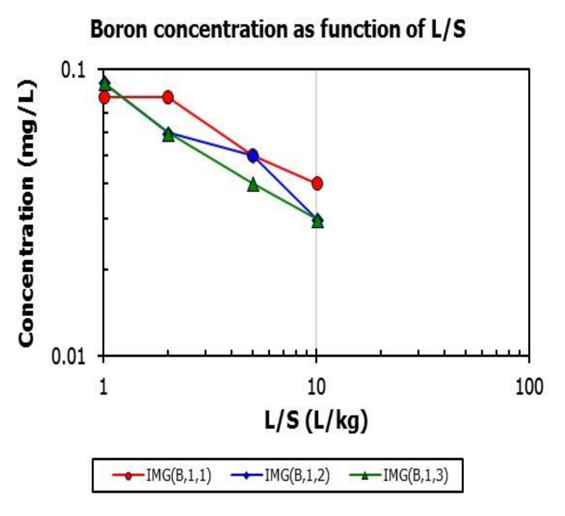

Vanadium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

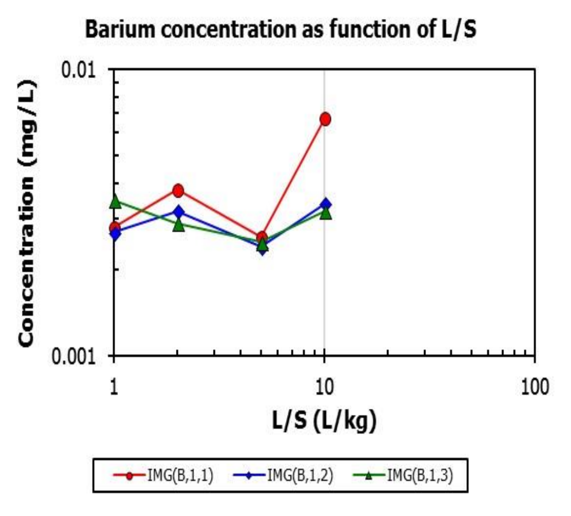

Release of Vanadium
Release (mg/kg)
1
0.1
0.01
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

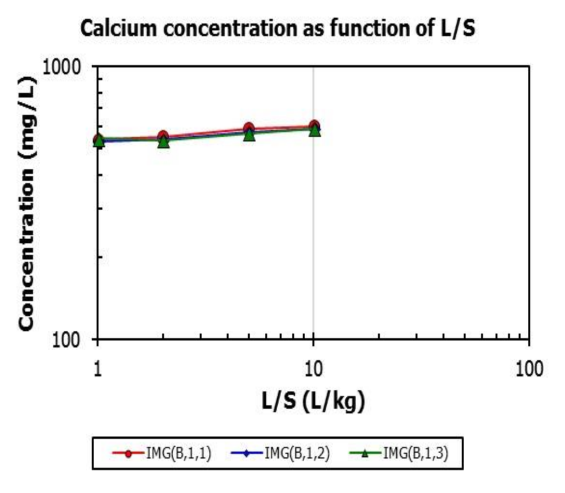

Zinc concentration as function of L/S
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
MDL
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

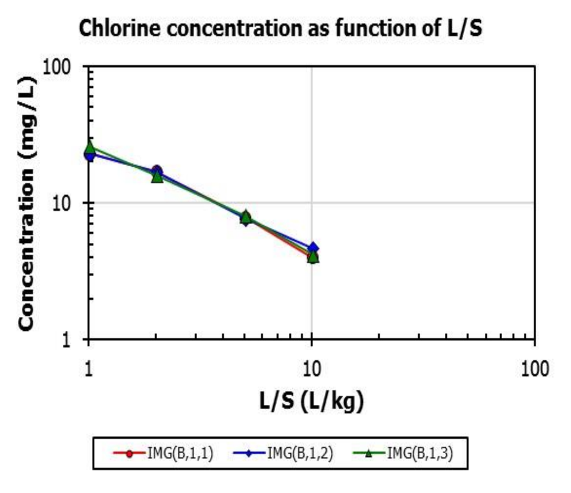

Release of Zinc
Release (mg/kg)
0.1
0.01
0.001
0.0001
0.1
1
10
100
L/S (L/kg)
NRP(B,1,1)
NRP(B,1,2)
NRP(B,1,3)

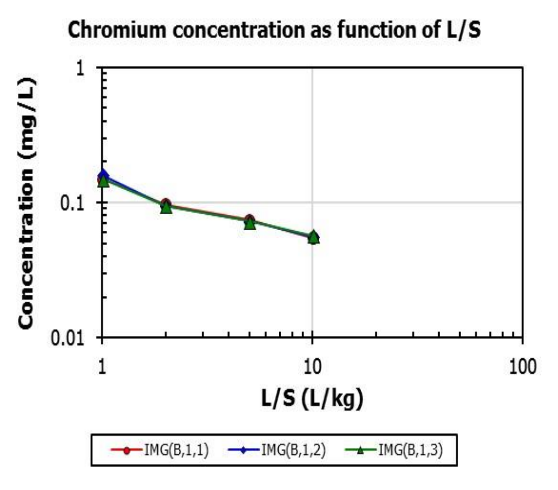
A7-3: By-product Ironman Gypsum (IMG)

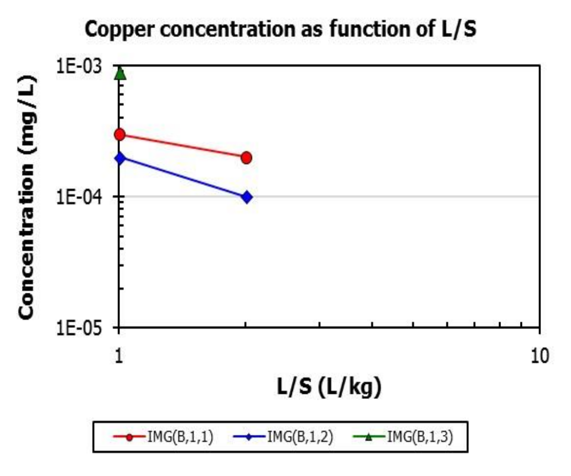

Boron concentration as function of L/S

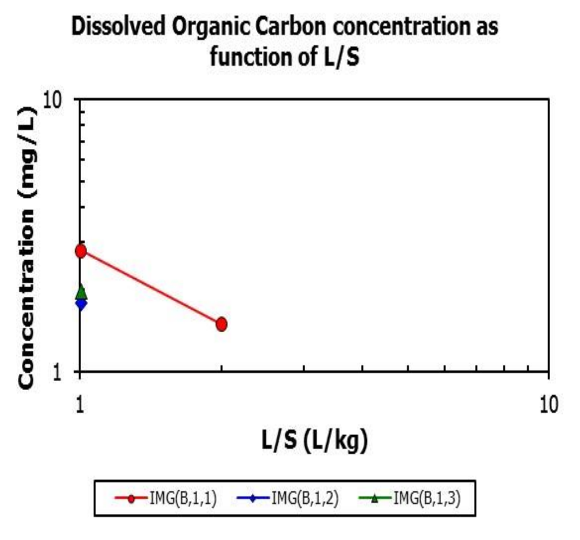

Barium concentration as function of L/S

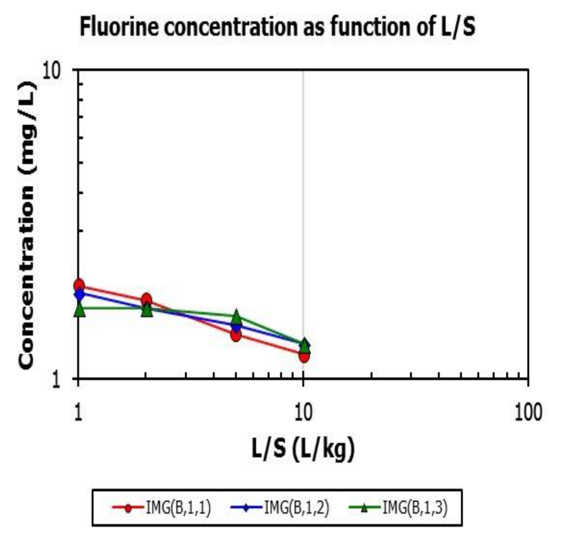

Calcium concentration as function of L/S

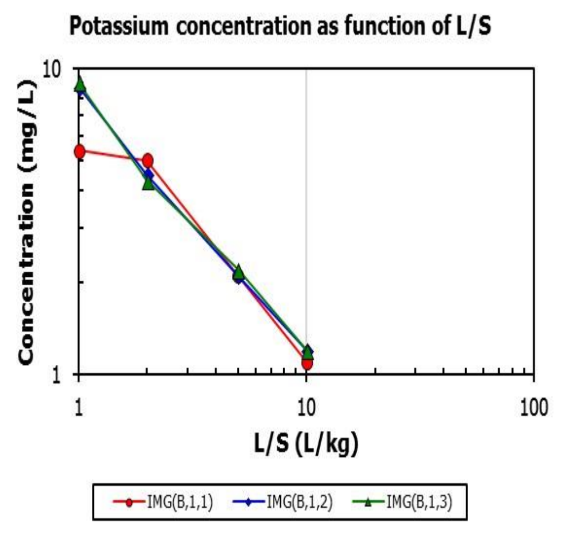

Chlorine concentration as function of L/S

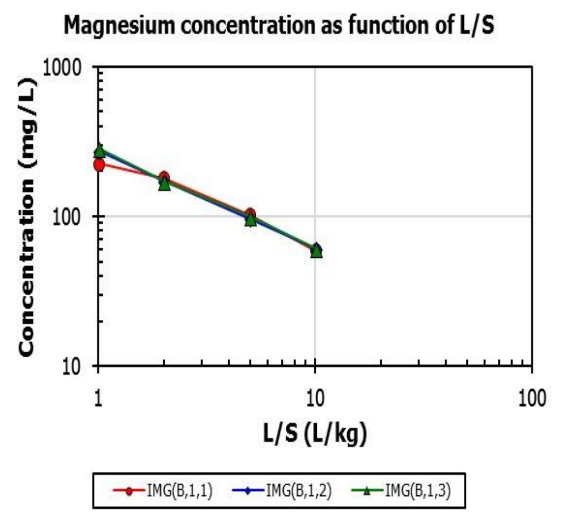

Chromium concentration as function of L/S

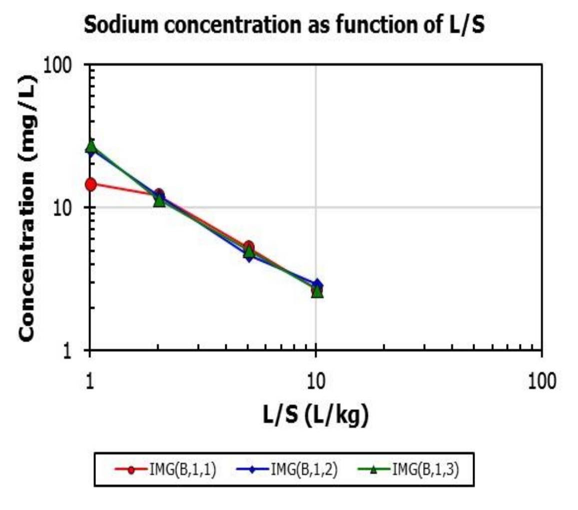

Copper concentration as function of L/S

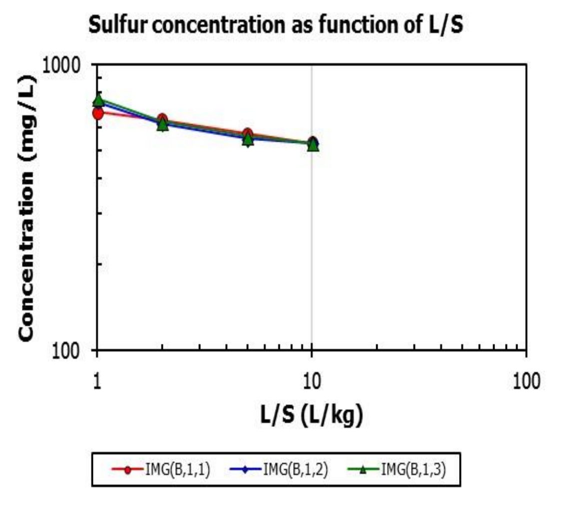

Dissolved Organic Carbon concentration as function of L/S
Concentration (mg/L)
10
1
1
10
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

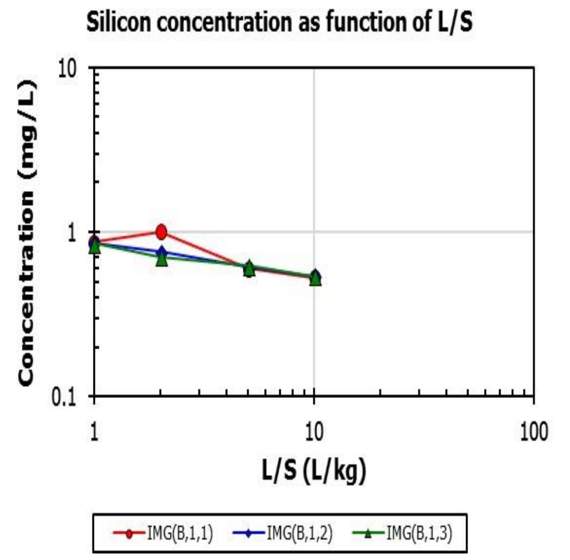

Fluorine concentration as function of L/S
Concentration (mg/L)
10
1
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

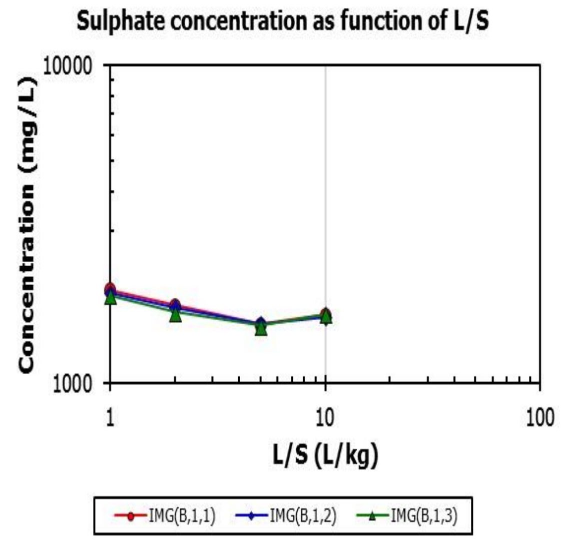

Potassium concentration as function of L/S
Concentration (mg/L)
10
1
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

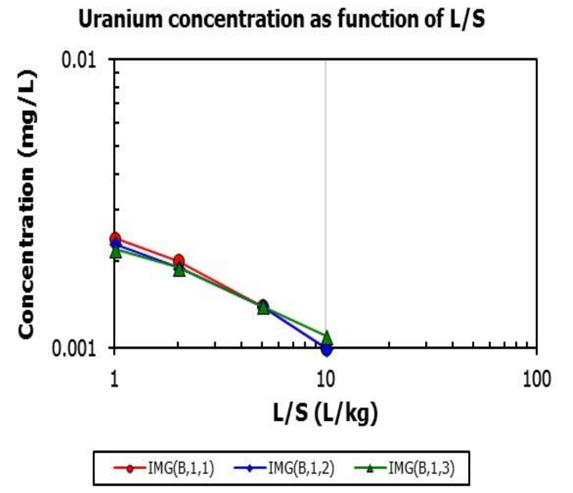

Magnesium concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

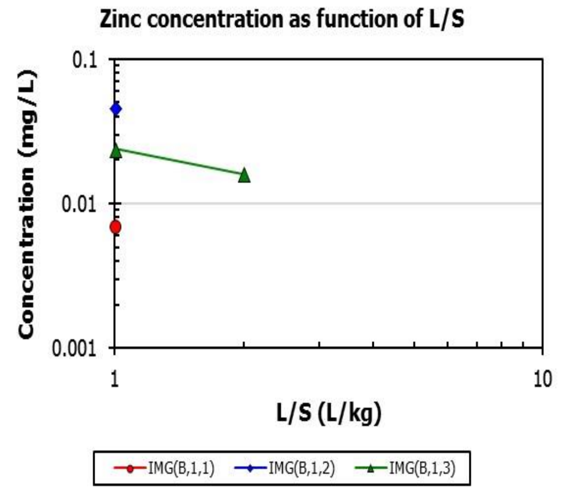

Sodium concentration as function of L/S
Concentration (mg/L)
100
10
1
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)


Sulfur concentration as function of L/S
Concentration (mg/L)
1000
100
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

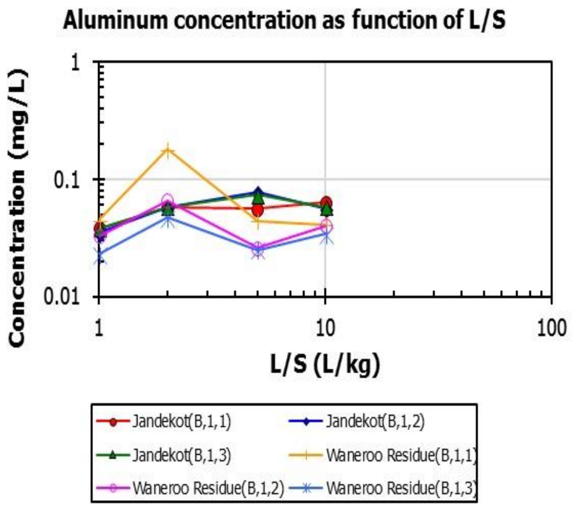

Silicon concentration as function of L/S
Concentration (mg/L)
10
1
0.1
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

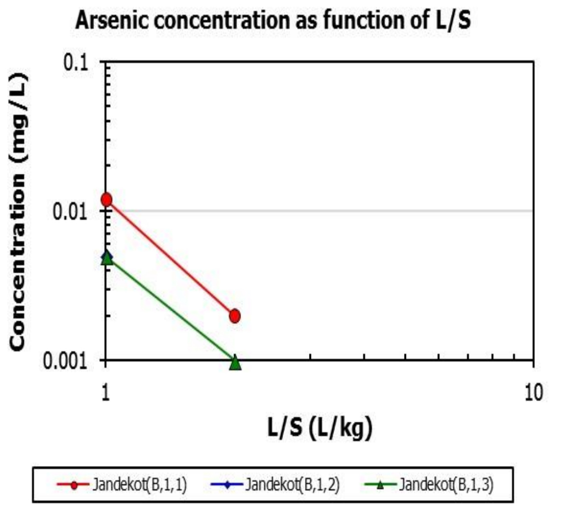

Sulphate concentration as function of L/S
Concentration (mg/L)
10000
1000
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

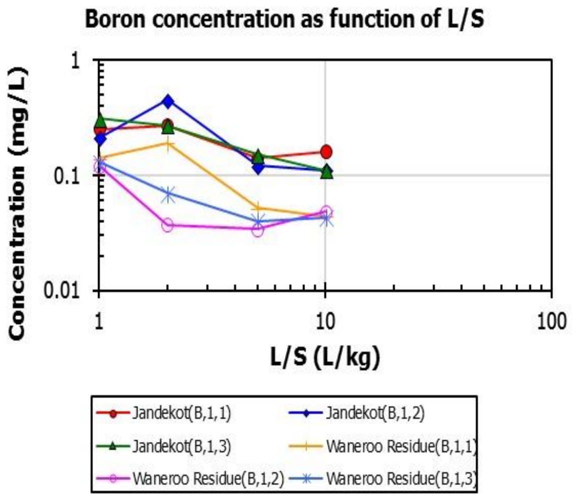

Uranium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
1
10
100
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

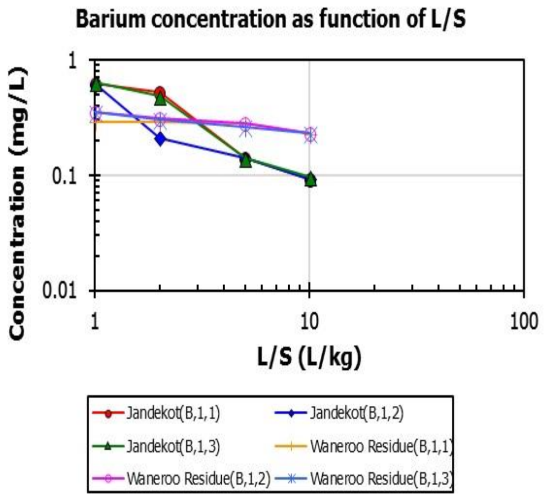

Zinc concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
1
10
L/S (L/kg)
IMG(B,1,1)
IMG(B,1,2)
IMG(B,1,3)

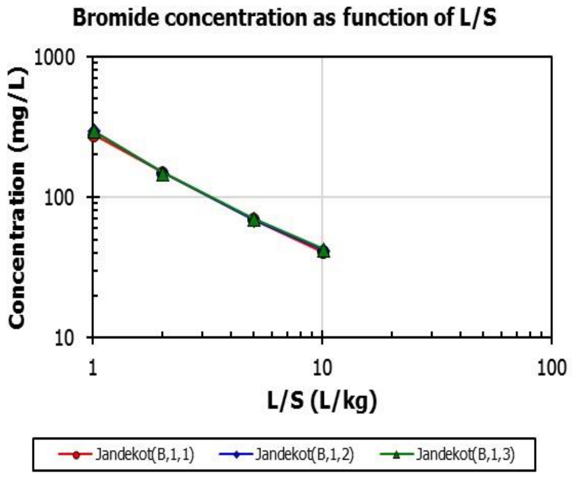
A7-4: Ground water Residue: Jandakot and Wanneroo

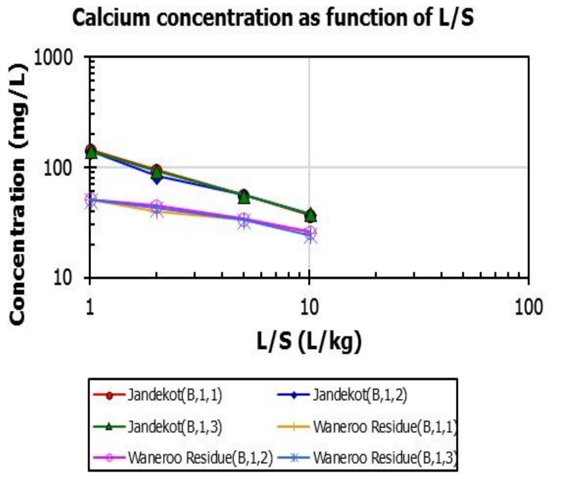


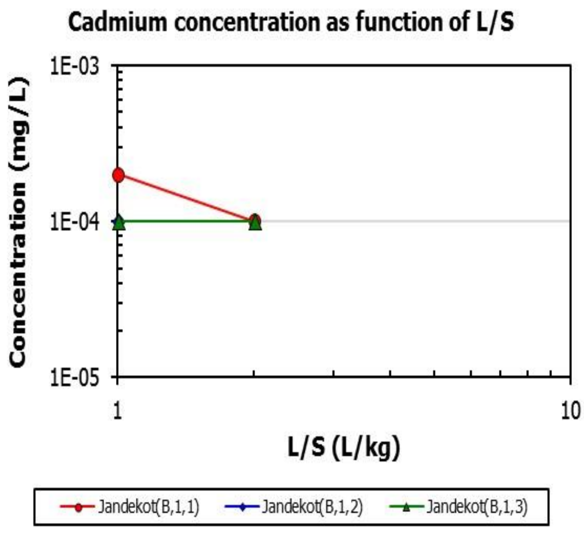


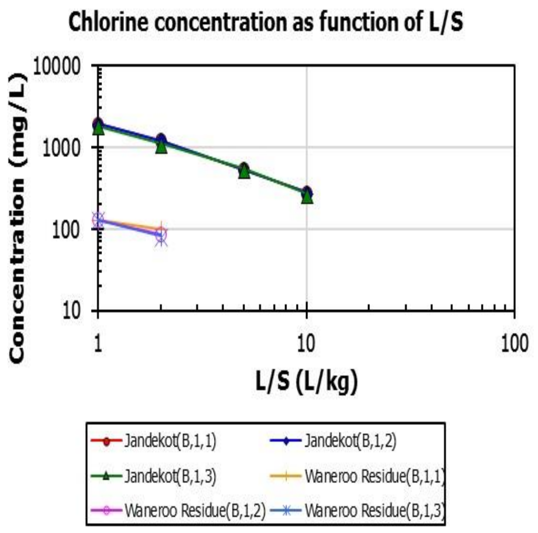


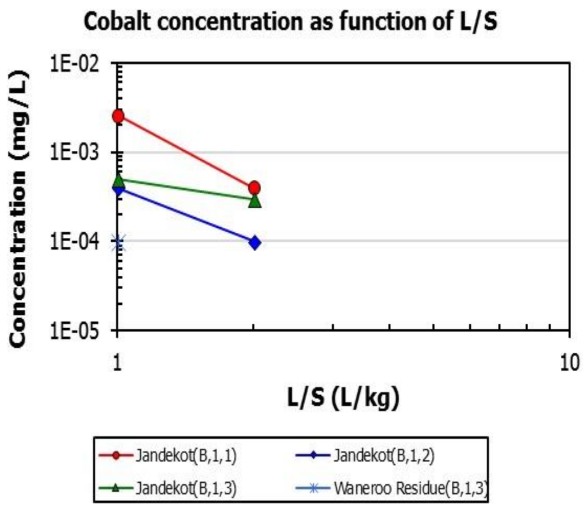


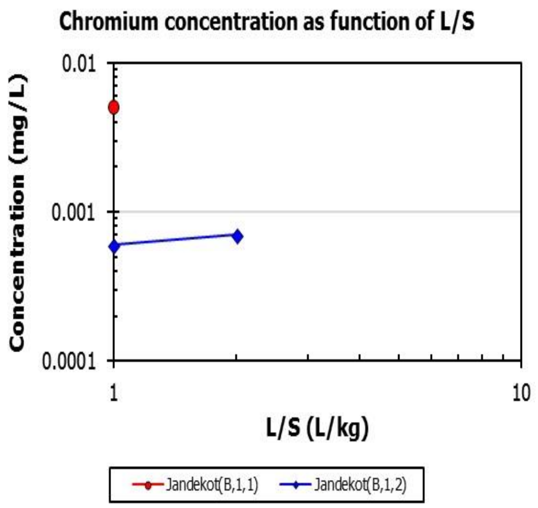


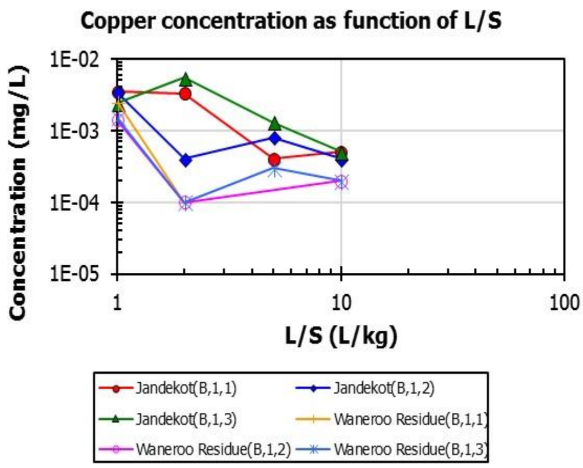


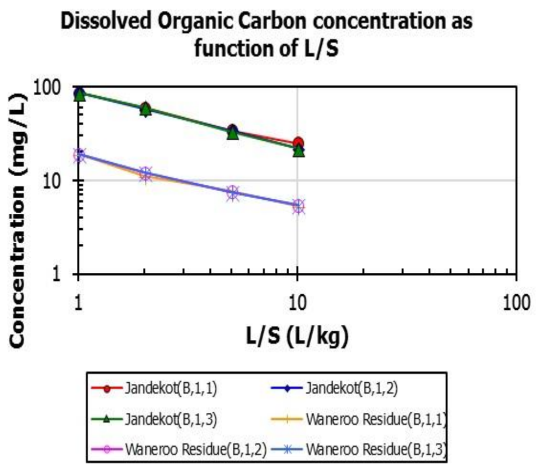

Cadmium concentration as function of L/S

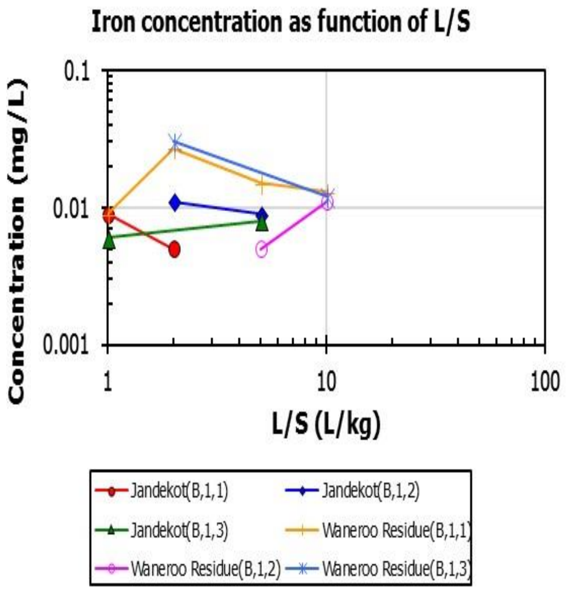

Chlorine concentration as function of L/S

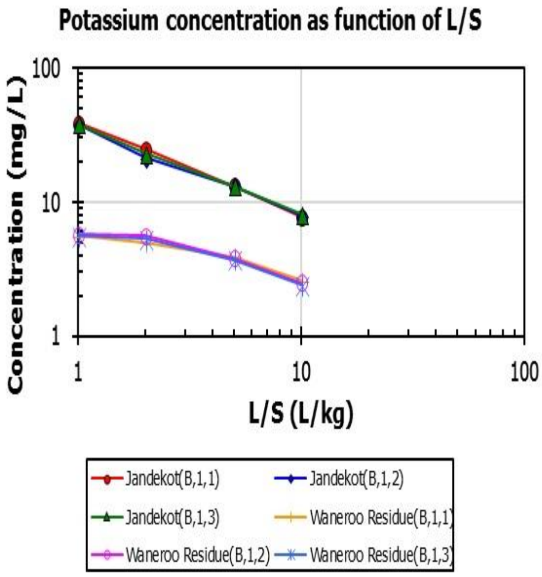

Cobalt concentration as function of L/S

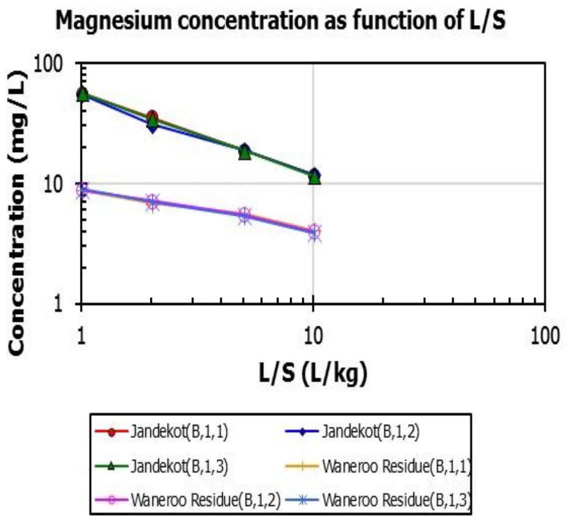

Chromium concentration as function of L/S

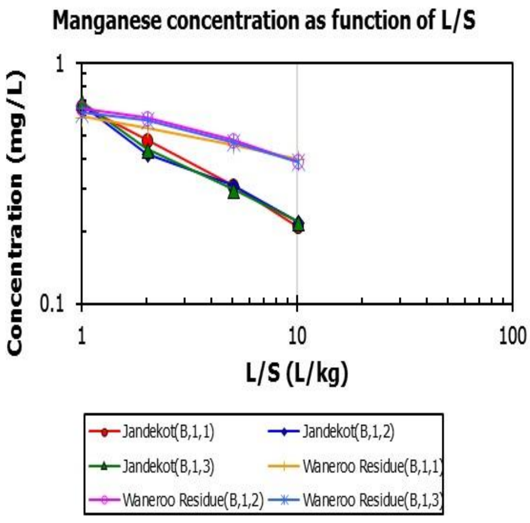

Copper concentration as function of L/S

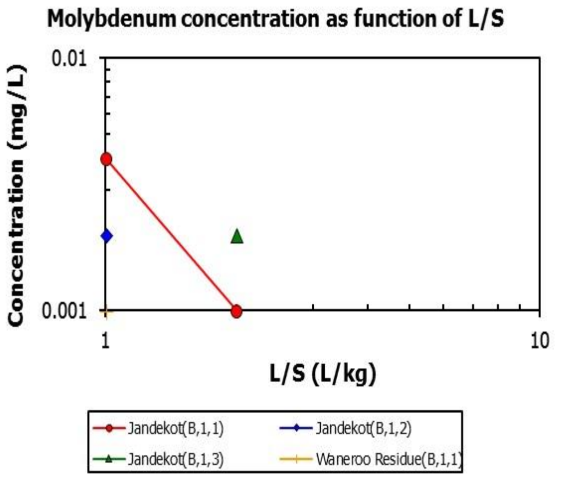

Dissolved Organic Carbon concentration as function of L/S

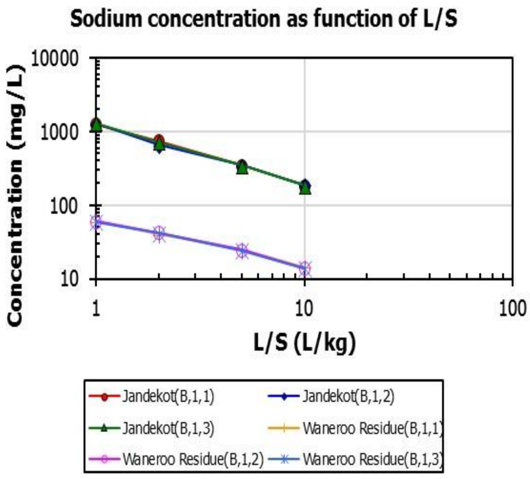

Iron concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

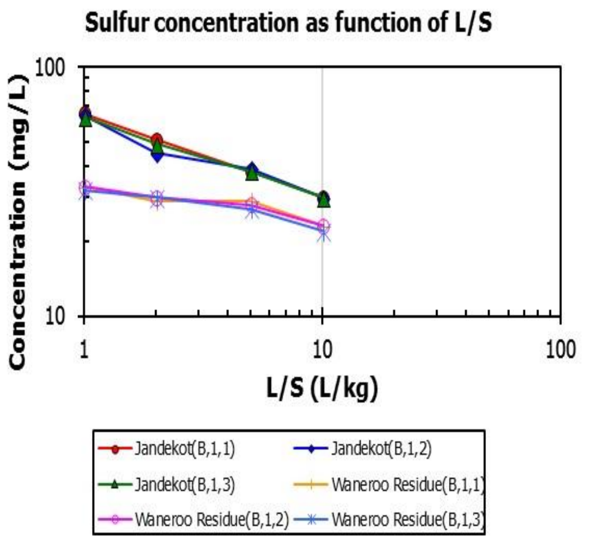

Potassium concentration as function of L/S
Concentration (mg/L)
100
10
1
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

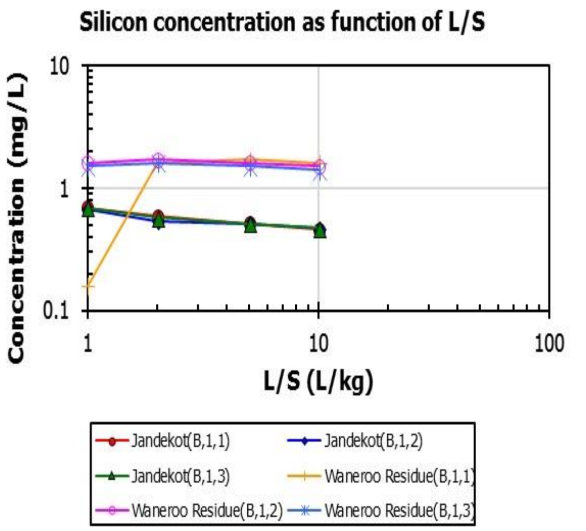

Magnesium concentration as function of L/S
Concentration (mg/L)
100
10
1
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

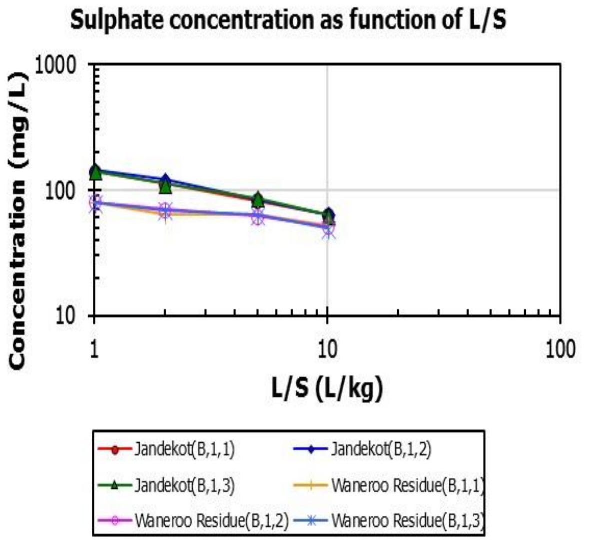

Manganese concentration as function of L/S
Concentration (mg/L)
1
0.1
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

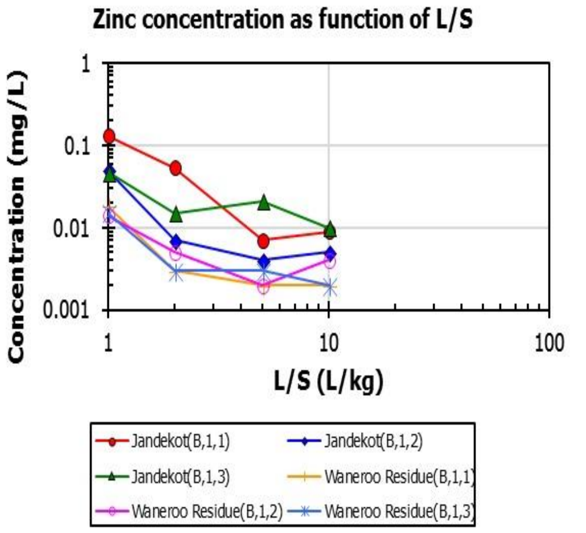

Molybdenum concentration as function of L/S
Concentration (mg/L)
0.01
0.001
1
10
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)


Sodium concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

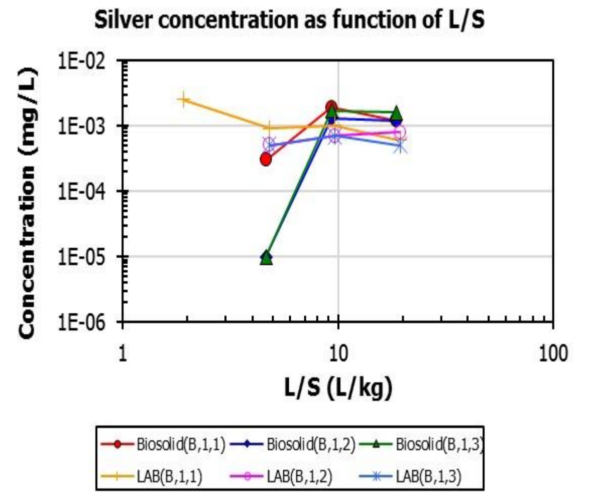

Sulfur concentration as function of L/S
Concentration (mg/L)
100
10
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

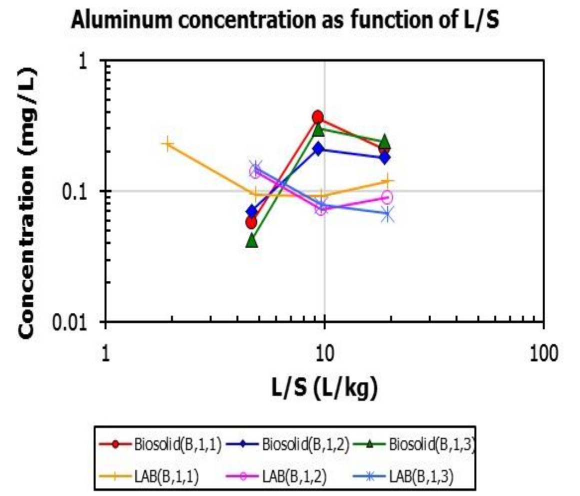

Silicon concentration as function of L/S
Concentration (mg/L)
10
1
0.1
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

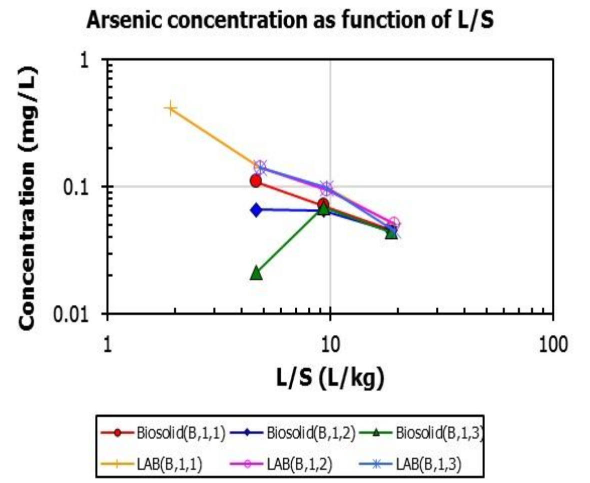

Sulphate concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

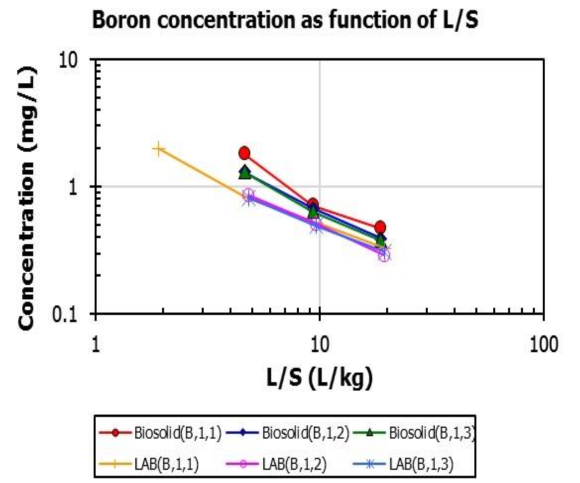

Zinc concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
0.001
1
10
100
L/S (L/kg)
Jandekot(B,1,1)
Jandekot(B,1,2)
Jandekot(B,1,3)
Waneroo Residue(B,1,1)
Waneroo Residue(B,1,2)
Waneroo Residue(B,1,3)

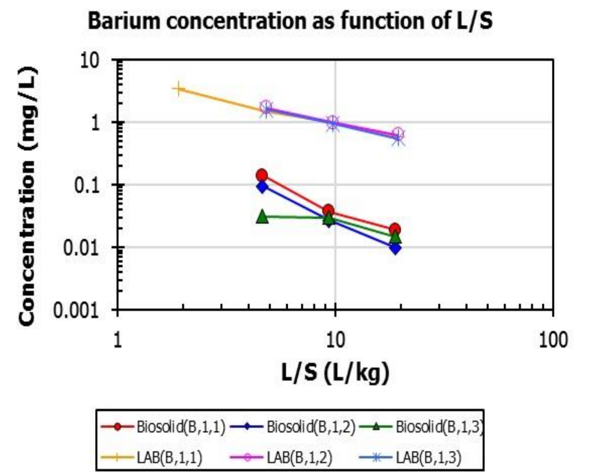
A7-5: Biosolids Cake and Lime Amended Biosolid (LAB)

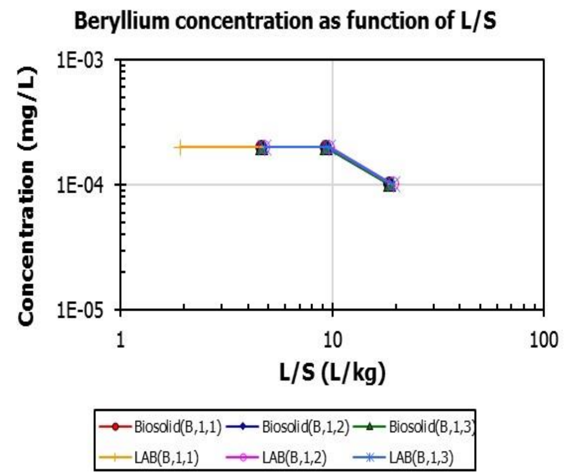


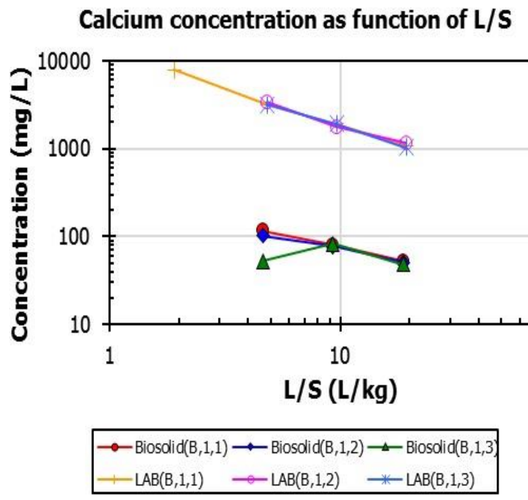


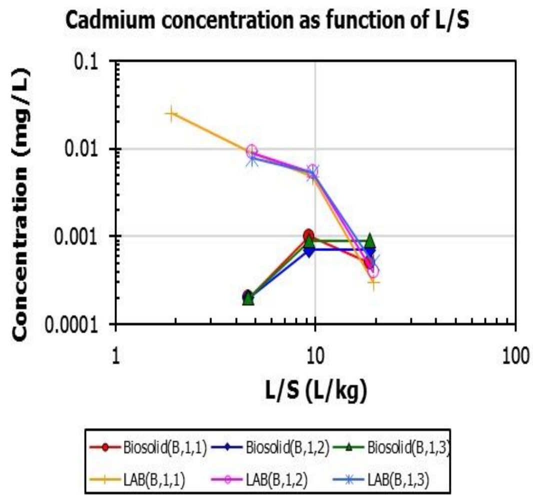


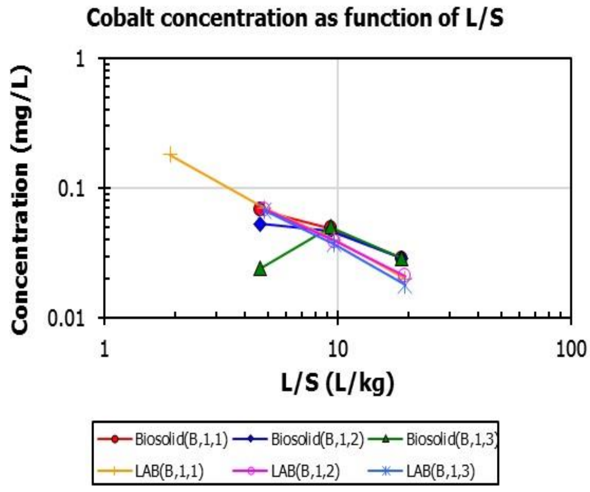


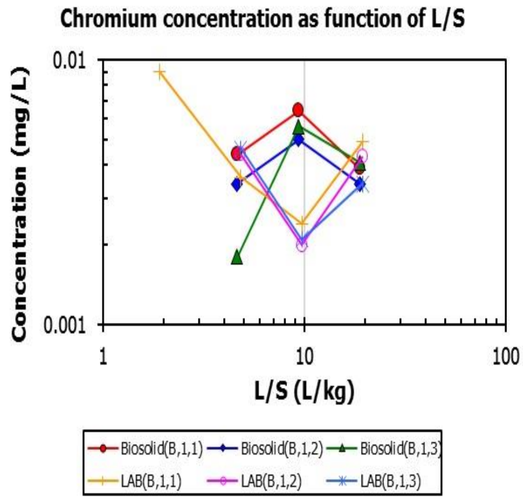


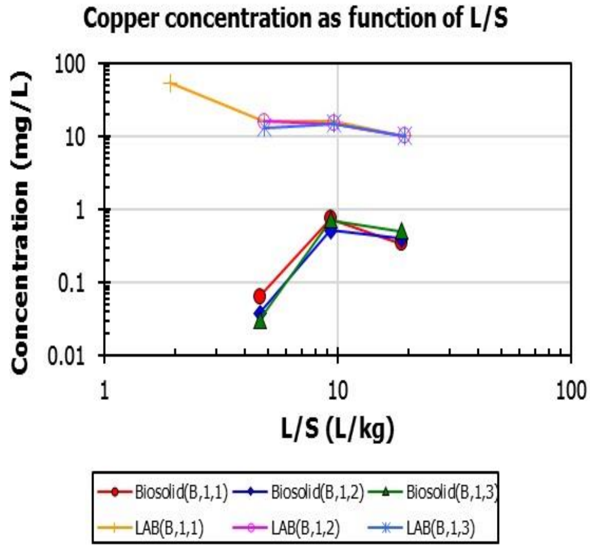


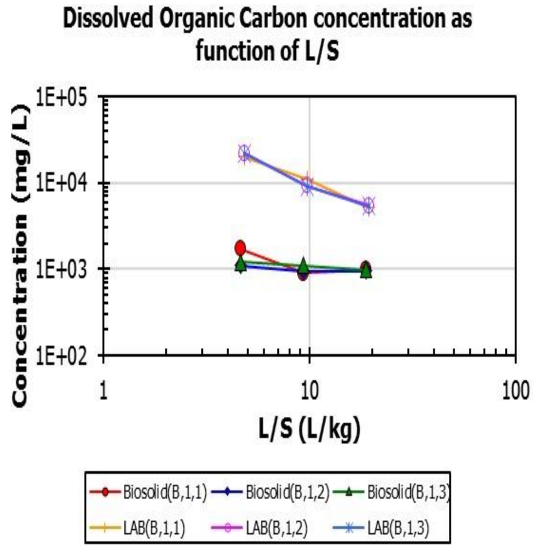

Calcium concentration as function of L/S
Concentration (mg/L)
10000
1000
100
10
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

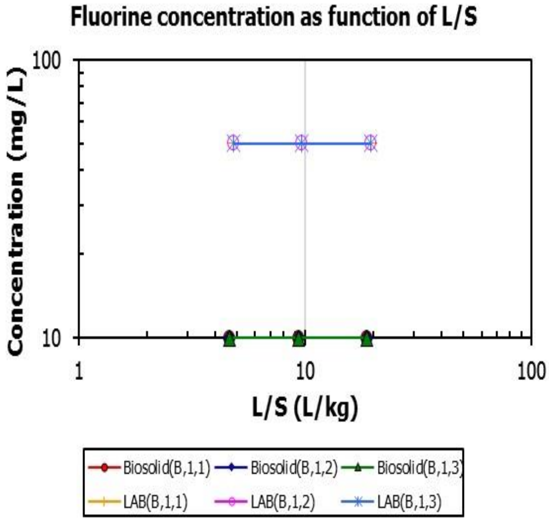

Cadmium concentration as function of L/S
Concentration (mg/L)
0.1
0.01
0.001
0.0001
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

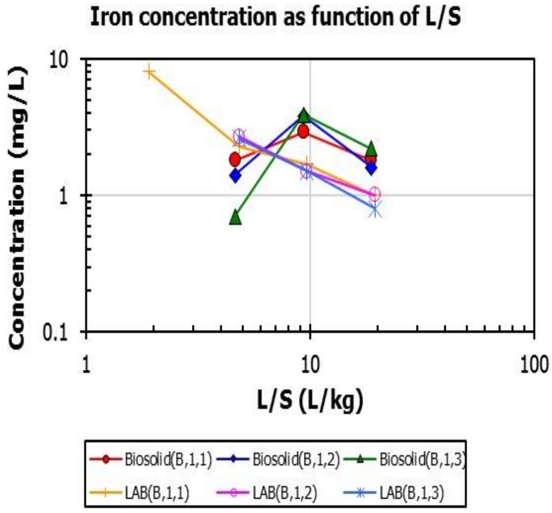

Cobalt concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

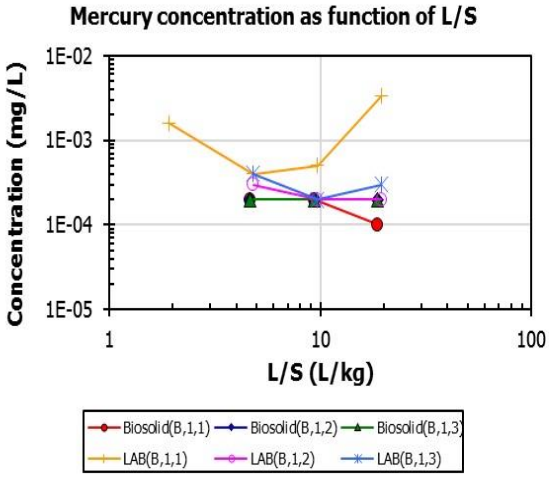

Chromium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

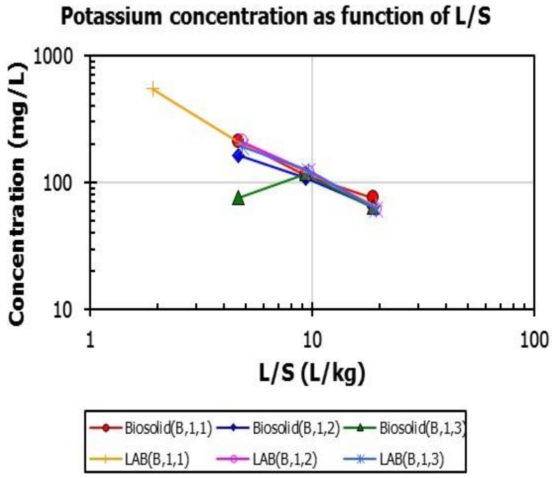

Copper concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
0.01
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

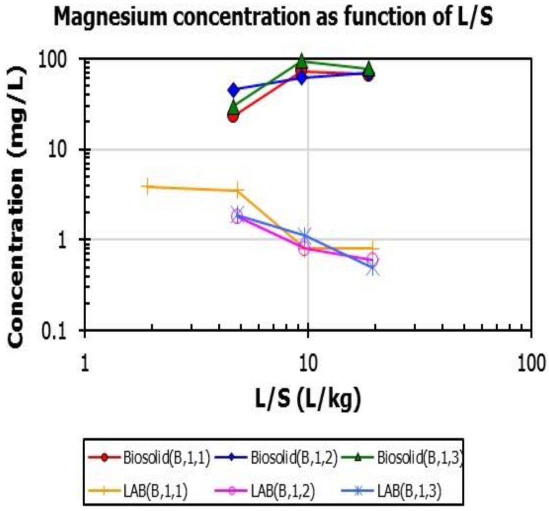

Dissolved Organic Carbon concentration as function of L/S
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

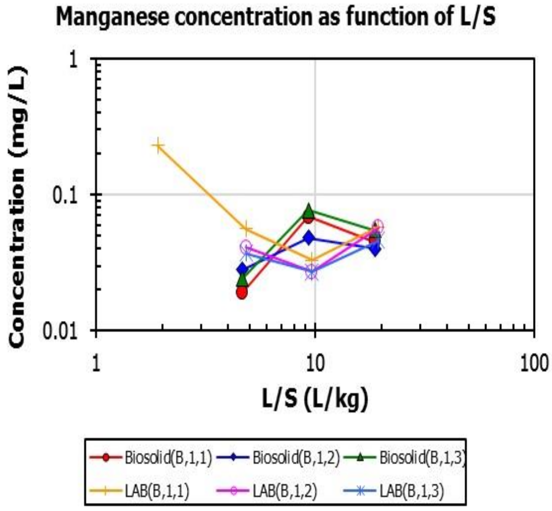

Fluorine concentration as function of L/S
Concentration (mg/L)
100
10
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)


Iron concentration as function of L/S
Concentration (mg/L)
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

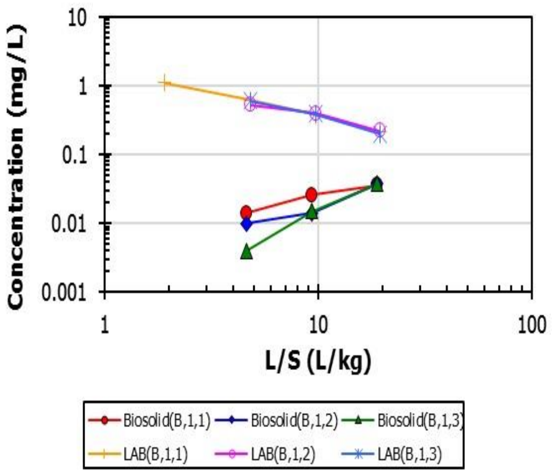

Mercury concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)


Potassium concentration as function of L/S
Concentration (mg/L)
1000
100
10
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

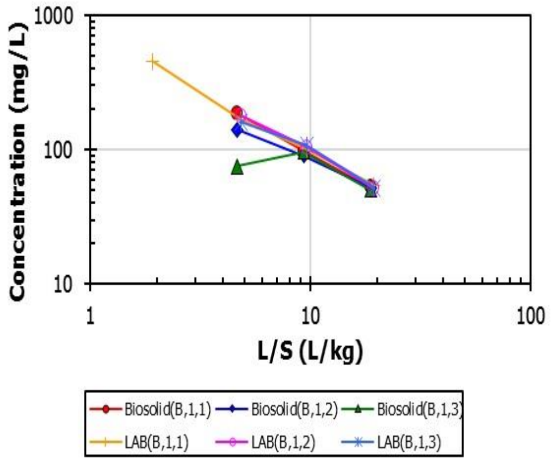

Magnesium concentration as function of L/S
Concentration (mg/L)
100
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)


Manganese concentration as function of L/S
Concentration (mg/L)
1
0.1
0.01
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

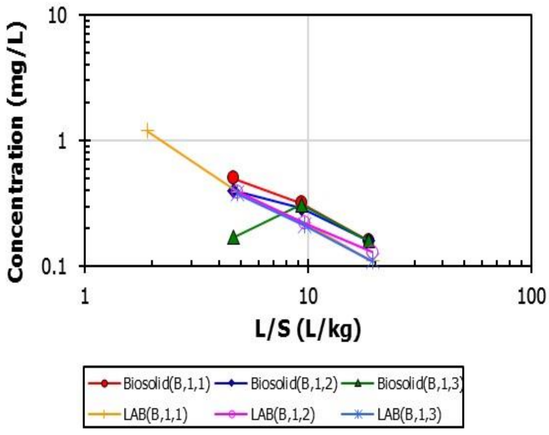
Molybdenum concentration as function of L/S



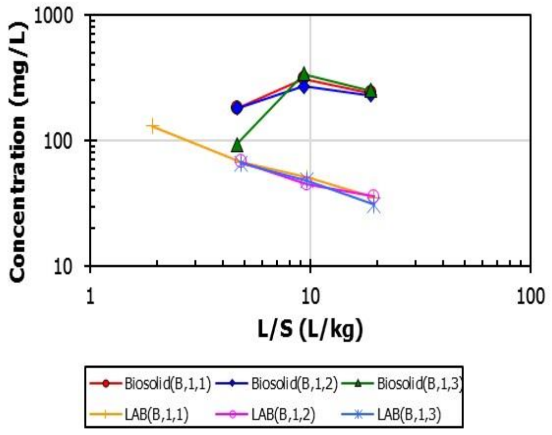
Sodium concentration as function of L/S



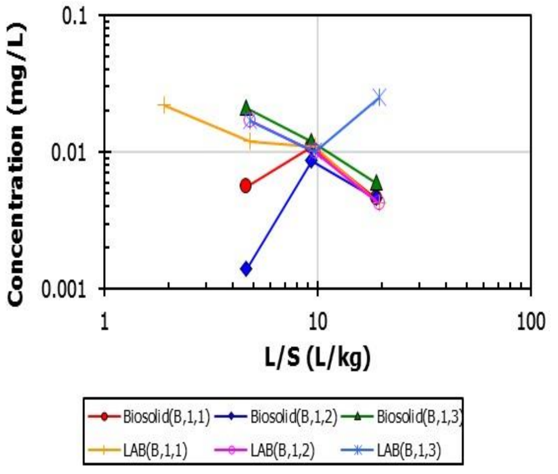
Nickel concentration as function of L/S



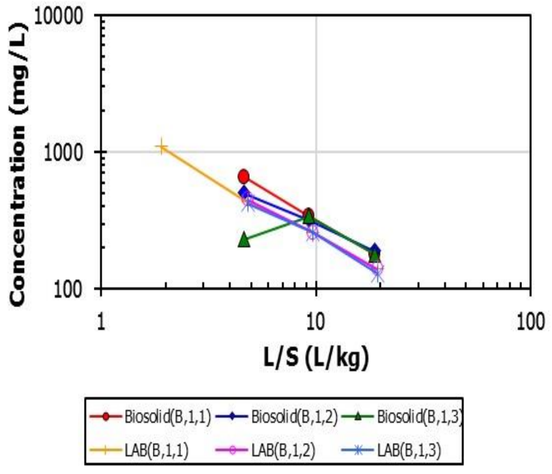
Phosphorus concentration as function of L/S

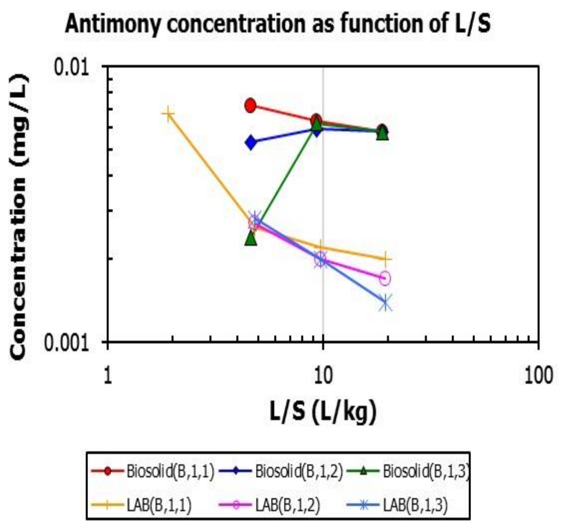


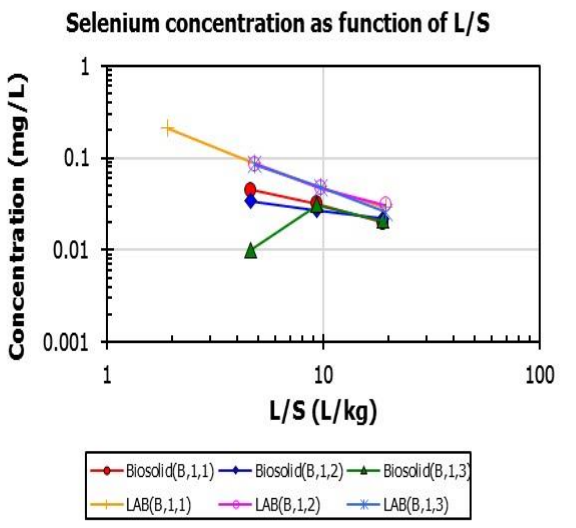
Lead concentration as function of L/S

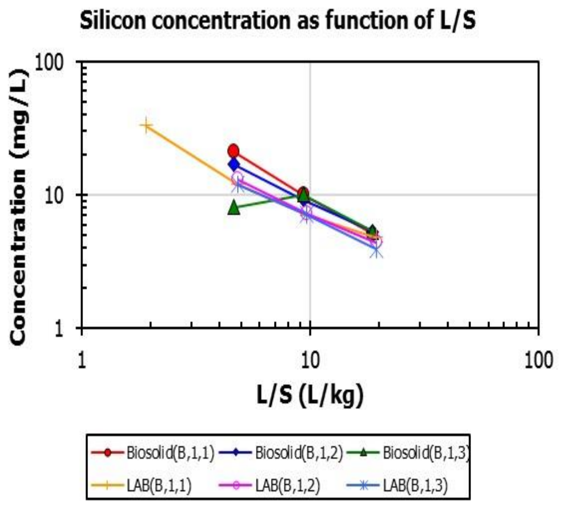


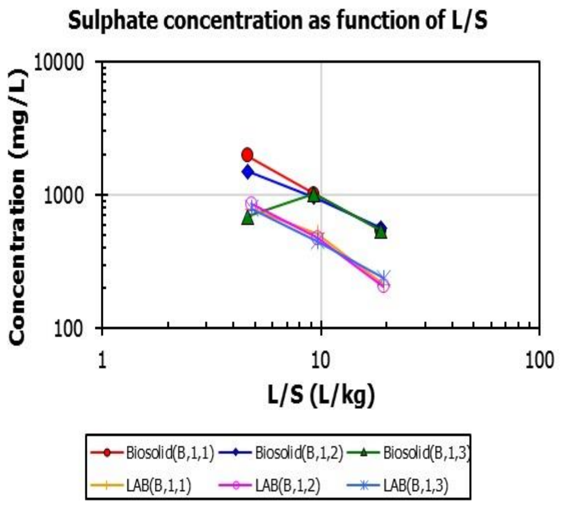
Sulfur concentration as function of L/S

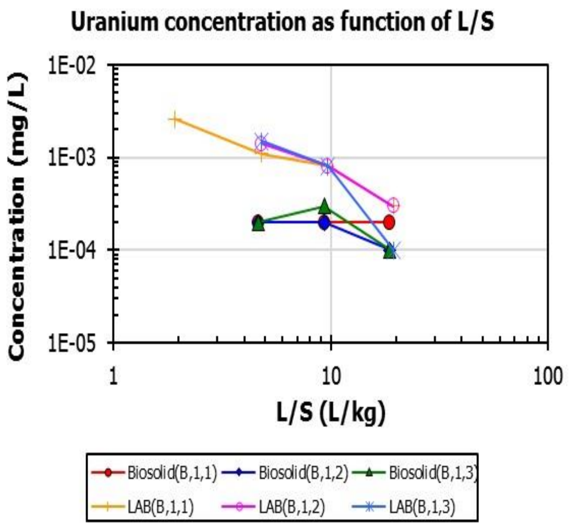


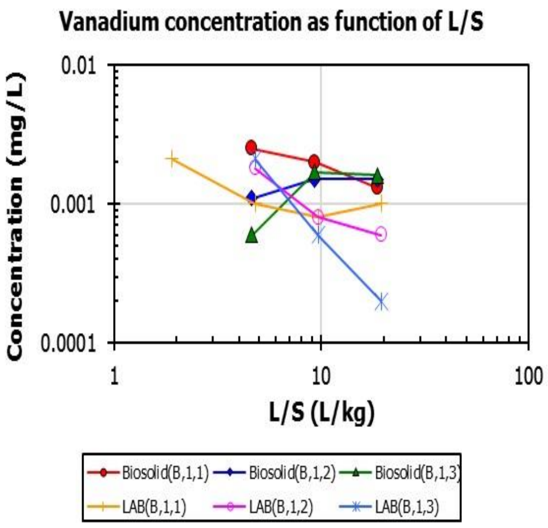

Antimony concentration as function of L/S

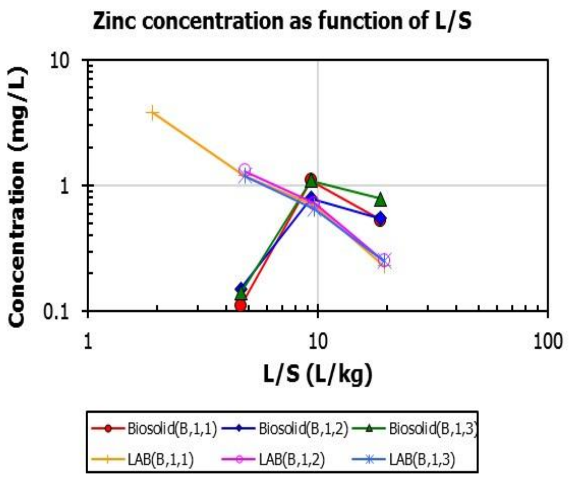

Selenium concentration as function of L/S


Silicon concentration as function of L/S


Sulphate concentration as function of L/S

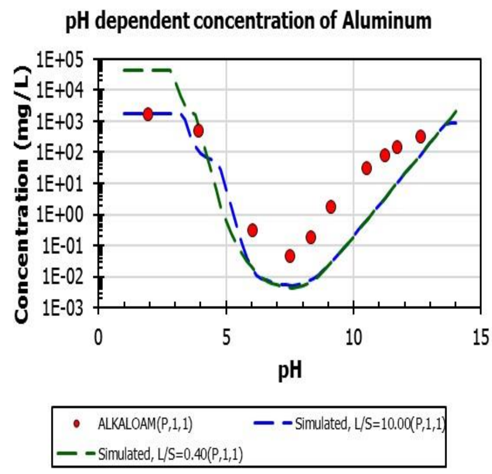

Uranium concentration as function of L/S
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

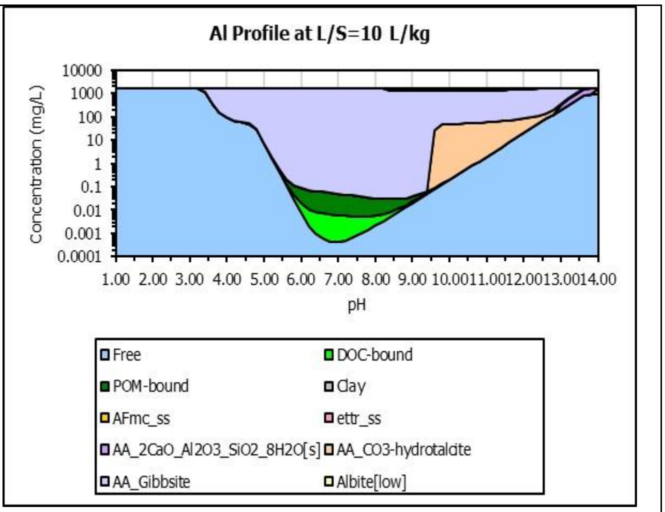

Vanadium concentration as function of L/S
Concentration (mg/L)
0.01
0.001
0.0001
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

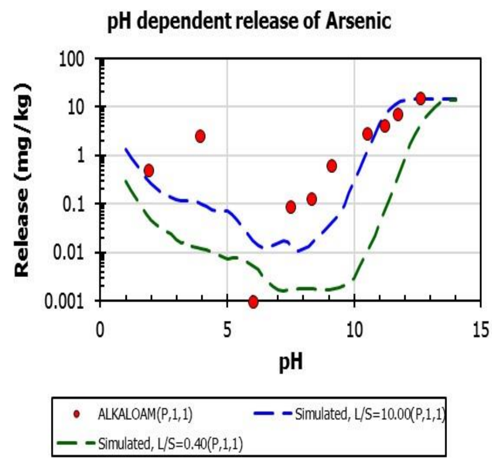

Zinc concentration as function of L/S
Concentration (mg/L)
10
1
0.1
1
10
100
L/S (L/kg)
Biosolid(B,1,1)
Biosolid(B,1,2)
Biosolid(B,1,3)
LAB(B,1,1)
LAB(B,1,2)
LAB(B,1,3)

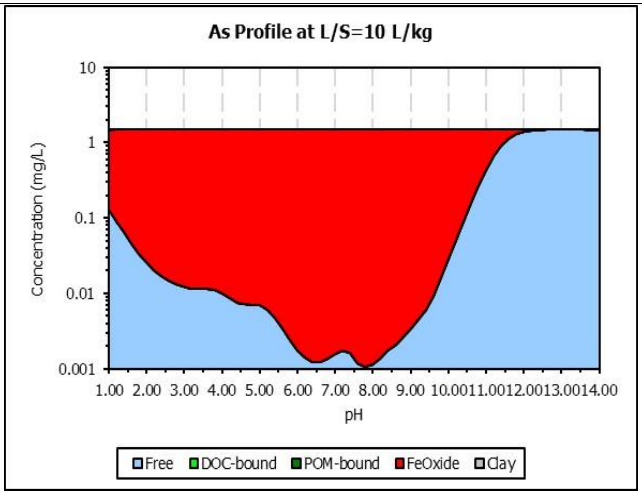
Appendix A8: Chemical Speciation Fingerprints for By-products.

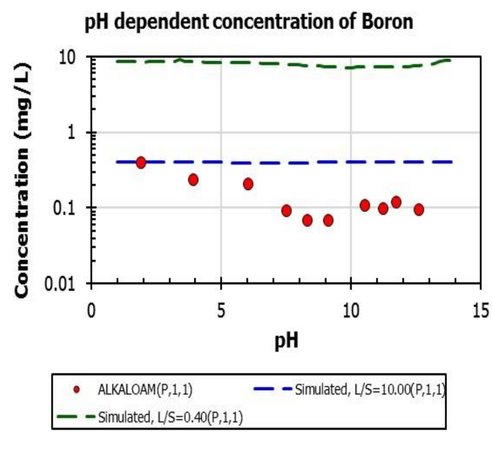
A8-1: By-product Alkaloam

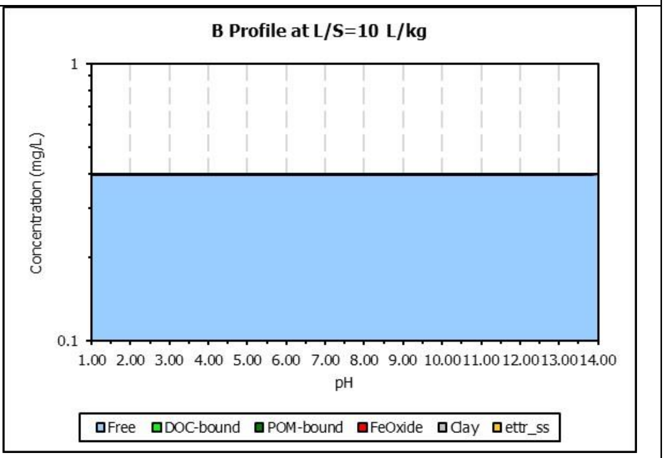


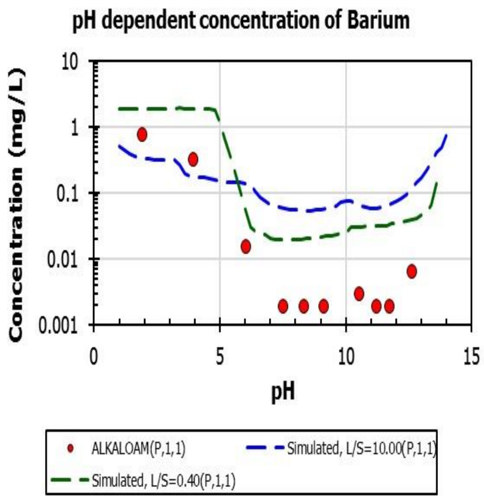


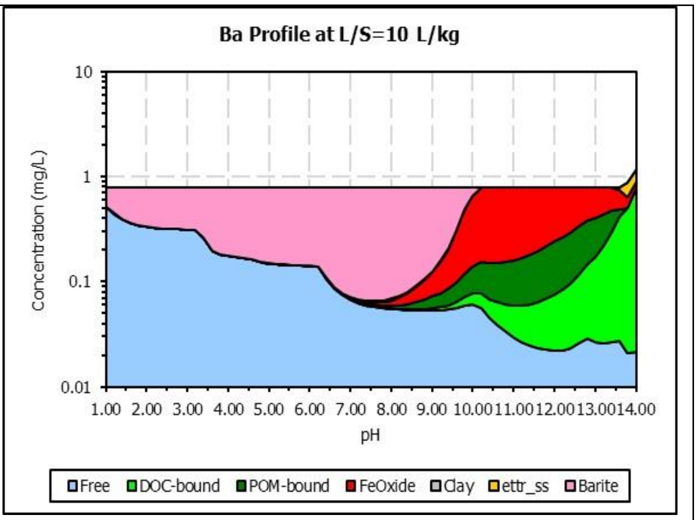


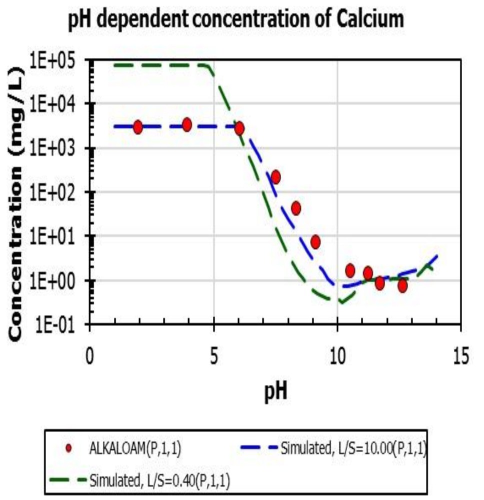


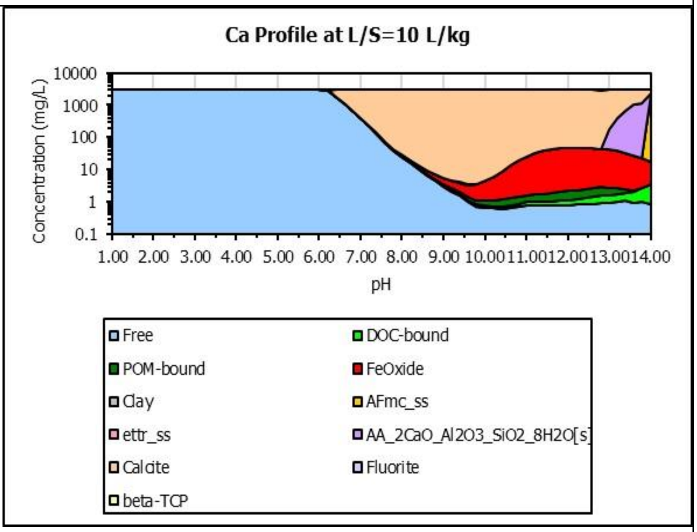


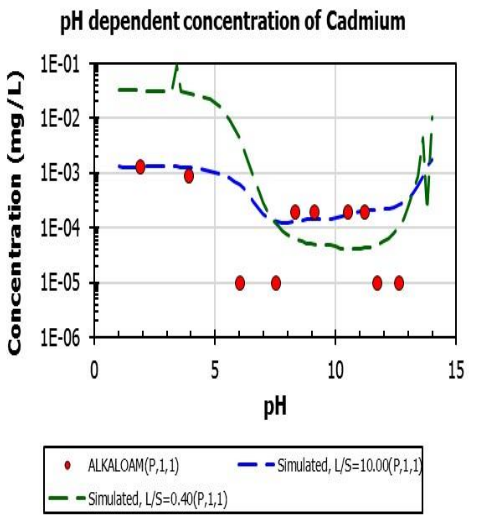


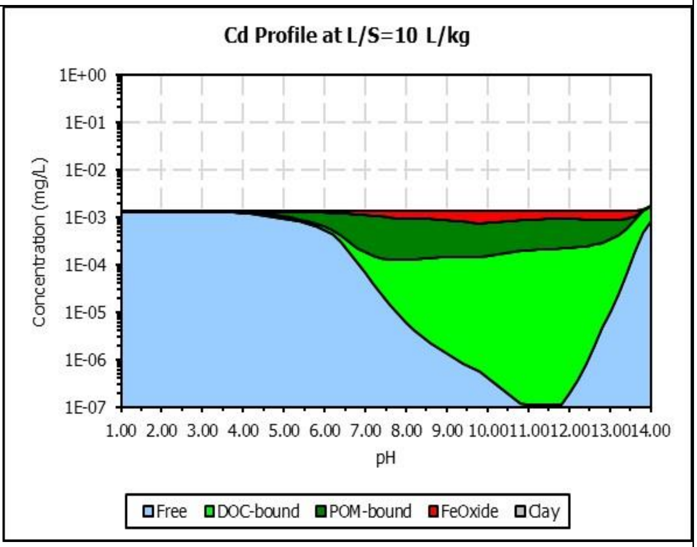

pH dependent concentration of Barium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

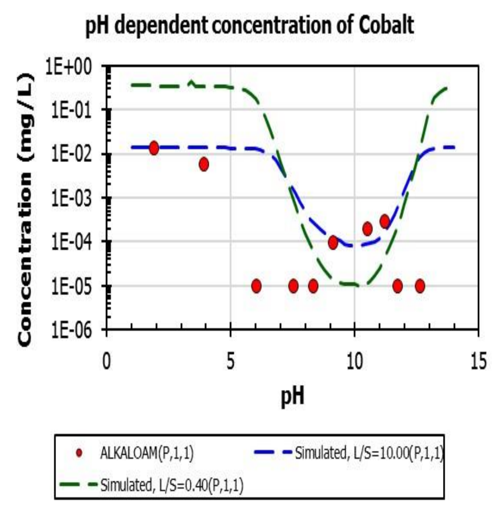

Ba Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

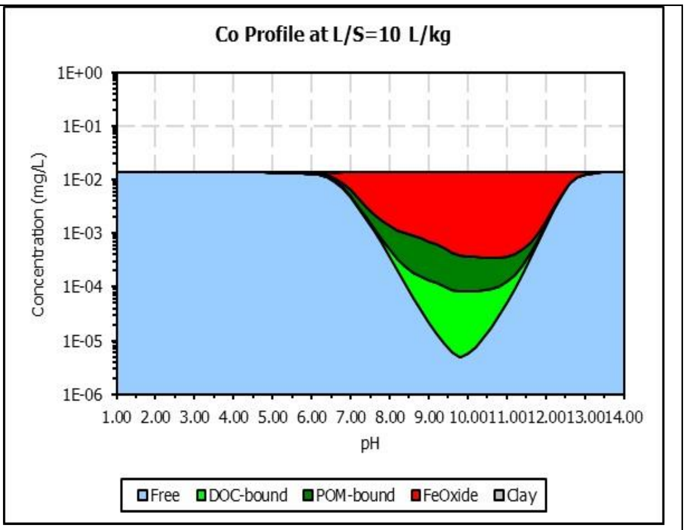

pH dependent concentration of Calcium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

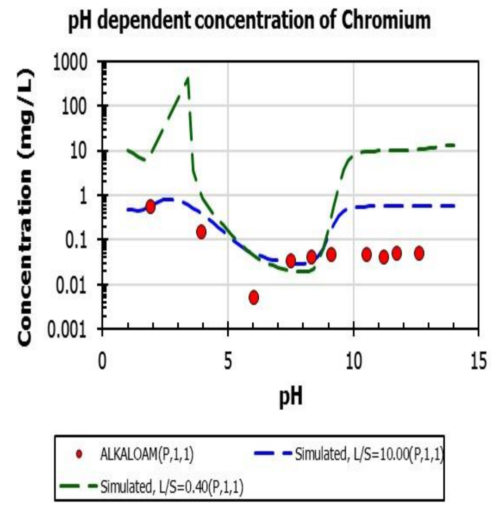

Ca Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AFmc_ss
ettr_ss
AA_2CaO_Al2O3_SiO2_8H2O[s]
Calcite
Fluorite
beta-TCP

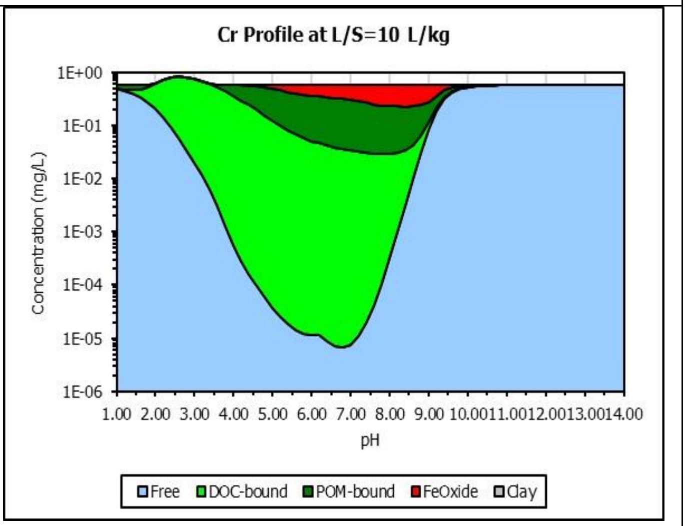

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

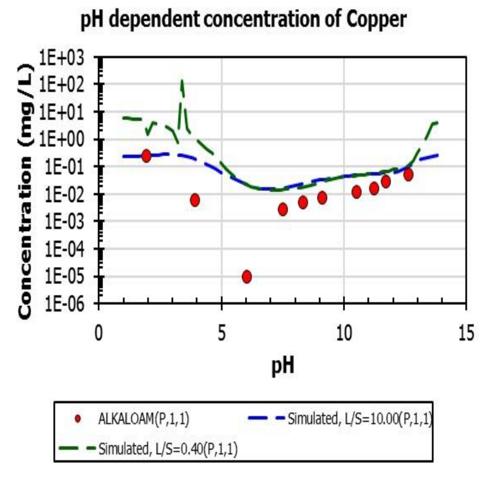

Cd Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

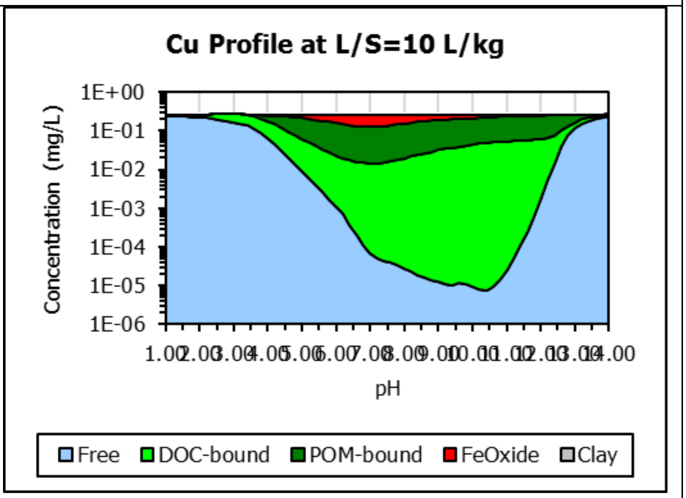

pH dependent concentration of Cobalt
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

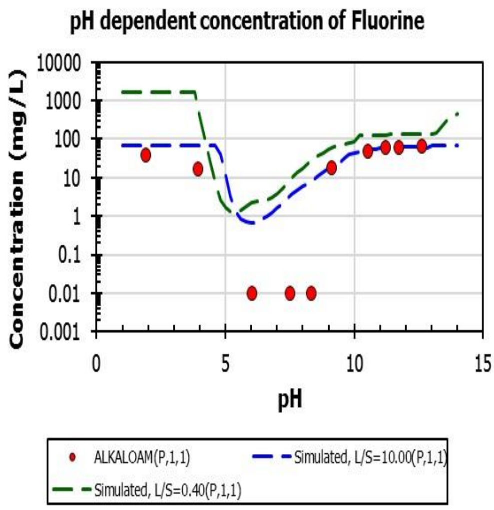

Co Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

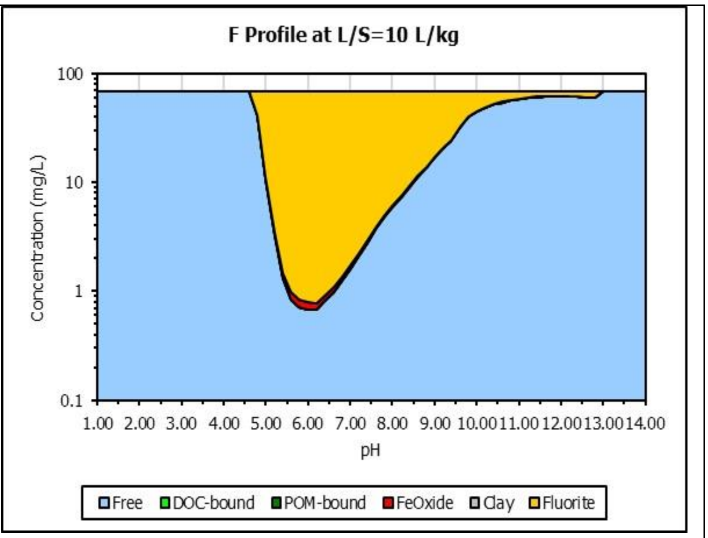

pH dependent concentration of Chromium
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

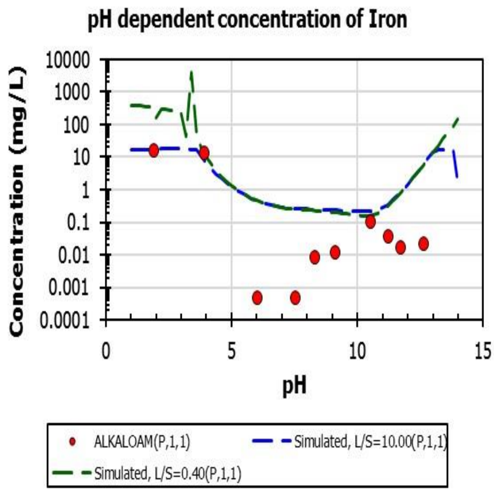

Cr Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

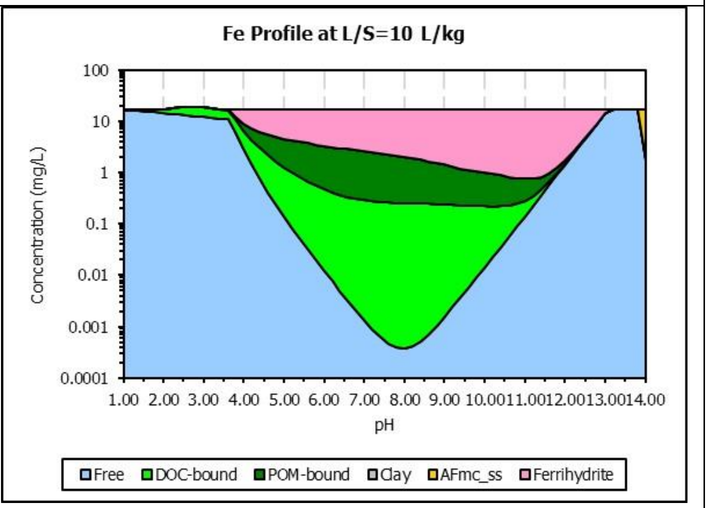

pH dependent concentration of Copper
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

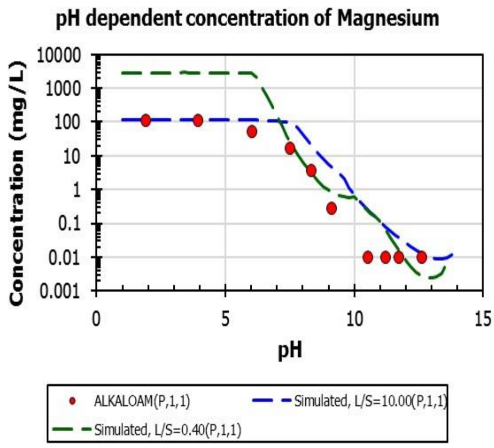

Cu Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

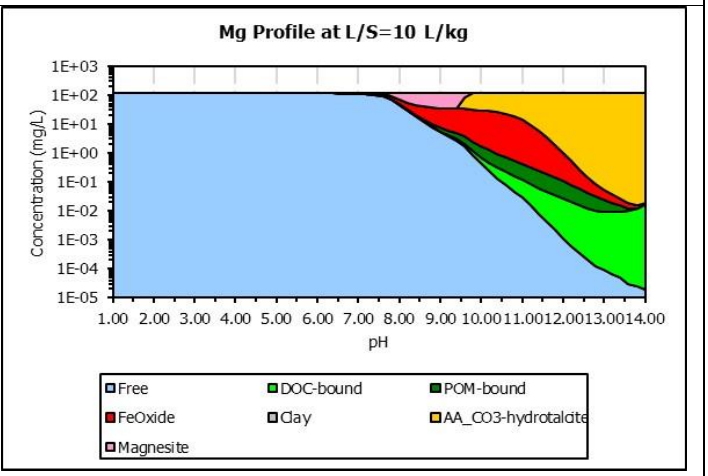

pH dependent concentration of Fluorine
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

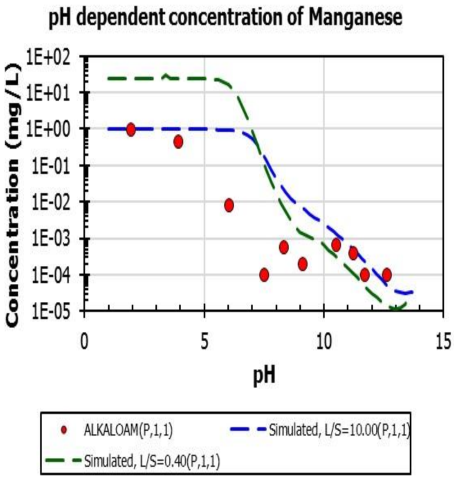

F Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite

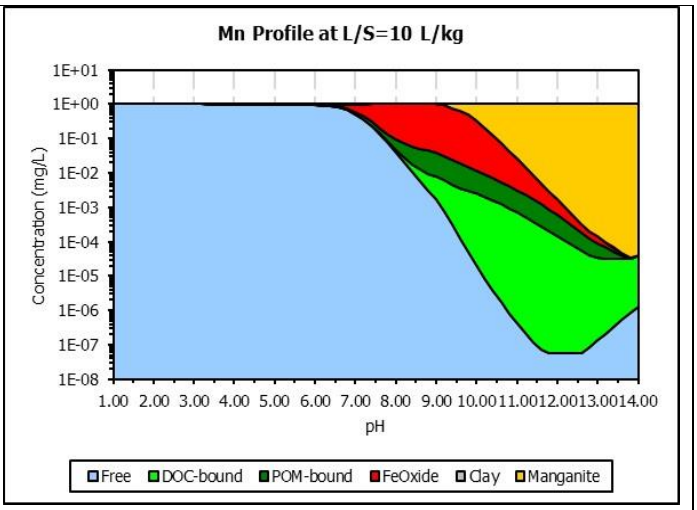

pH dependent concentration of Iron
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

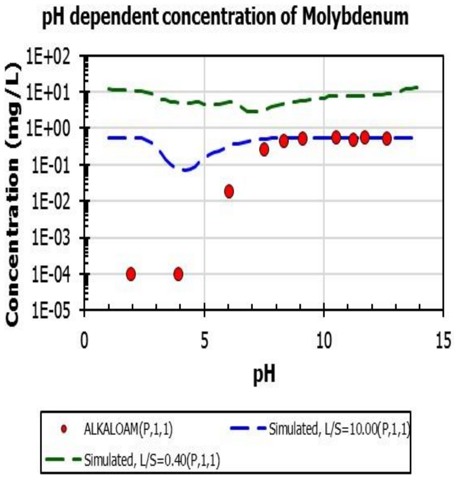

Fe Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
AFmc_ss
Ferrihydrite

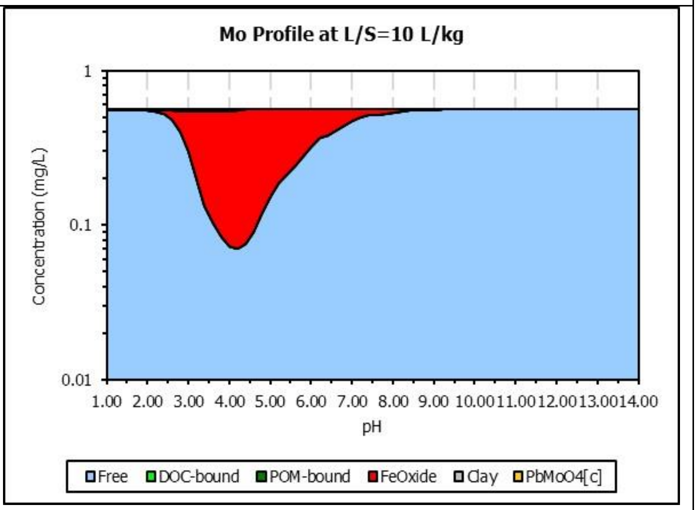

pH dependent concentration of Magnesium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

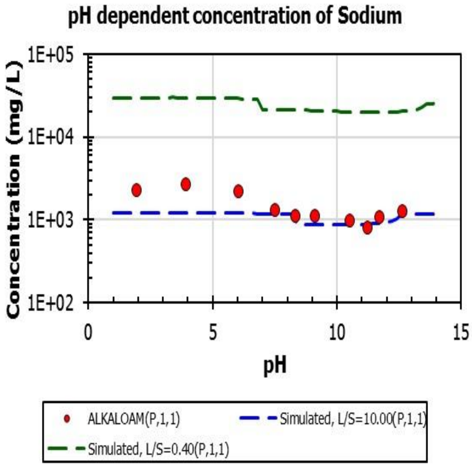

Mg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AA_CO3-hydrotalcite
Magnesite

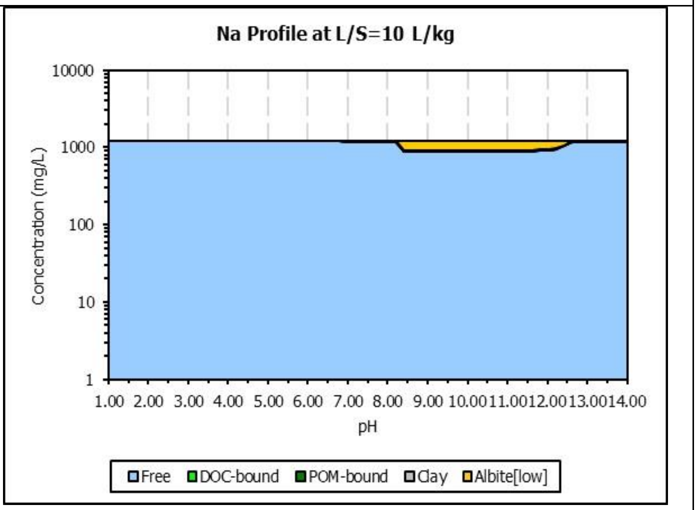

pH dependent concentration of Manganese
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

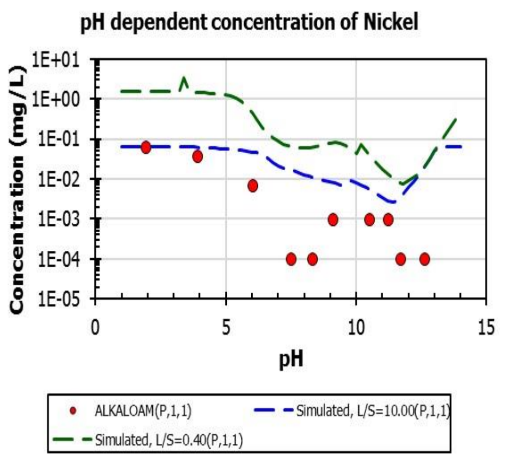

Mn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

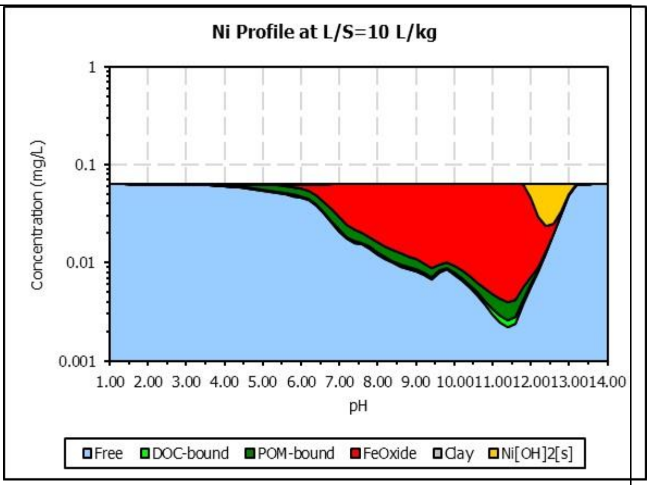

pH dependent concentration of Molybdenum
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

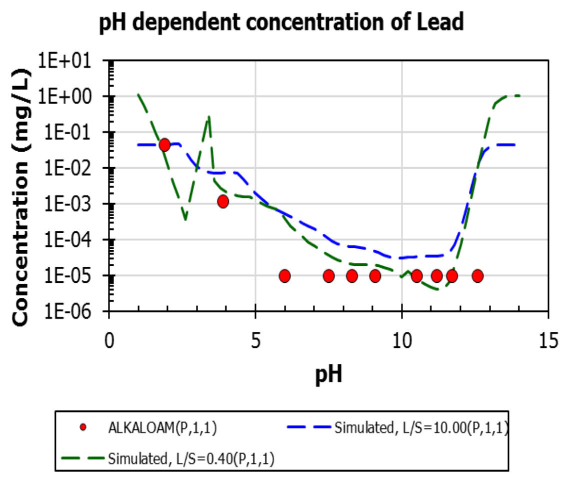

Mo Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
PbMoO4[c]

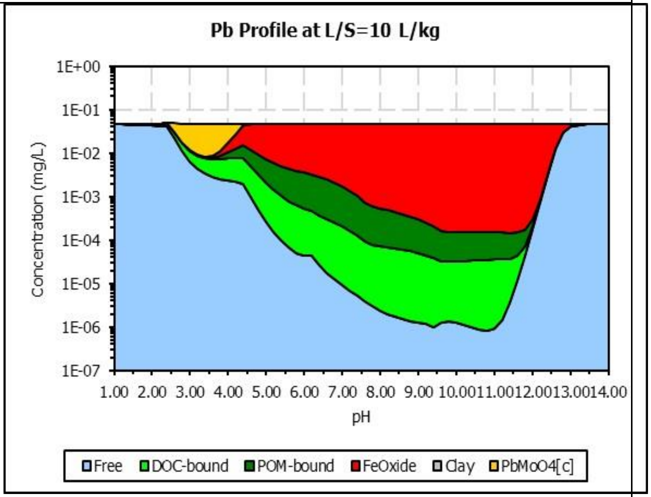

pH dependent concentration of Sodium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

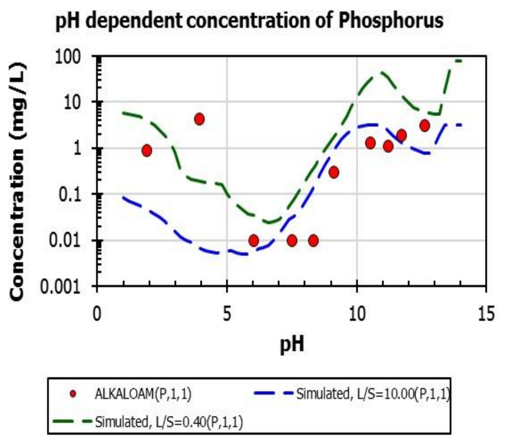

Na Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Albite[low]

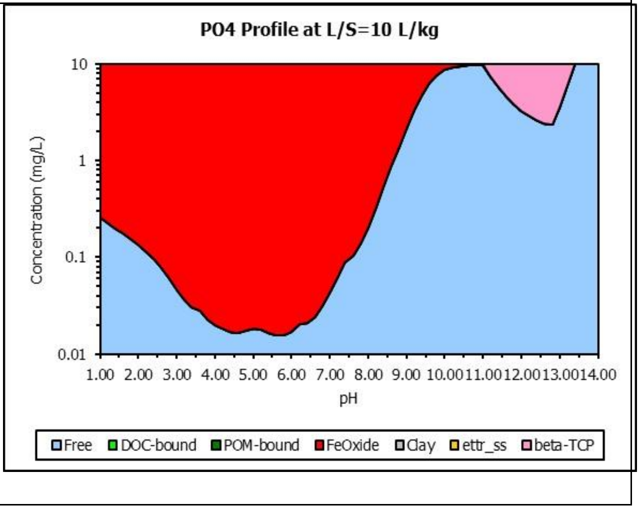

pH dependent concentration of Nickel
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

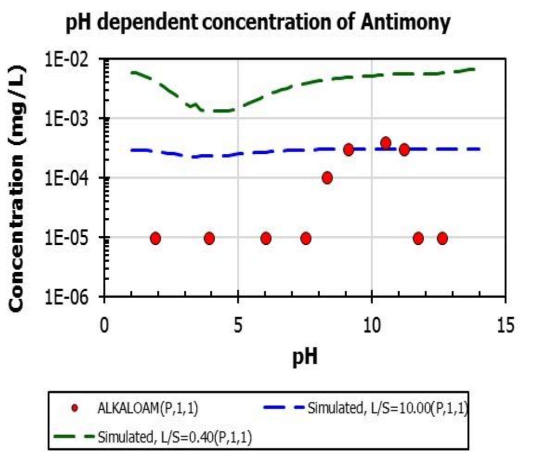

Ni Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Ni[OH]2[s]

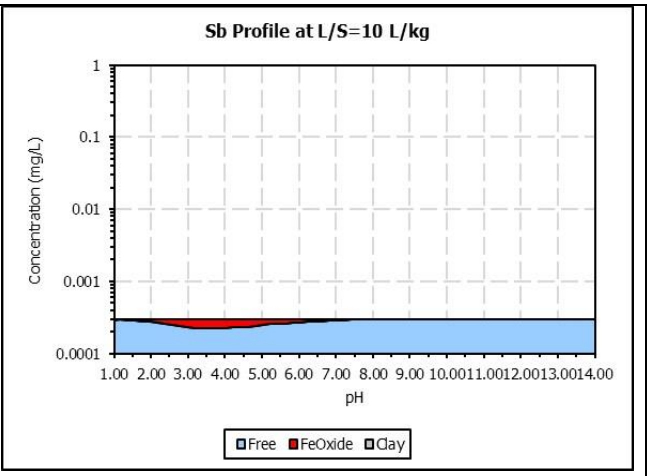

pH dependent concentration of Lead
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

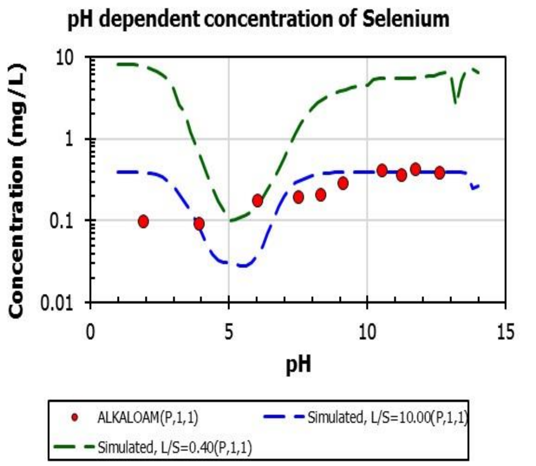

Pb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
PbMoO4[c]

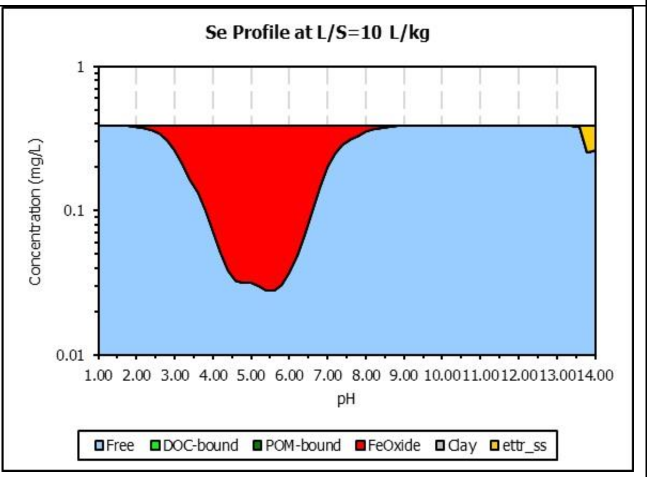

pH dependent concentration of Phosphorus
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

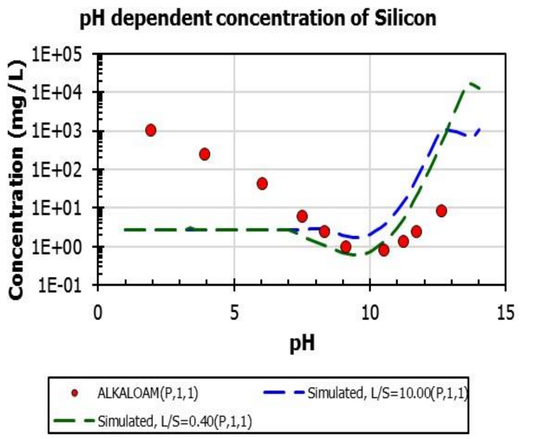

PO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
beta-TCP

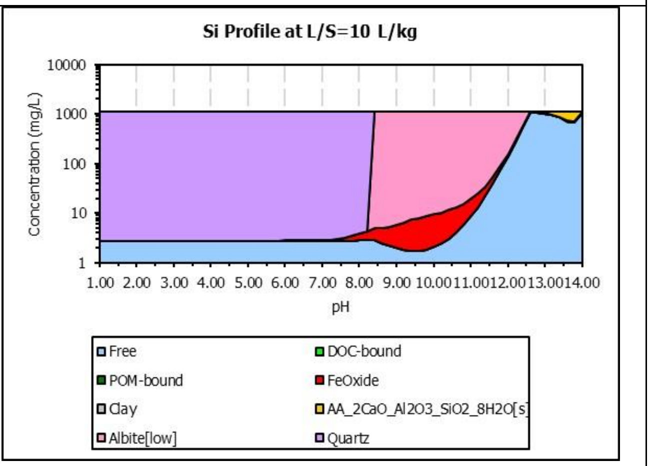

pH dependent concentration of Antimony
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

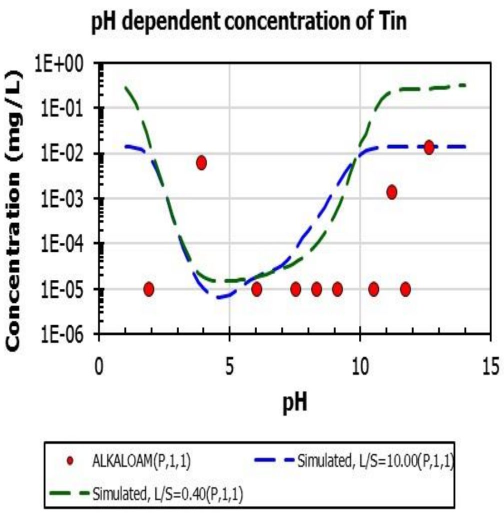

Sb Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

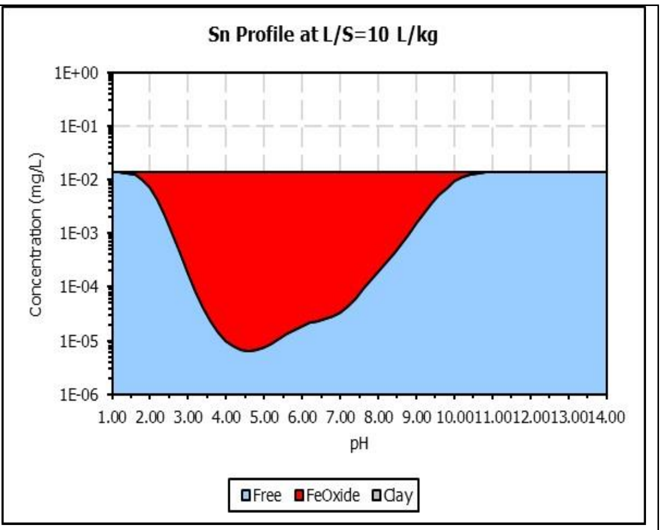

pH dependent concentration of Selenium
Concentration (mg/L)
10
1
0.1
0.01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

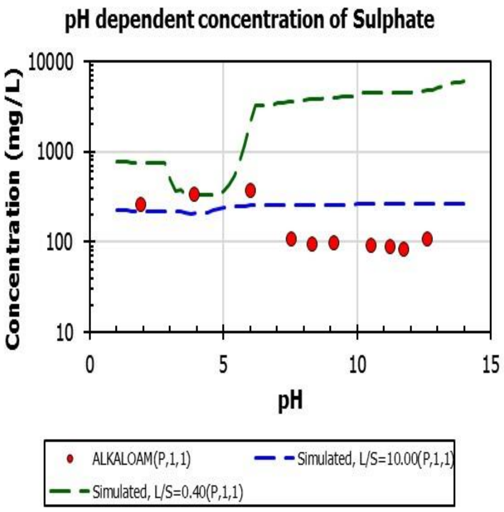

Se Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

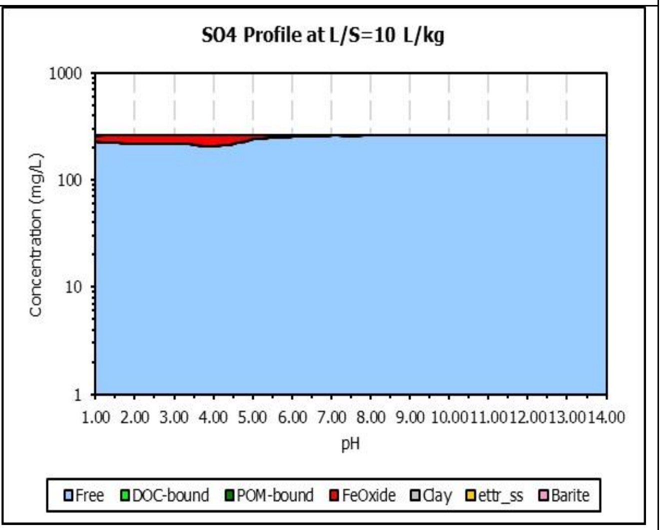

pH dependent concentration of Silicon
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

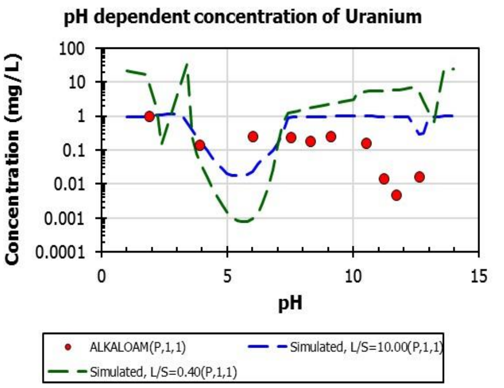

Si Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AA_2CaO_Al2O3_SiO2_8H2O[s]
Albite[low]
Quartz

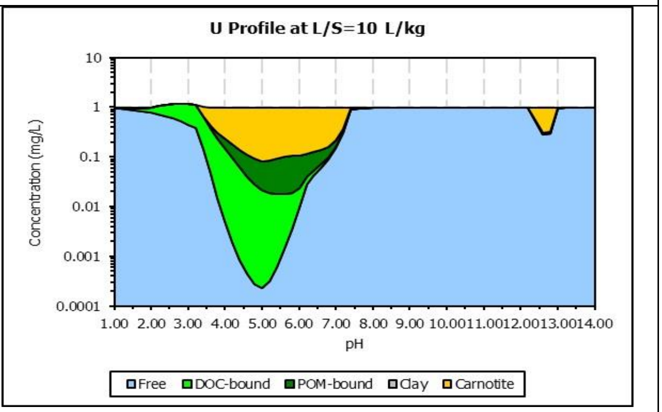

pH dependent concentration of Tin
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

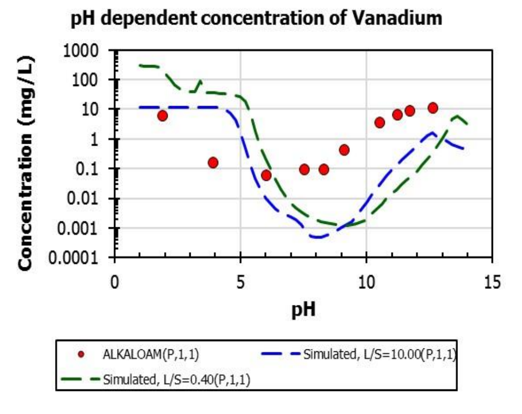

Sn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

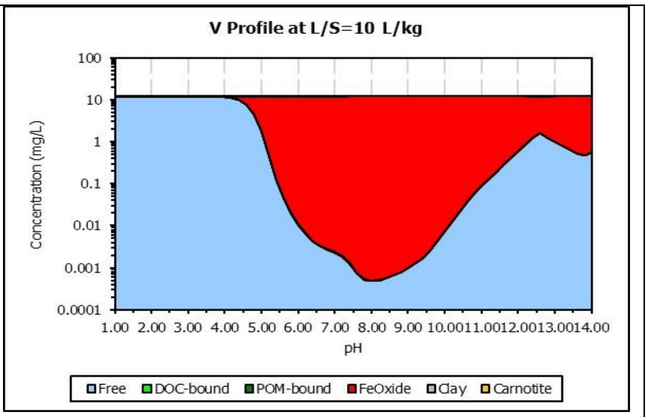

pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
10
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

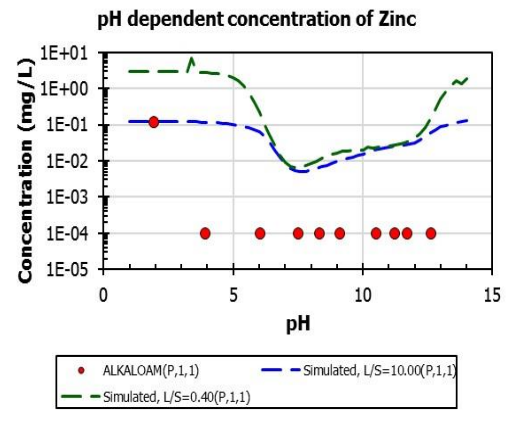

SO4 Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

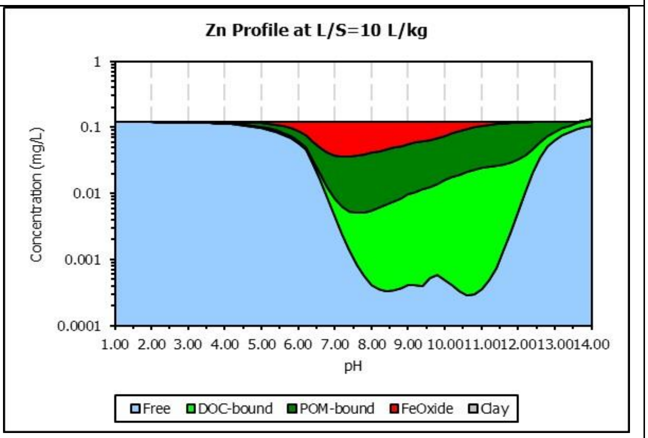

pH dependent concentration of Uranium
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Carnotite

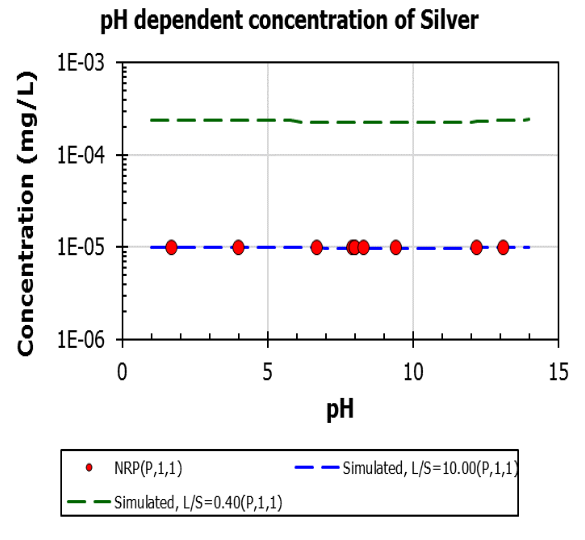

pH dependent concentration of Vanadium
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

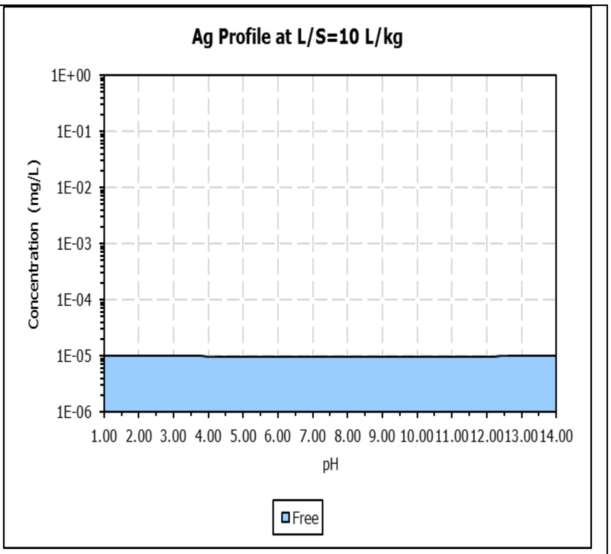

V Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Carnotite

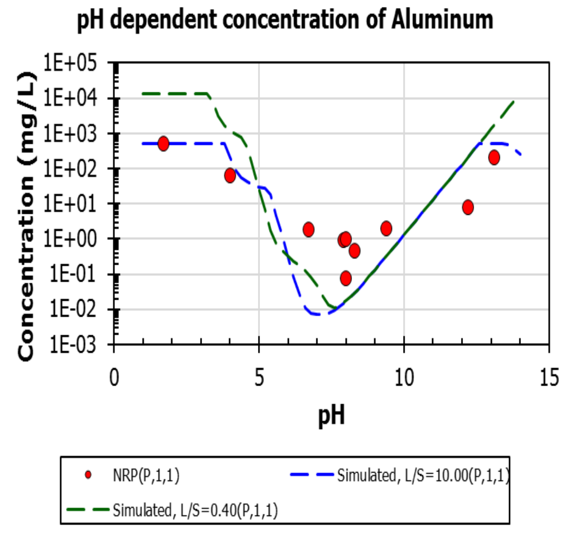

pH dependent concentration of Zinc
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

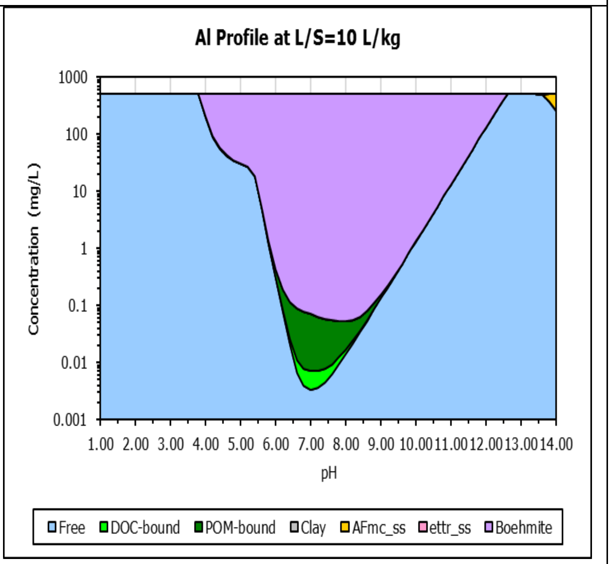

Zn Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

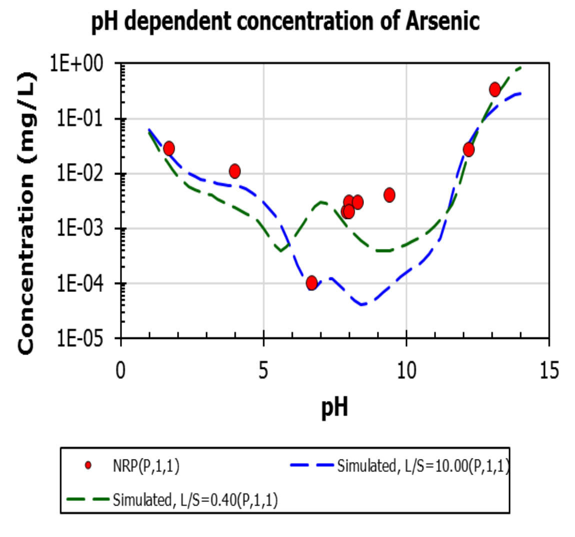
A8-2: By-product NRP

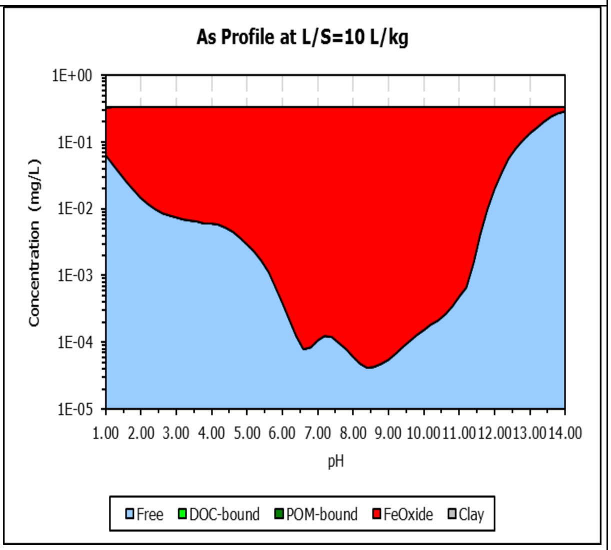


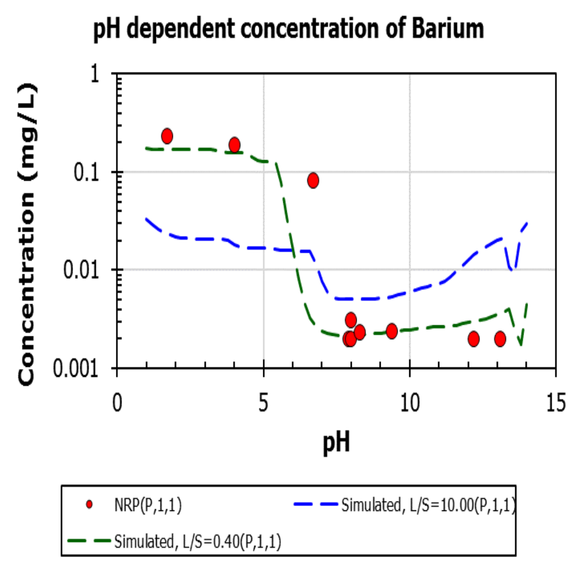


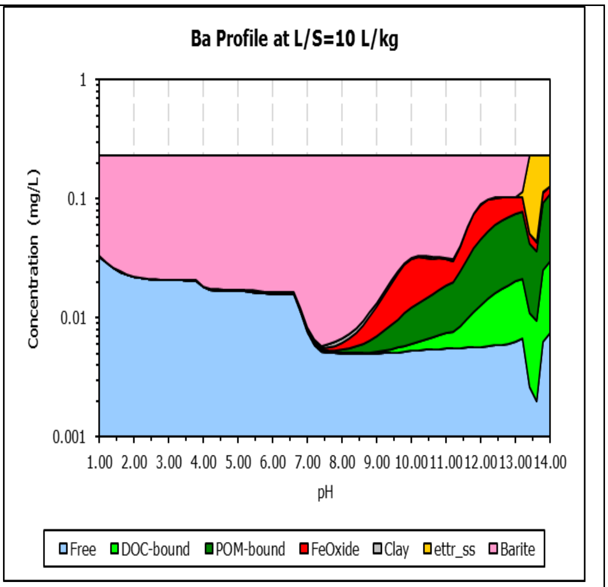


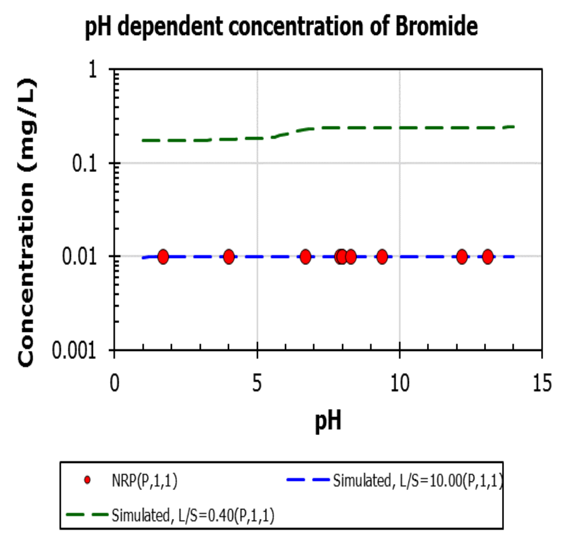


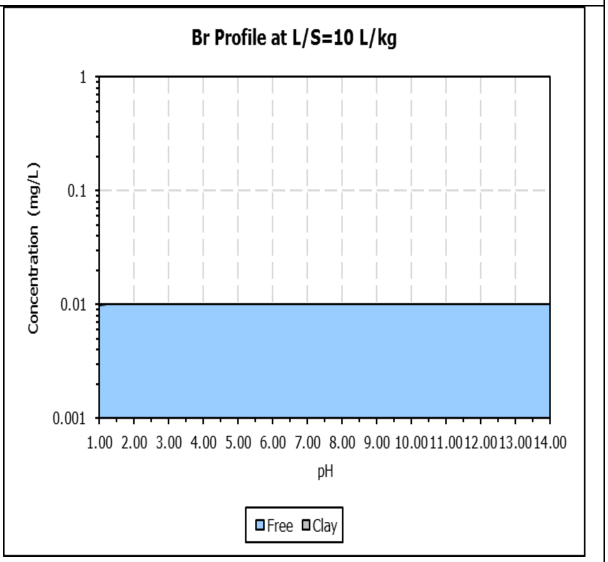


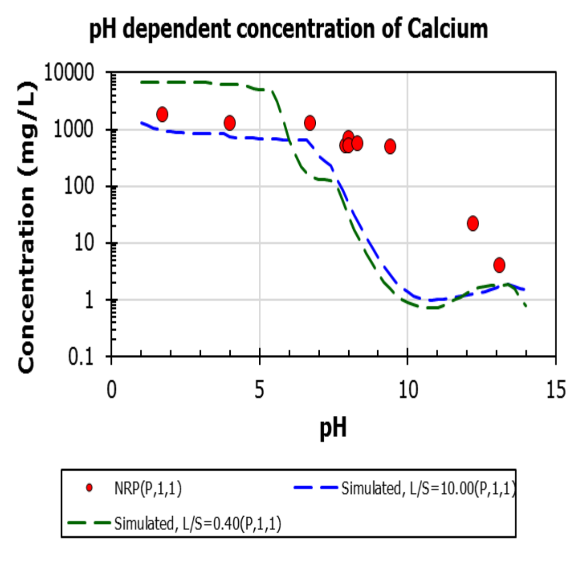


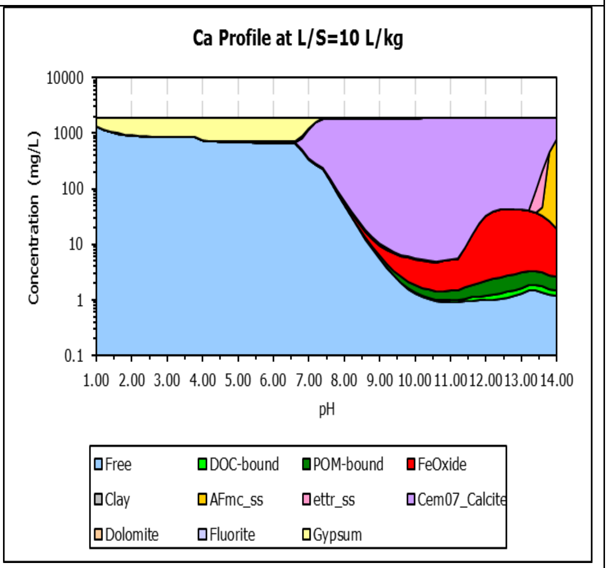

pH dependent concentration of Barium
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

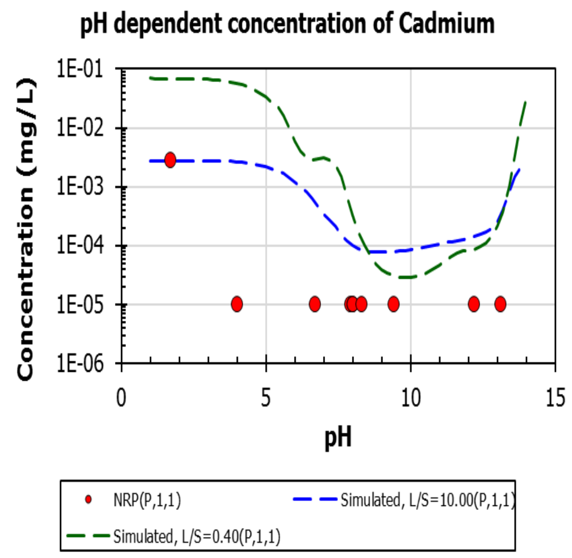

Ba Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

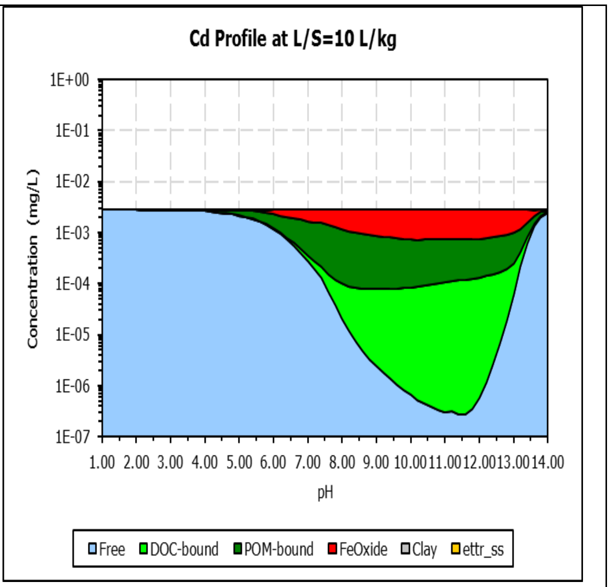

pH dependent concentration of Bromide
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

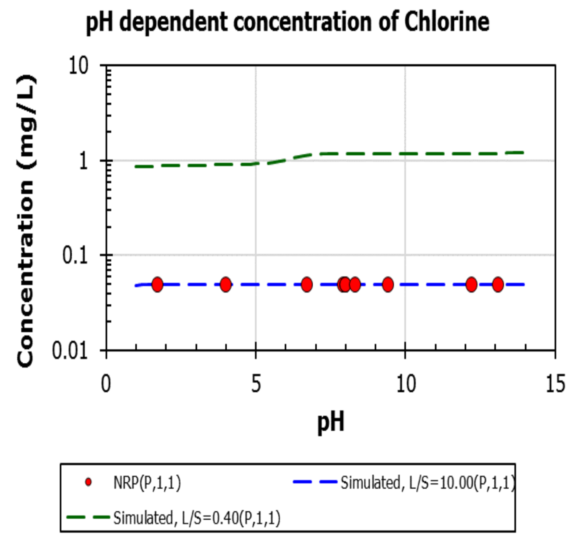

Br Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
Clay

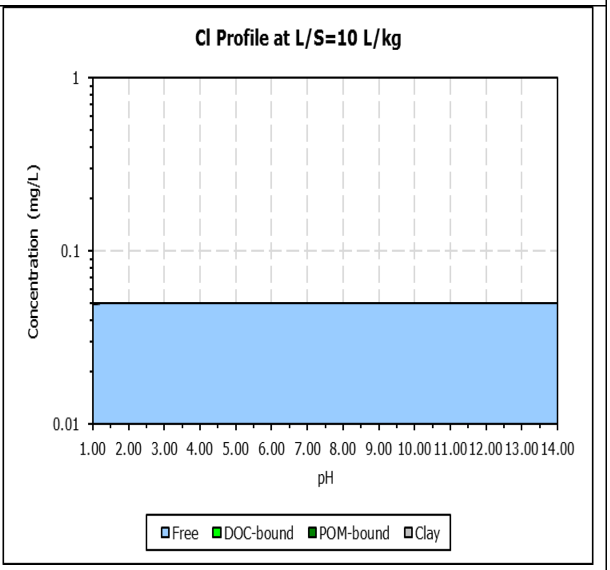

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

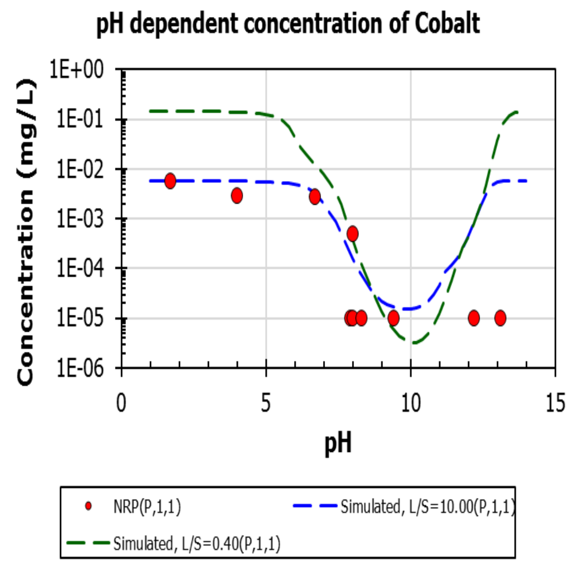

Ca Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AFmc_ss
ettr_ss
Cem07_Calcite
Dolomite
Fluorite
Gypsum

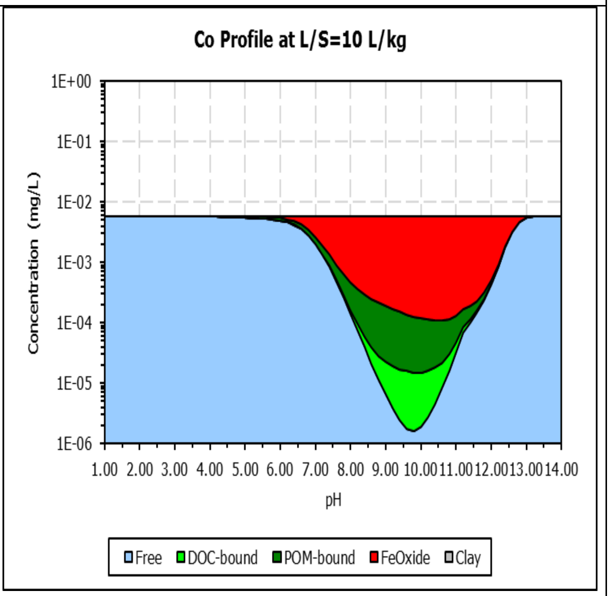

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

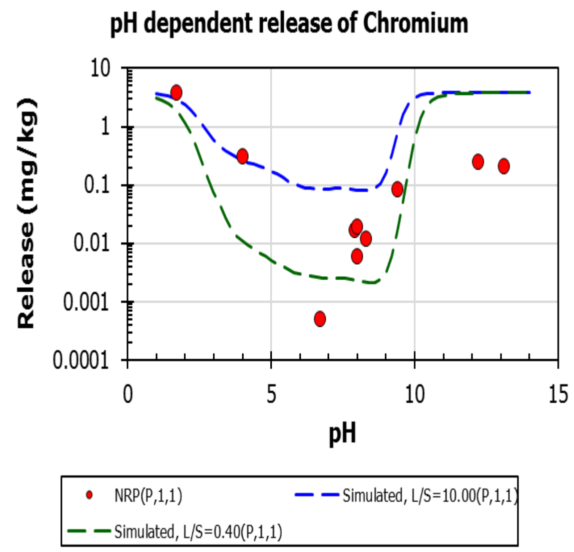

Cd Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss


pH dependent concentration of Chlorine
Concentration (mg/L)
10
1
0.1
0.01
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

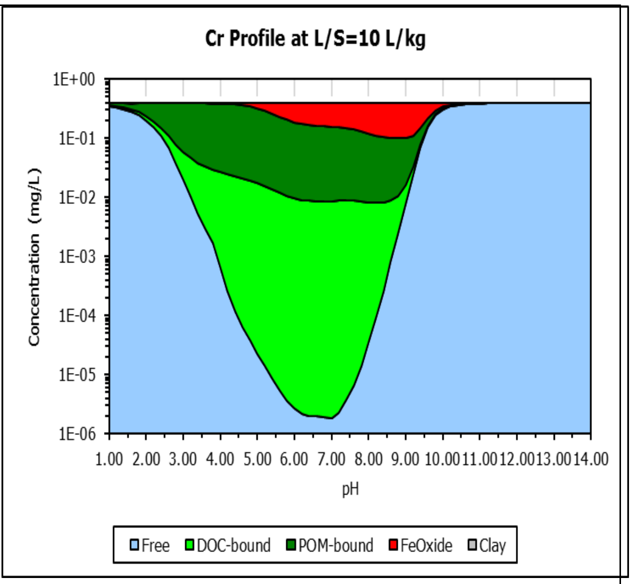

Cl Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay


pH dependent concentration of Cobalt
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

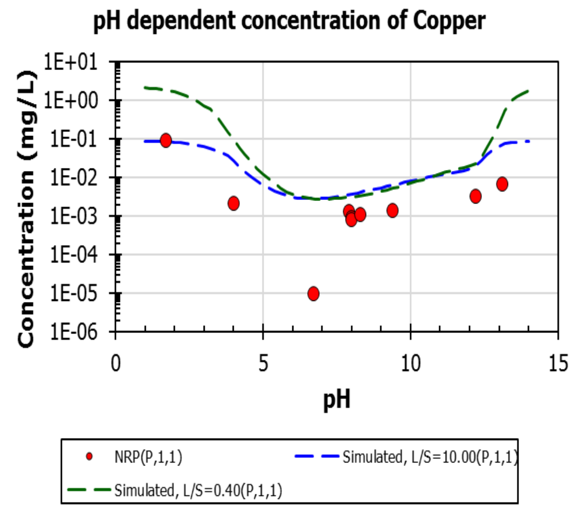

Co Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay



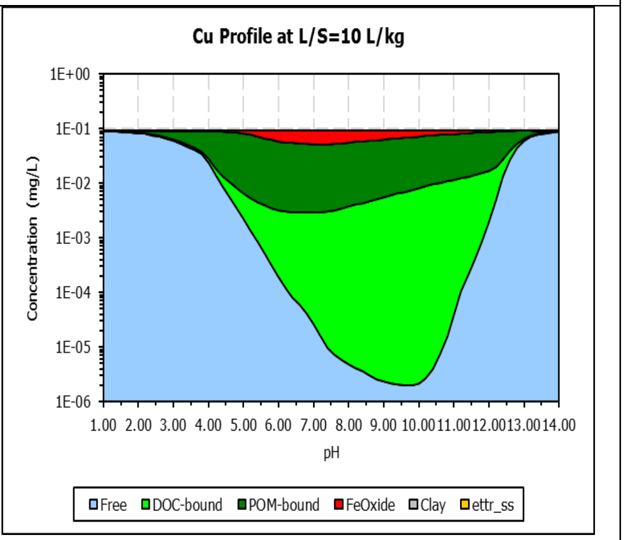
pH dependent release of Chromium



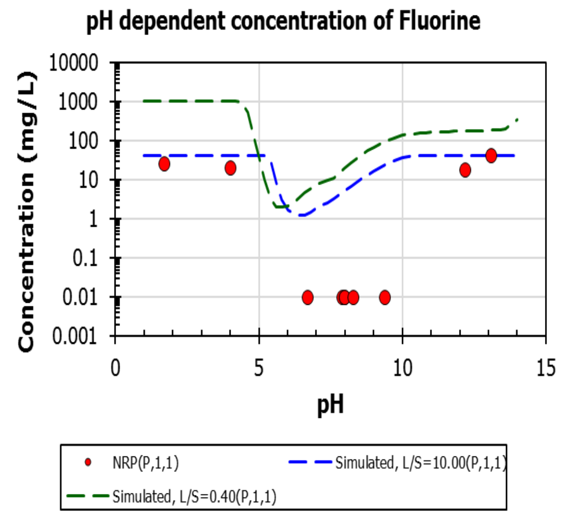
Cr Profile at L/S=10 L/kg



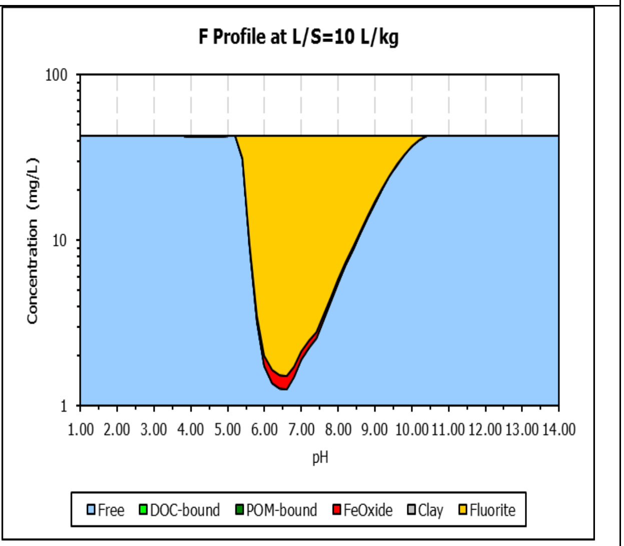
pH dependent concentration of Copper



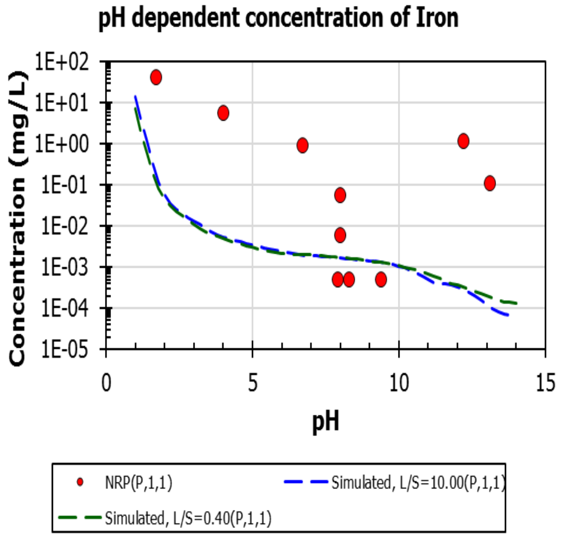
Cu Profile at L/S=10 L/kg

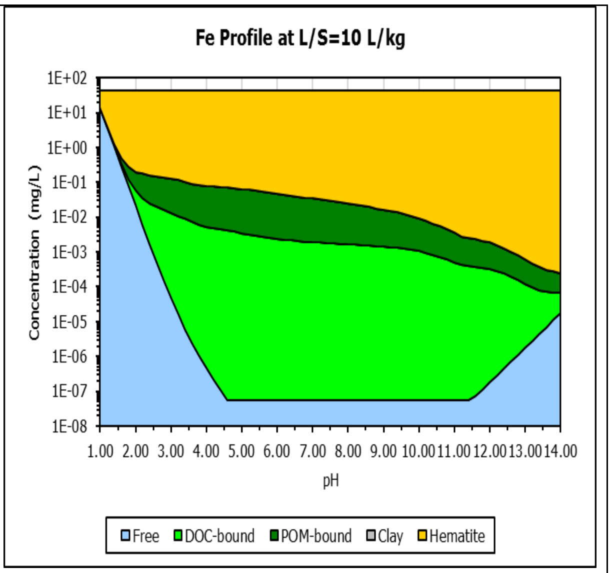


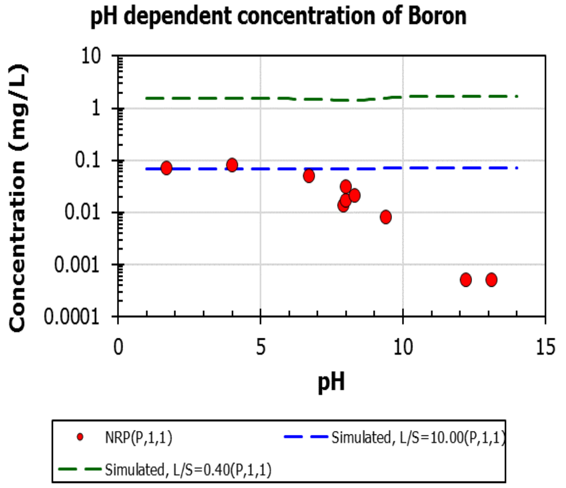
pH dependent concentration of Fluorine

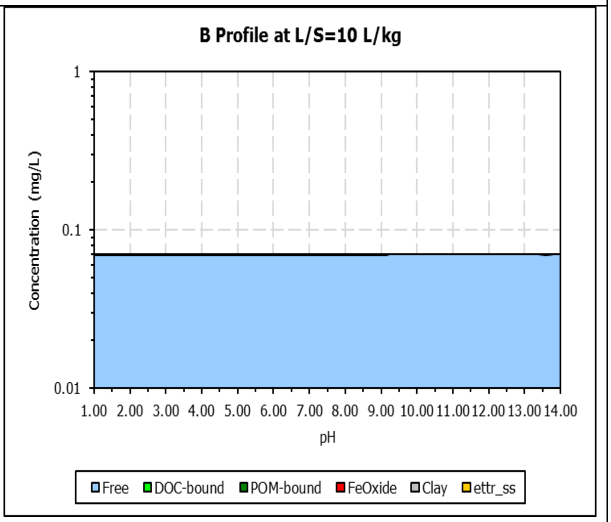


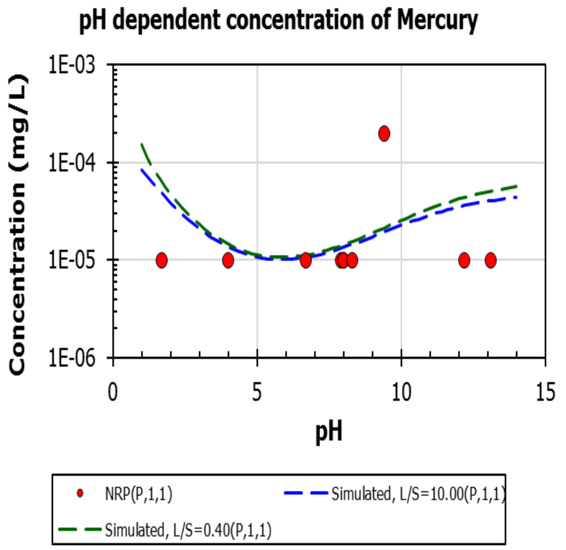
F Profile at L/S=10 L/kg

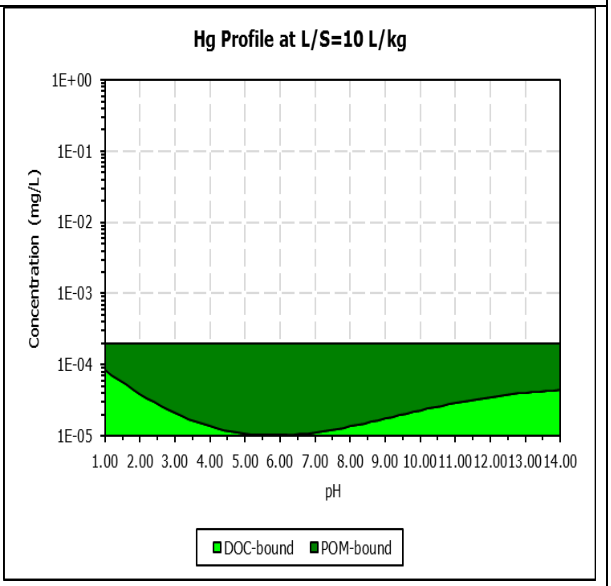

pH dependent concentration of Iron
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

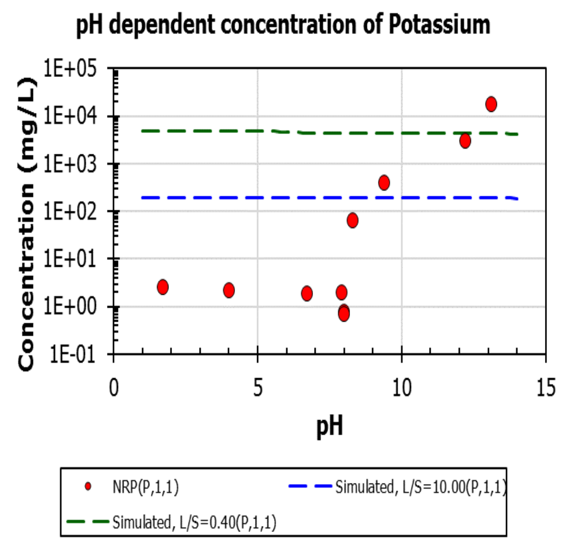

Fe Profile at L/S=10 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Hematite

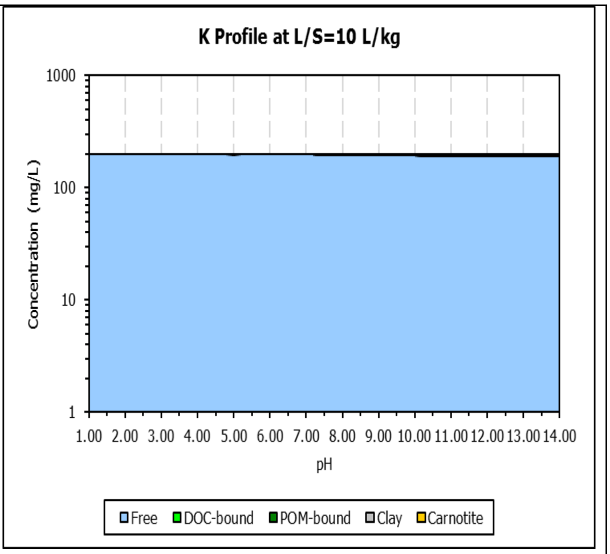

pH dependent concentration of Boron
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

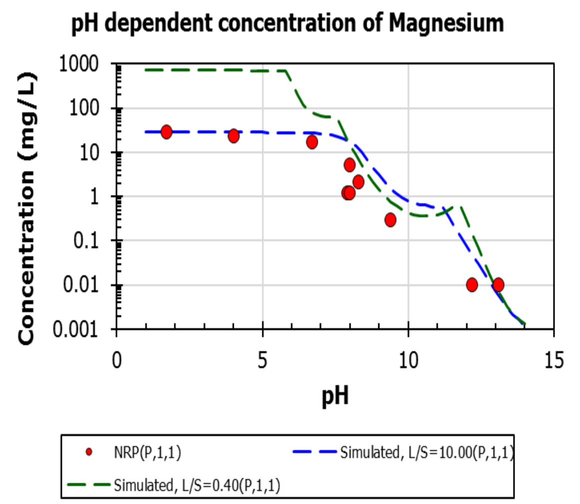

B Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

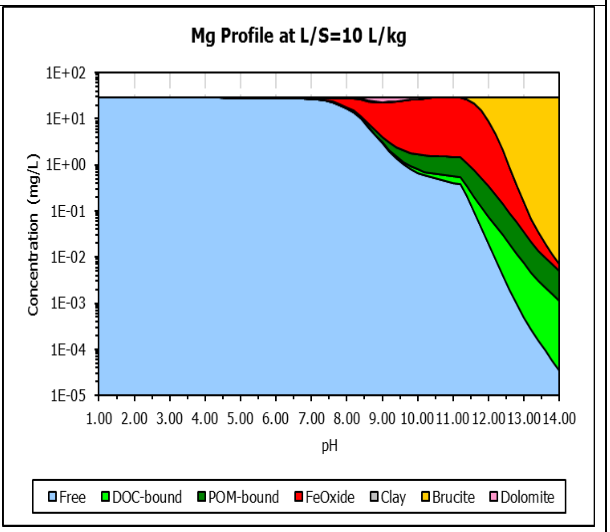

pH dependent concentration of Mercury
Concentration (mg/L)
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

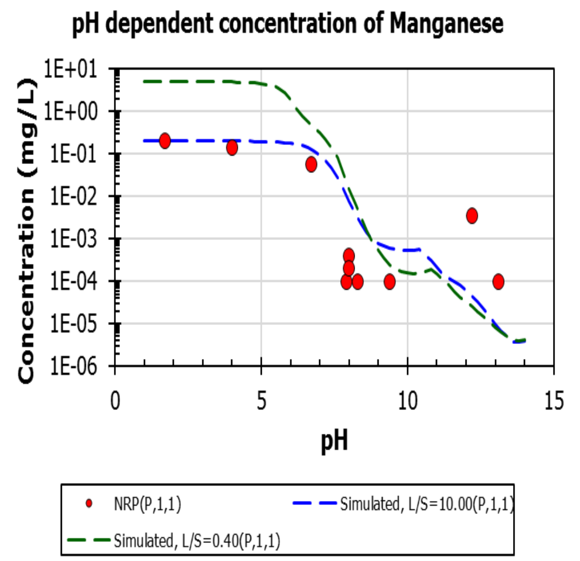

Hg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
DOC-bound
POM-bound

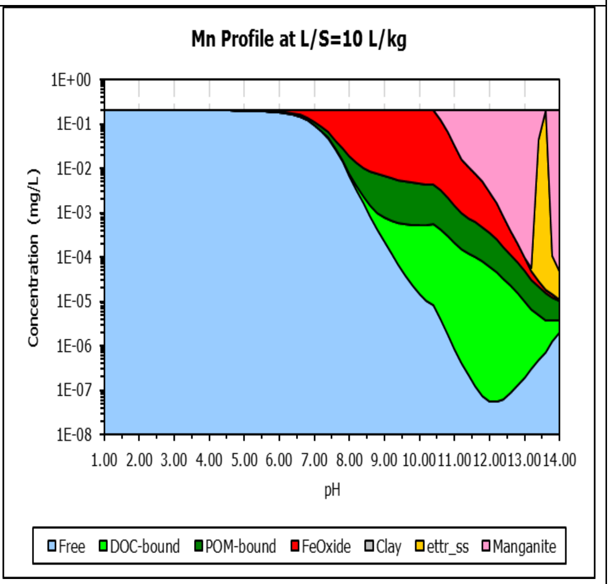

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

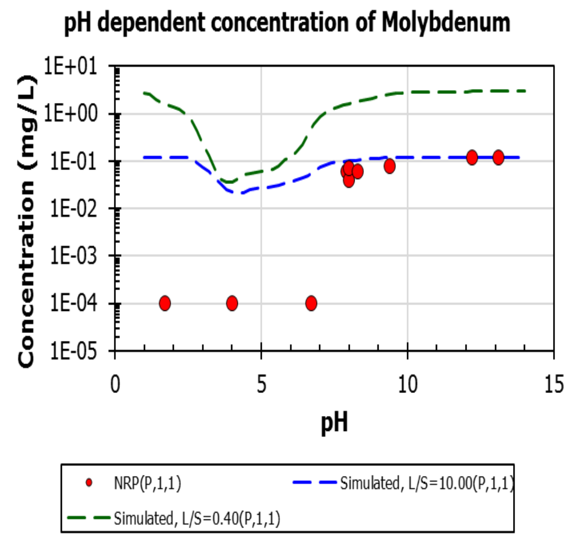

K Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Carnotite

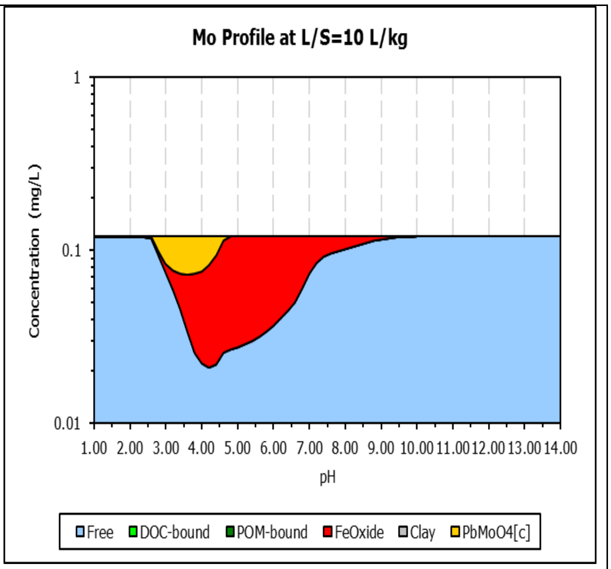

pH dependent concentration of Magnesium
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

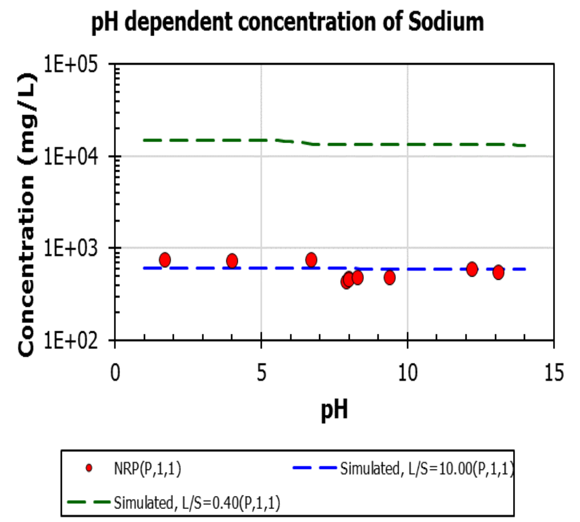

Mg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Brucite
Dolomite

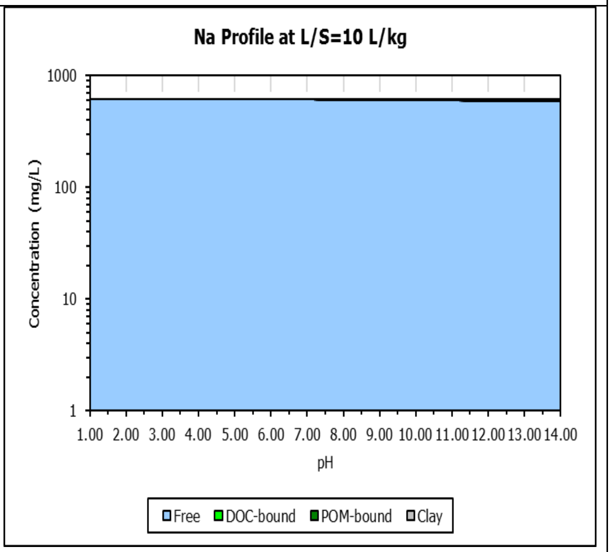

pH dependent concentration of Manganese
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

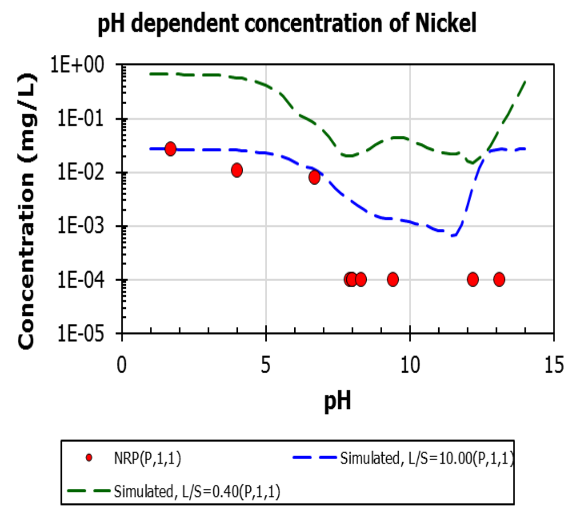

Mn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Manganite

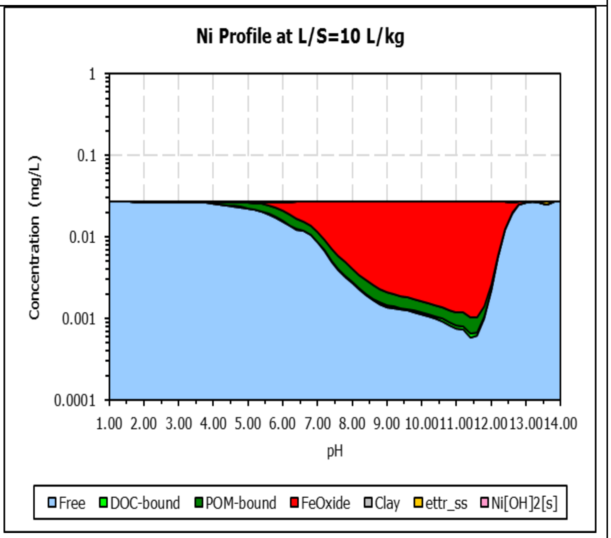

pH dependent concentration of Molybdenum
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

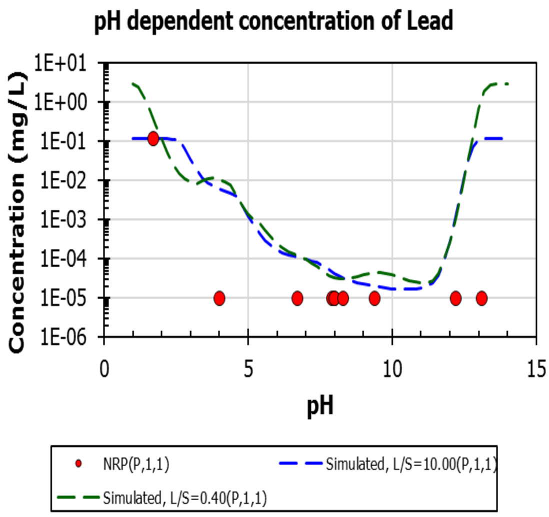

Mo Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
PbMoO4[c]

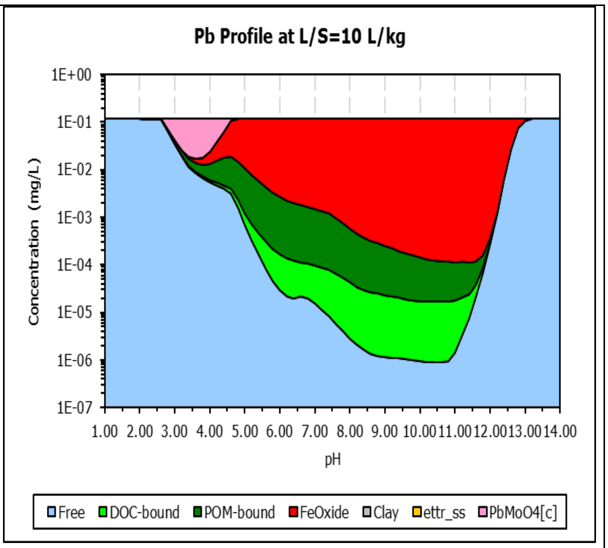

pH dependent concentration of Sodium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

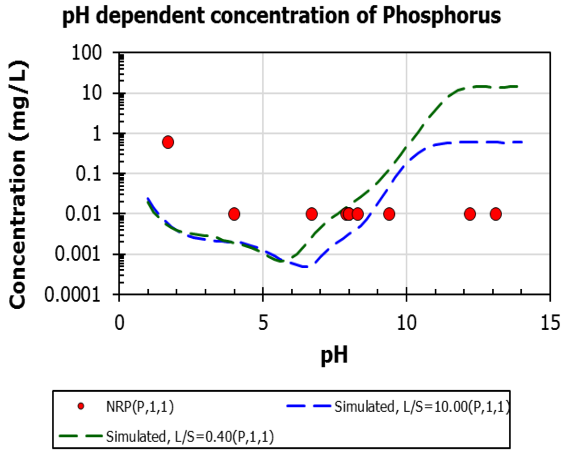

Na Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

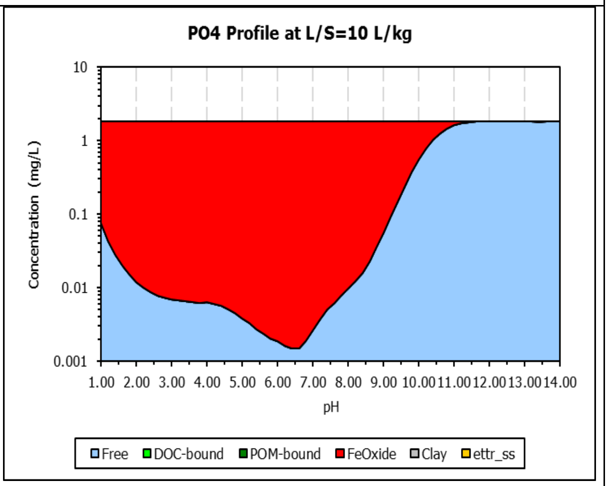

pH dependent concentration of Nickel
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

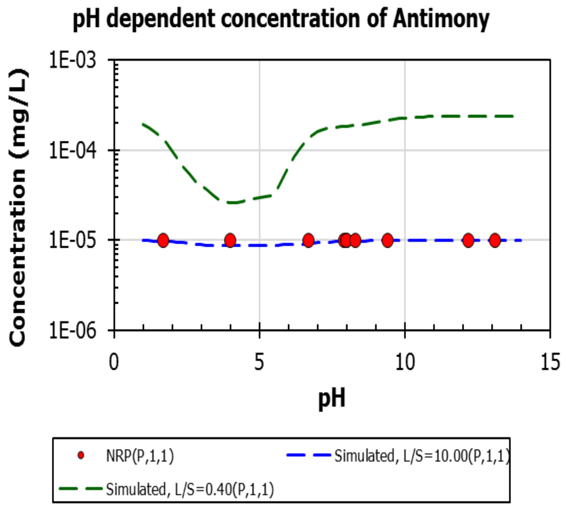

Ni Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.0011.0012.0013.0014.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Ni[OH]2[s]

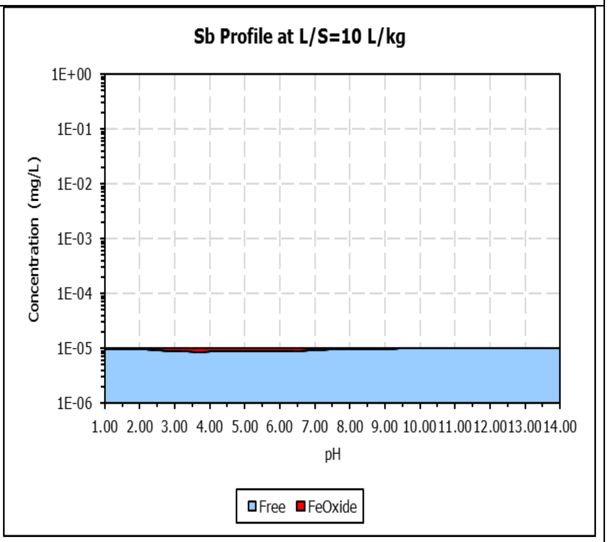

pH dependent concentration of Lead
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

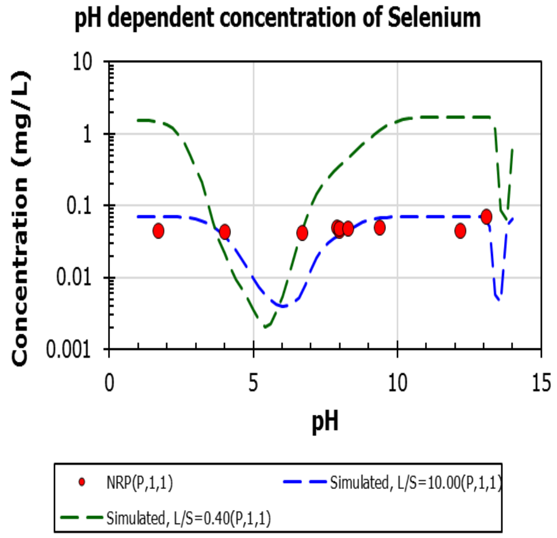

Pb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
PbMoO4[c]

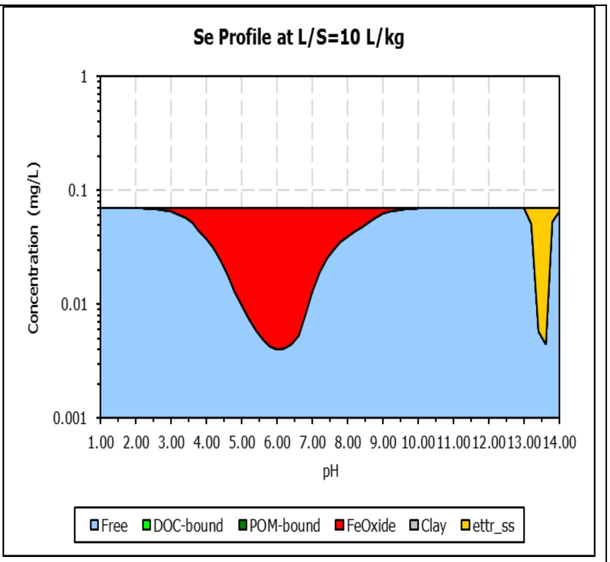

pH dependent concentration of Phosphorus
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

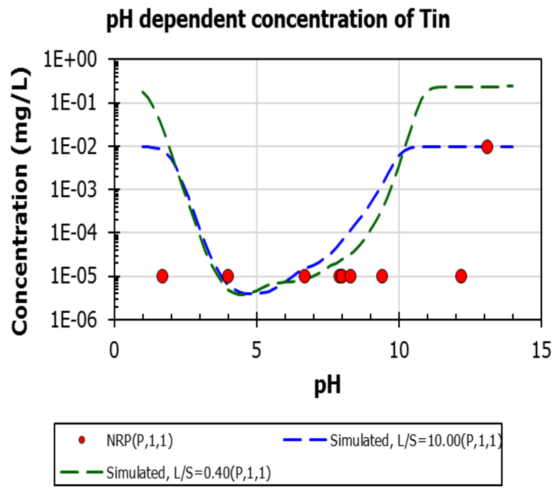

PO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
0.01
0.001
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

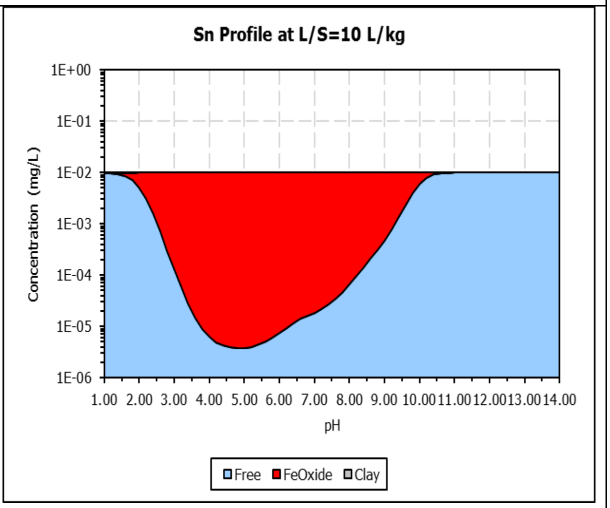

pH dependent concentration of Antimony
Concentration (mg/L)
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

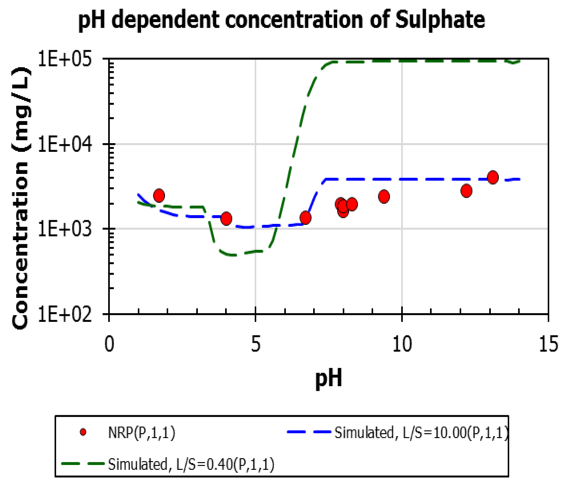

Sb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
FeOxide

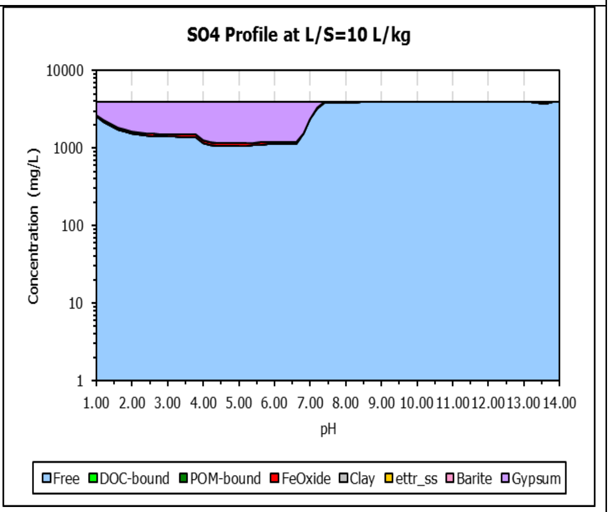

pH dependent concentration of Selenium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
● NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

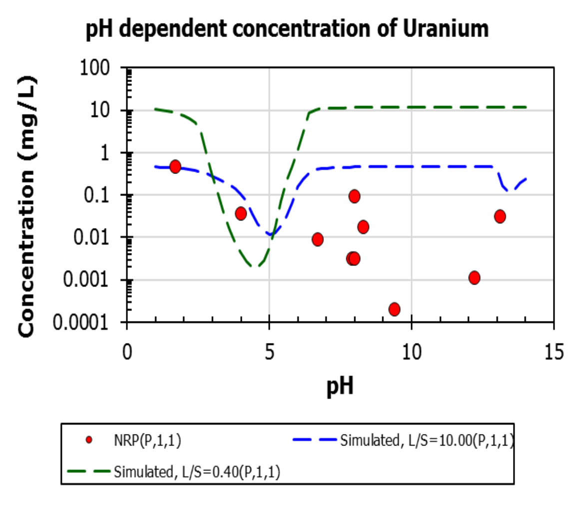

Se Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

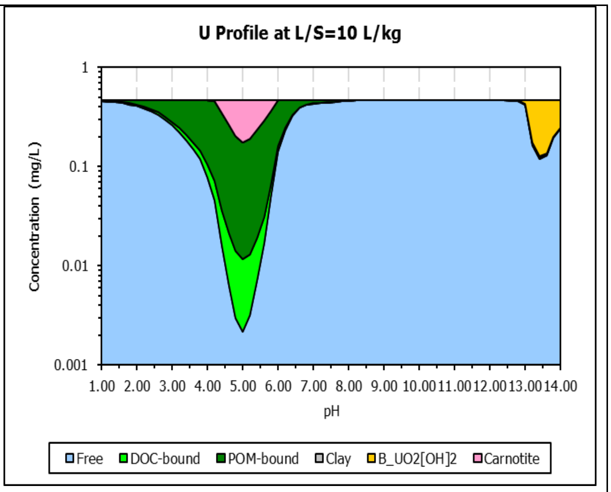

pH dependent concentration of Tin
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
● NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

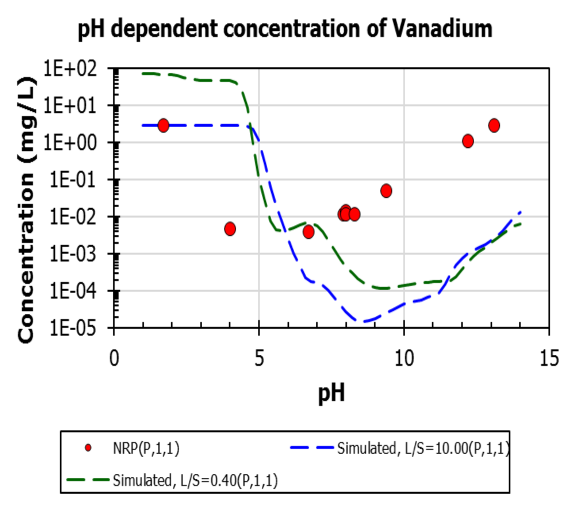

Sn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

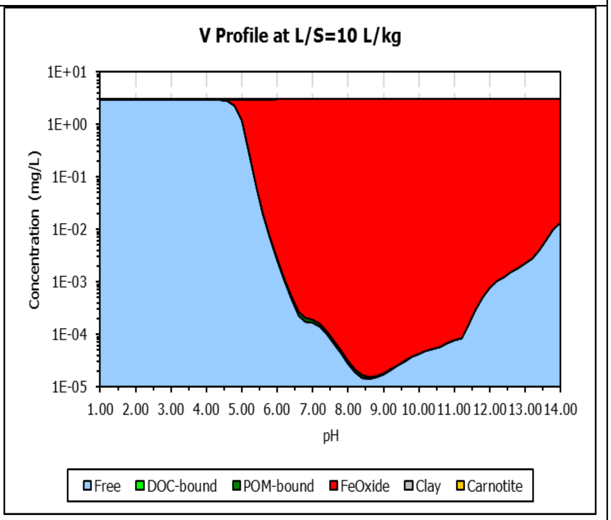

pH dependent concentration of Sulphate
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
● NRP(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

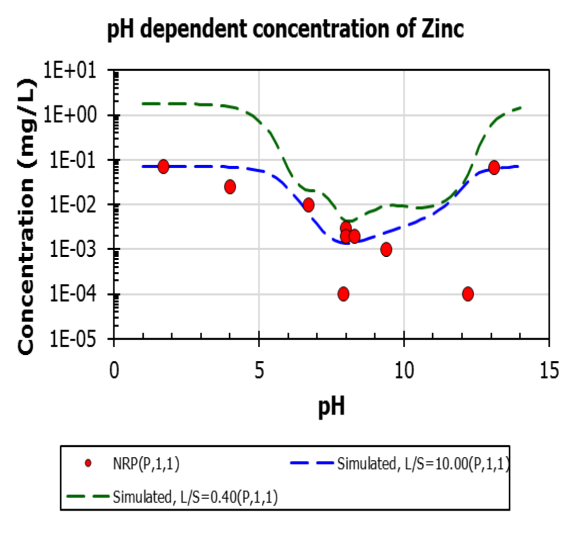

SO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite
Gypsum

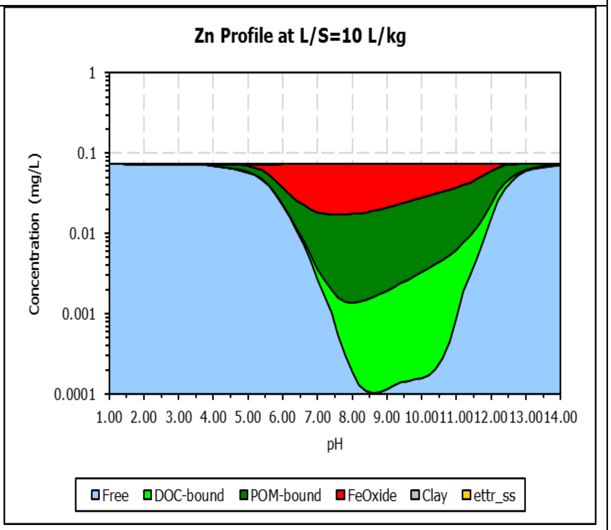

pH dependent concentration of Uranium


U Profile at L/S=10 L/kg

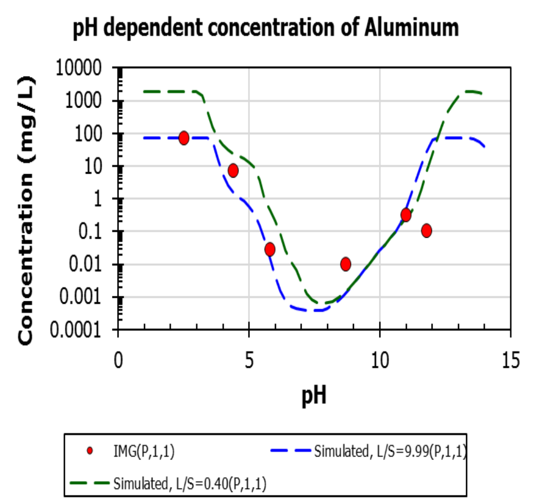

pH dependent concentration of Vanadium

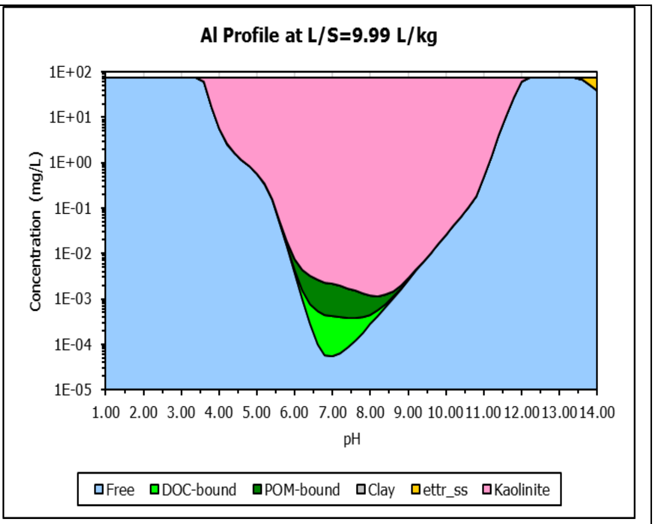

V Profile at L/S=10 L/kg

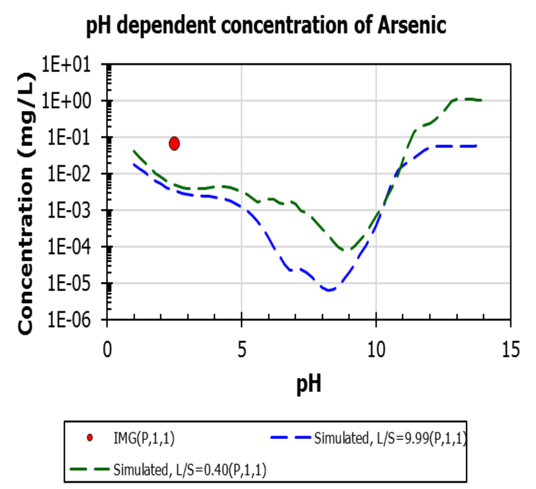

pH dependent concentration of Zinc

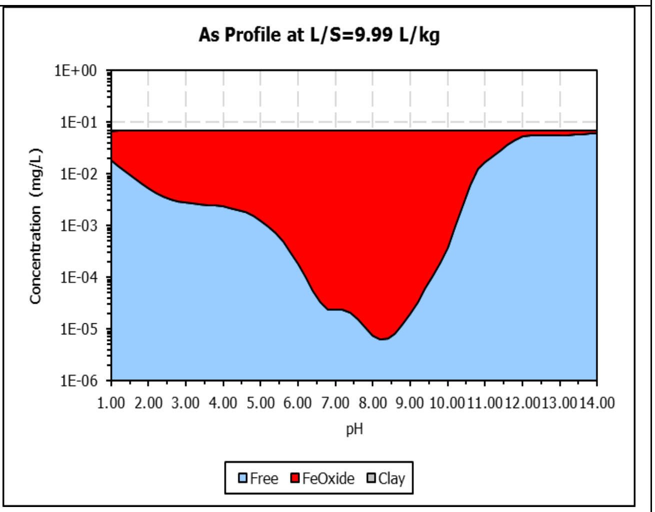

Zn Profile at L/S=10 L/kg

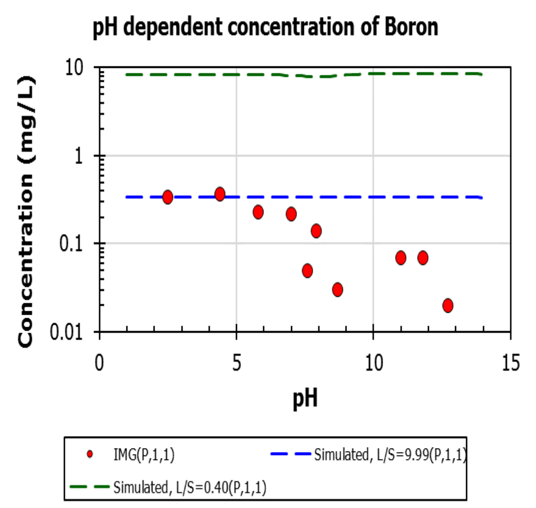
A8-3: By-product Ironman Gypsum (IMG)

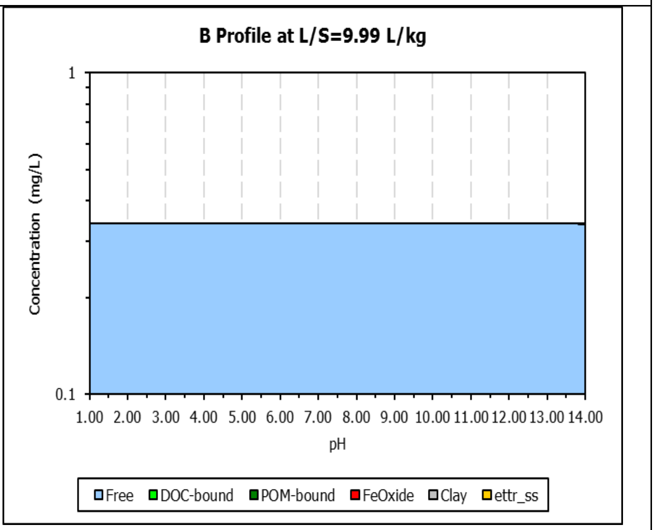


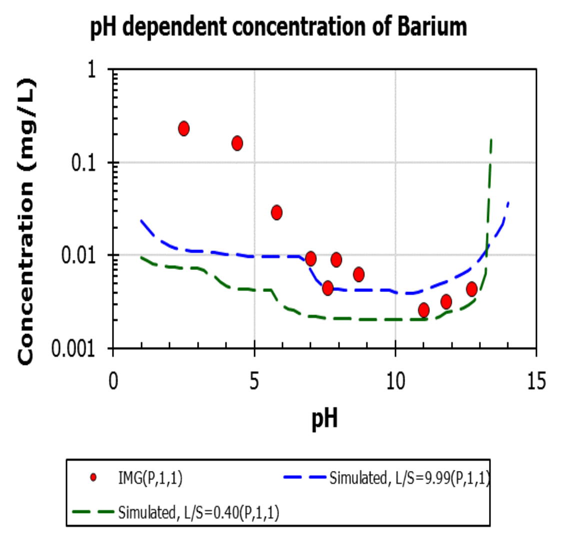


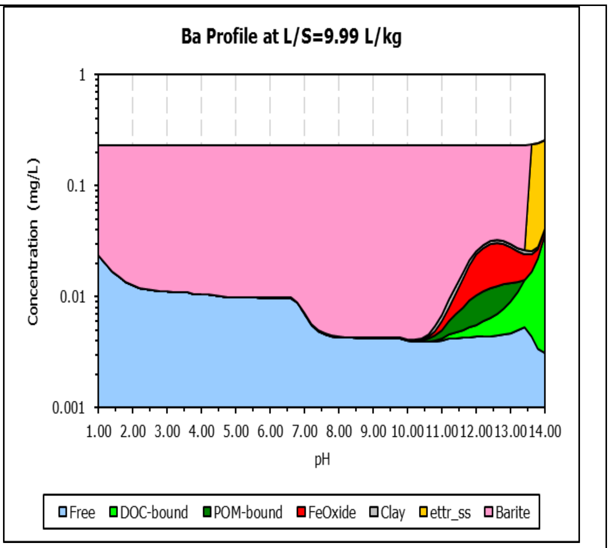


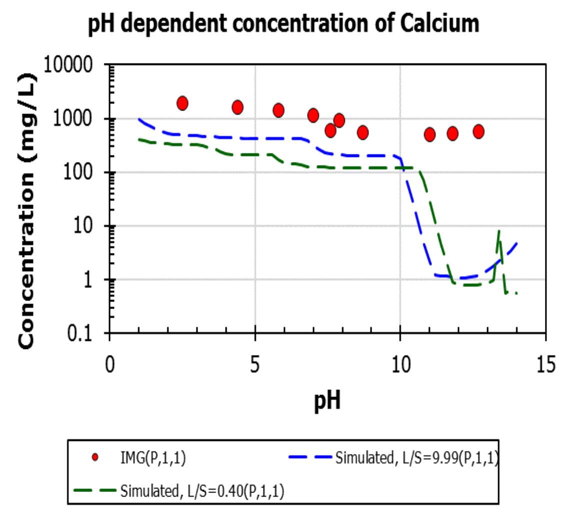


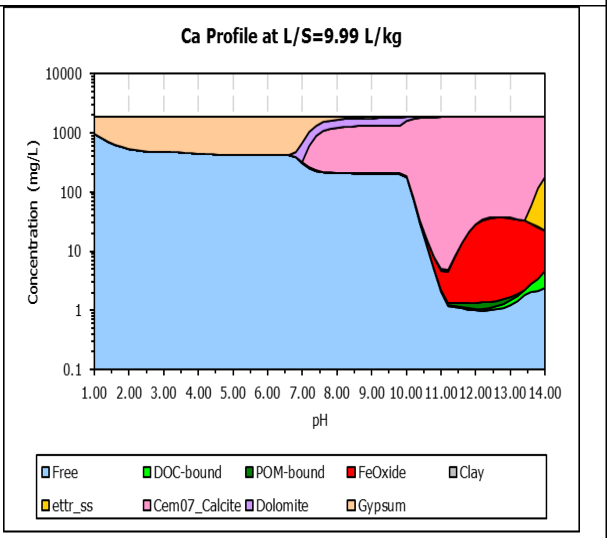


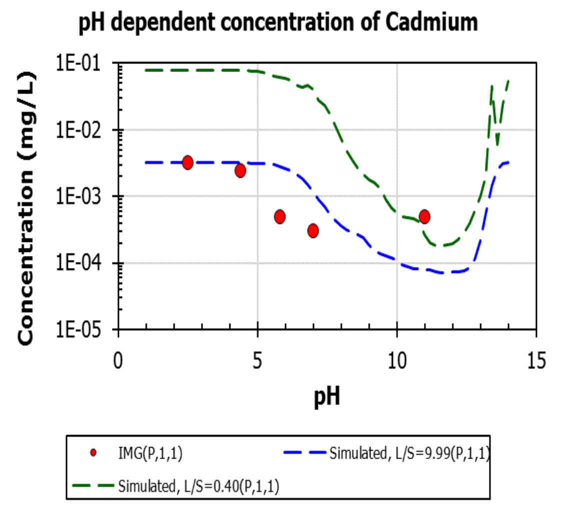


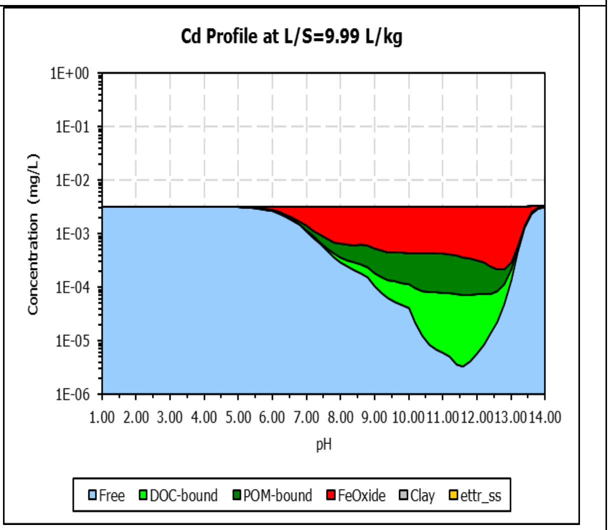

pH dependent concentration of Barium
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

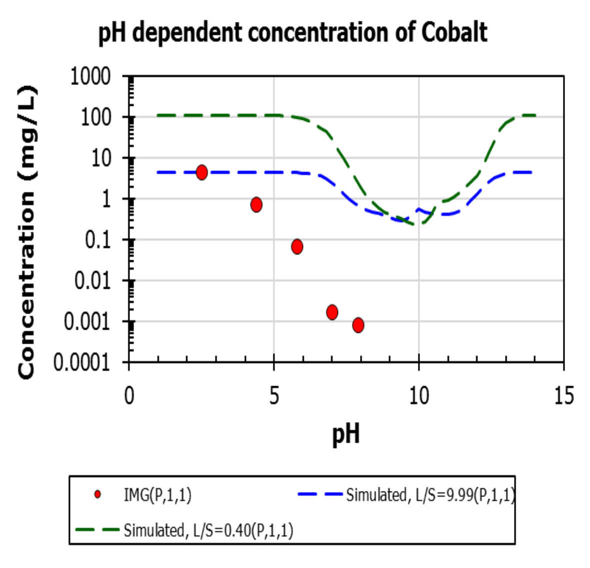

Ba Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

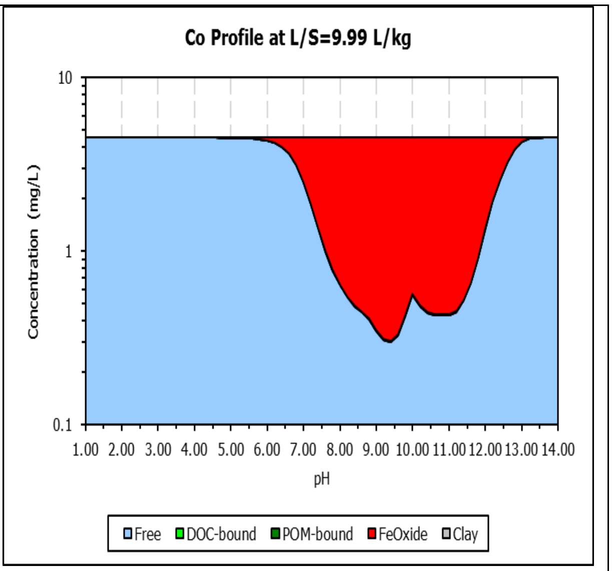

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

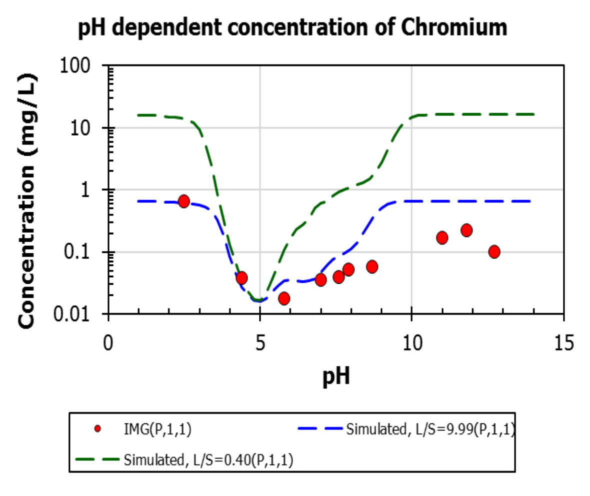

Ca Profile at L/S=9.99 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Cem07_Calcite
Dolomite
Gypsum

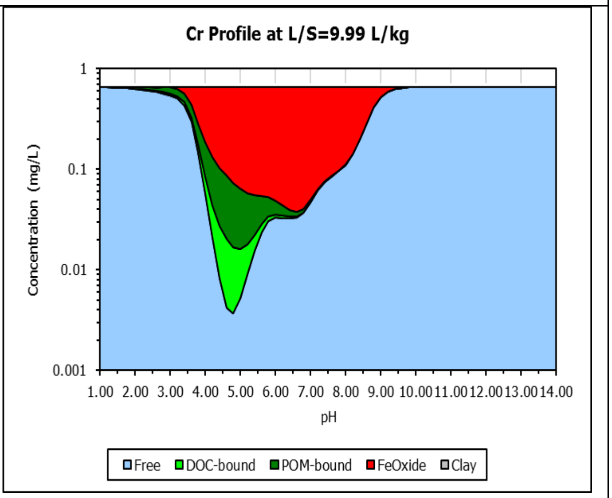

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

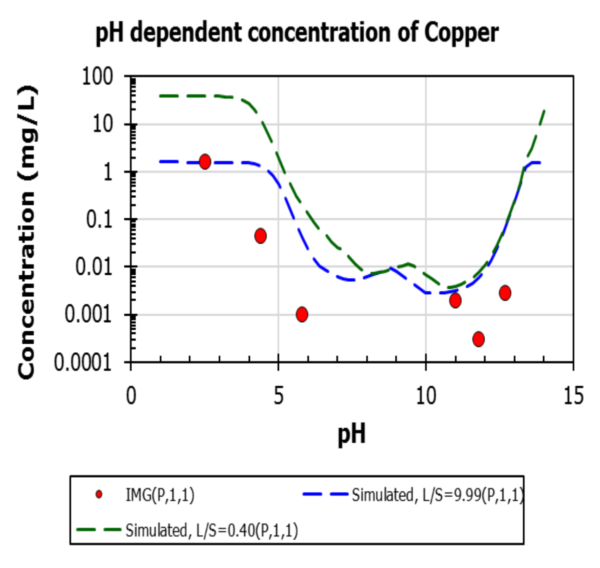

Cd Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

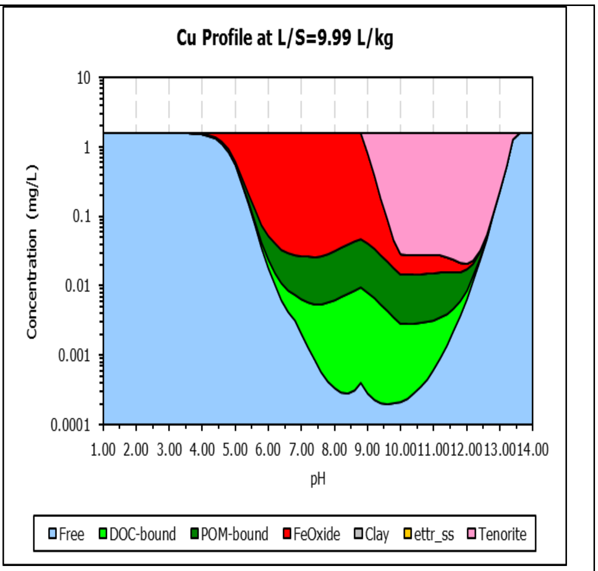

pH dependent concentration of Cobalt
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

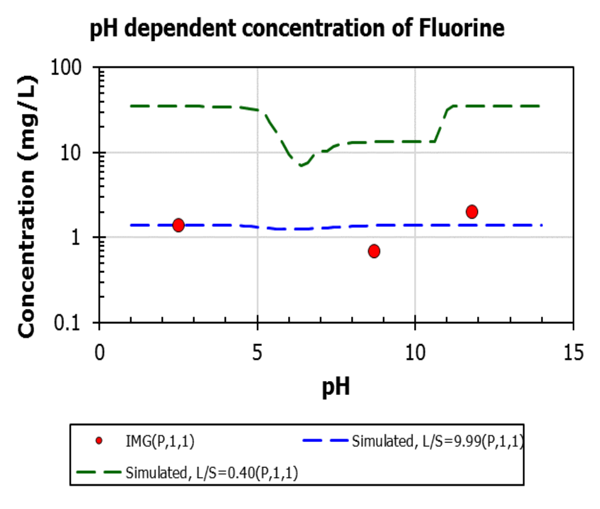

Co Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

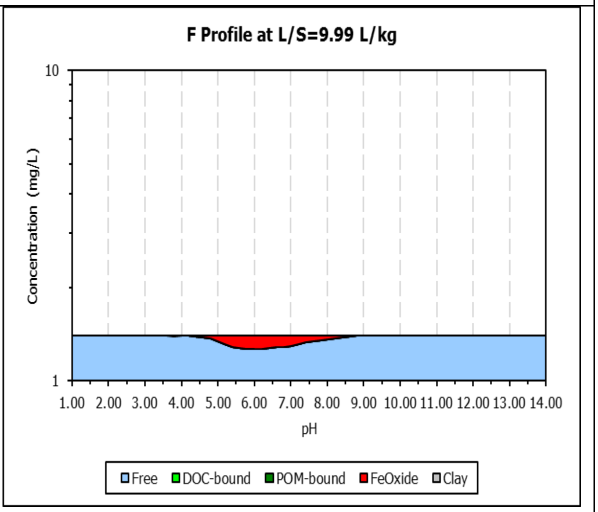

pH dependent concentration of Chromium
Concentration (mg/L)
100
10
1
0.1
0.01
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

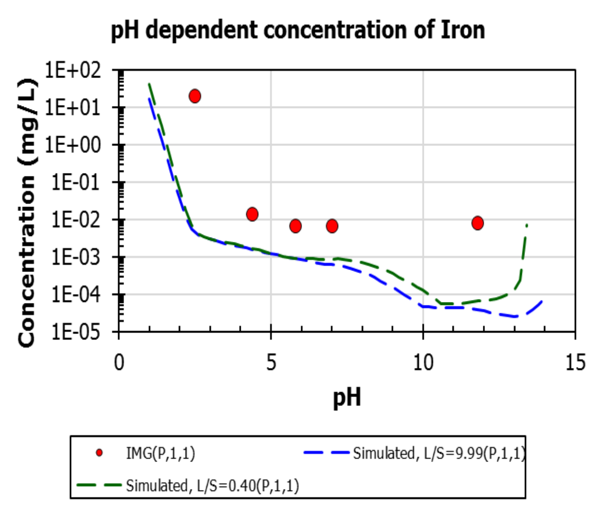

Cr Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

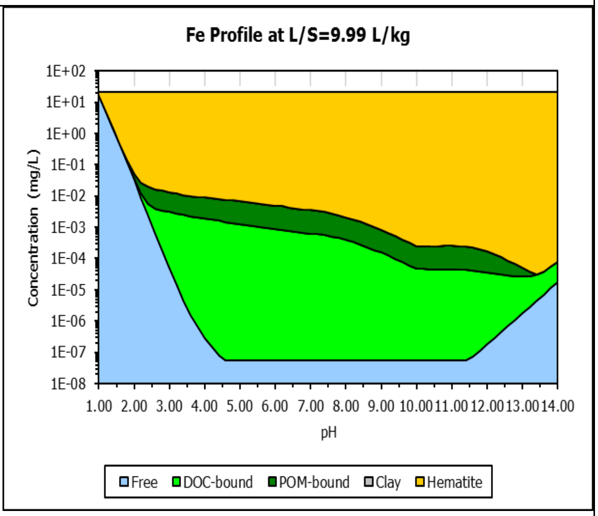

pH dependent concentration of Copper
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
● IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

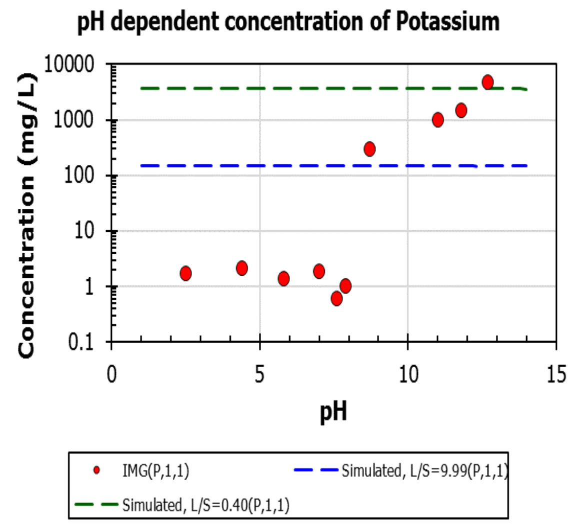

Cu Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Tenorite

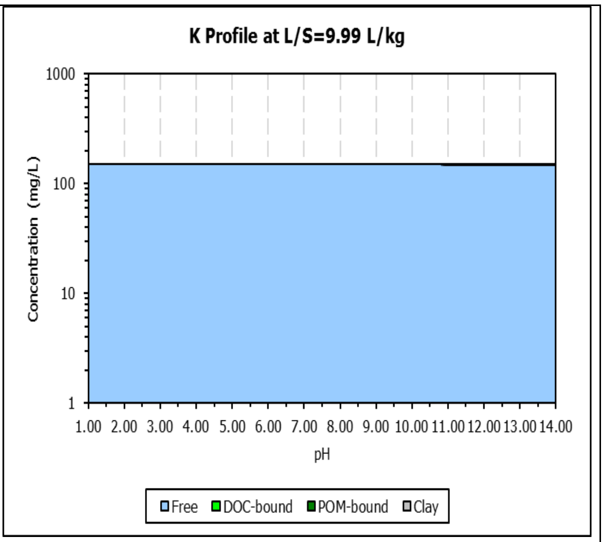

pH dependent concentration of Fluorine
Concentration (mg/L)
100
10
1
0.1
0
5
10
15
pH
● IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

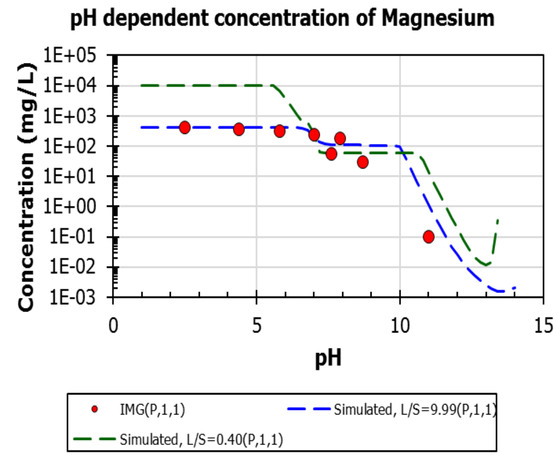

F Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

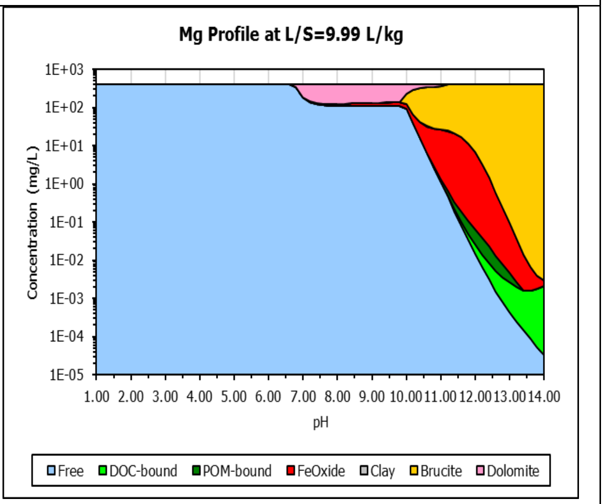

pH dependent concentration of Iron
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
● IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

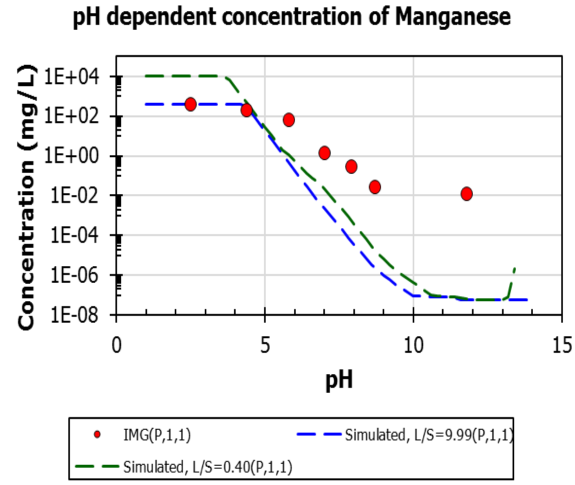

Fe Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
Clay
Hematite

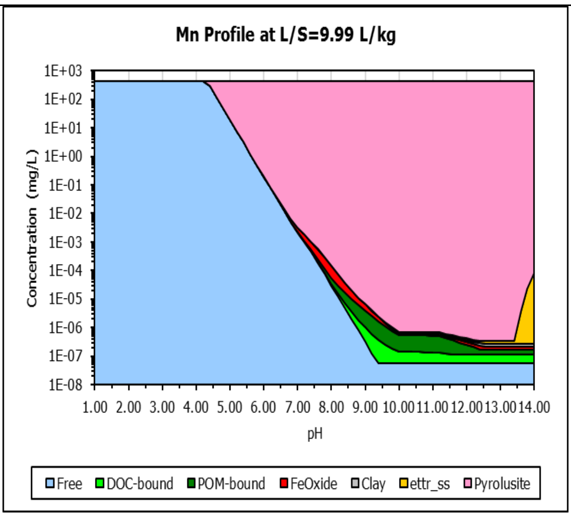

pH dependent concentration of Potassium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

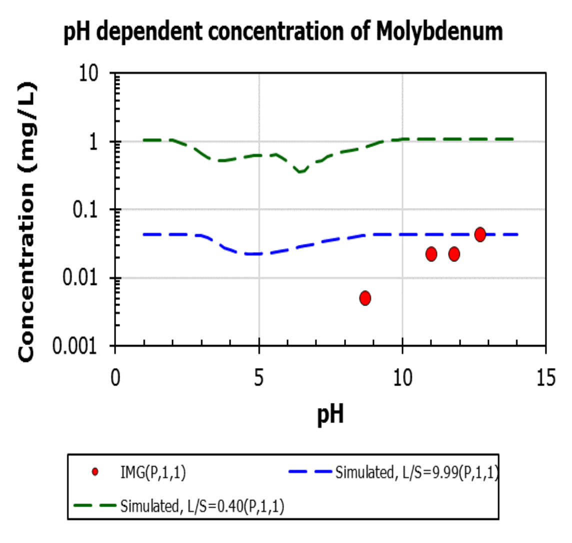

K Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

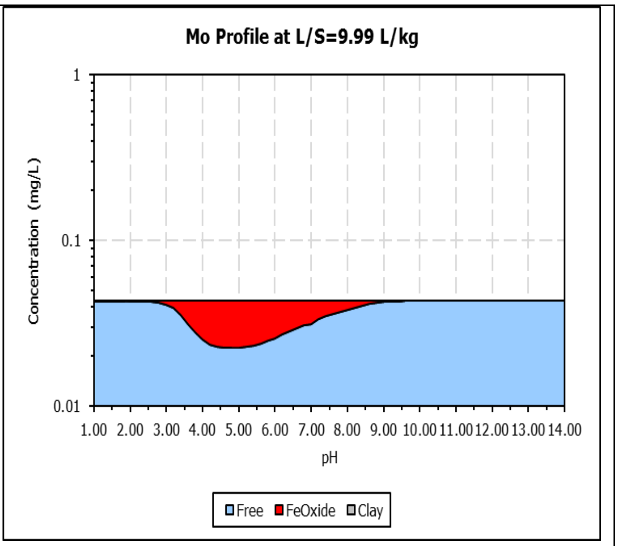

pH dependent concentration of Magnesium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

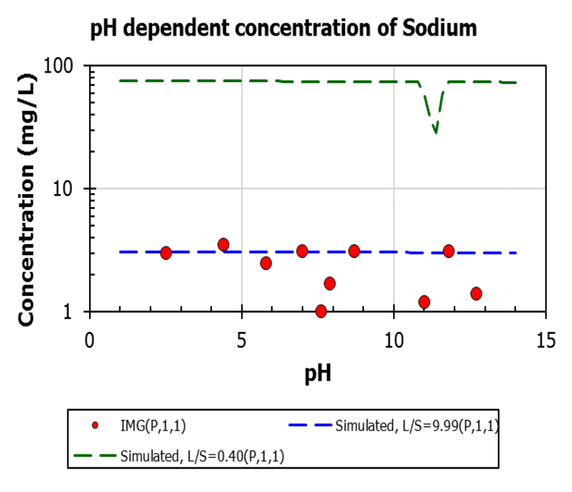

Mg Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Brucite
Dolomite

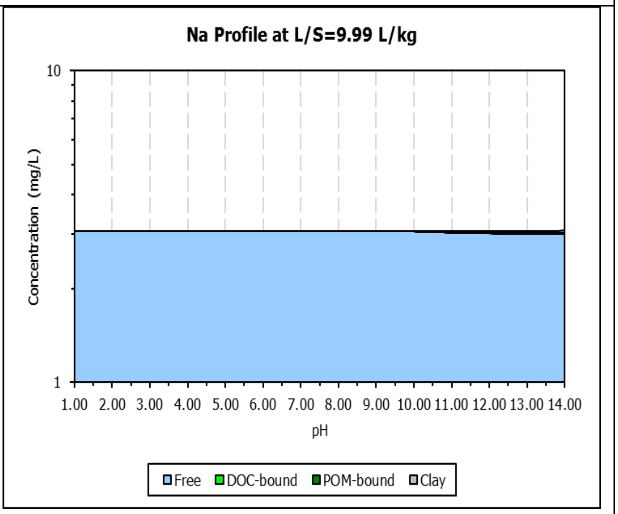

pH dependent concentration of Manganese
Concentration (mg/L)
1E+04
1E+02
1E+00
1E-02
1E-04
1E-06
1E-08
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

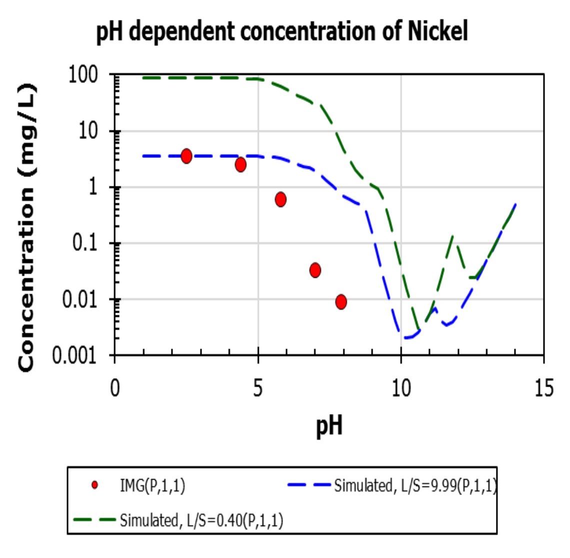

Mn Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Pyrolusite

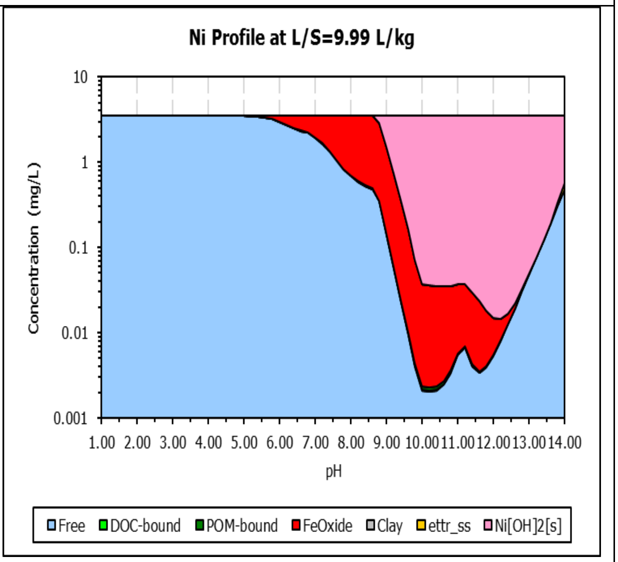

pH dependent concentration of Molybdenum
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

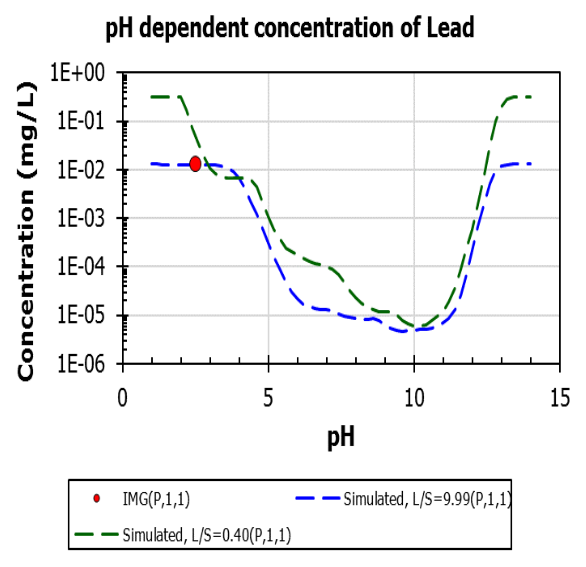

Mo Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

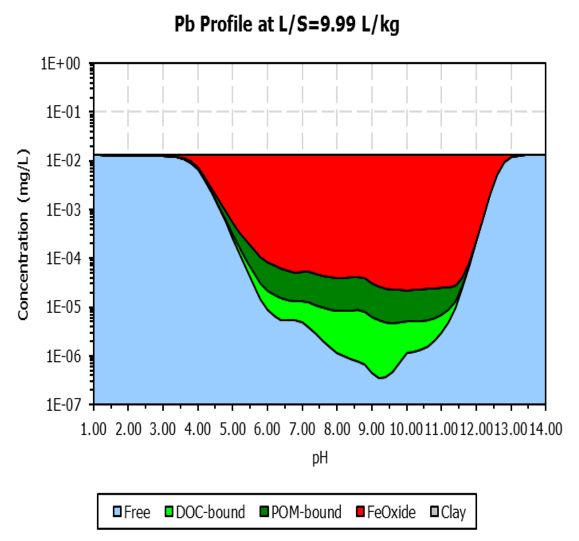

pH dependent concentration of Sodium
Concentration (mg/L)
100
10
1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

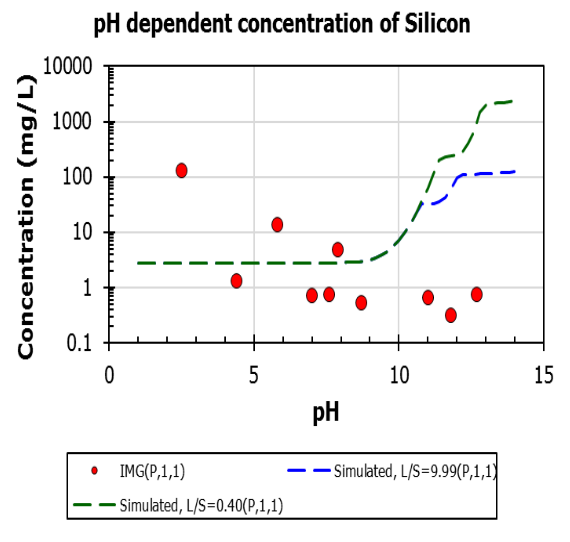

Na Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

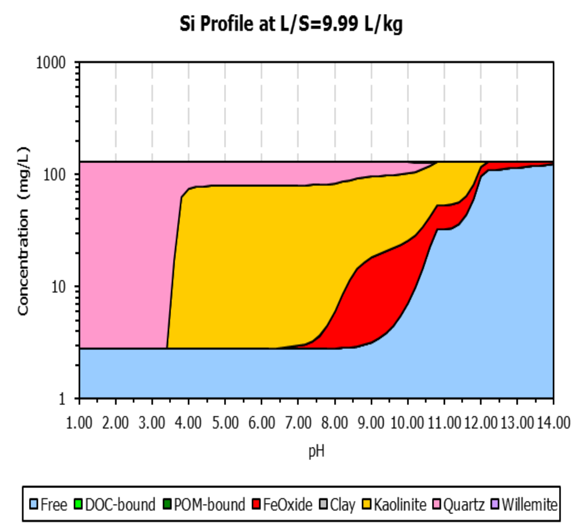

pH dependent concentration of Nickel
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

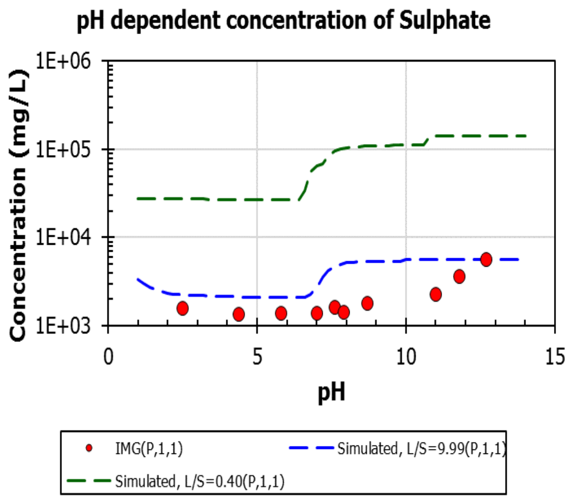

Ni Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Ni[OH]2[s]

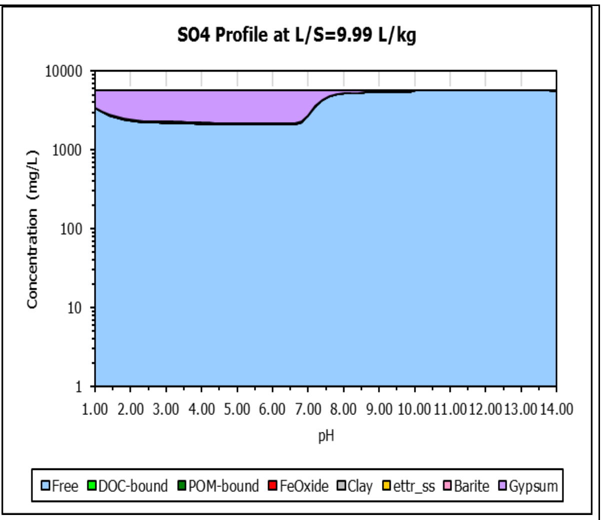

pH dependent concentration of Lead
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

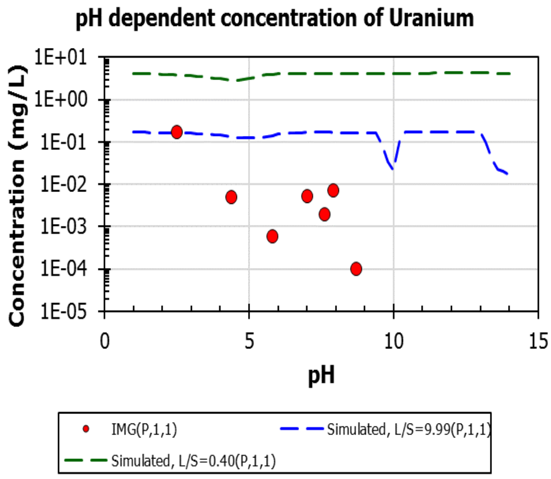

Pb Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

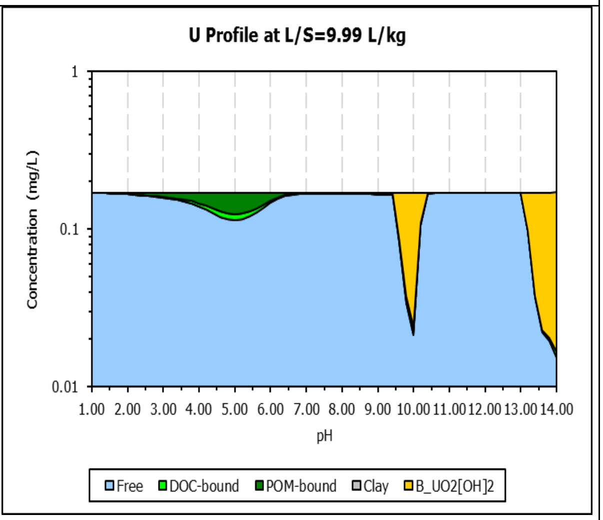

pH dependent concentration of Silicon
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

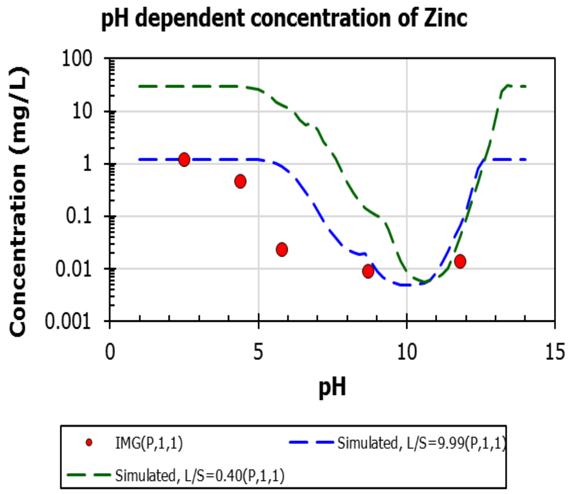

Si Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Kaolinite
Quartz
Willemite

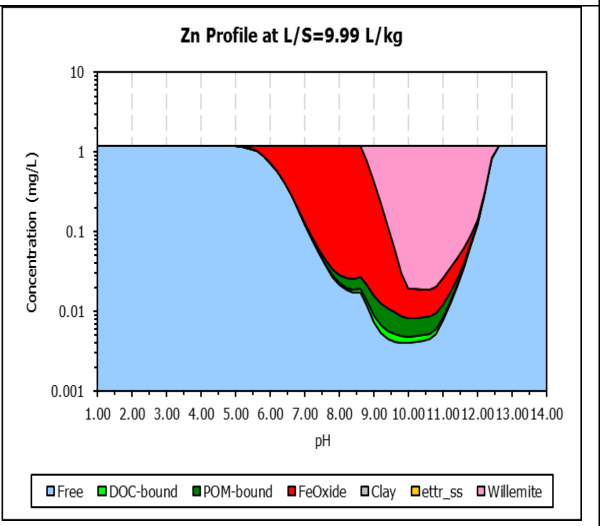

pH dependent concentration of Sulphate


SO4 Profile at L/S=9.99 L/kg

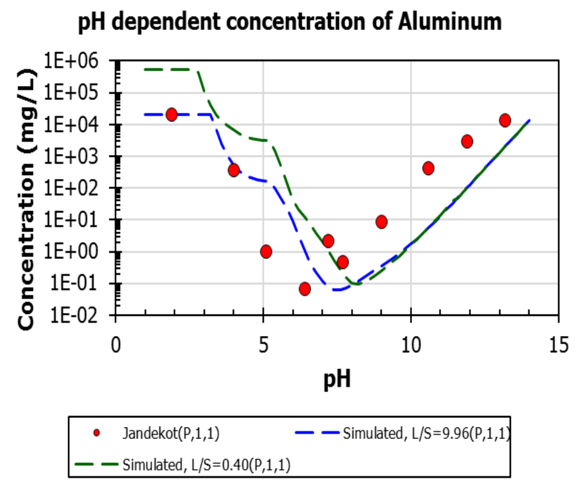

pH dependent concentration of Uranium

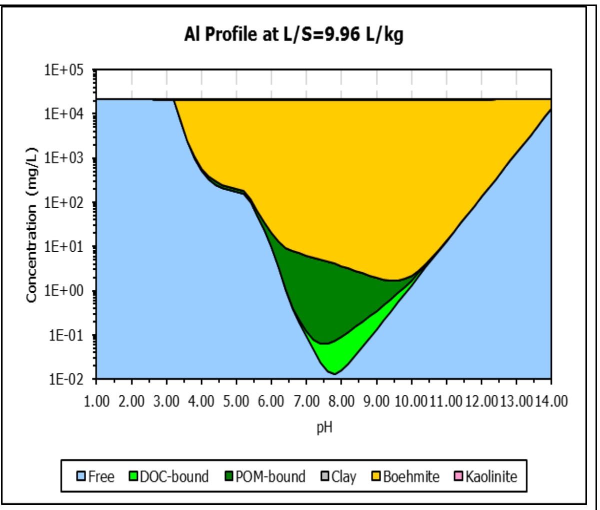

U Profile at L/S=9.99 L/kg

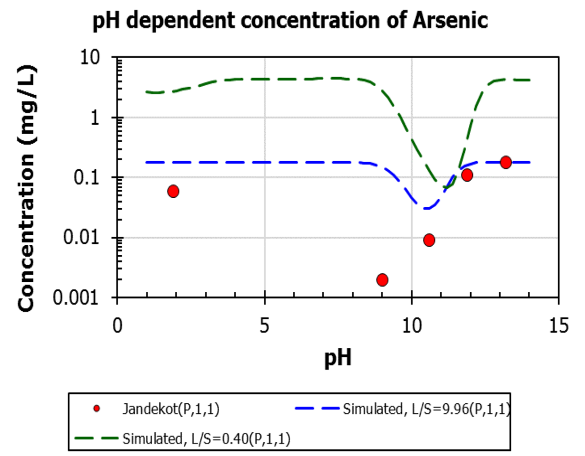

pH dependent concentration of Zinc

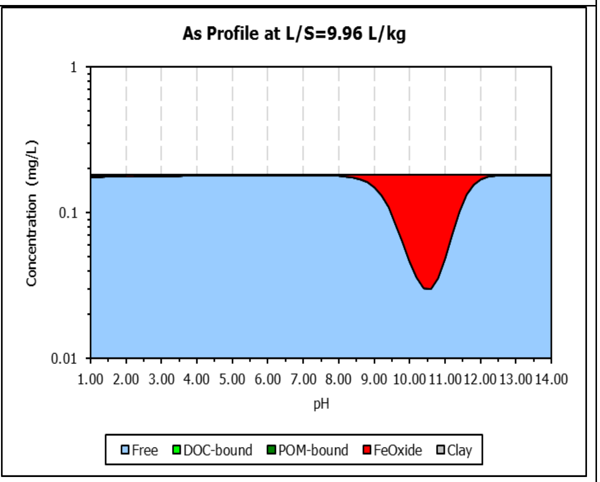

Zn Profile at L/S=9.99 L/kg

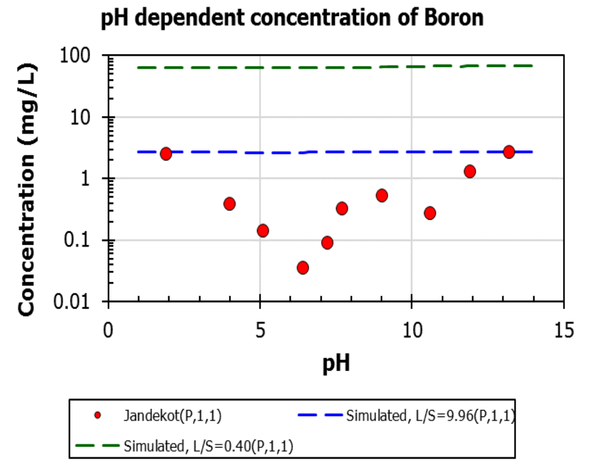
A8-4: Ground water treatment Jandakot Residue

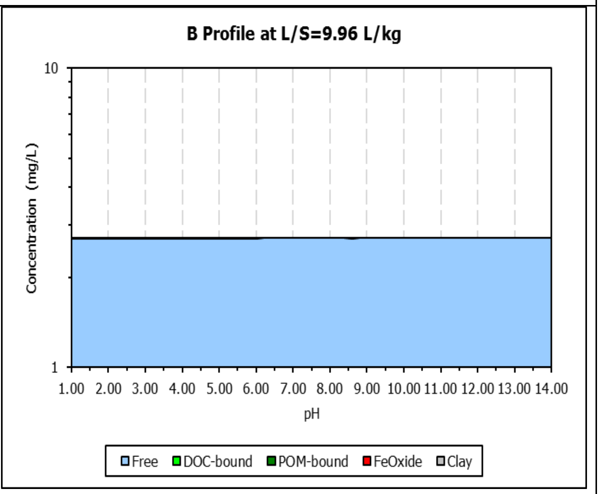


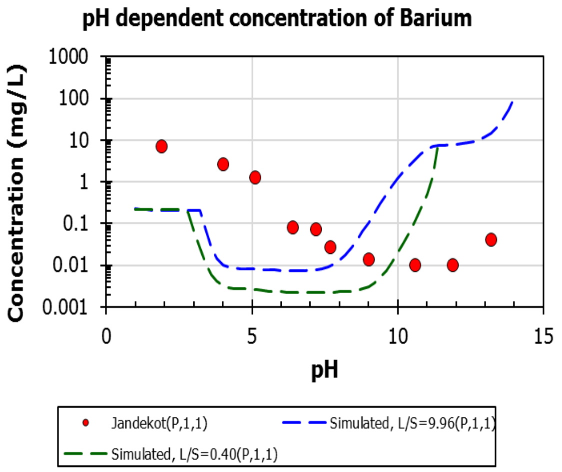


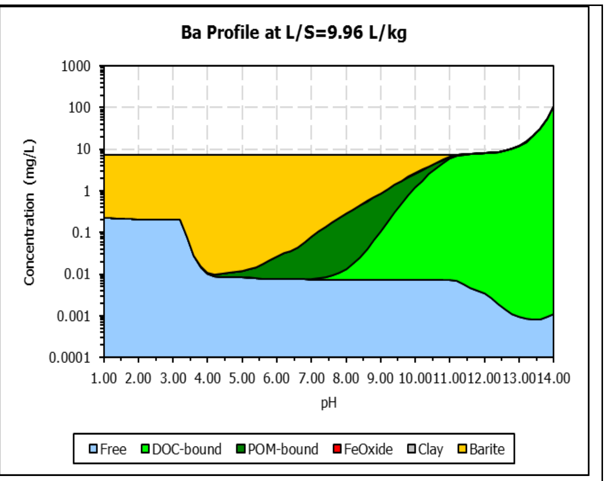


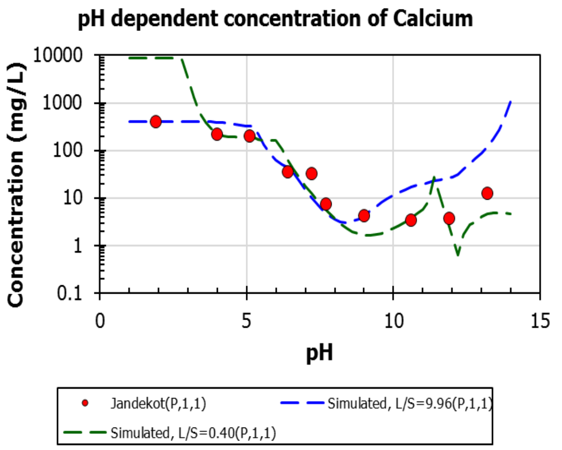


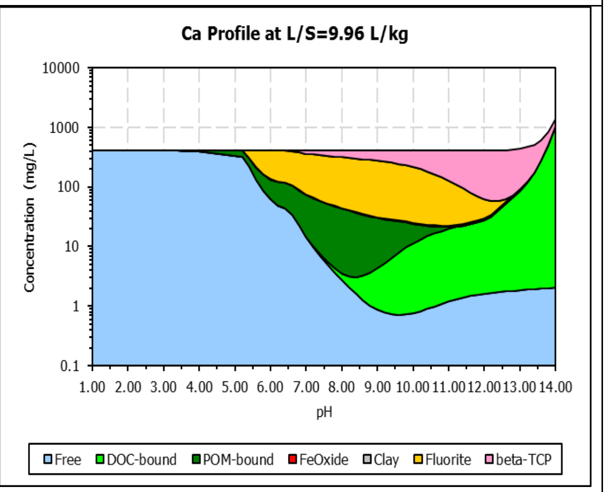


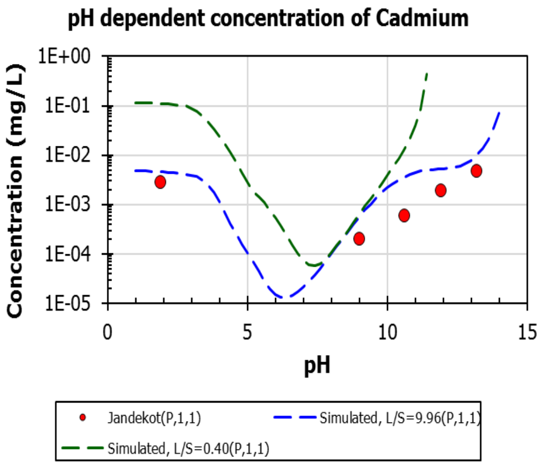


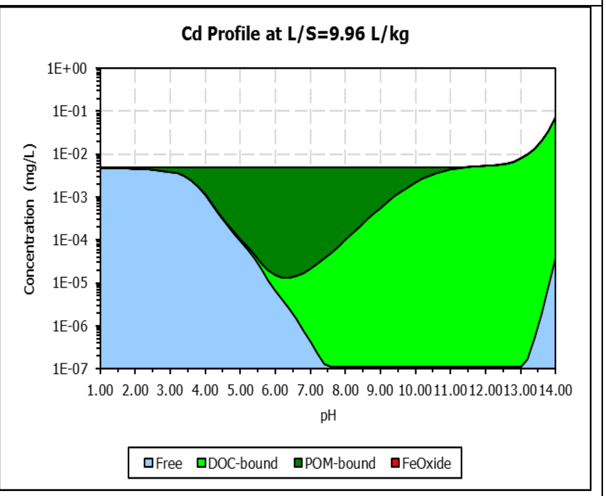

pH dependent concentration of Barium
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

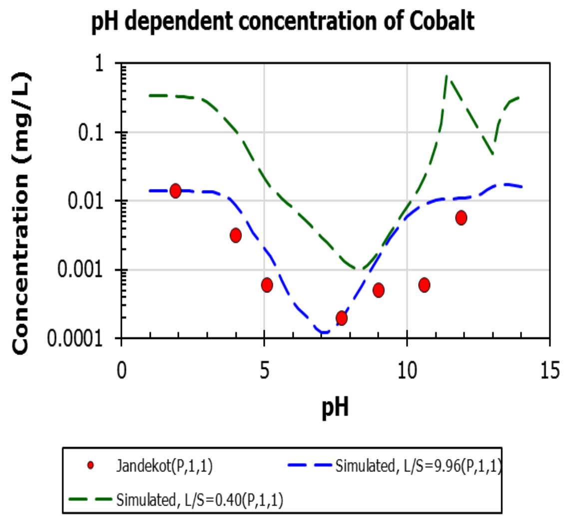

Ba Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite

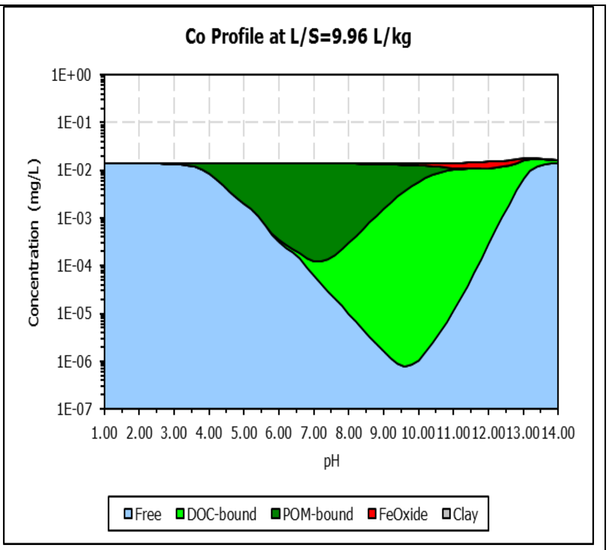

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

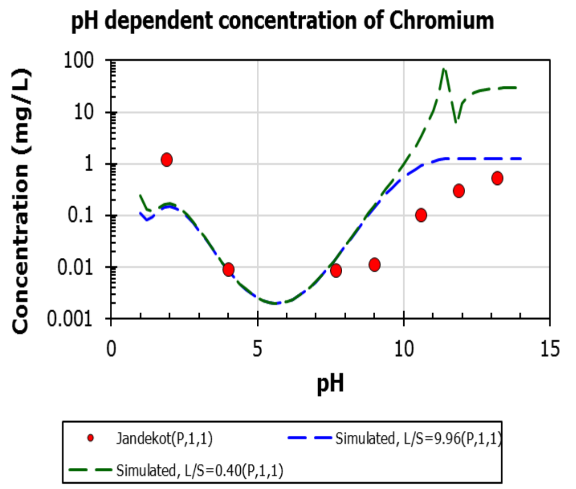

Ca Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite
beta-TCP

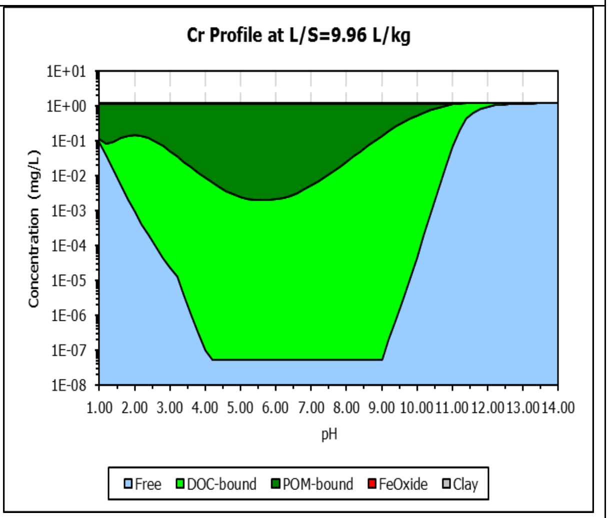

pH dependent concentration of Cadmium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

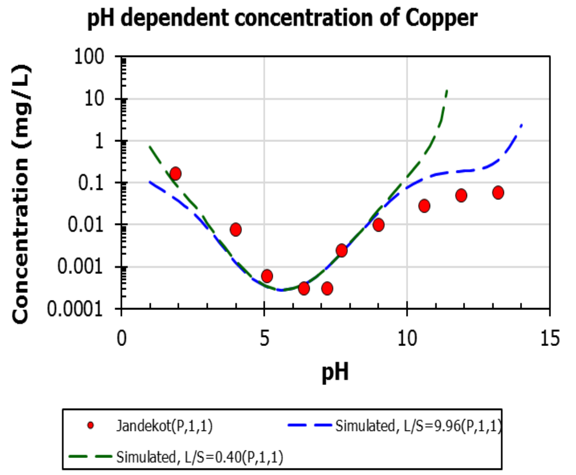

Cd Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide

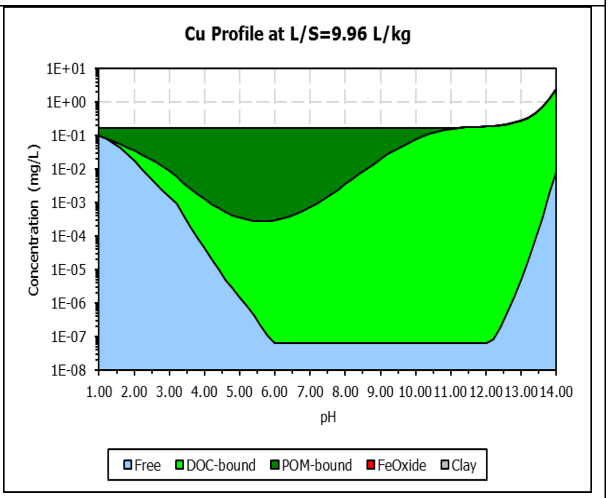

pH dependent concentration of Cobalt
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

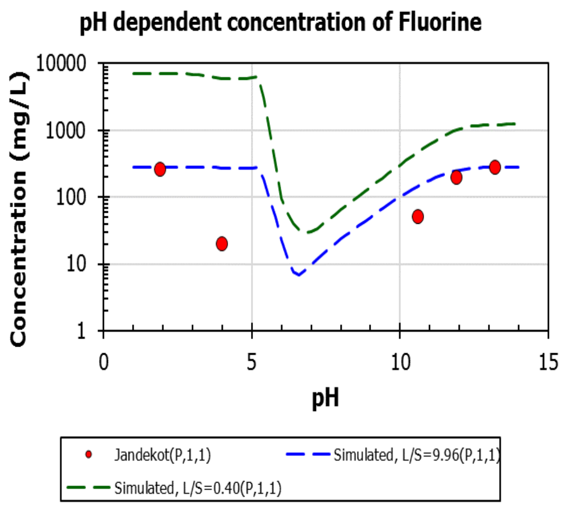

Co Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

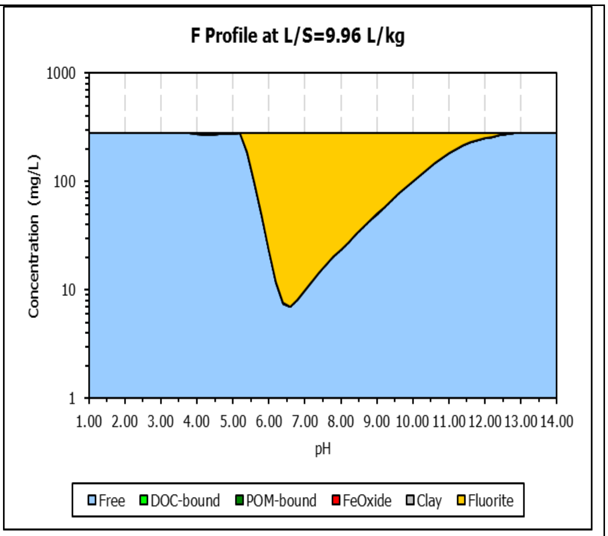

pH dependent concentration of Chromium
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

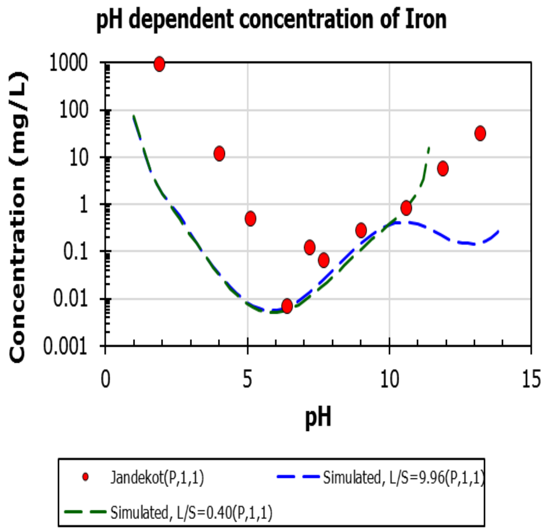

Cr Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

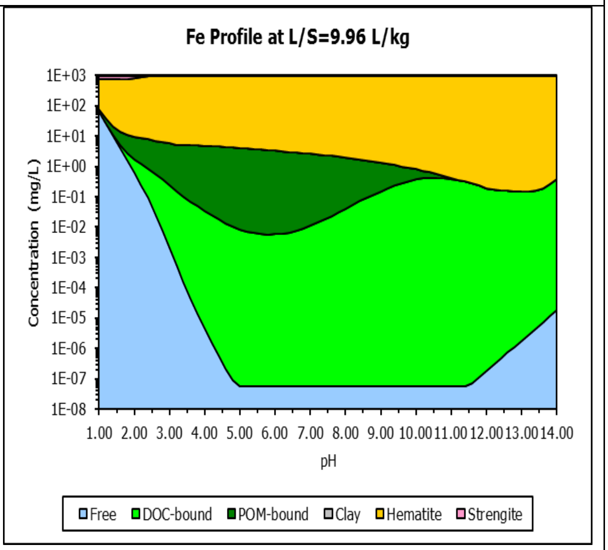

pH dependent concentration of Copper
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

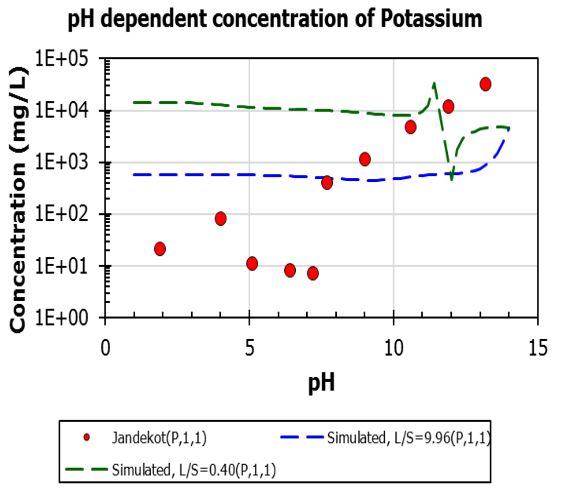

Cu Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

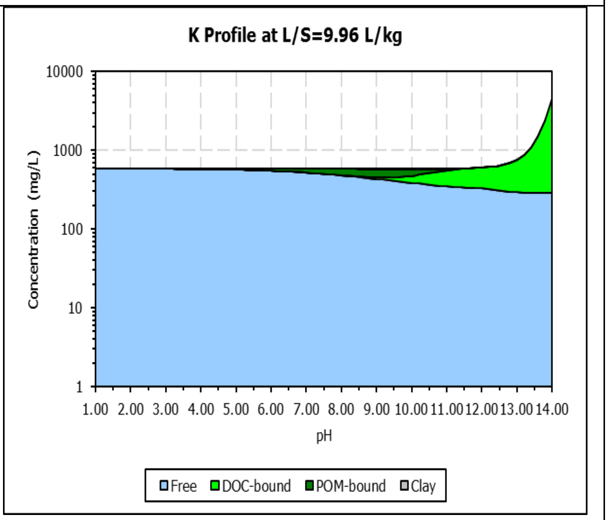

pH dependent concentration of Fluorine
Concentration (mg/L)
10000
1000
100
10
1
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

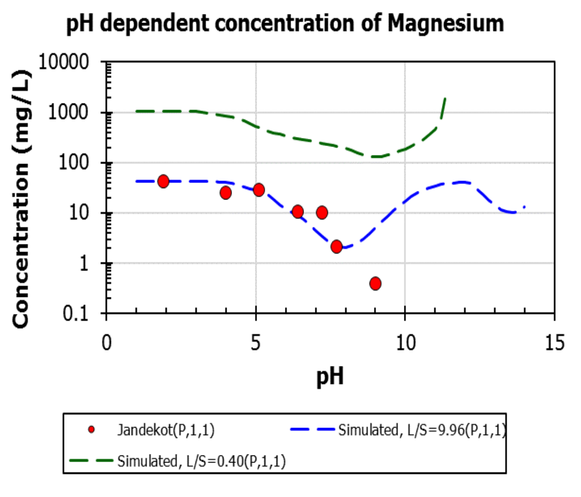

F Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite

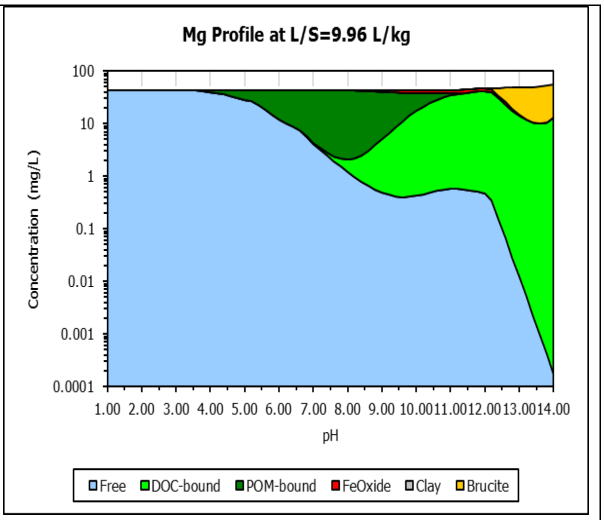

pH dependent concentration of Iron
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

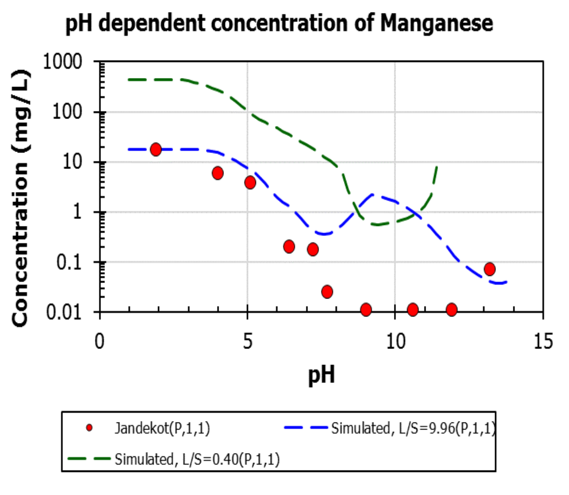

Fe Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
Clay
Hematite
Strengite

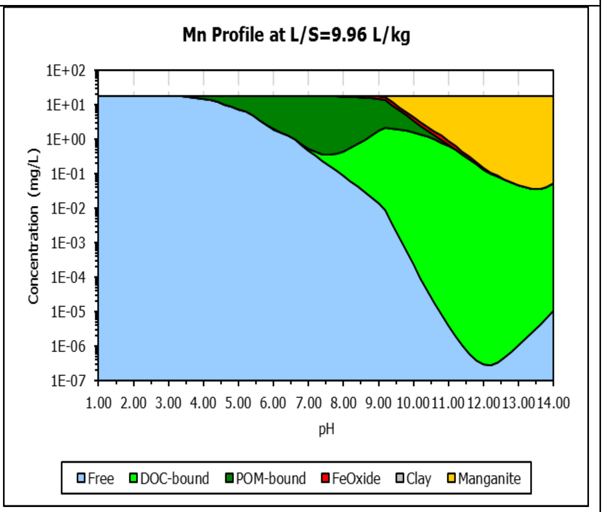

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

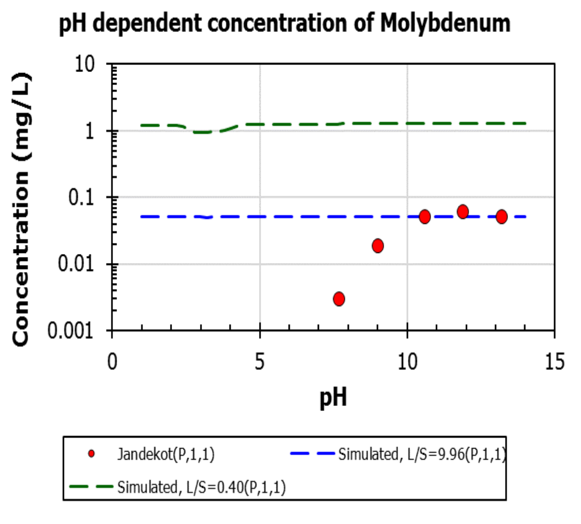

K Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
Clay

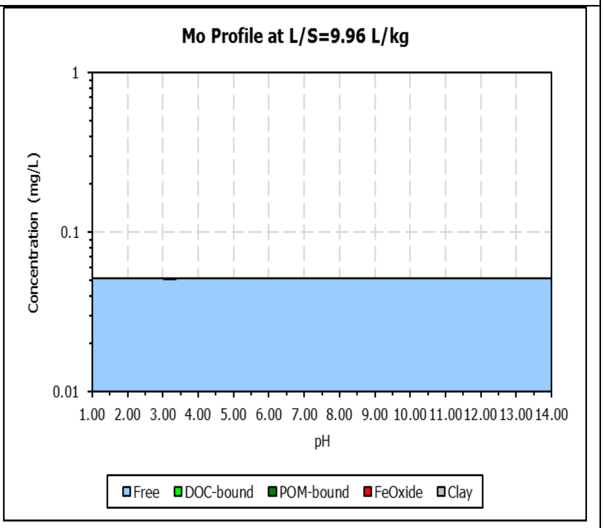

pH dependent concentration of Magnesium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

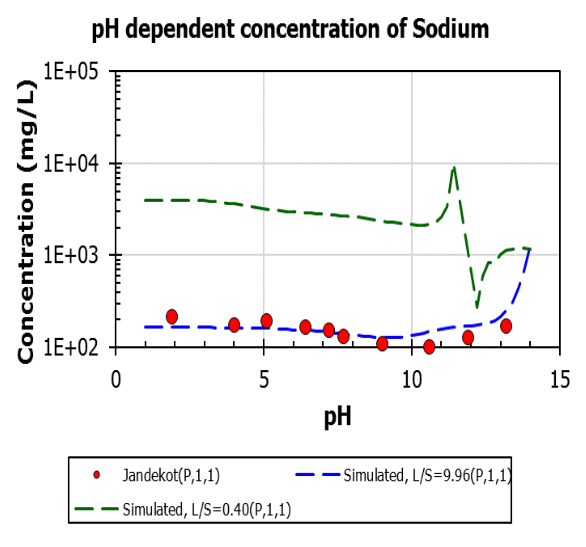

Mg Profile at L/S=9.96 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Brucite

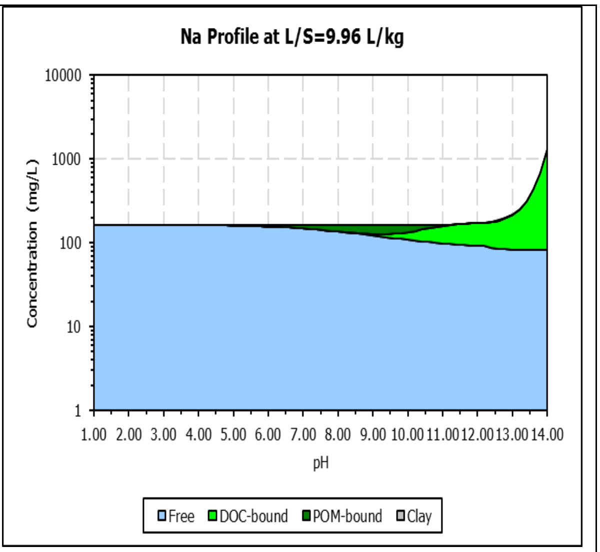

pH dependent concentration of Manganese
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

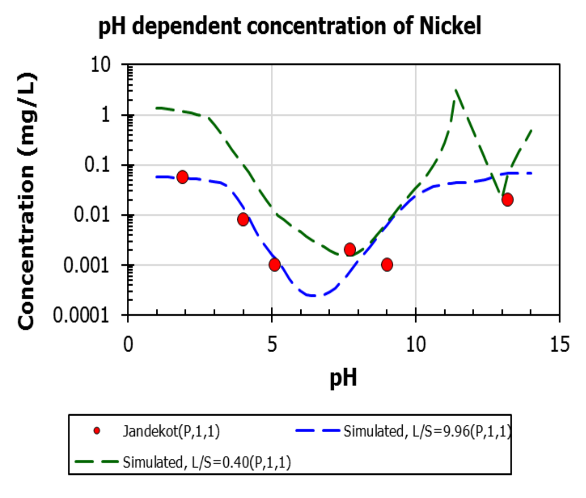

Mn Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

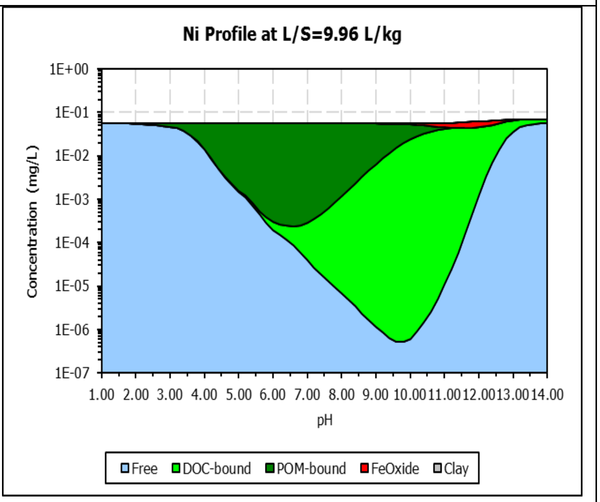

pH dependent concentration of Molybdenum
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

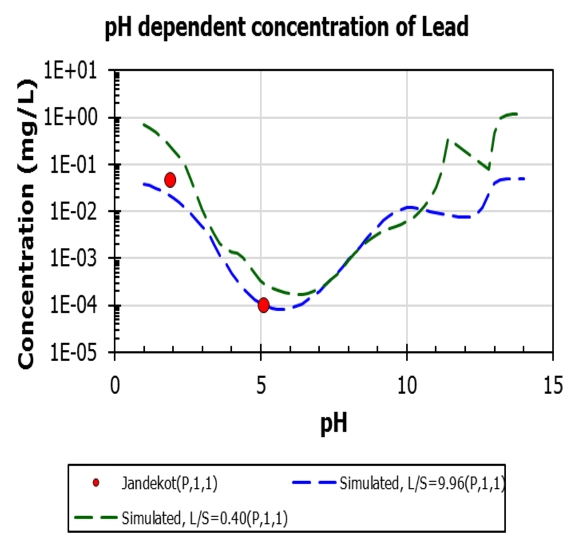

Mo Profile at L/S=9.96 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

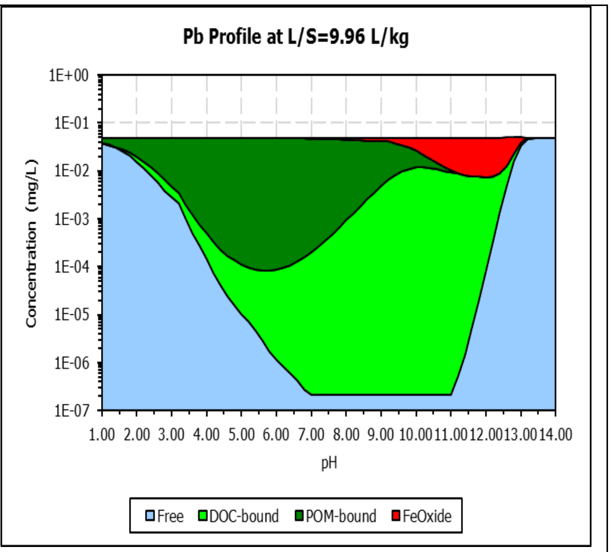

pH dependent concentration of Sodium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

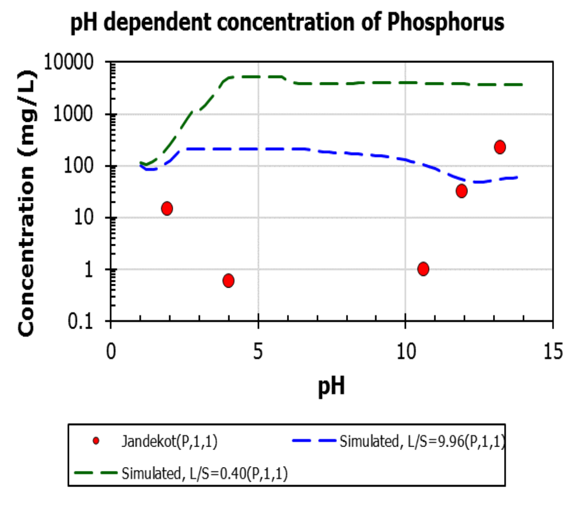

Na Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

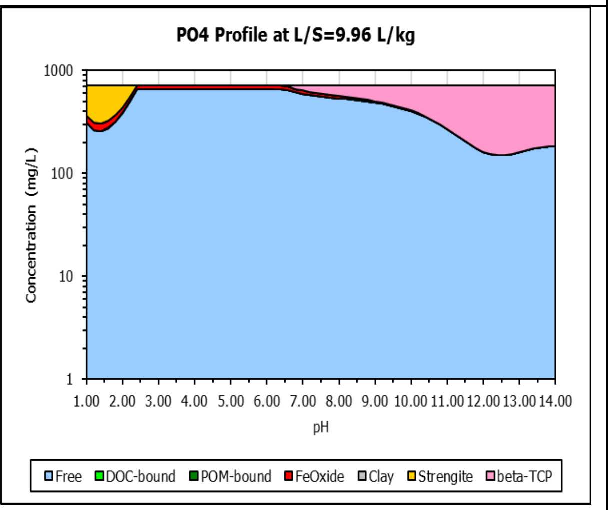

pH dependent concentration of Nickel
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

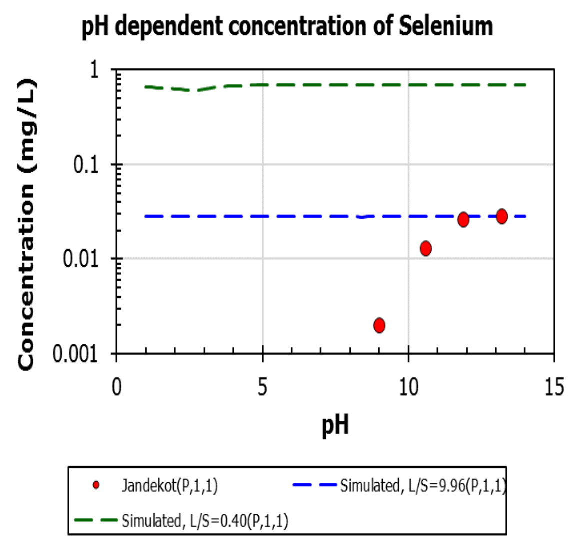

Ni Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

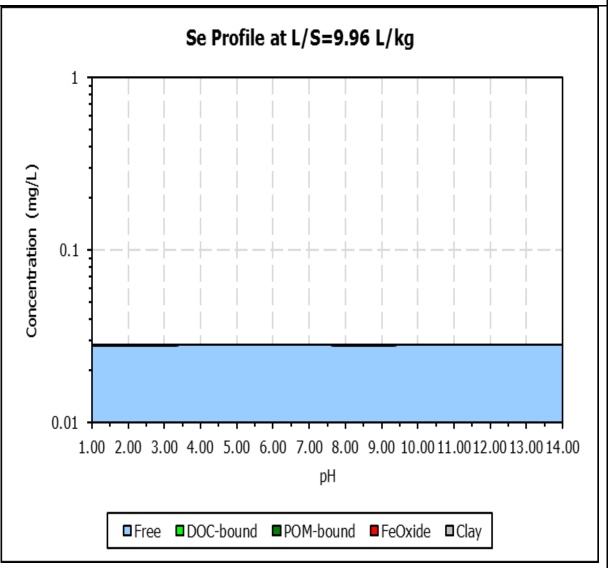

pH dependent concentration of Lead
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

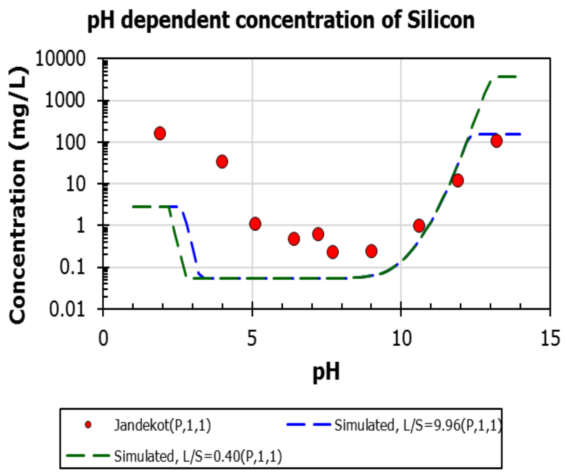

Pb Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide

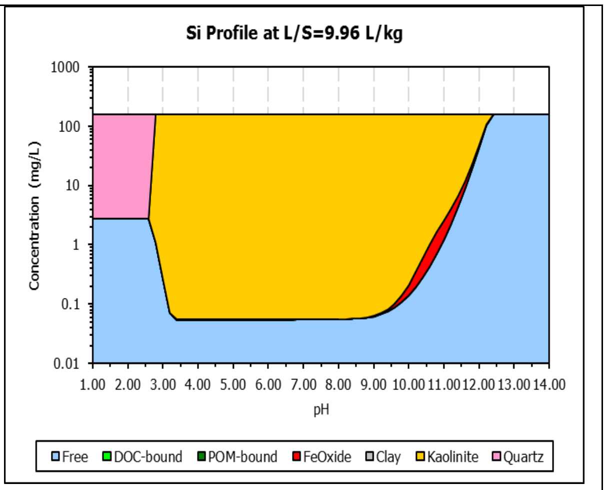

pH dependent concentration of Phosphorus
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

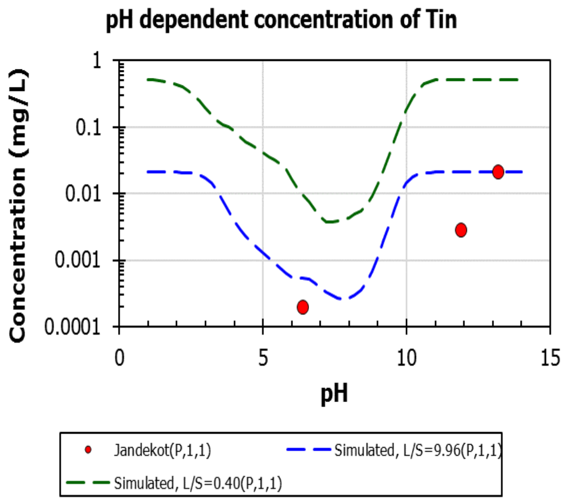

PO4 Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Strengite
beta-TCP

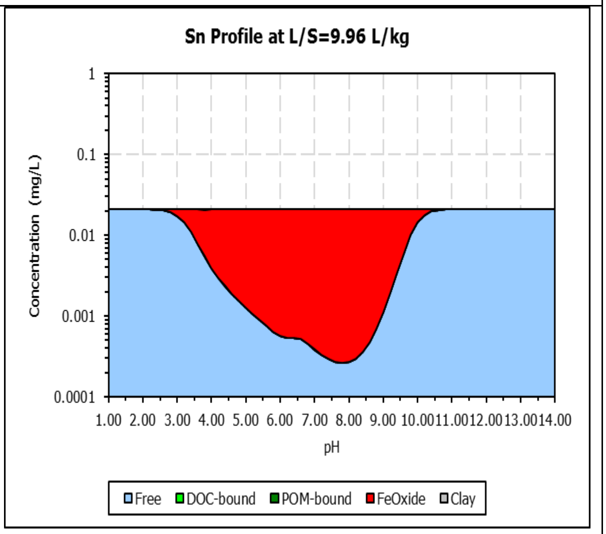

pH dependent concentration of Selenium
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

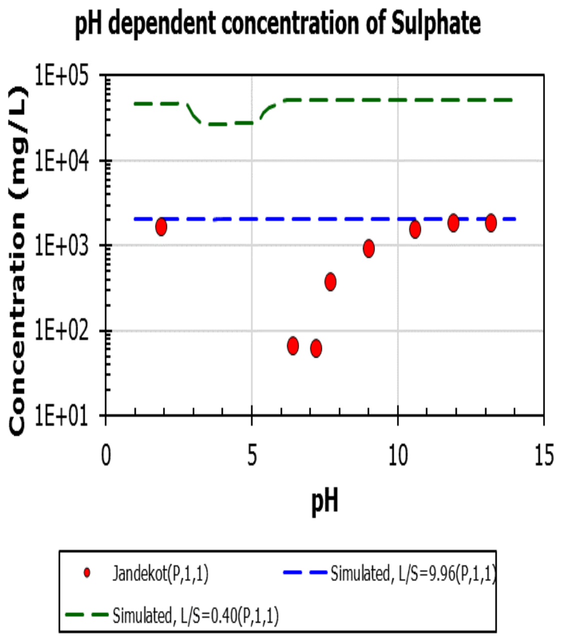

Se Profile at L/S=9.96 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

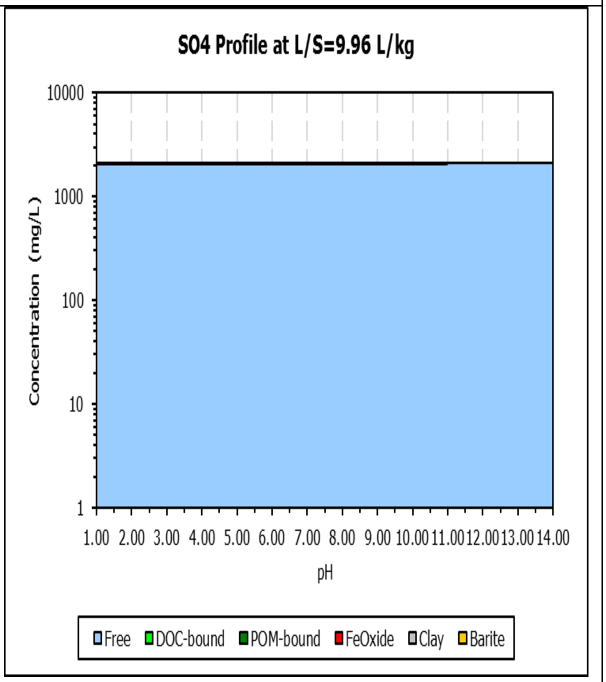

pH dependent concentration of Silicon
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

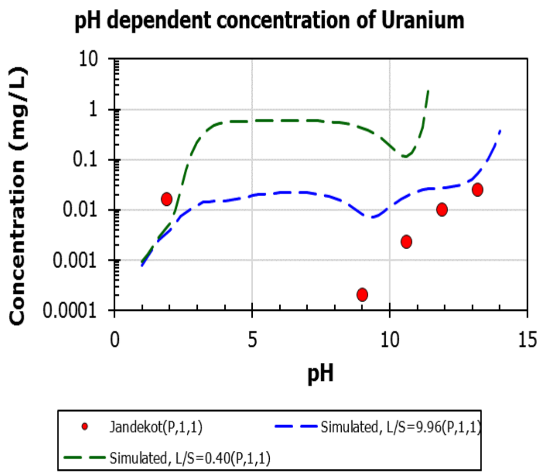

Si Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Kaolinite
Quartz

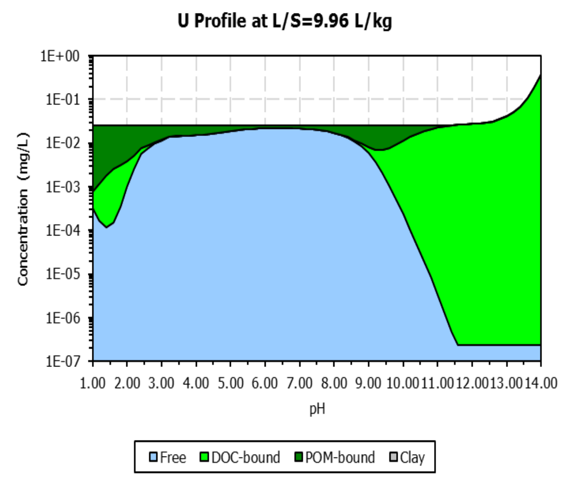

pH dependent concentration of Tin
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

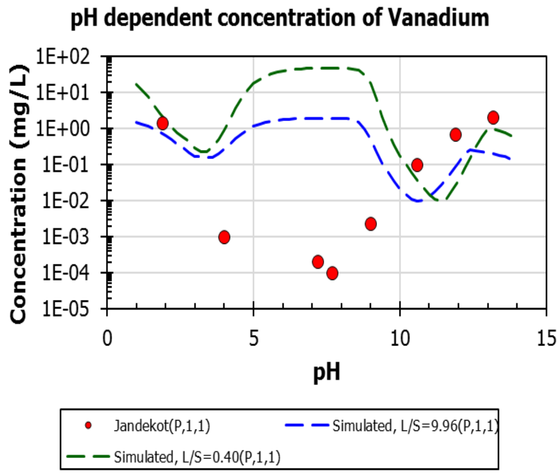

Sn Profile at L/S=9.96 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

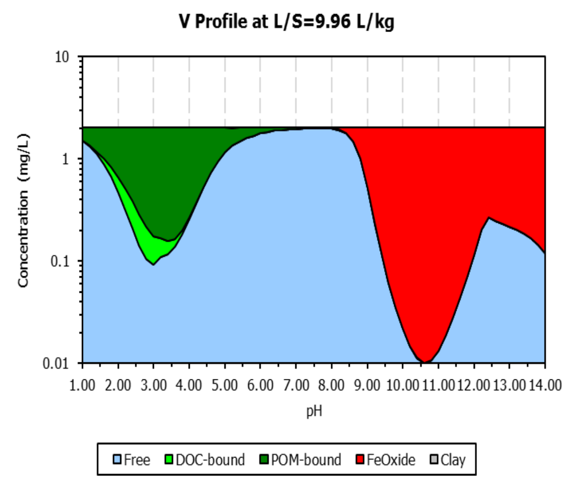

pH dependent concentration of Sulphate
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

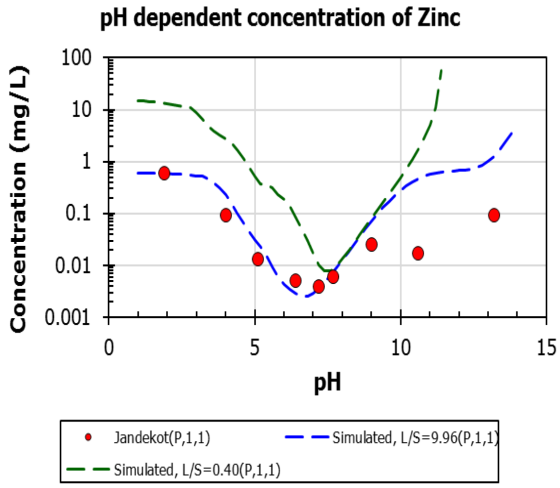

SO4 Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite

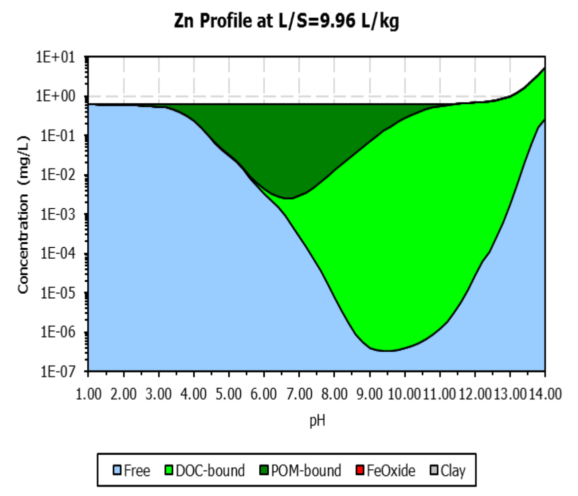

pH dependent concentration of Uranium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

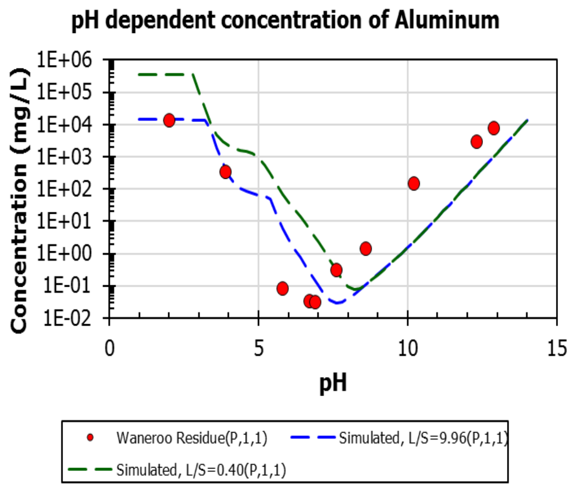

pH dependent concentration of Vanadium
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

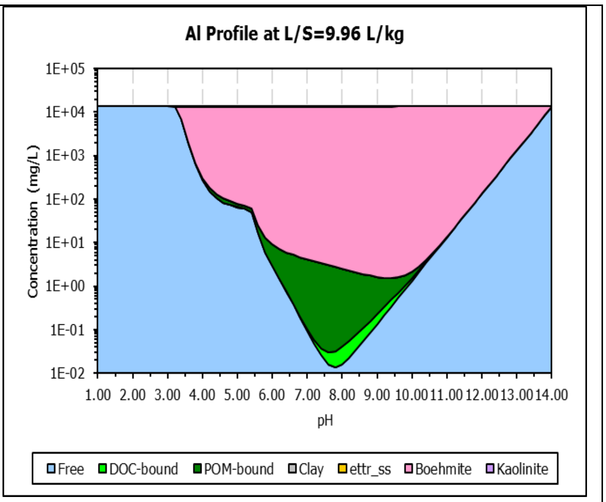

V Profile at L/S=9.96 L/kg
Concentration (mg/L)
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

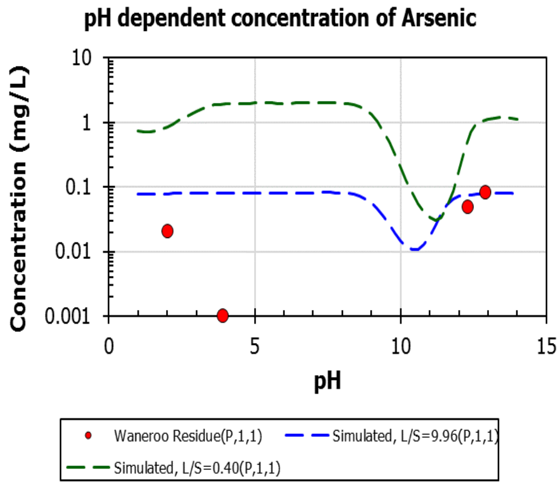

pH dependent concentration of Zinc
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Jandekot(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

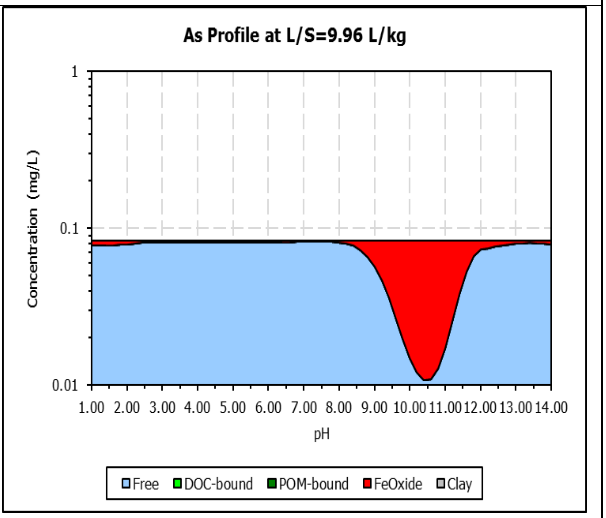

Zn Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

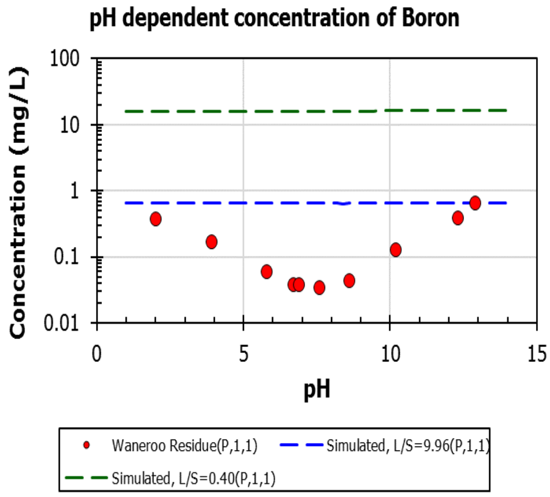
A8-5: Groundwater treatment Wanneroo Residue

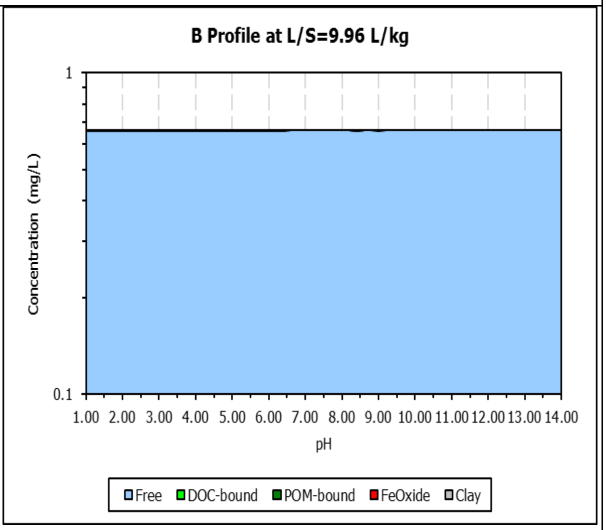


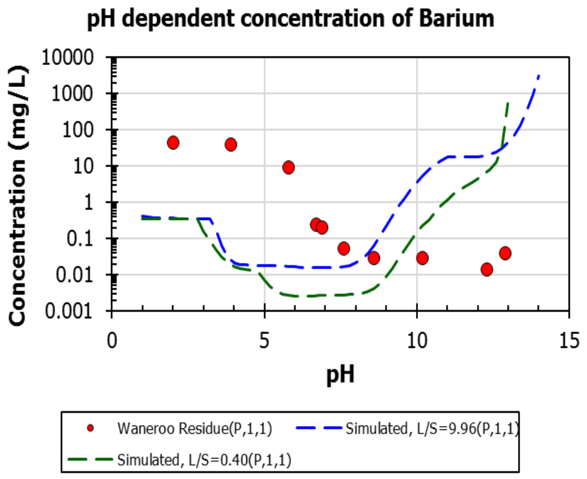




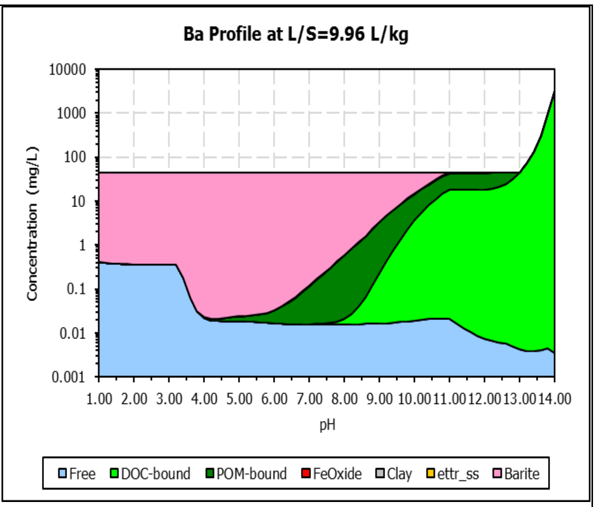




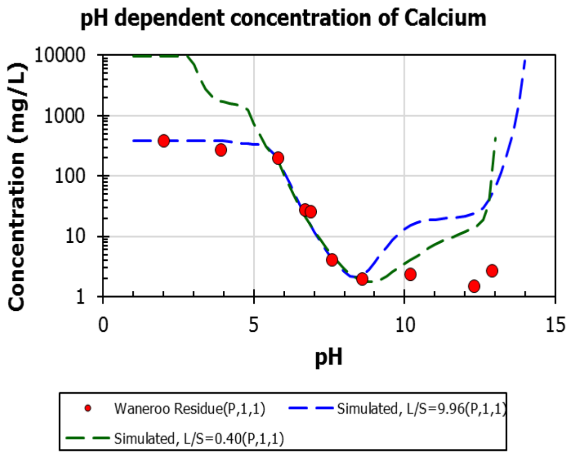




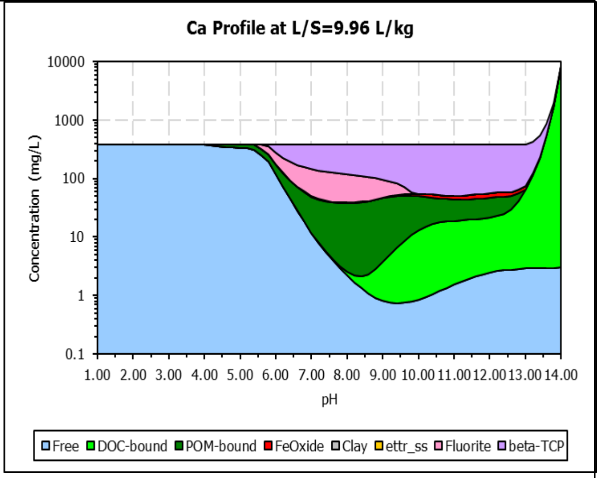
pH dependent concentration of Barium



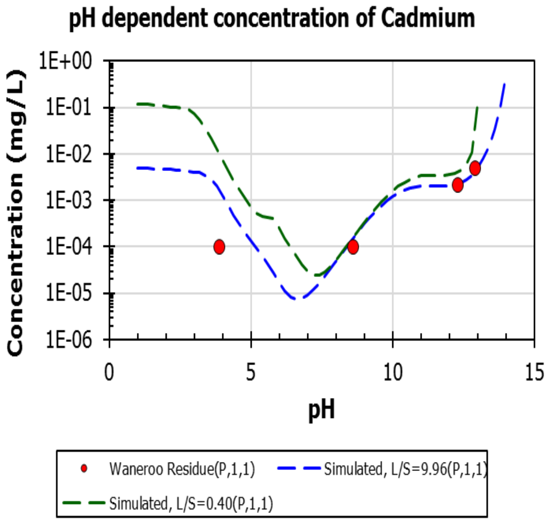
Ba Profile at L/S=9.96 L/kg



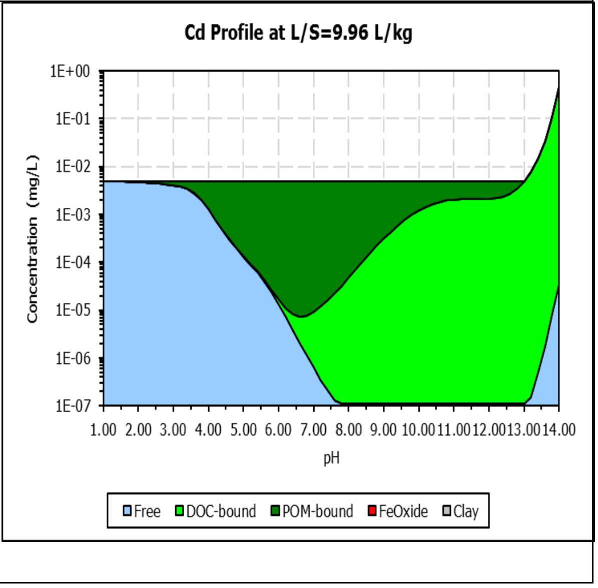
pH dependent concentration of Calcium



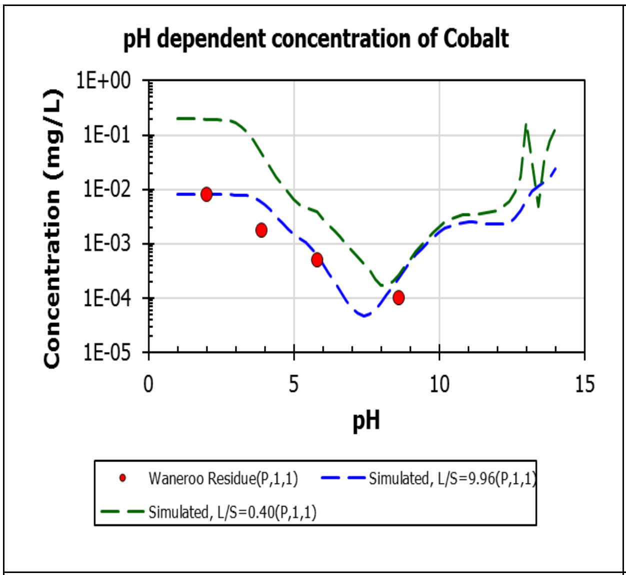
Ca Profile at L/S=9.96 L/kg



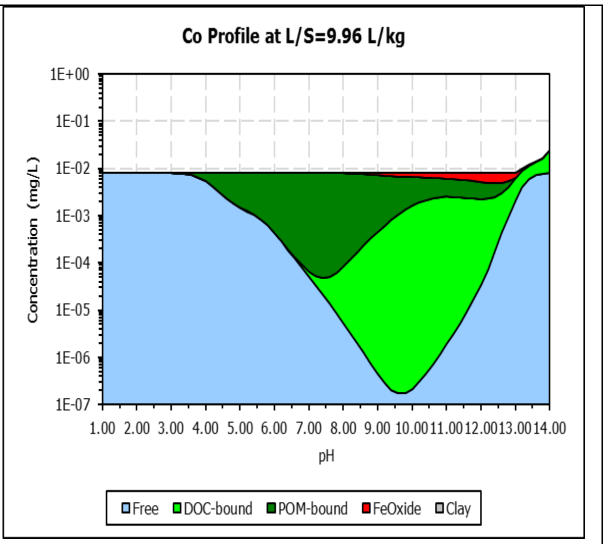
pH dependent concentration of Cadmium



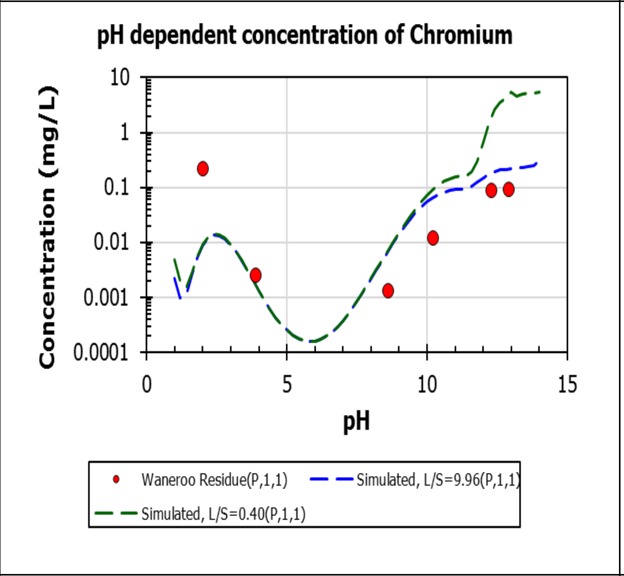
Cd Profile at L/S=9.96 L/kg



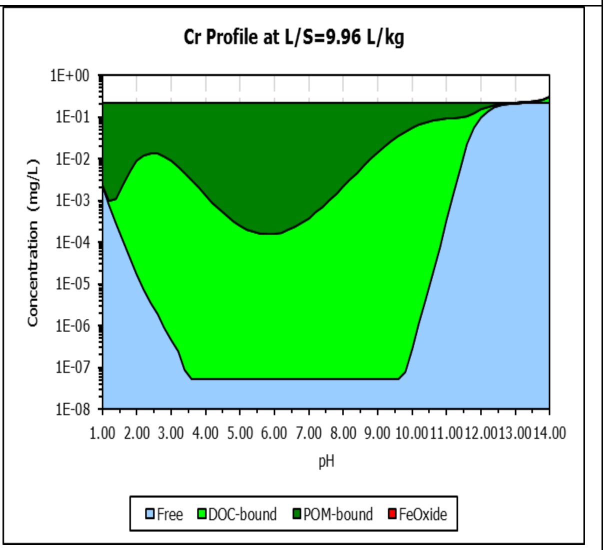
pH dependent concentration of Cobalt



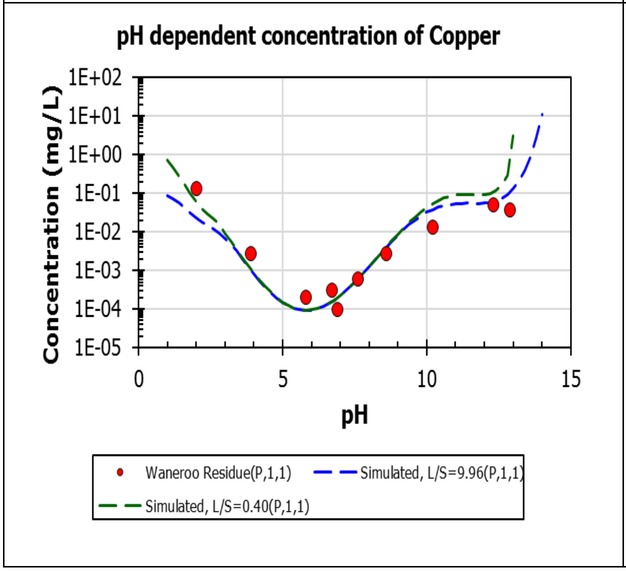
Co Profile at L/S=9.96 L/kg



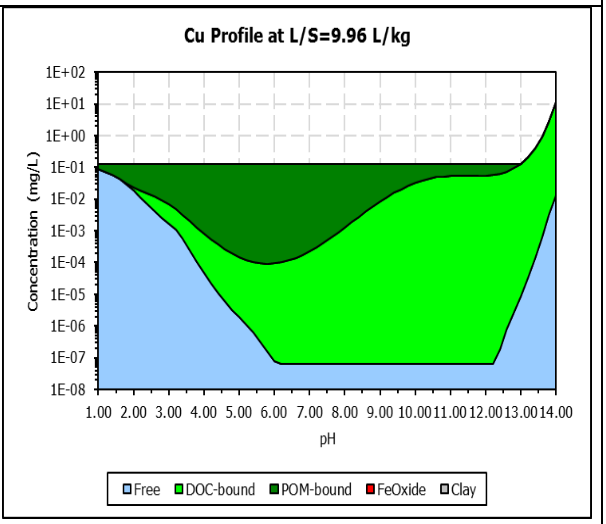
pH dependent concentration of Chromium



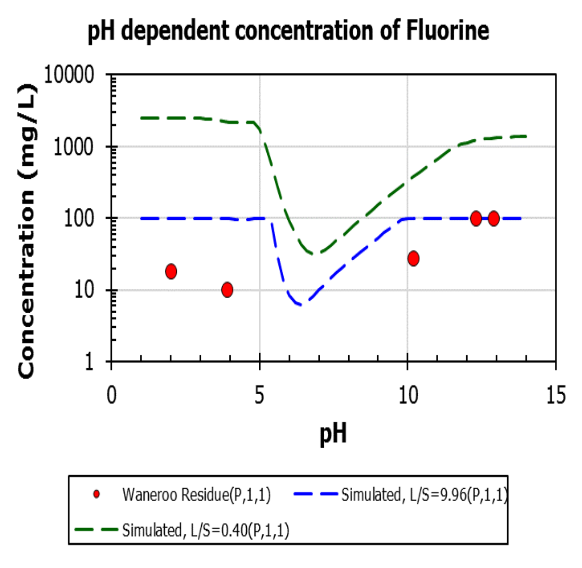
Cr Profile at L/S=9.96 L/kg

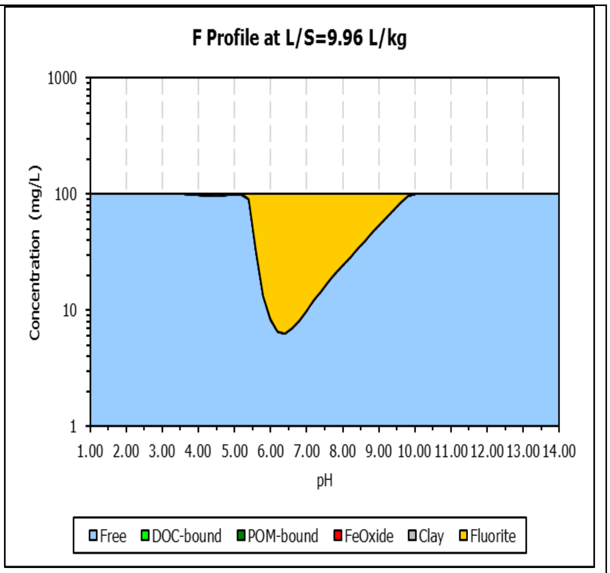


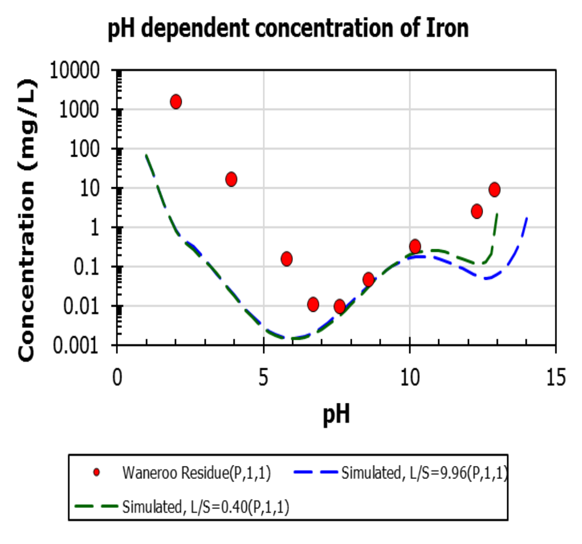
pH dependent concentration of Copper

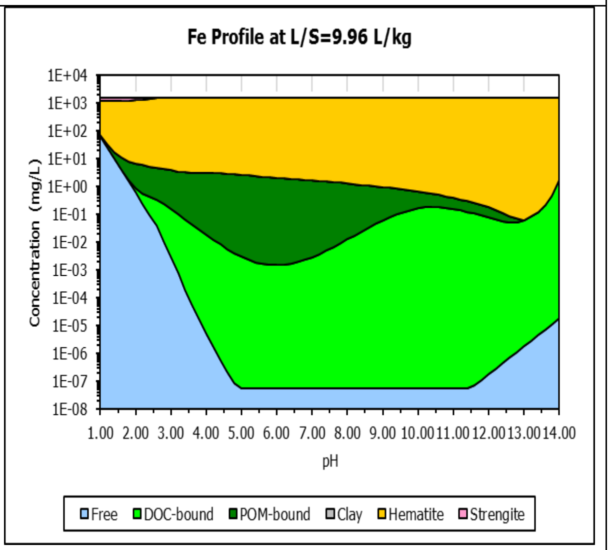


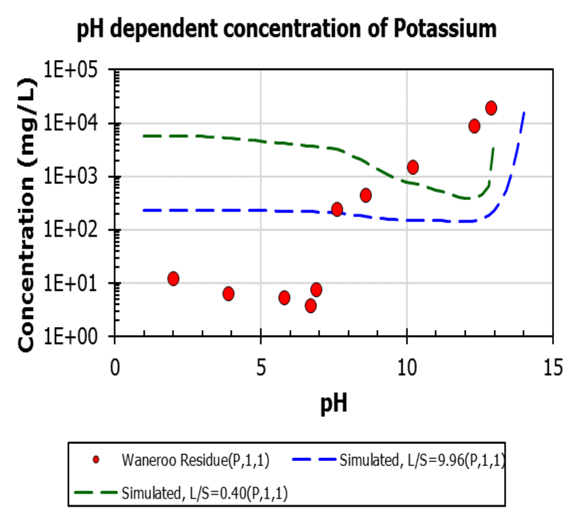
Cu Profile at L/S=9.96 L/kg

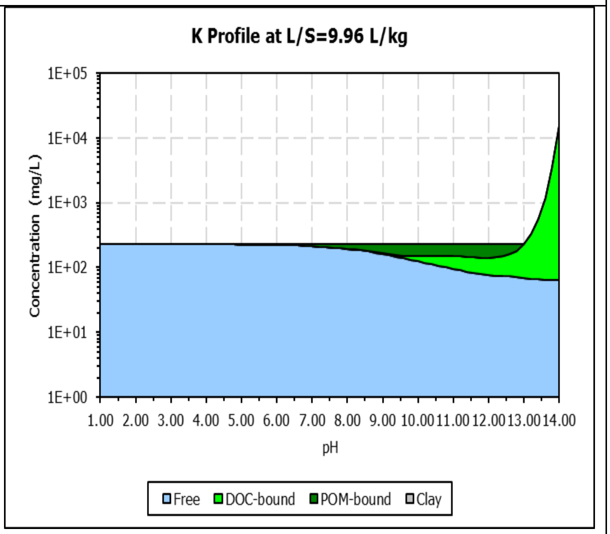

pH dependent concentration of Fluorine
Concentration (mg/L)
10000
1000
100
10
1
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

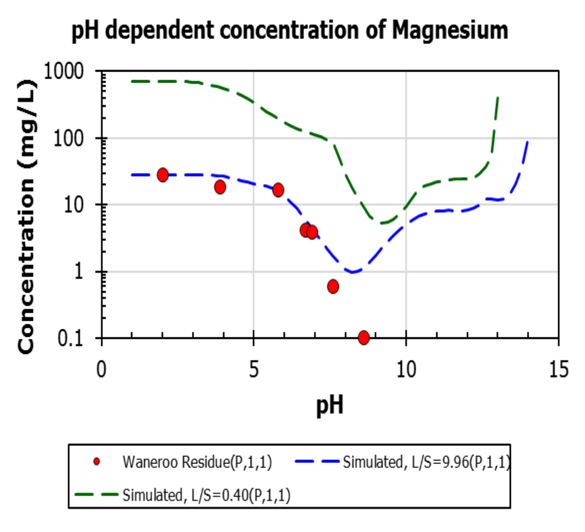

F Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite

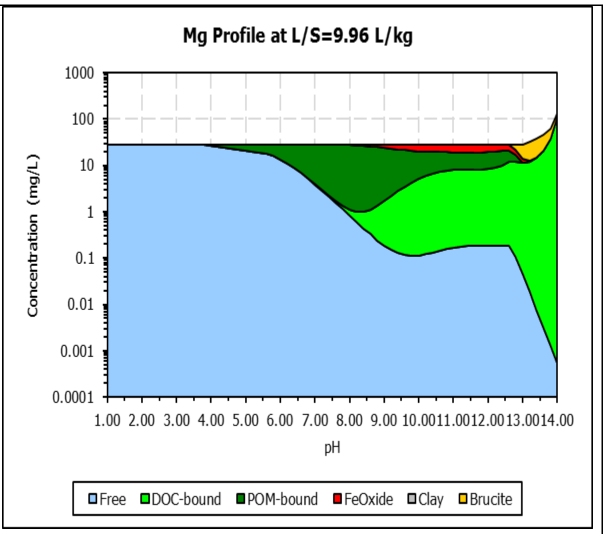

pH dependent concentration of Iron
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

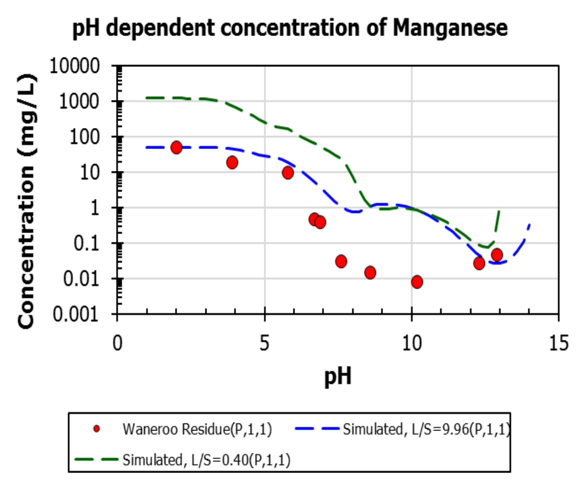

Fe Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Hematite
Strengite

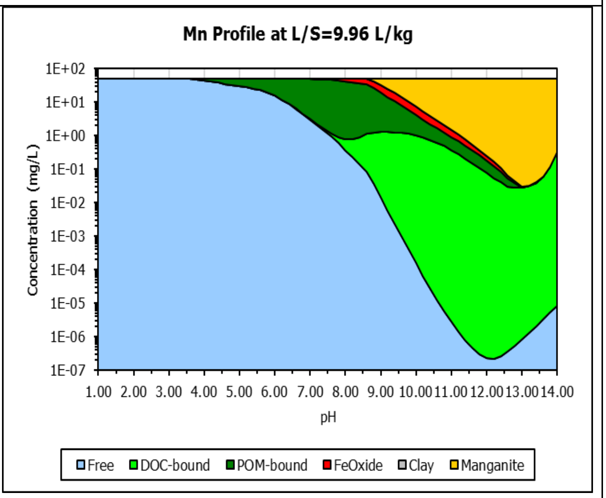

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

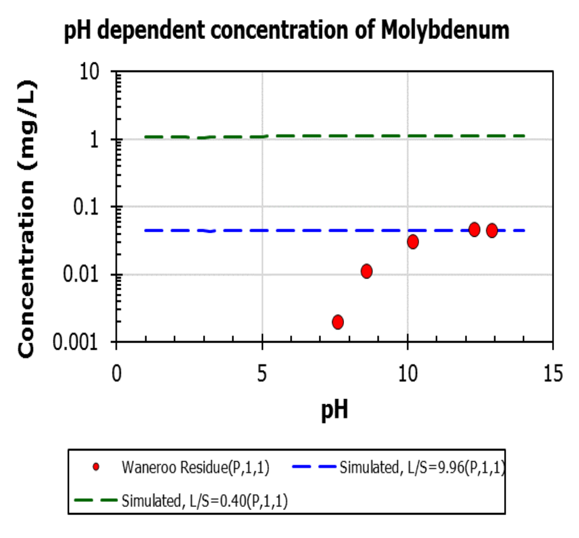

K Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

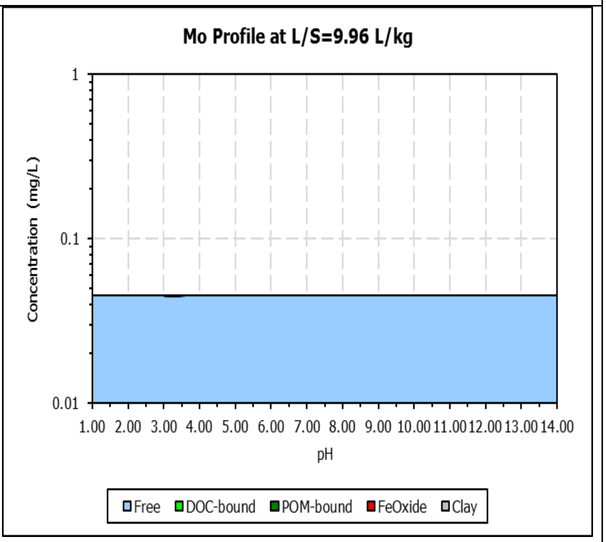

pH dependent concentration of Magnesium
Concentration (mg/L)
1000
100
10
1
0.1
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

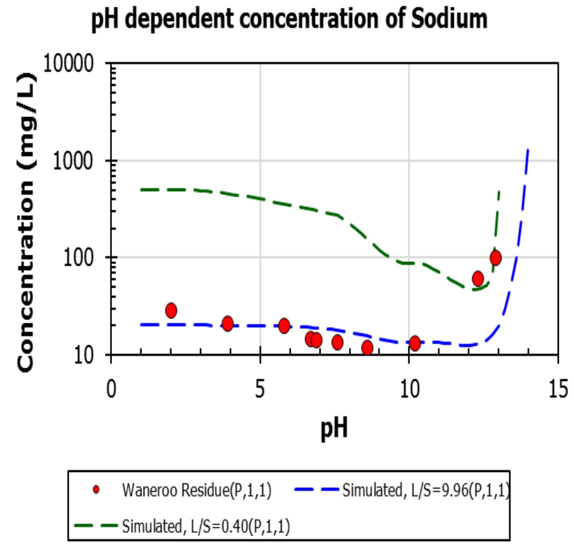

Mg Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Brucite

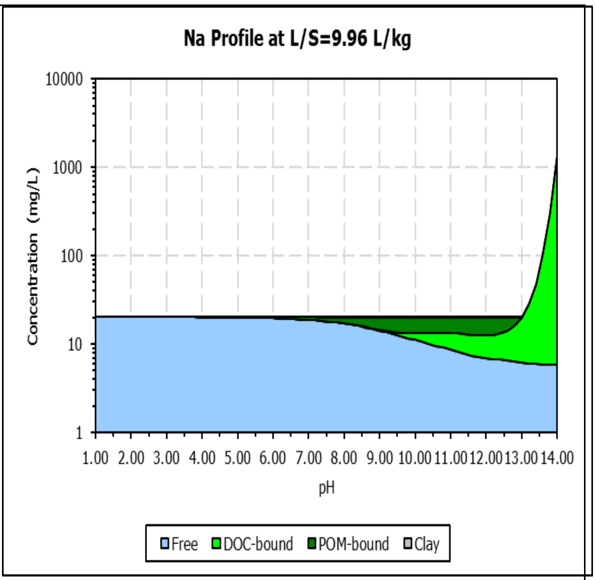

pH dependent concentration of Manganese
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

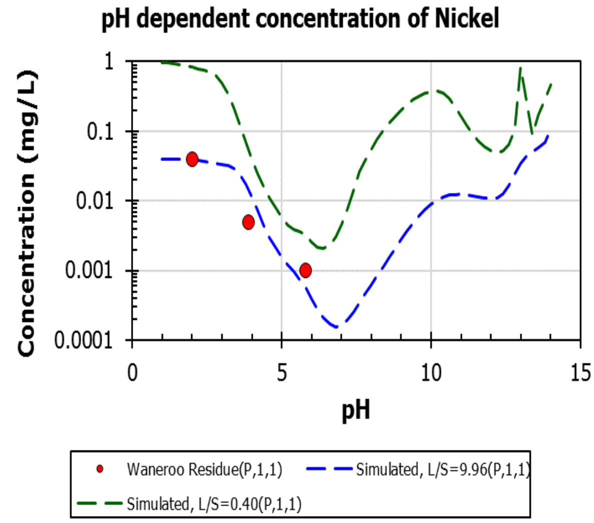

Mn Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

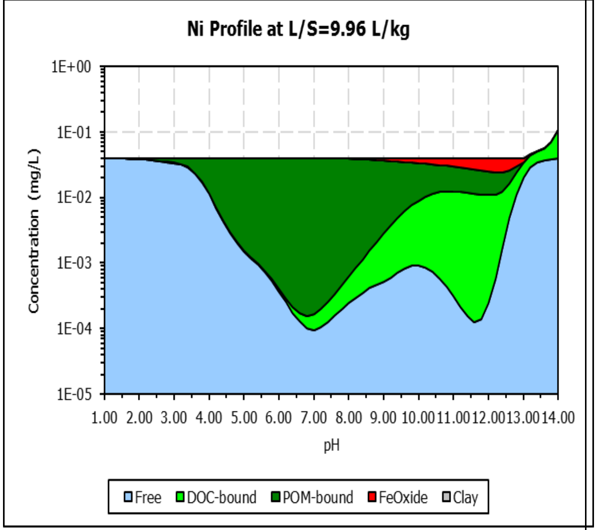

pH dependent concentration of Molybdenum
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

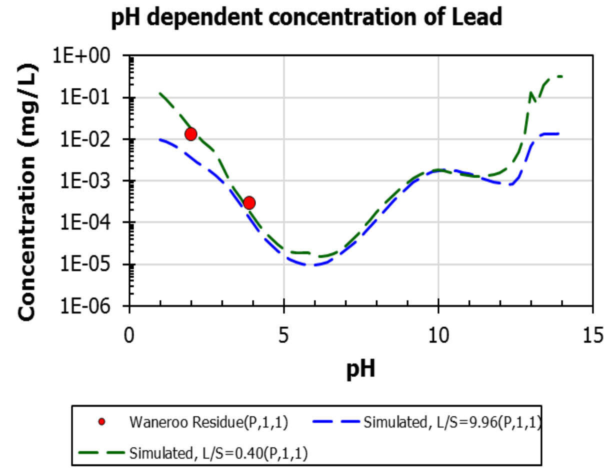

Mo Profile at L/S=9.96 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

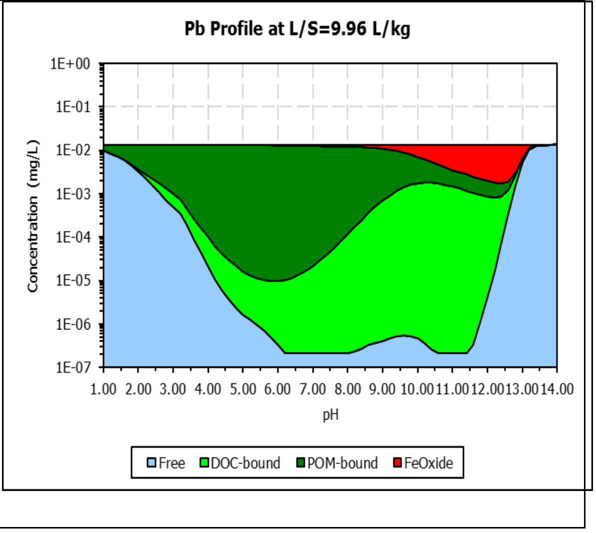

pH dependent concentration of Sodium
Concentration (mg/L)
10000
1000
100
10
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

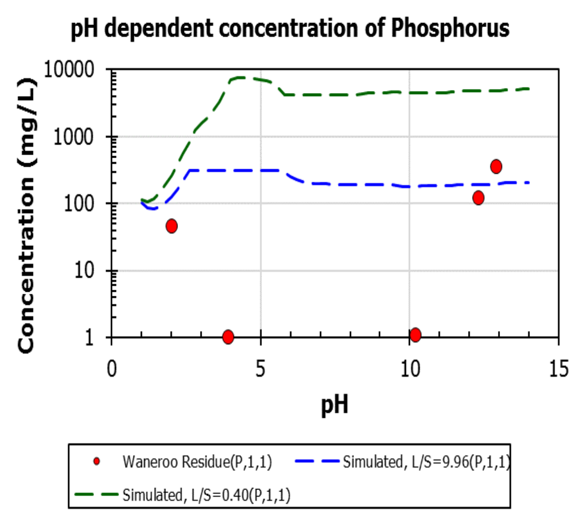

Na Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

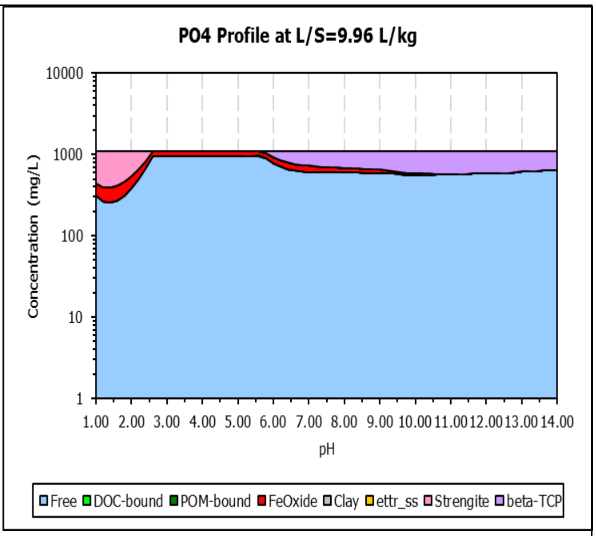

pH dependent concentration of Nickel
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

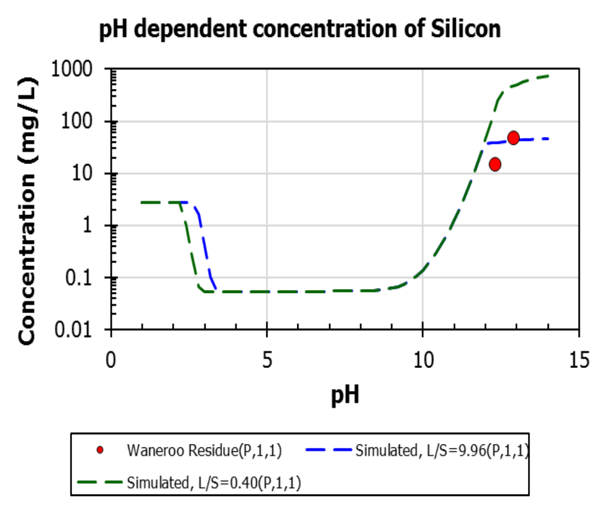

Ni Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

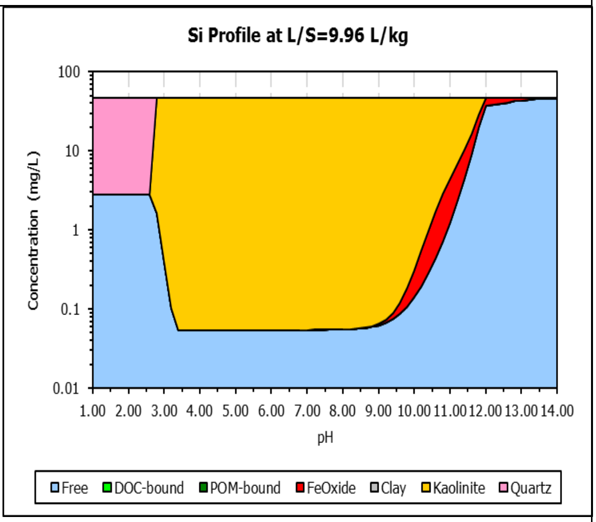

pH dependent concentration of Lead
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

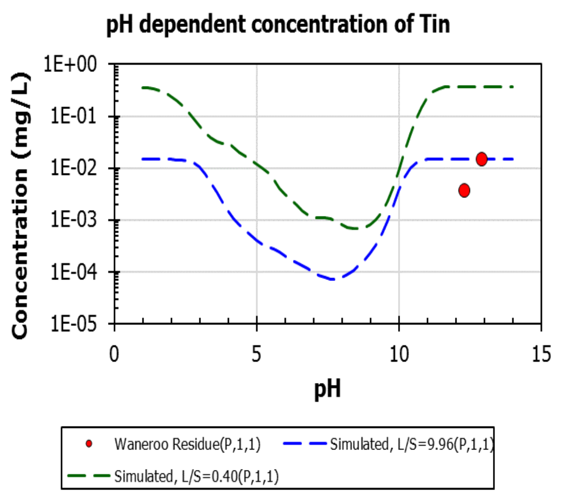

Pb Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide

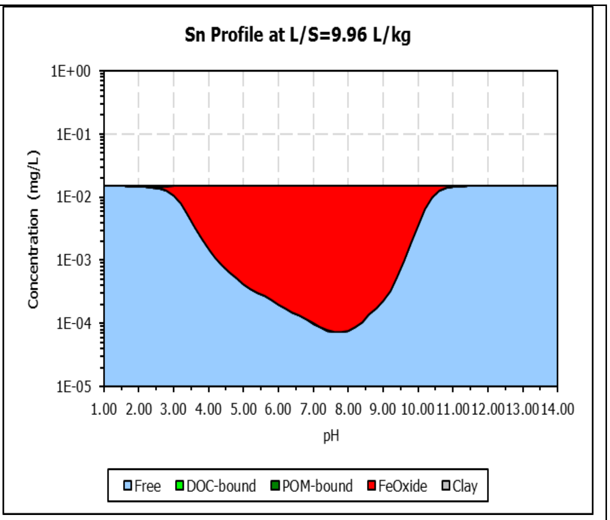

pH dependent concentration of Phosphorus
Concentration (mg/L)
10000
1000
100
10
1
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

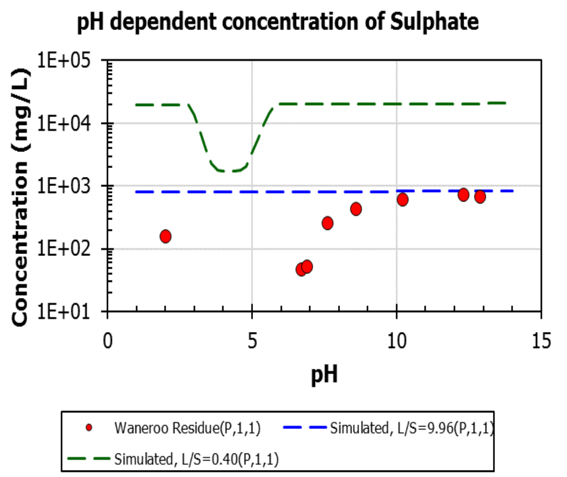

PO4 Profile at L/S=9.96 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Strengite
beta-TCP

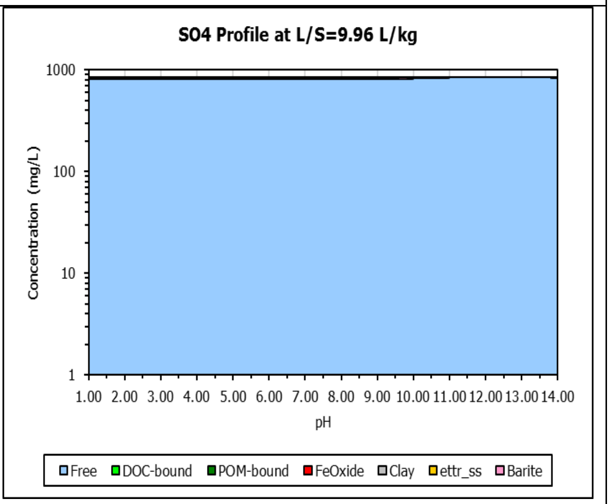

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

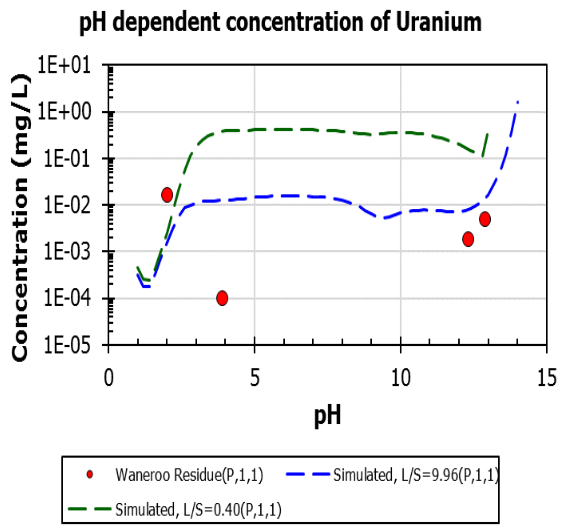

Si Profile at L/S=9.96 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Kaolinite
Quartz

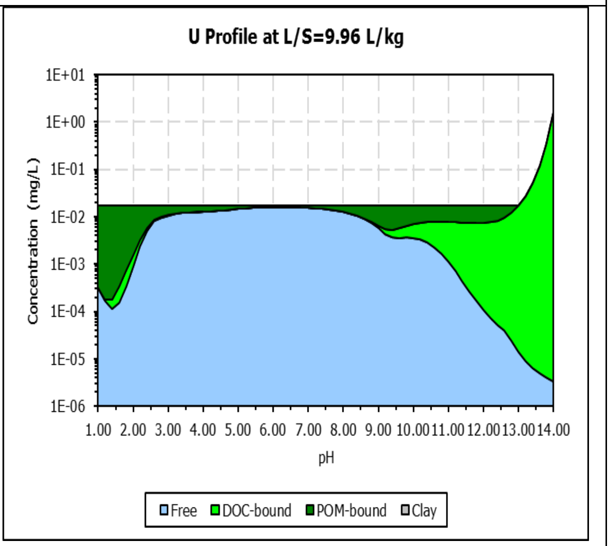

pH dependent concentration of Tin
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

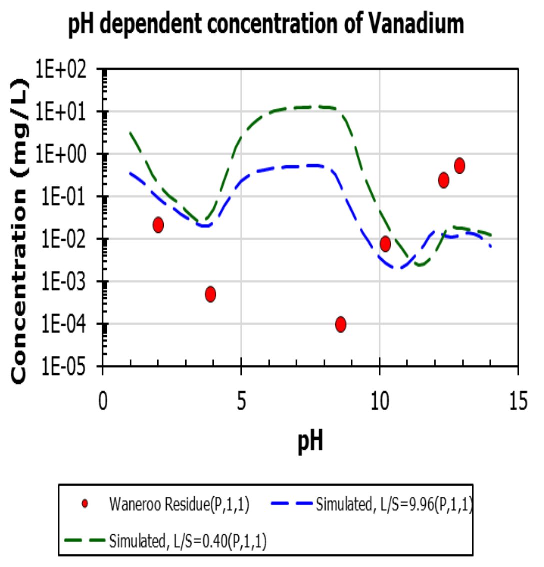

Sn Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

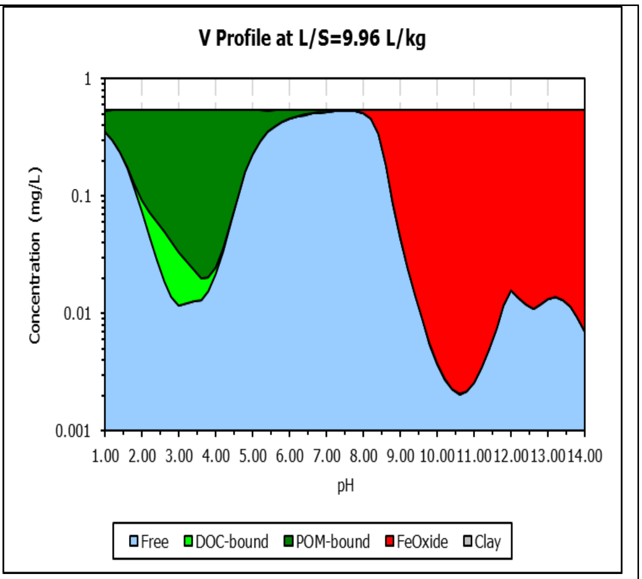

pH dependent concentration of Sulphate
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)

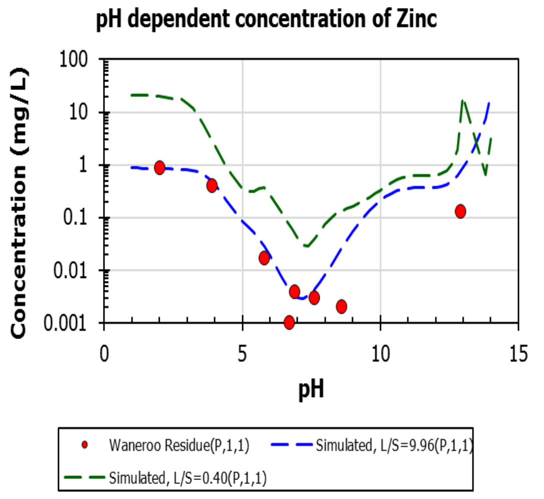

SO4 Profile at L/S=9.96 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

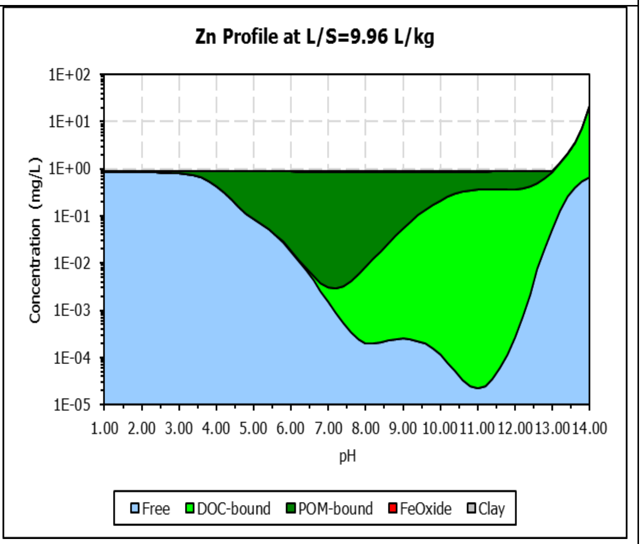

pH dependent concentration of Uranium
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Waneroo Residue(P,1,1)
Simulated, L/S=9.96(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=9.96 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

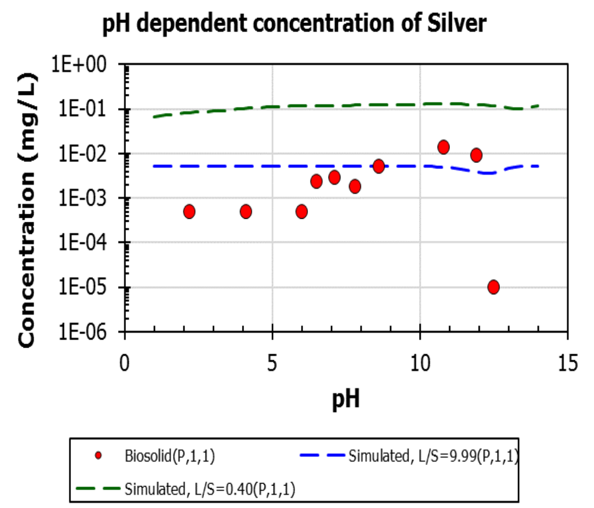

pH dependent concentration of Vanadium

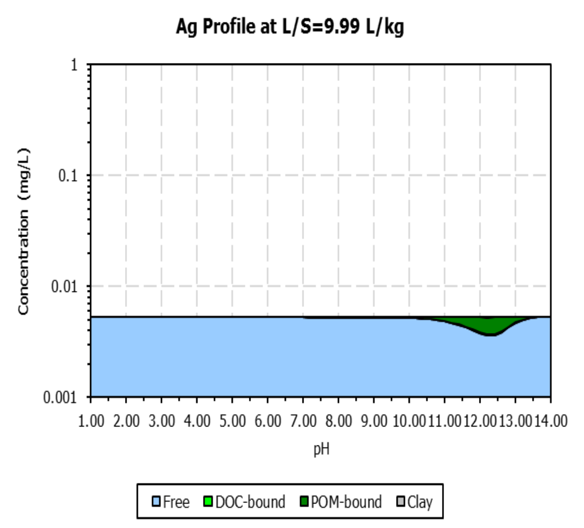

V Profile at L/S=9.96 L/kg

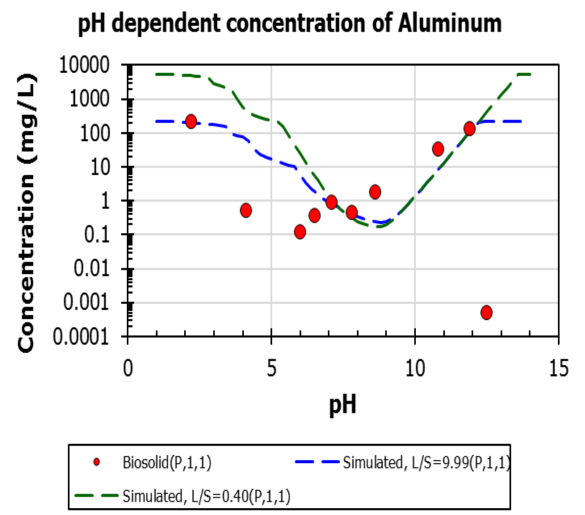

pH dependent concentration of Zinc

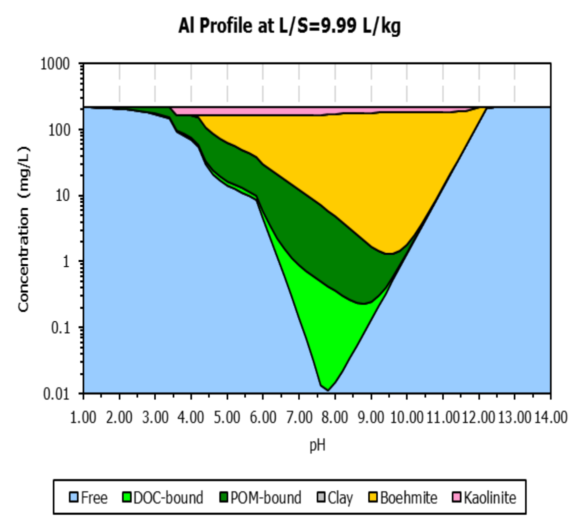

Zn Profile at L/S=9.96 L/kg

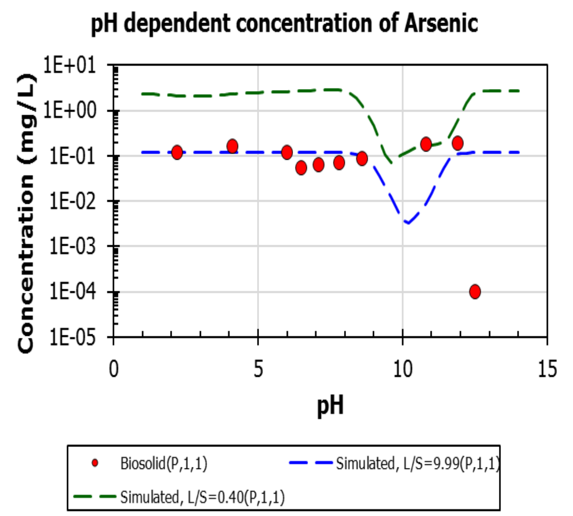
A8-6: Biosolids Cake

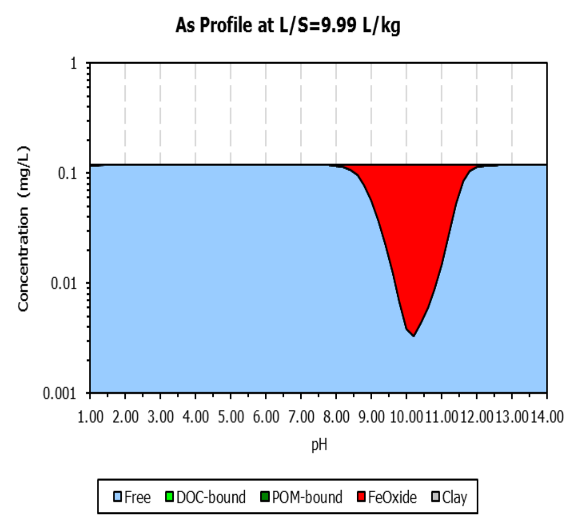


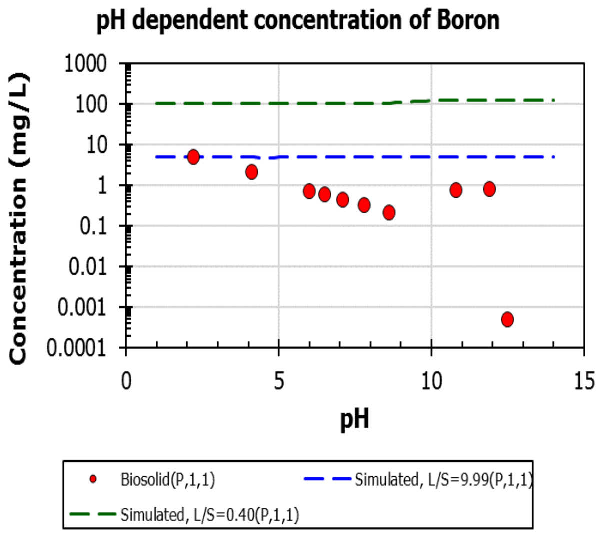


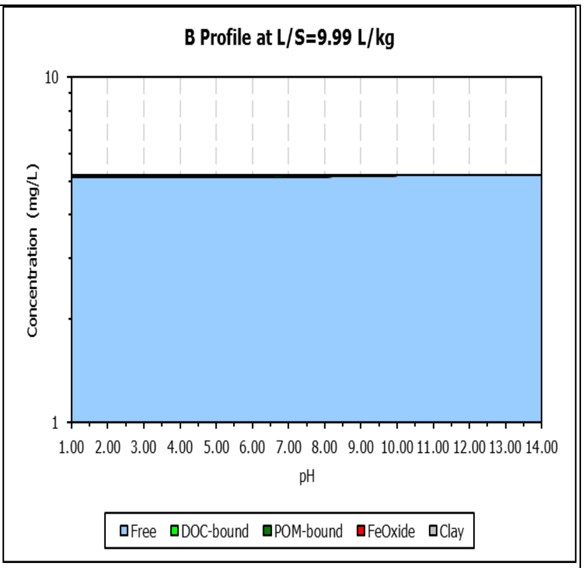


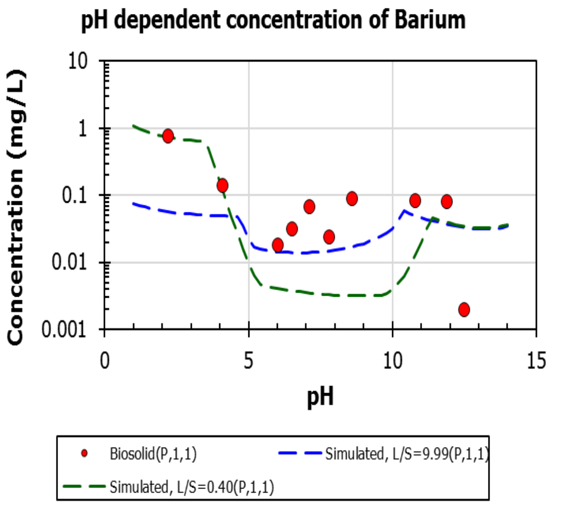


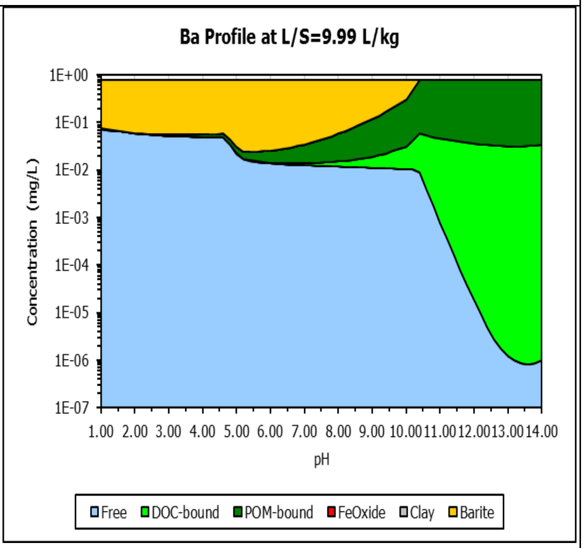


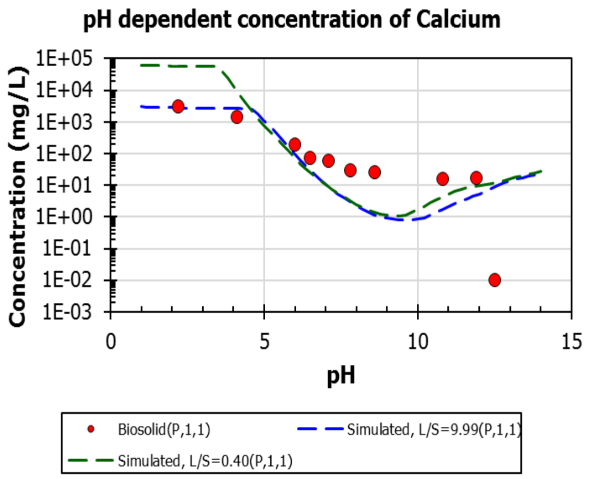


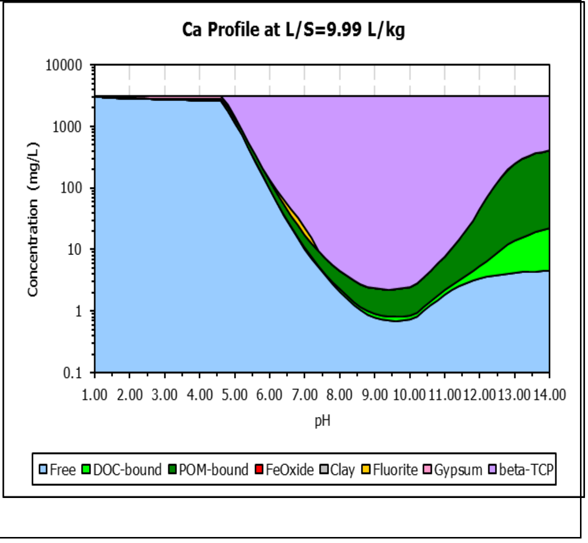

pH dependent concentration of Boron
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

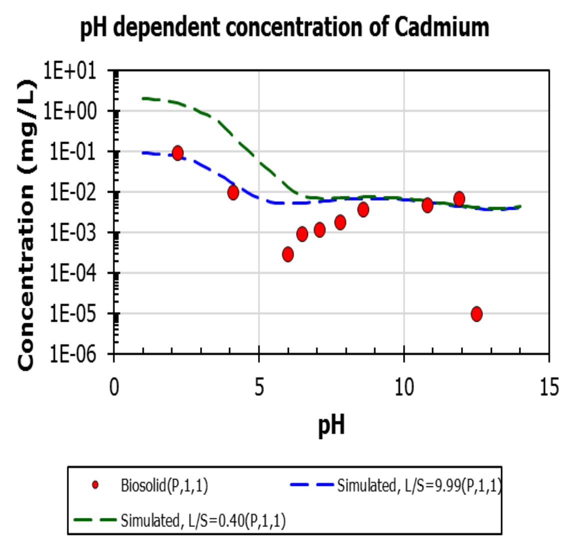

B Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

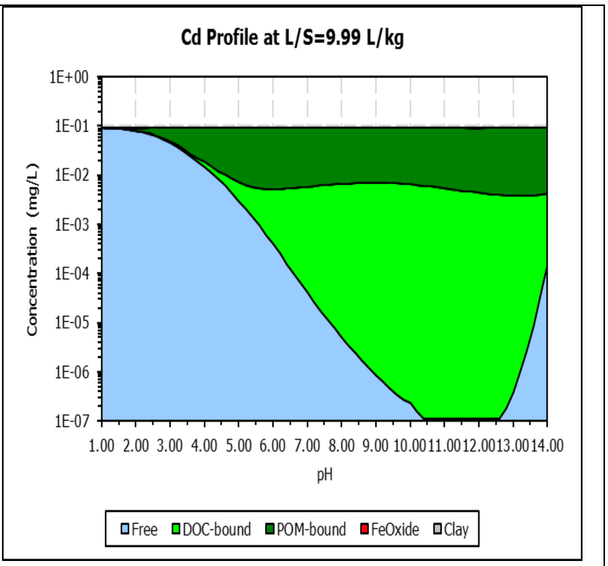

pH dependent concentration of Barium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

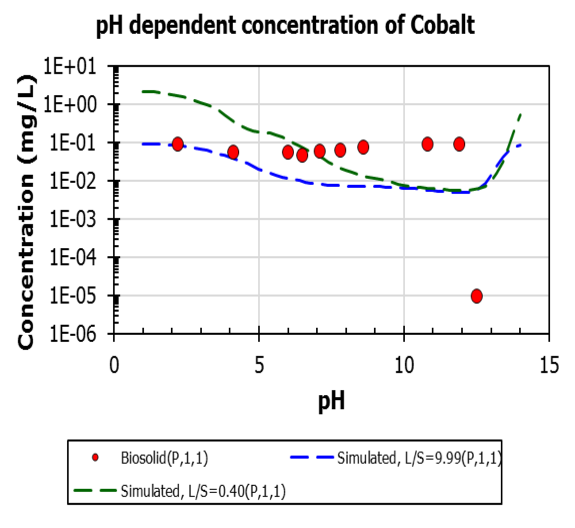

Ba Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite

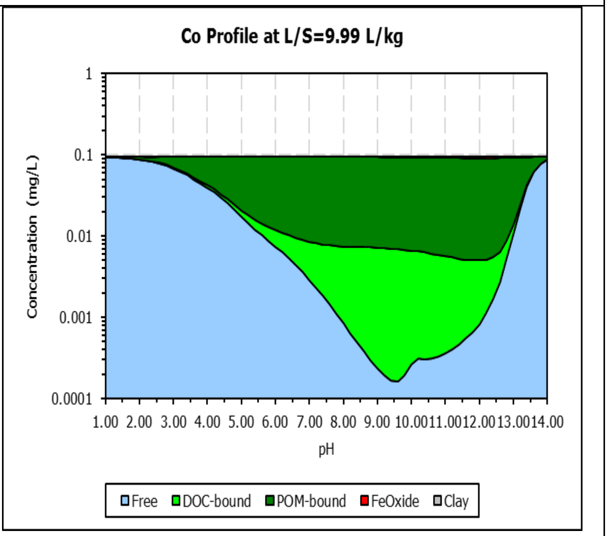

pH dependent concentration of Calcium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

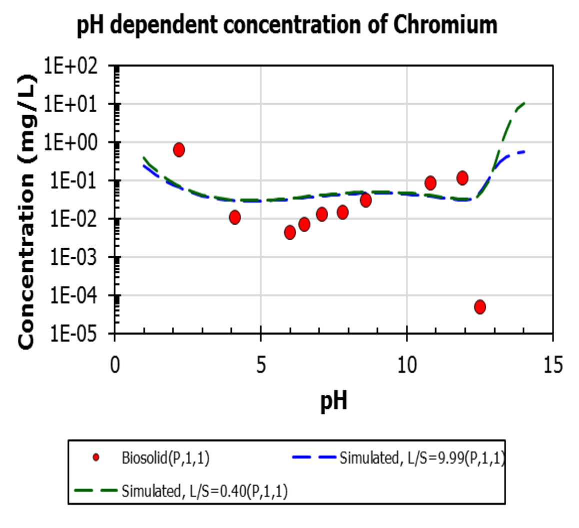

Ca Profile at L/S=9.99 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite
Gypsum
beta-TCP

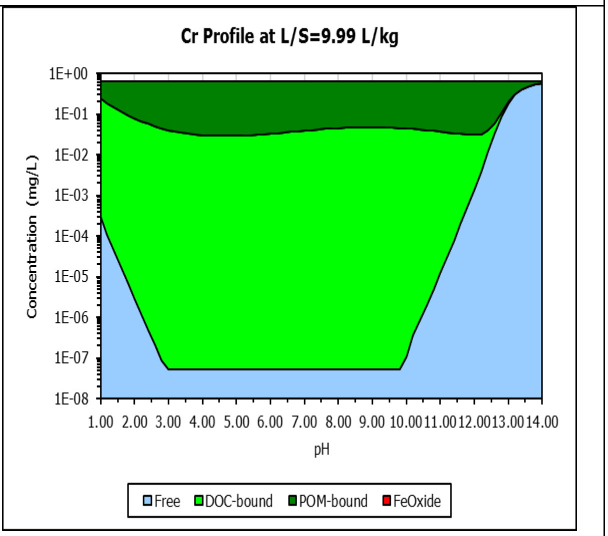

pH dependent concentration of Cadmium
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

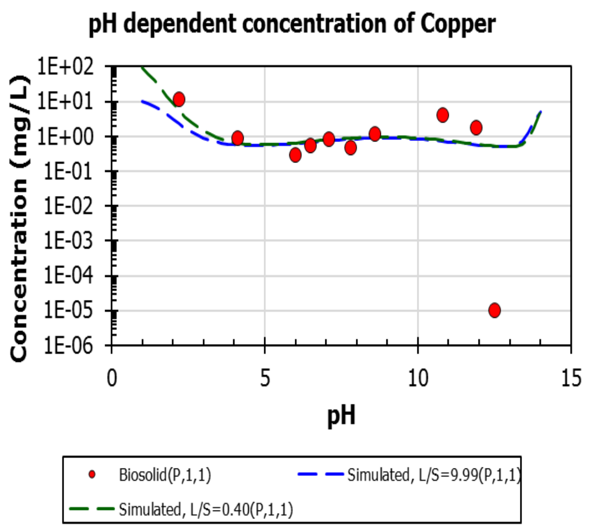

Cd Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

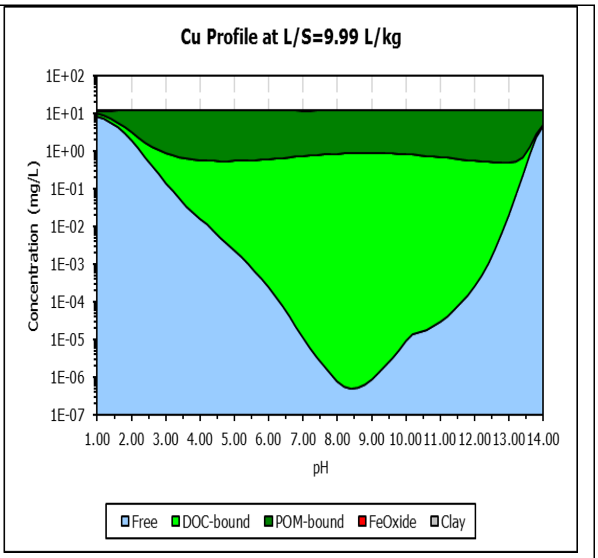

pH dependent concentration of Cobalt
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

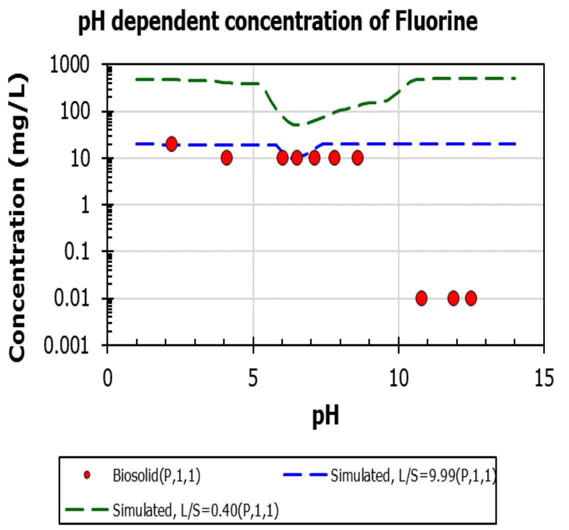

Co Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

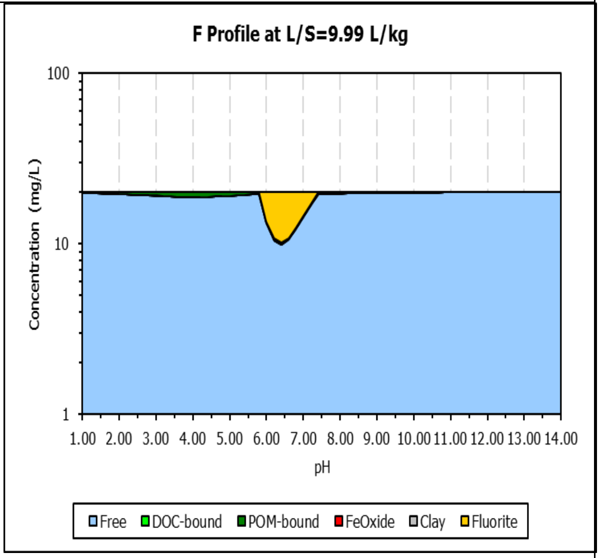

pH dependent concentration of Chromium
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

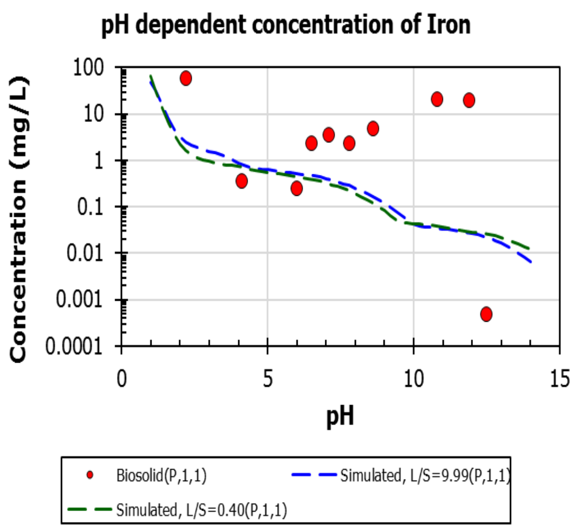

Cr Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide

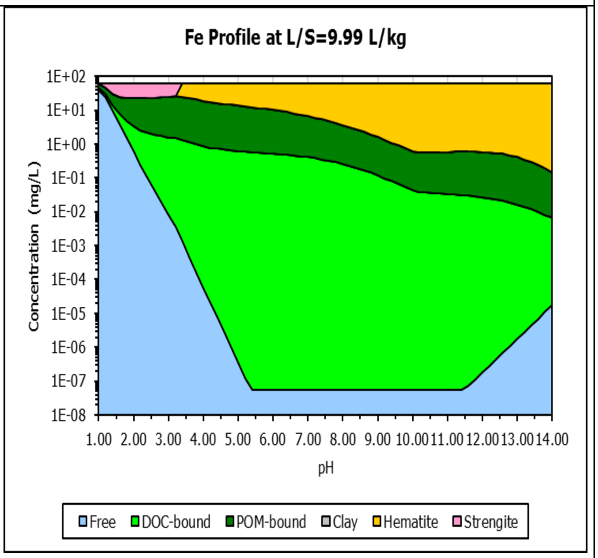

pH dependent concentration of Copper
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

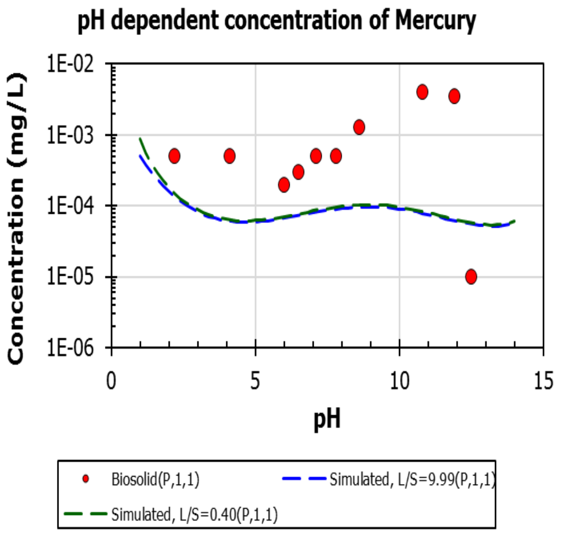

Cu Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

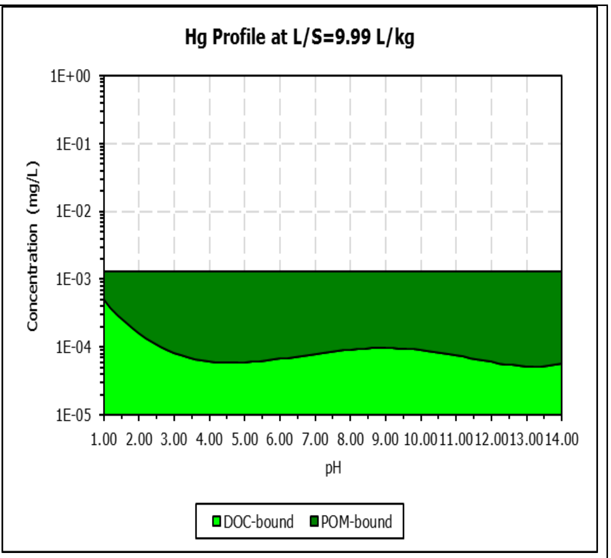

pH dependent concentration of Fluorine
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

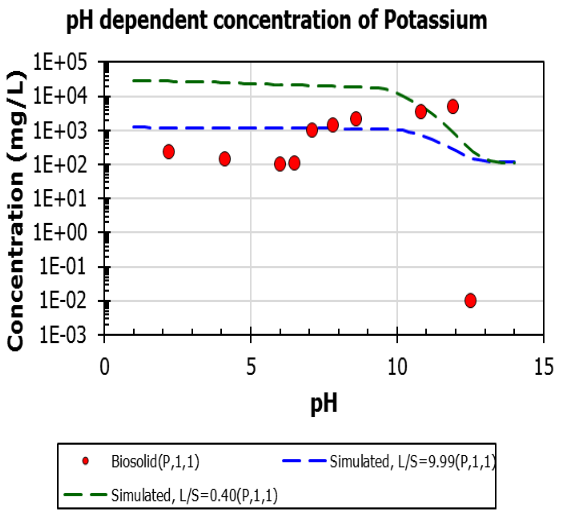

F Profile at L/S=9.99 L/kg
Concentration (mg/L)
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite

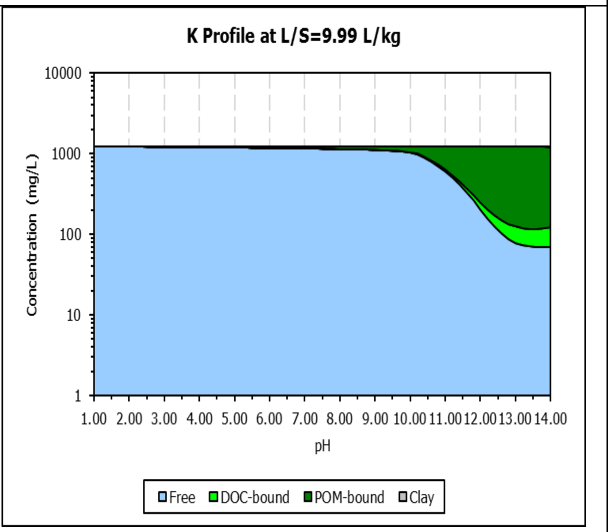

pH dependent concentration of Iron
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

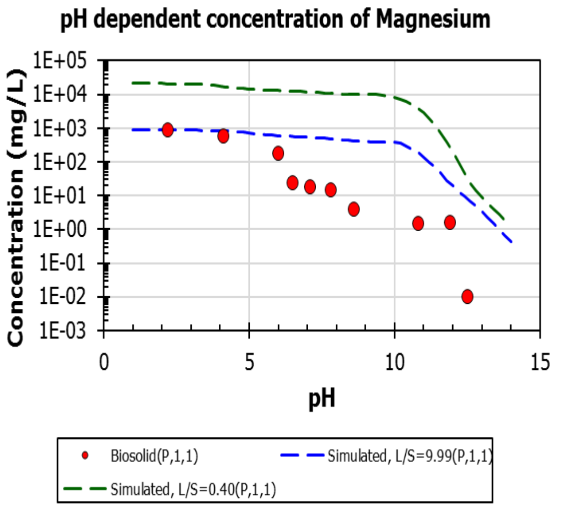

Fe Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Hematite
Strengite

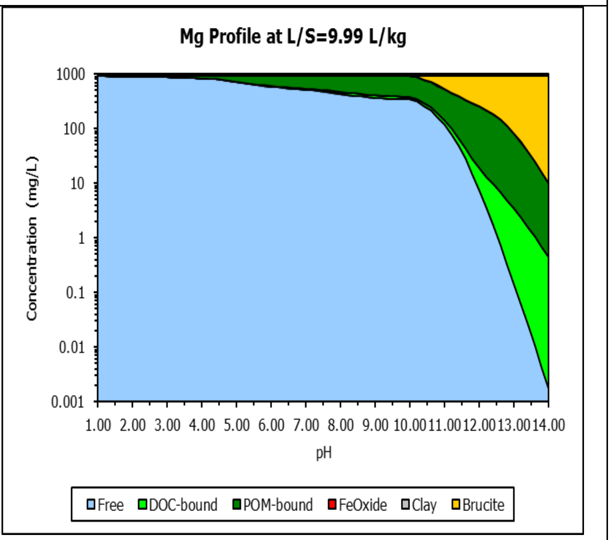

pH dependent concentration of Mercury
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

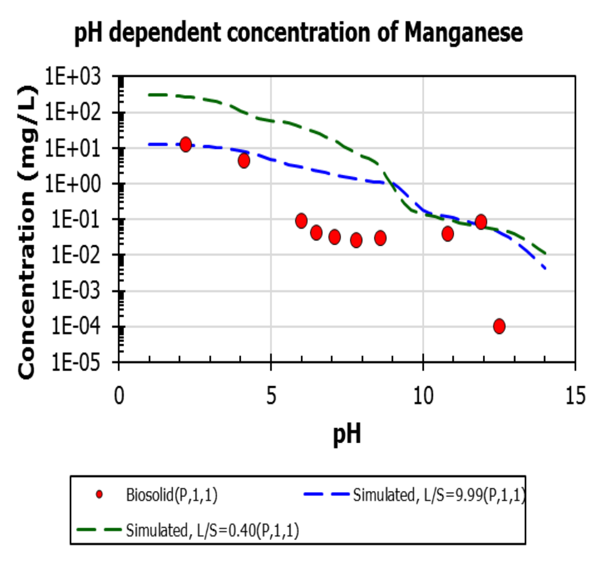

Hg Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
DOC-bound
POM-bound

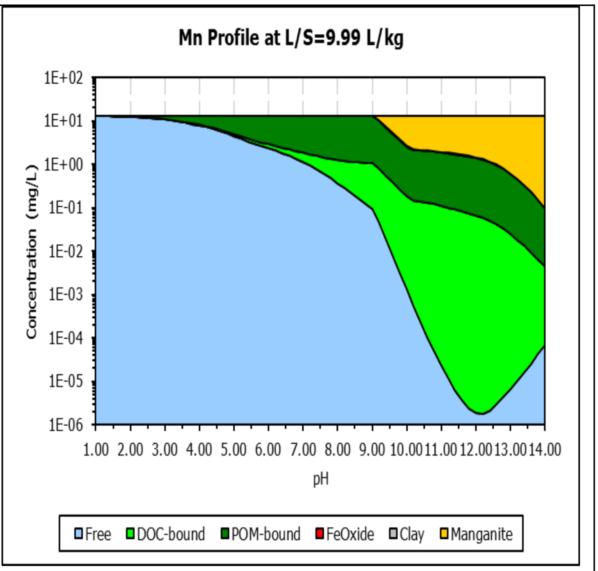

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

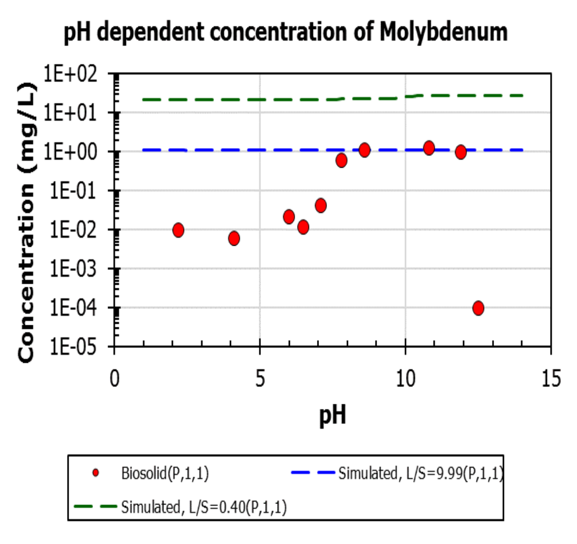

K Profile at L/S=9.99 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

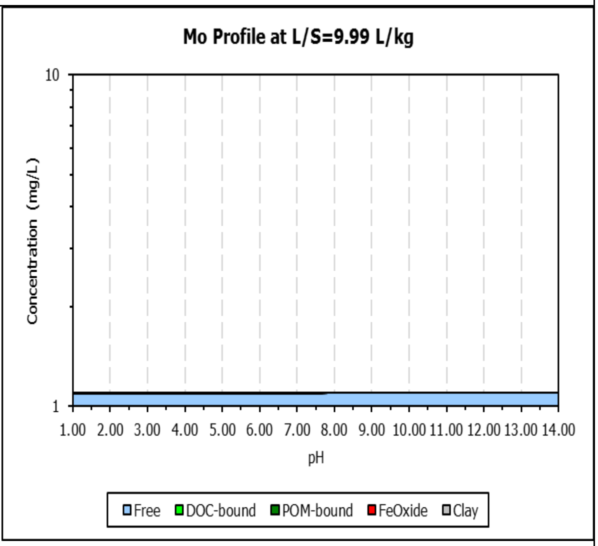

pH dependent concentration of Magnesium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

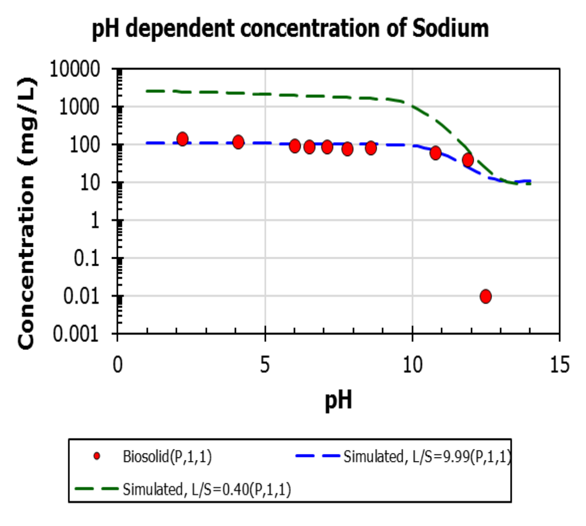

Mg Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Brucite

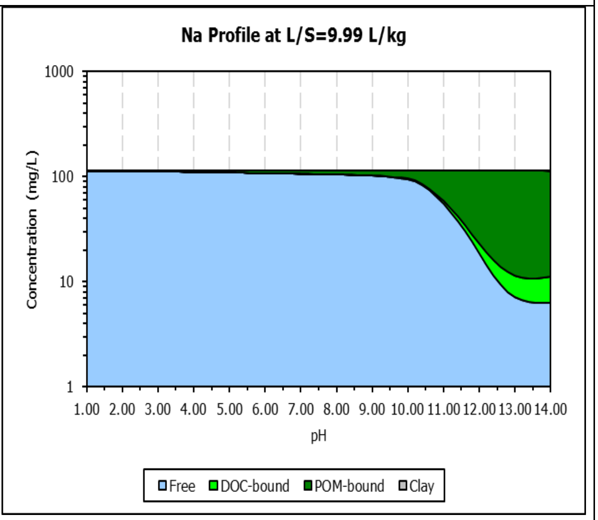

pH dependent concentration of Manganese
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

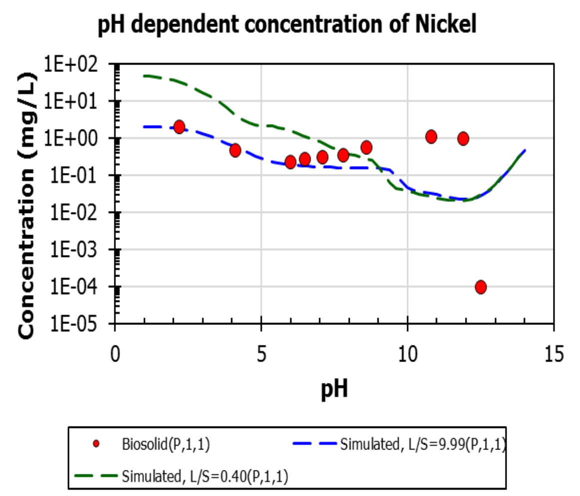

Mn Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

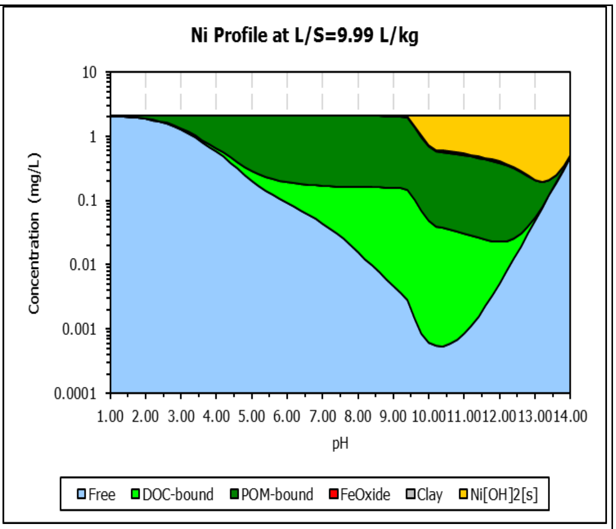

pH dependent concentration of Molybdenum
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

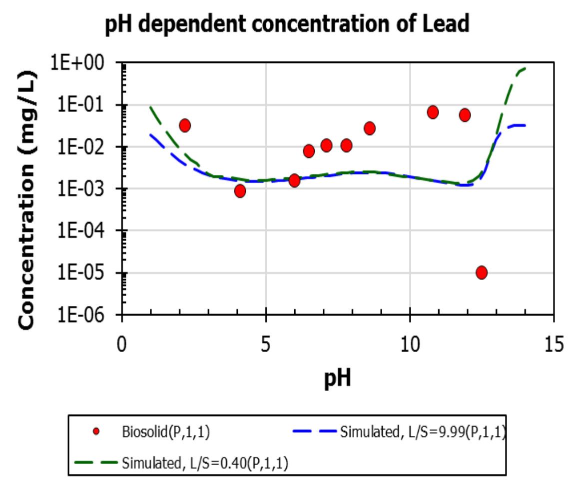

Mo Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

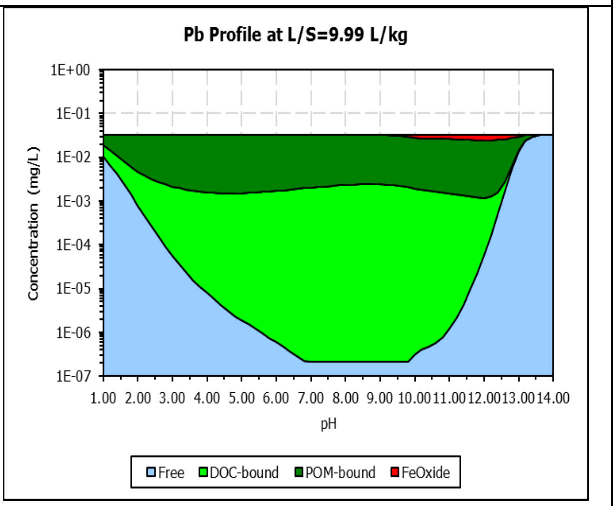

pH dependent concentration of Sodium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

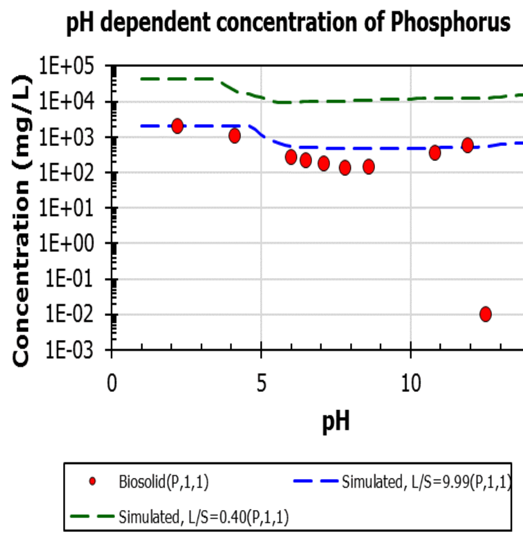

Na Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

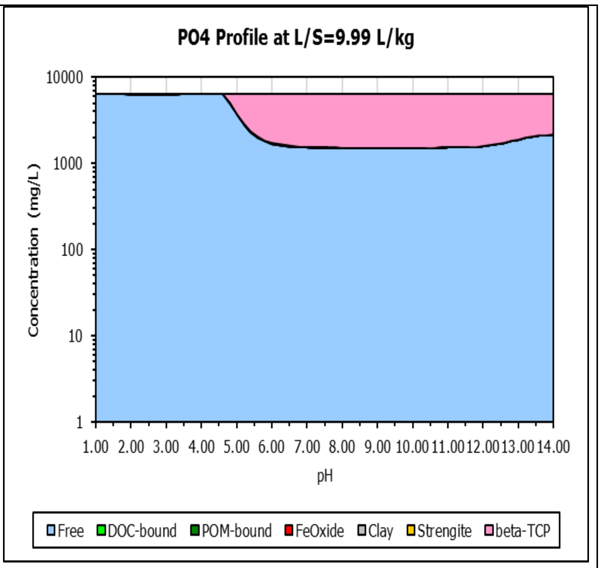

pH dependent concentration of Nickel

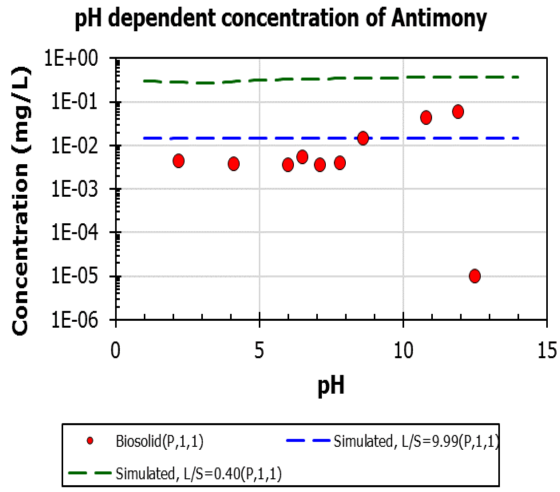

Ni Profile at L/S=9.99 L/kg

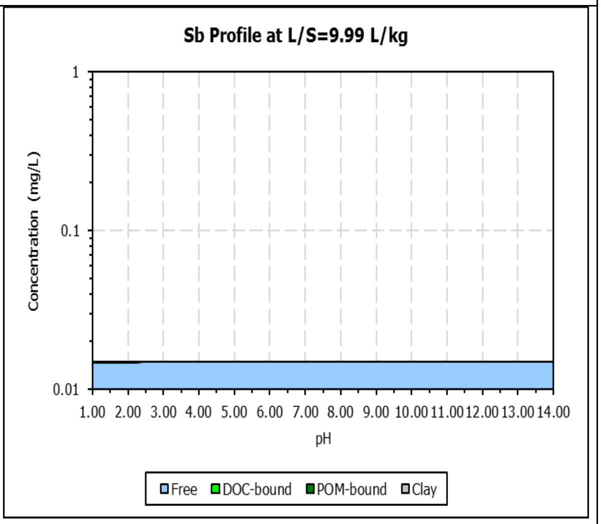

pH dependent concentration of Lead

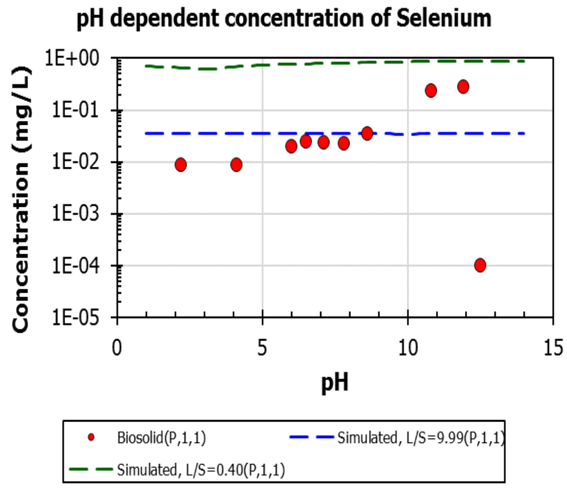

Pb Profile at L/S=9.99 L/kg

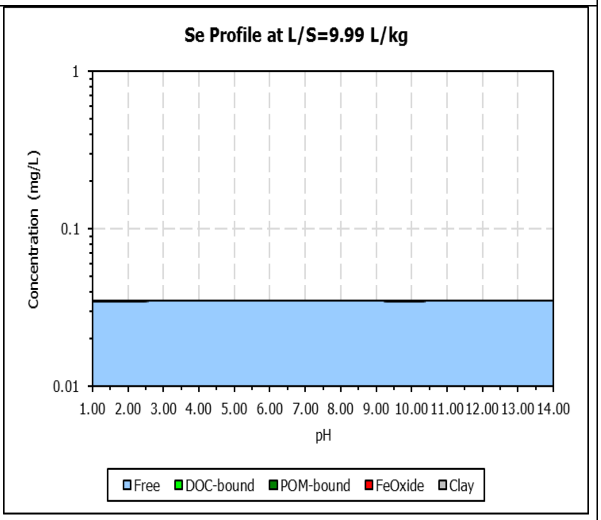

pH dependent concentration of Phosphorus
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

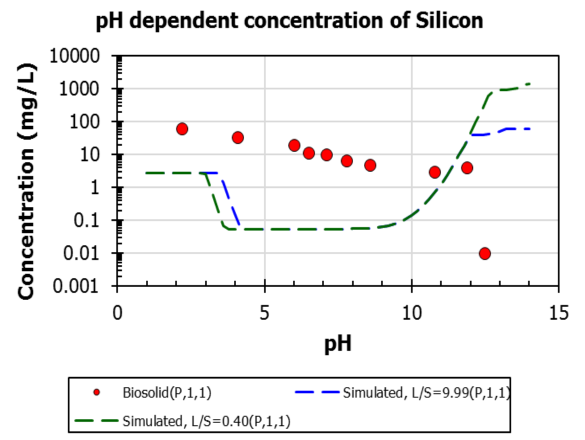

PO4 Profile at L/S=9.99 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Strengite
beta-TCP

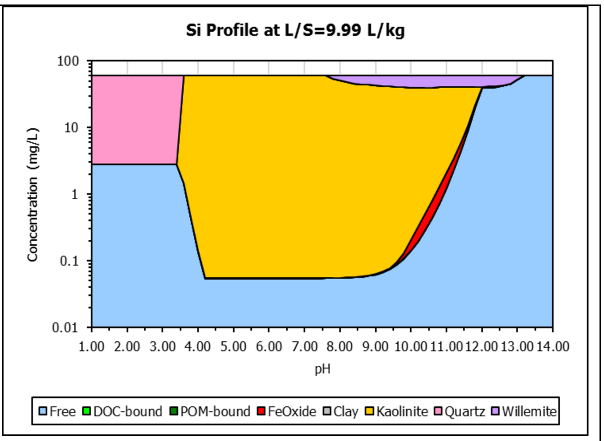

pH dependent concentration of Antimony
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

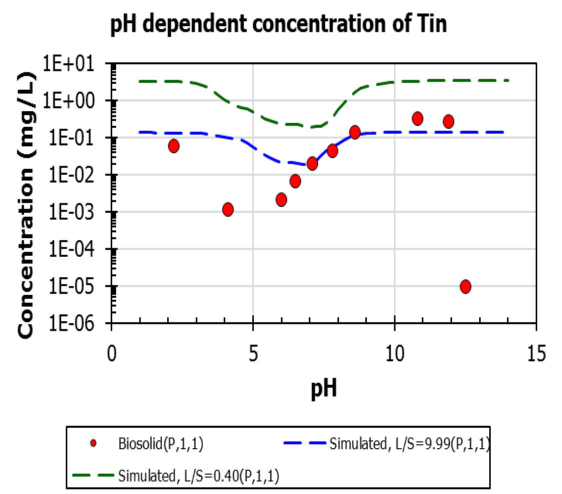

Sb Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

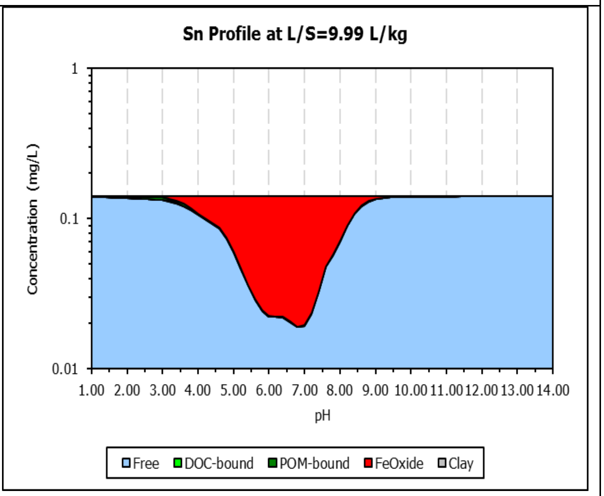

pH dependent concentration of Selenium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

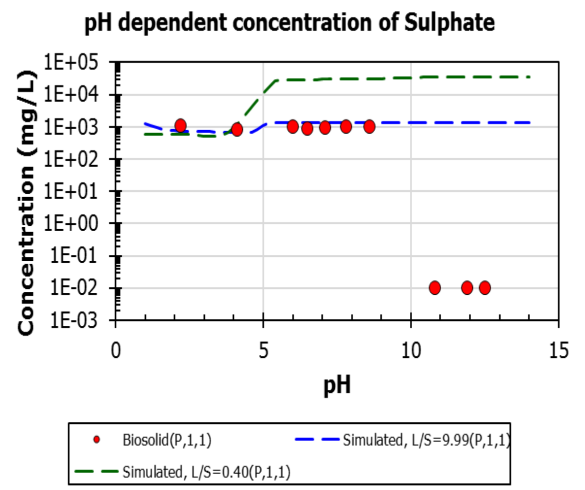

Se Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

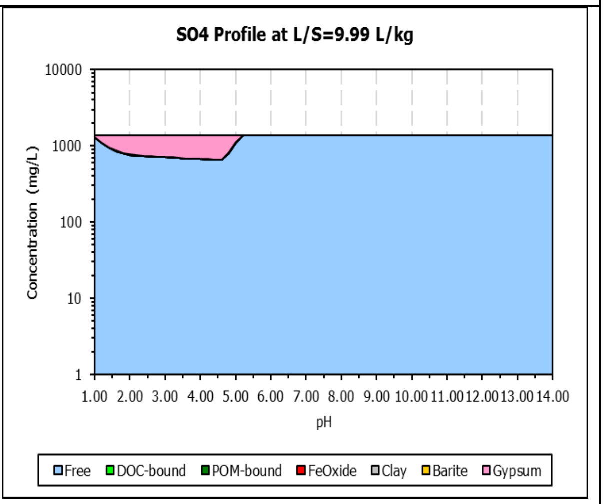

pH dependent concentration of Silicon
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

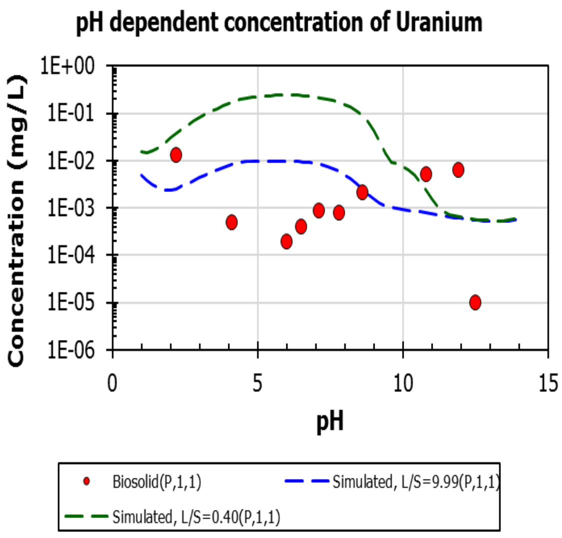

Si Profile at L/S=9.99 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Kaolinite
Quartz
Willemite

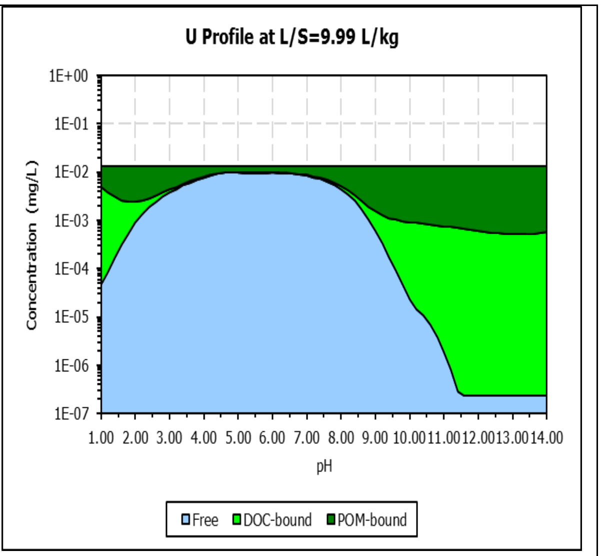

pH dependent concentration of Tin
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

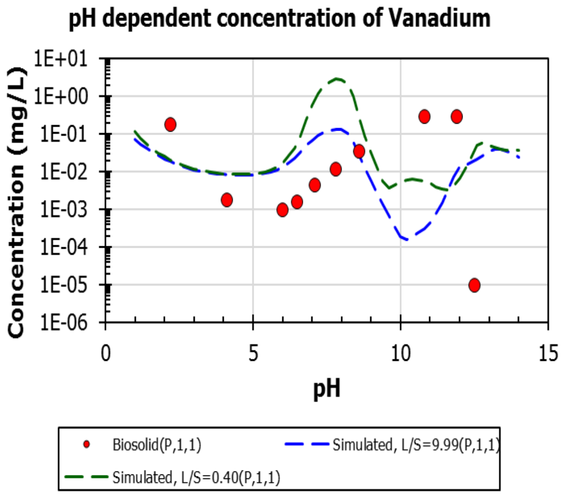

Sn Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

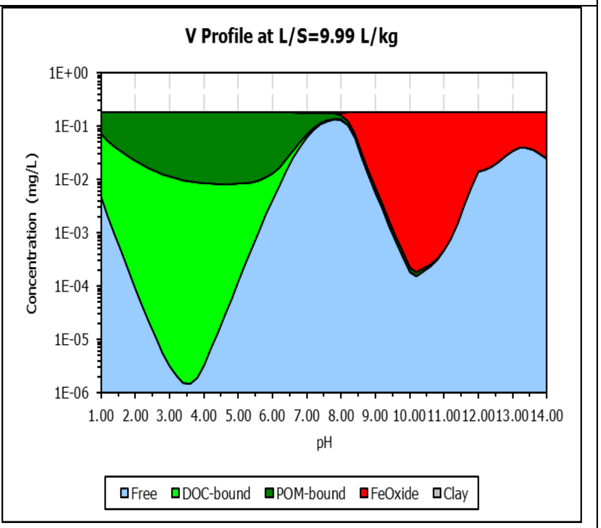

pH dependent concentration of Sulphate
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

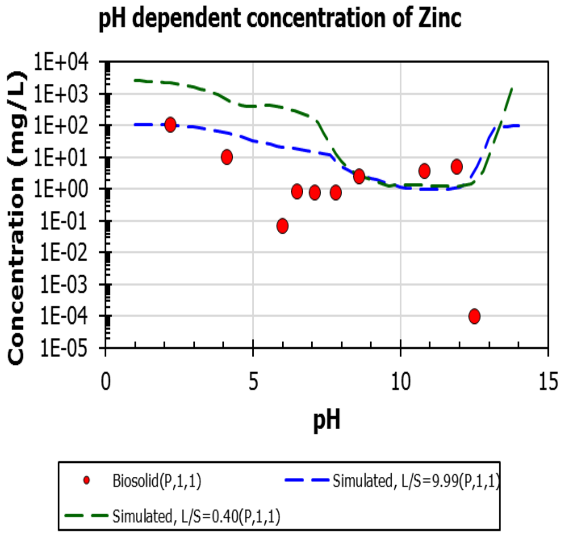

SO4 Profile at L/S=9.99 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite
Gypsum

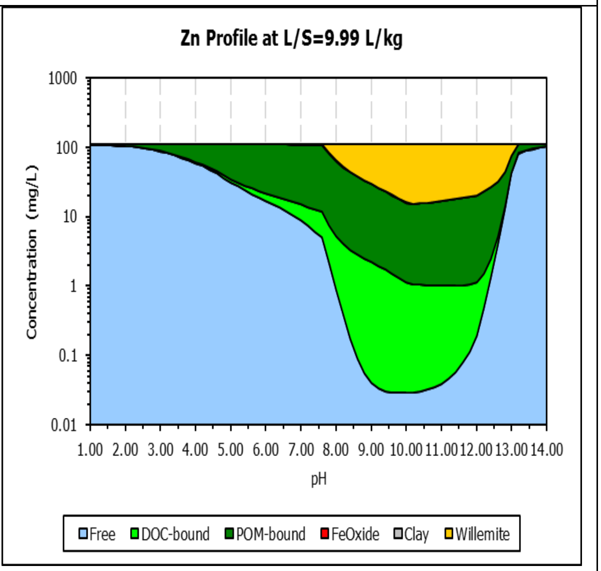

pH dependent concentration of Uranium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound

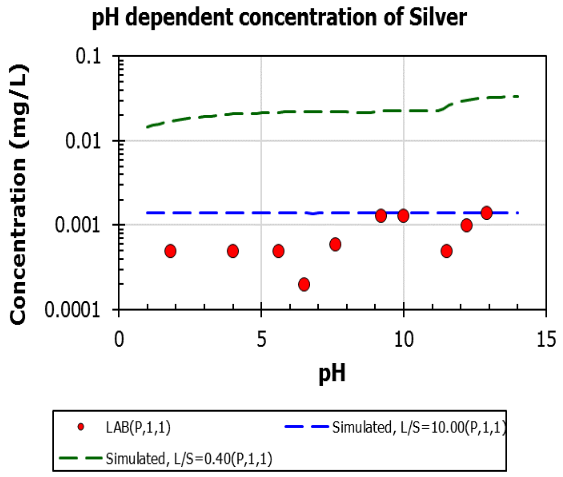

pH dependent concentration of Vanadium
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

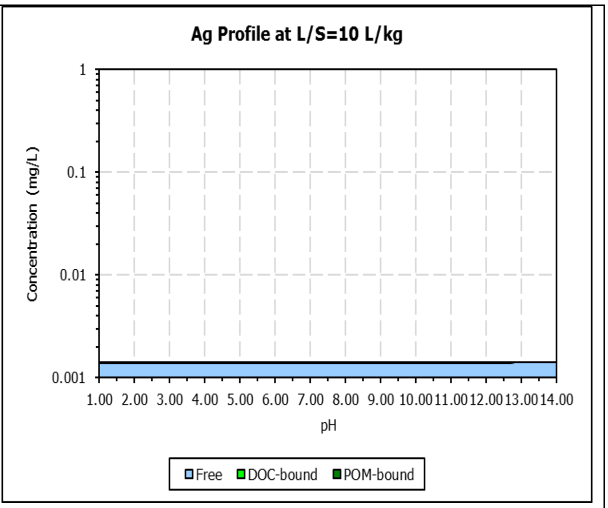

V Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

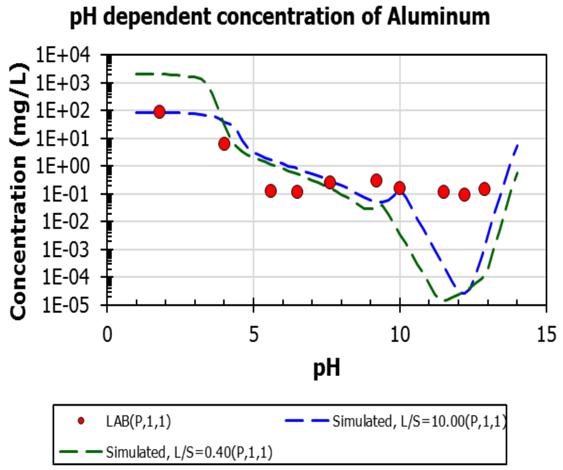

pH dependent concentration of Zinc
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Biosolid(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

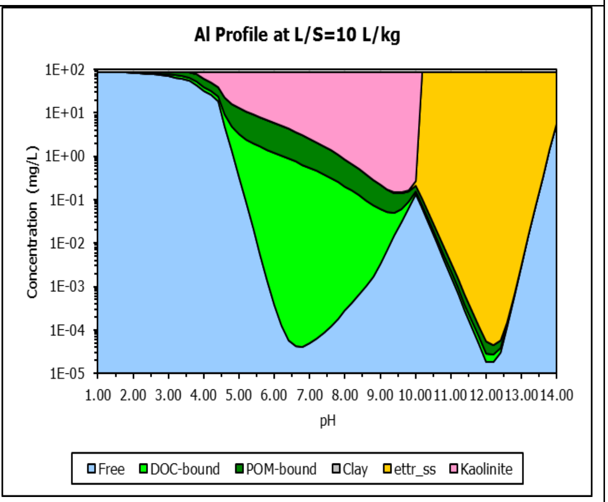

Zn Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Willemite

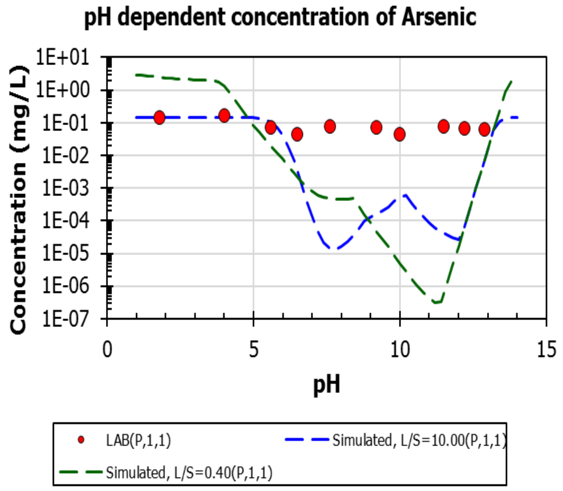
A8-7: Lime Amended Biosolid (LAB)

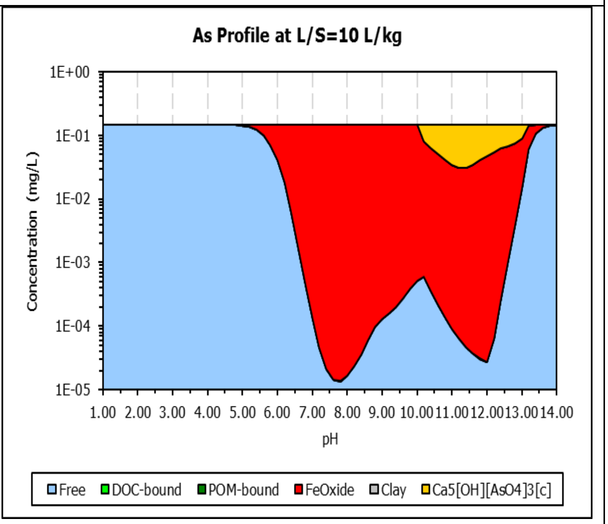


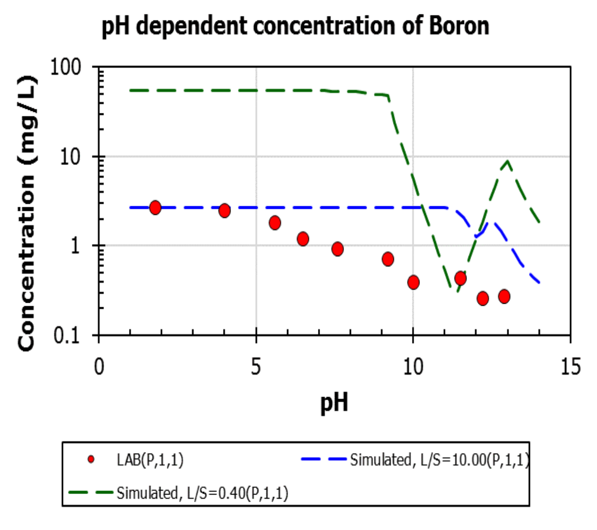


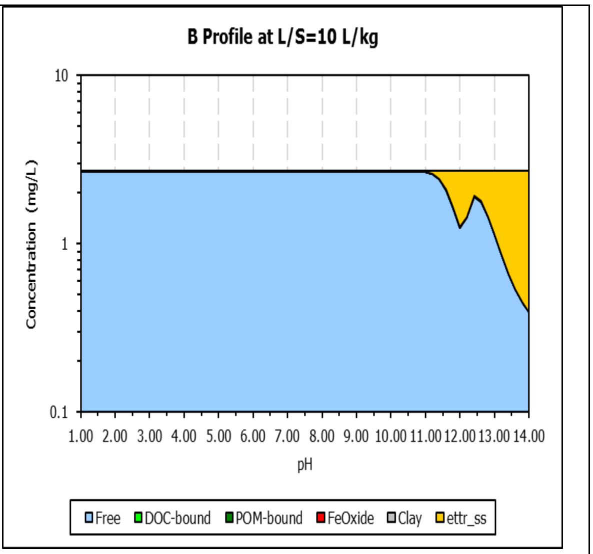


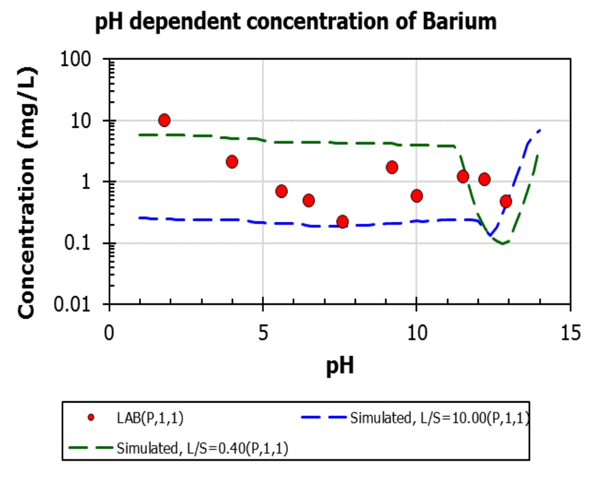


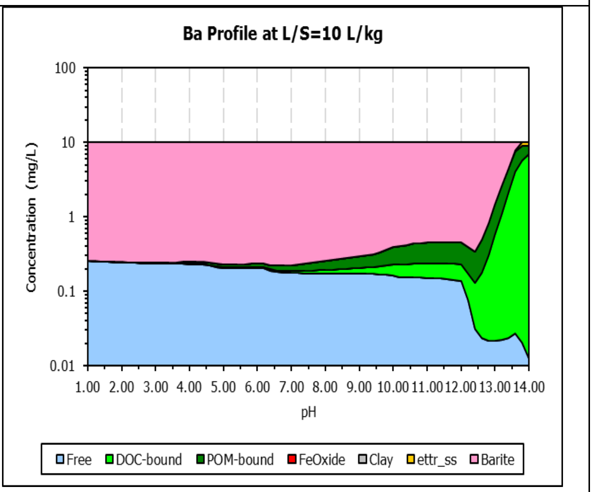


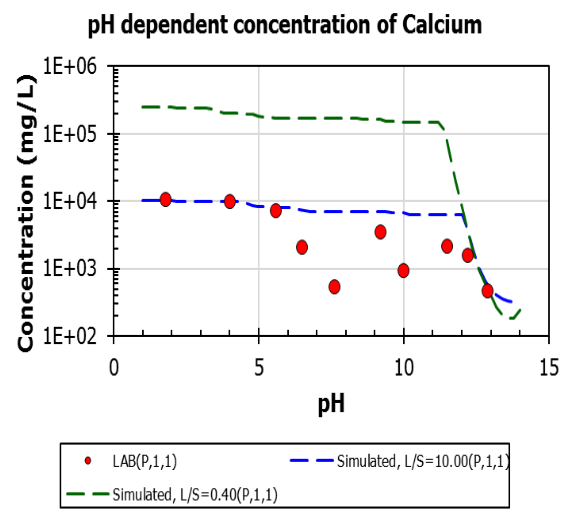


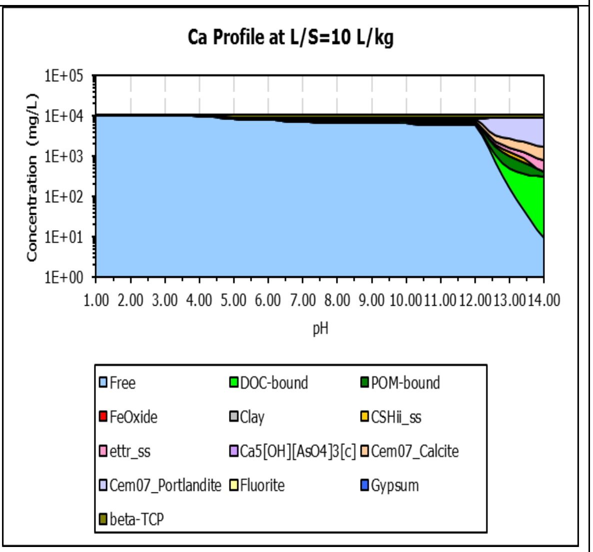

pH dependent concentration of Boron
Concentration (mg/L)
100
10
1
0.1
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

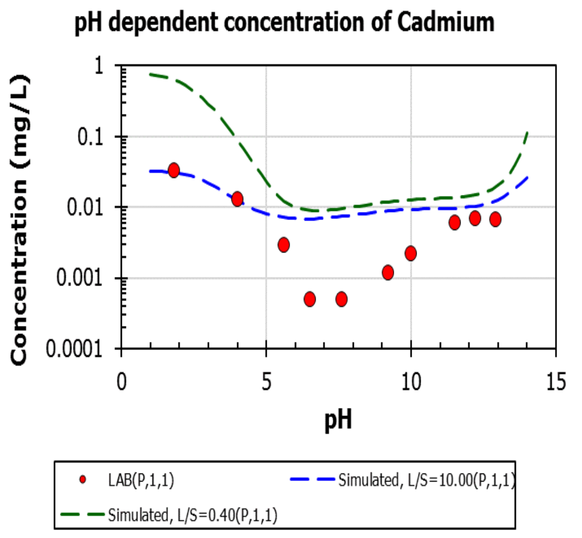

B Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

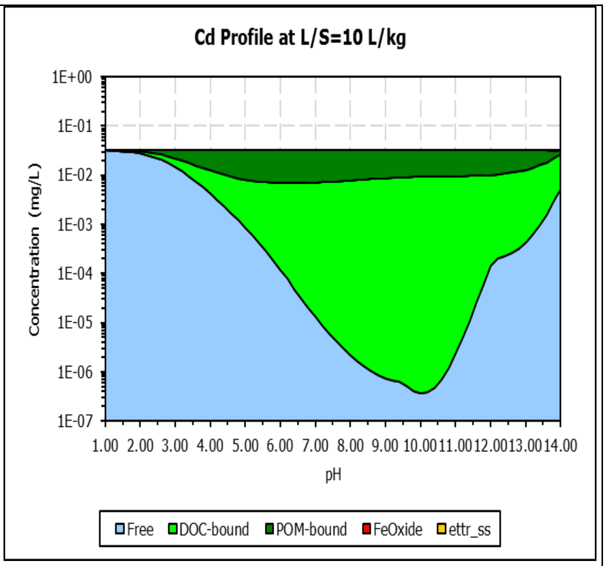

pH dependent concentration of Barium
Concentration (mg/L)
100
10
1
0.1
0.01
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

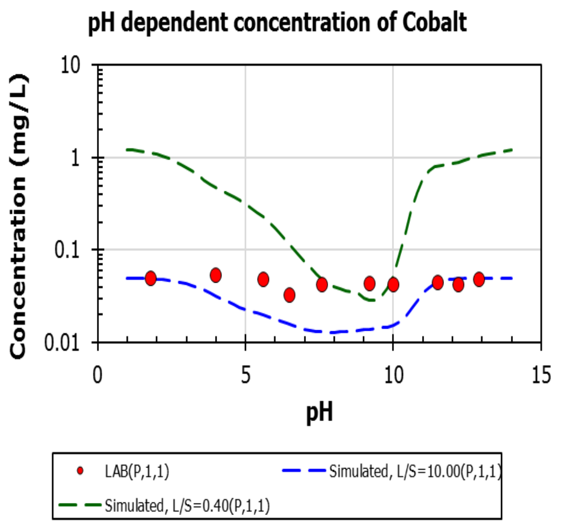

Ba Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

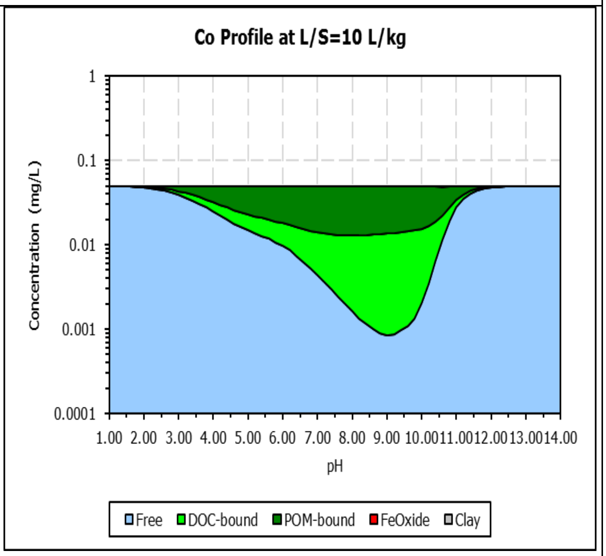

pH dependent concentration of Calcium
Concentration (mg/L)
1E+06
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

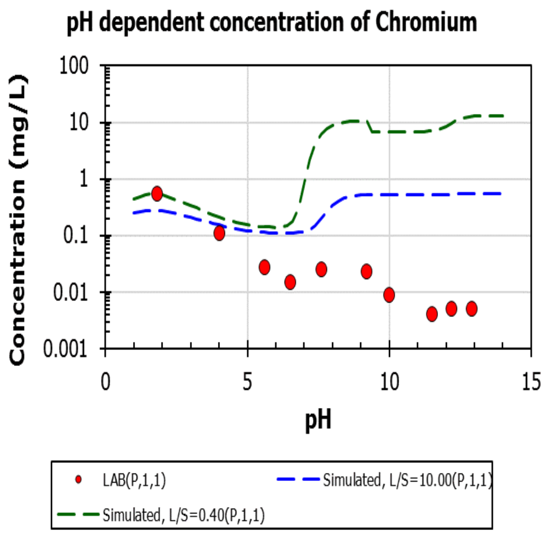

Ca Profile at L/S=10 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
CSHii_ss
ettr_ss
Ca5[OH][AsO4]3[c]
Cem07_Calcite
Cem07_Portlandite
Fluorite
Gypsum
beta-TCP

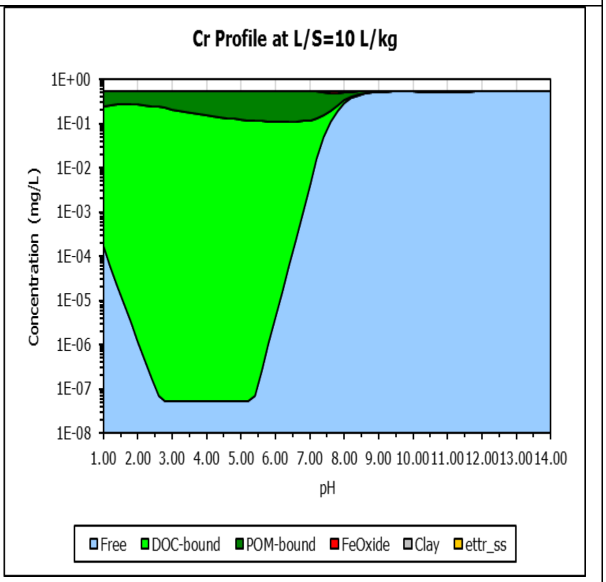

pH dependent concentration of Cadmium
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
● LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

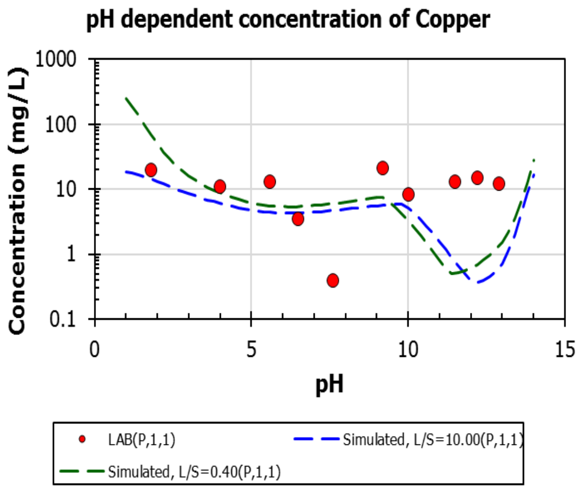

Cd Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
ettr_ss

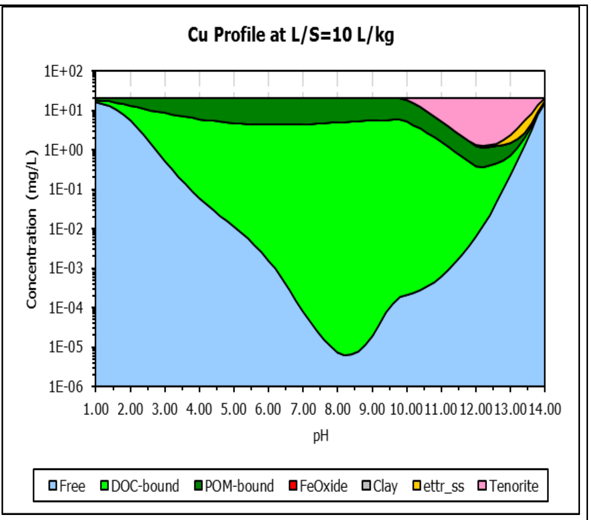

pH dependent concentration of Cobalt
Concentration (mg/L)
10
1
0.1
0.01
0
5
10
15
pH
● LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

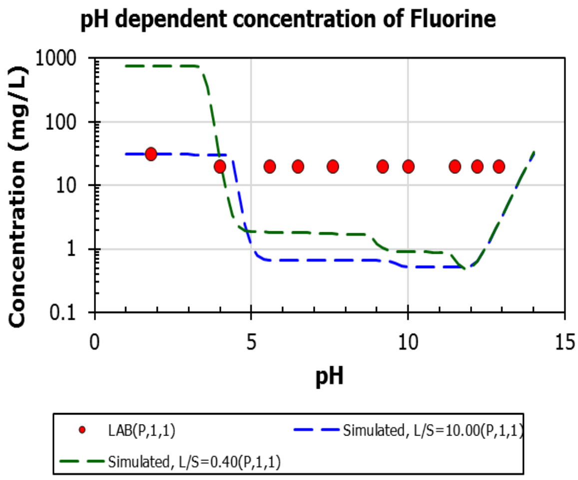

Co Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

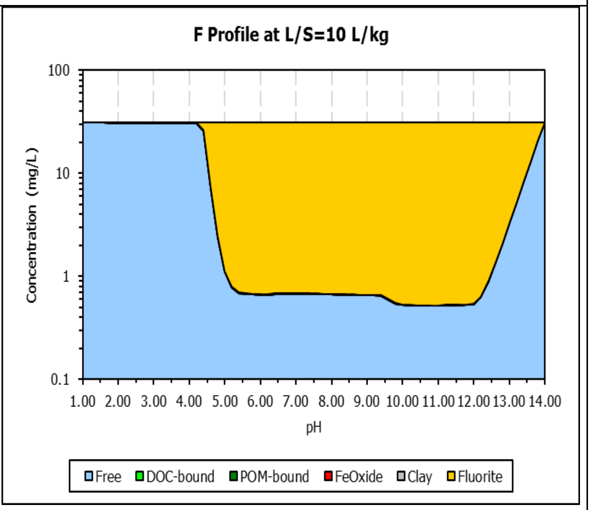

pH dependent concentration of Chromium
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
● LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

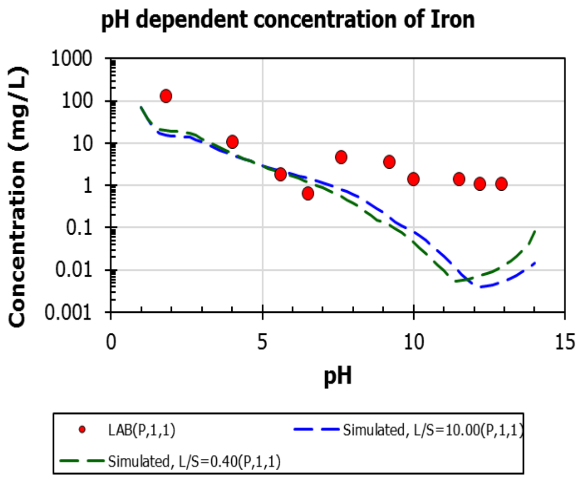

Cr Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

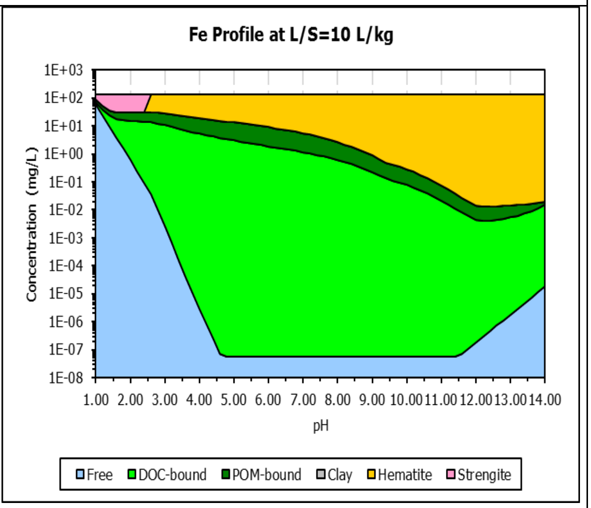

pH dependent concentration of Copper

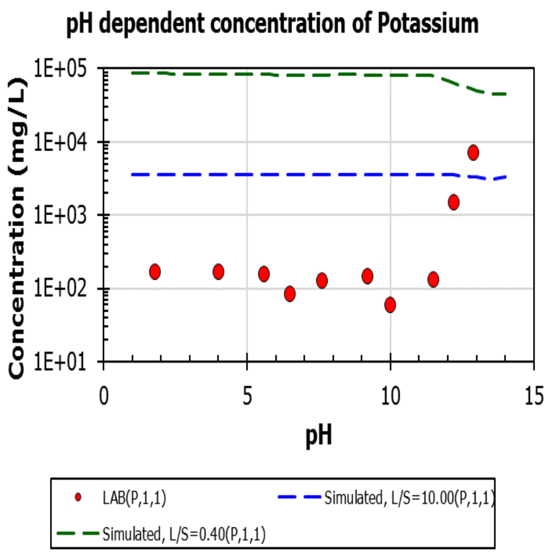

Cu Profile at L/S=10 L/kg

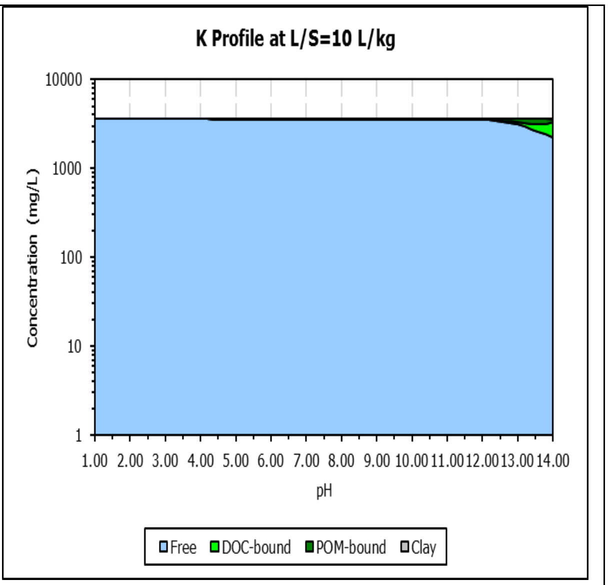

pH dependent concentration of Fluorine

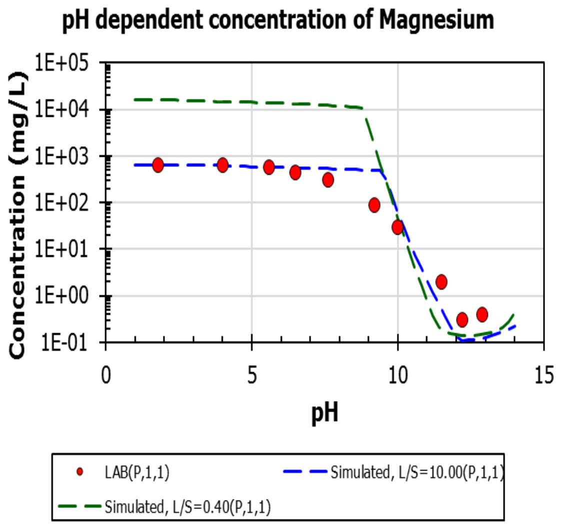

F Profile at L/S=10 L/kg

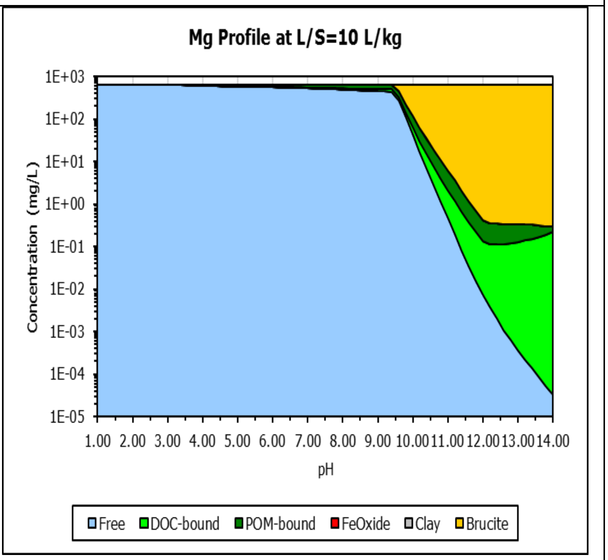

pH dependent concentration of Iron

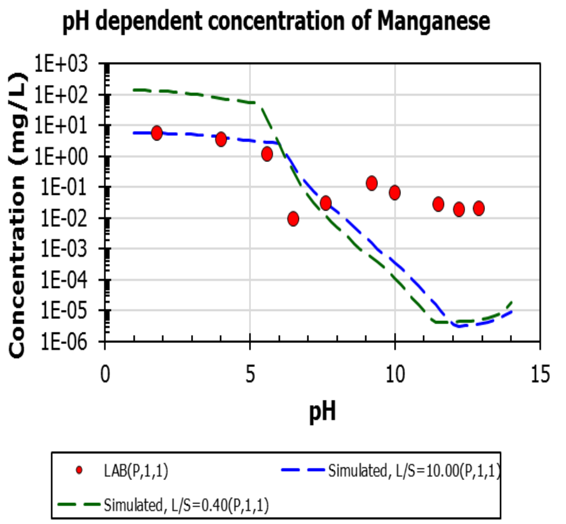

Fe Profile at L/S=10 L/kg

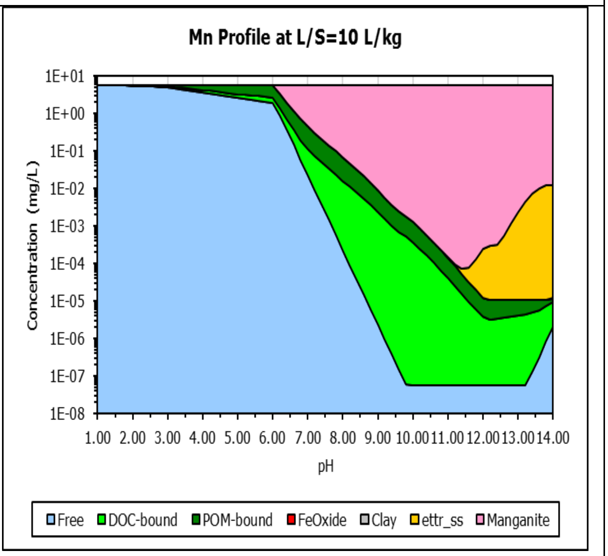

pH dependent concentration of Potassium

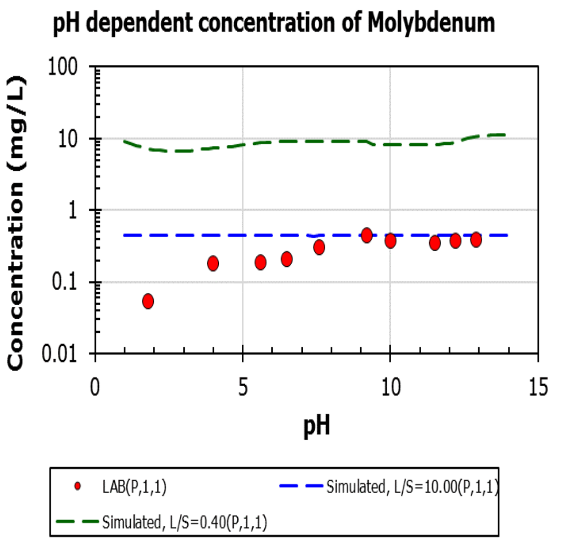

K Profile at L/S=10 L/kg

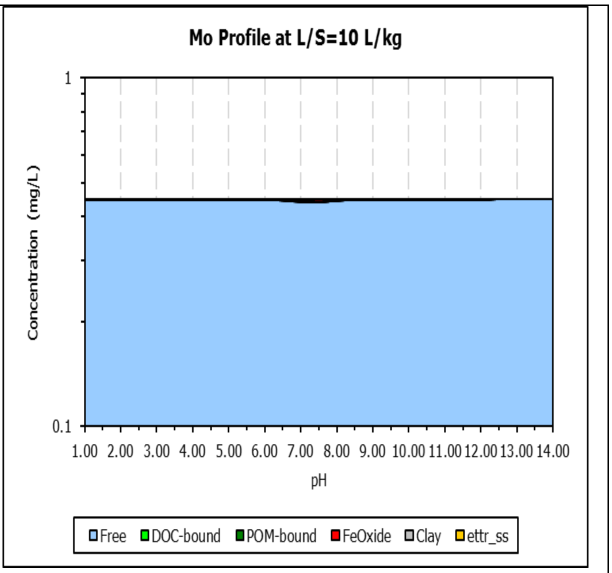

pH dependent concentration of Magnesium

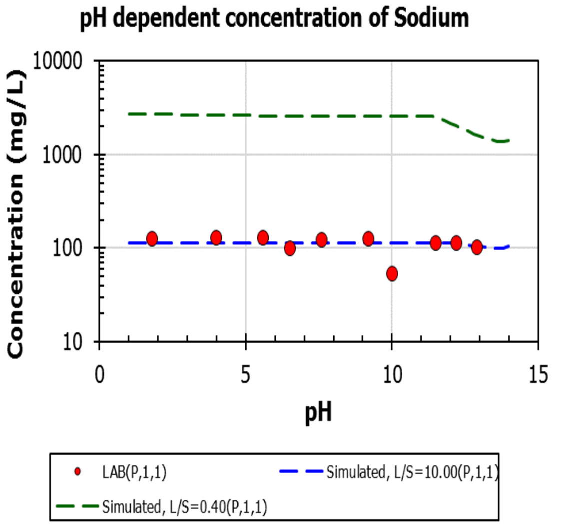

Mg Profile at L/S=10 L/kg

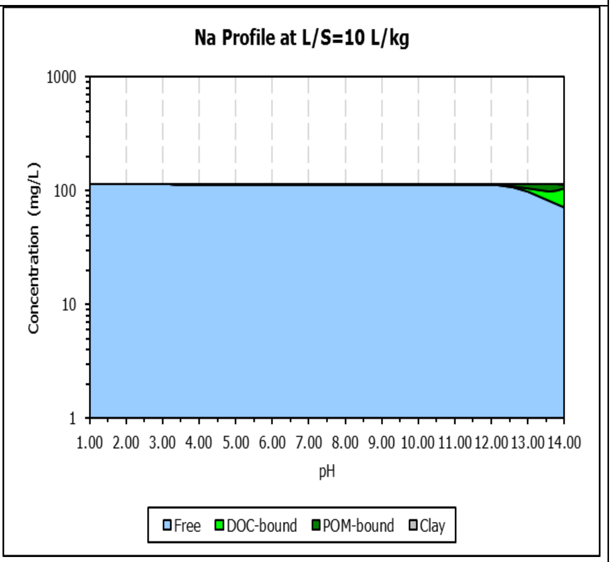

pH dependent concentration of Manganese

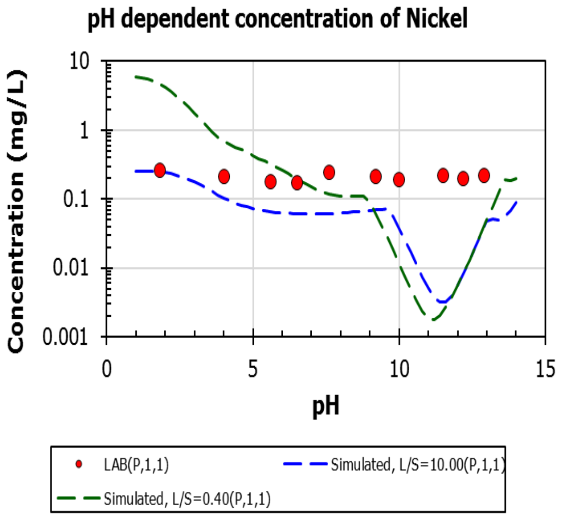

Mn Profile at L/S=10 L/kg

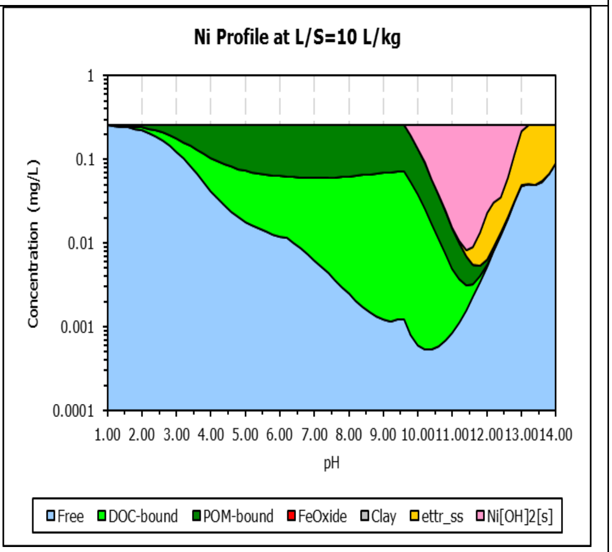

pH dependent concentration of Molybdenum
Concentration (mg/L)
100
10
1
0.1
0.01
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

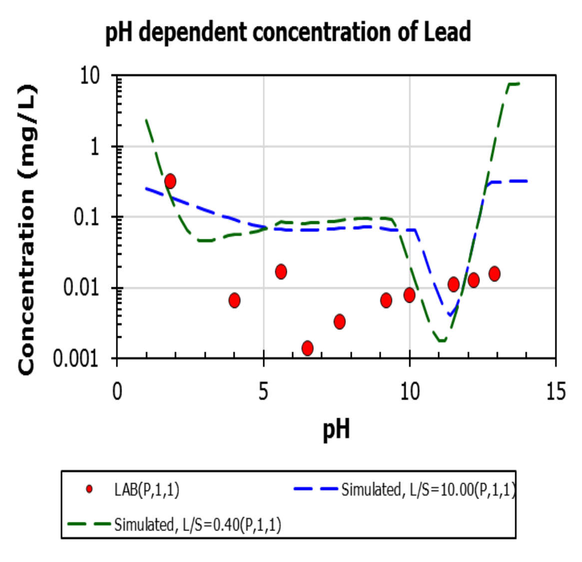

Mo Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

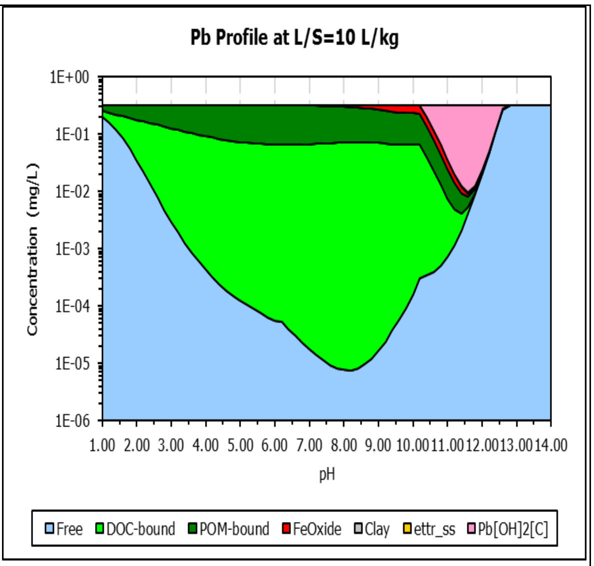

pH dependent concentration of Sodium
Concentration (mg/L)
10000
1000
100
10
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

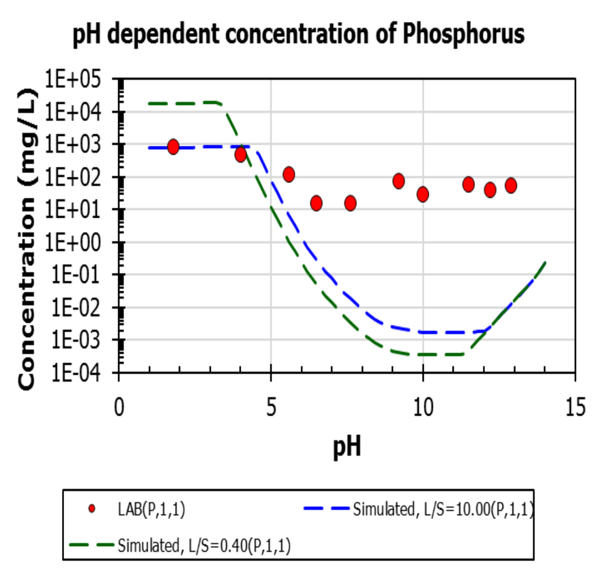

Na Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

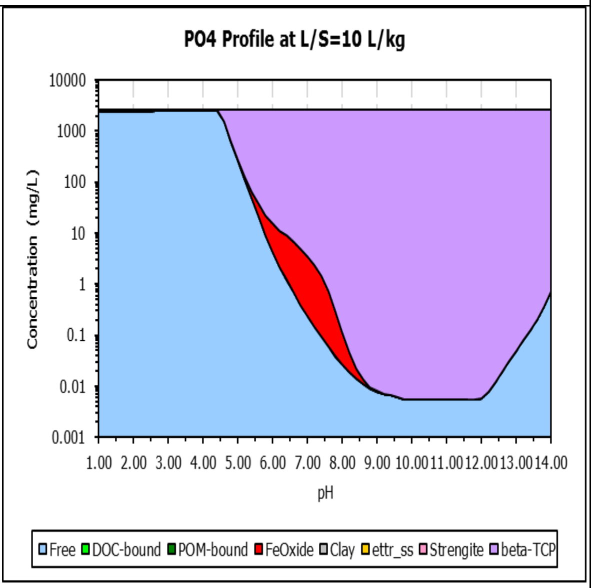

pH dependent concentration of Nickel
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

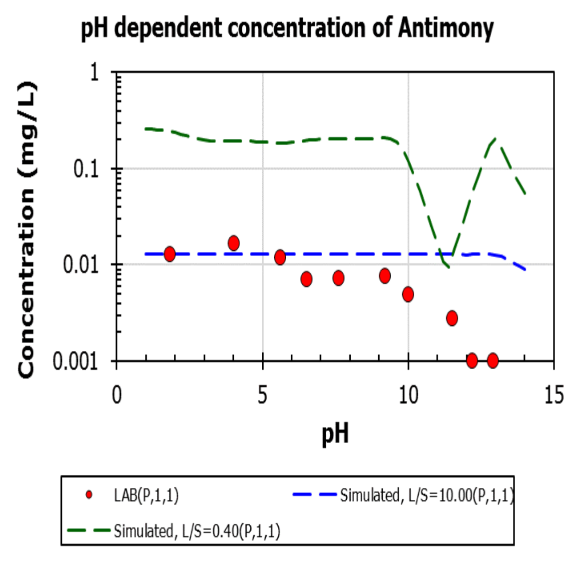

Ni Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Ni[OH]2[s]

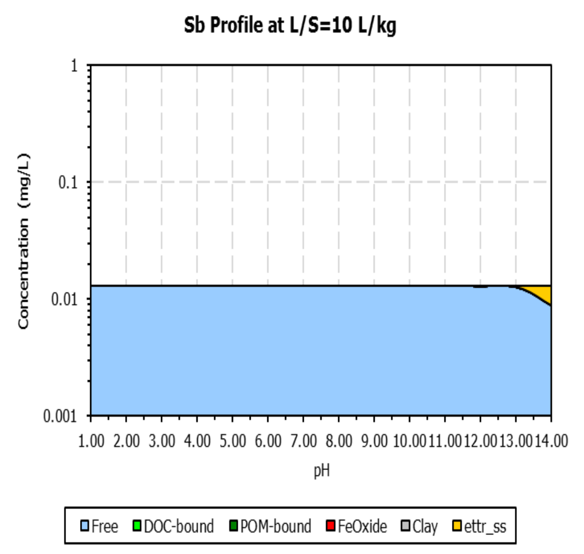

pH dependent concentration of Lead
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

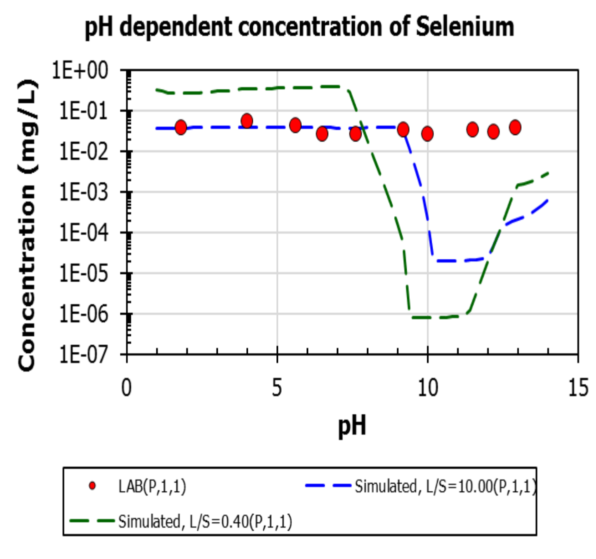

Pb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Pb[OH]2[C]

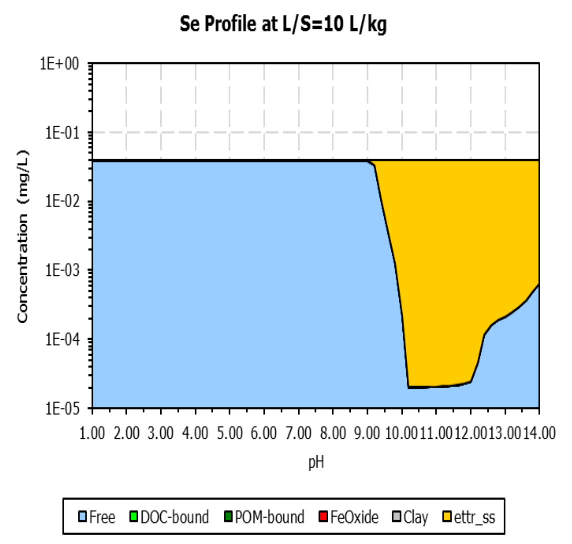

pH dependent concentration of Phosphorus
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

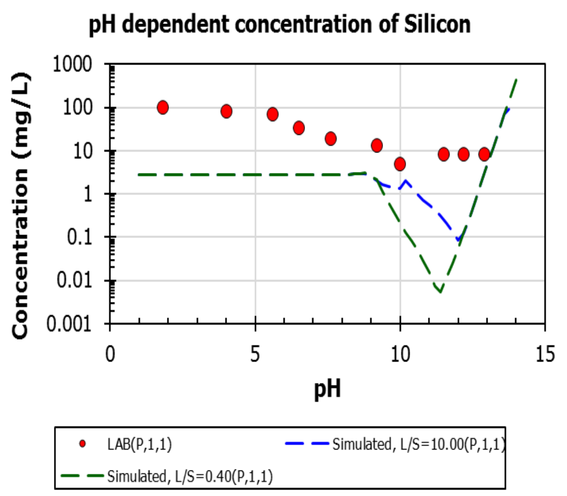

PO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Strengite
beta-TCP

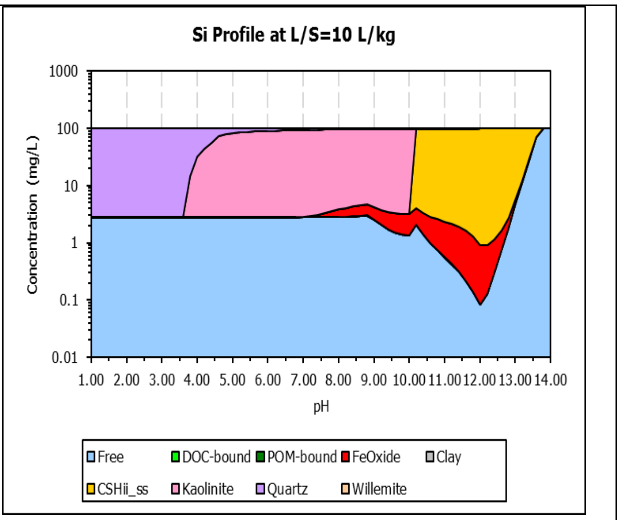

pH dependent concentration of Antimony
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

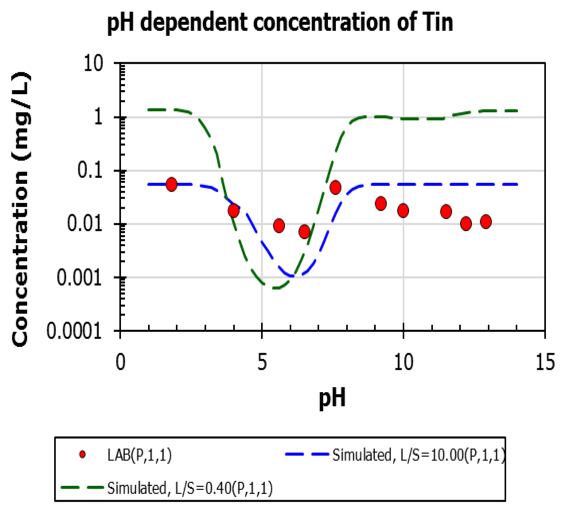

Sb Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

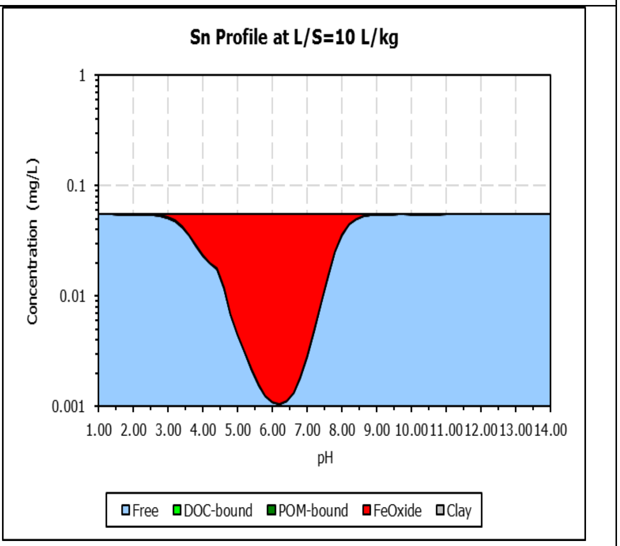

pH dependent concentration of Selenium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

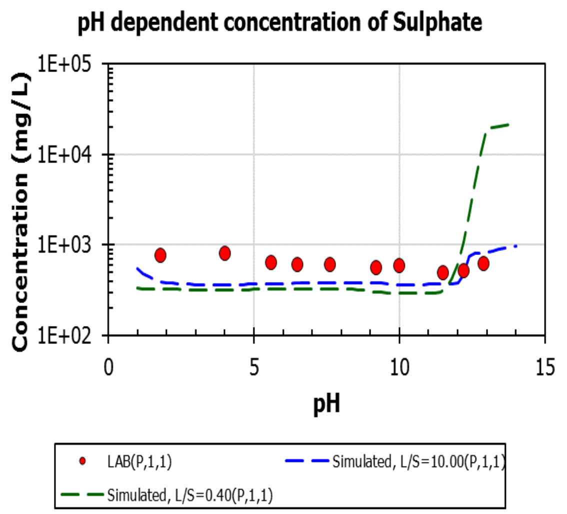

Se Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

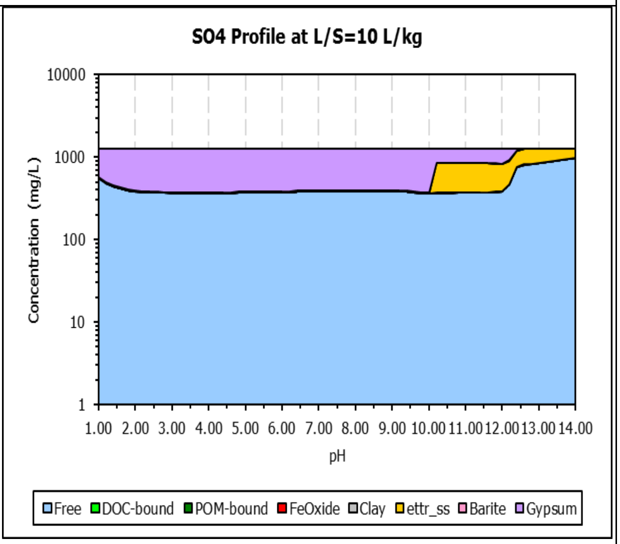

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

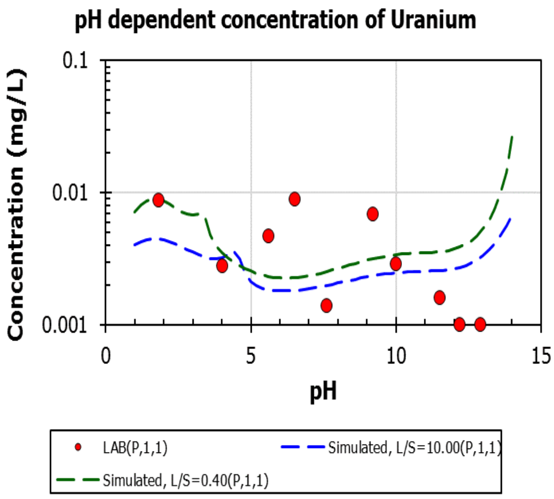

Si Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
CSHii_ss
Kaolinite
Quartz
Willemite

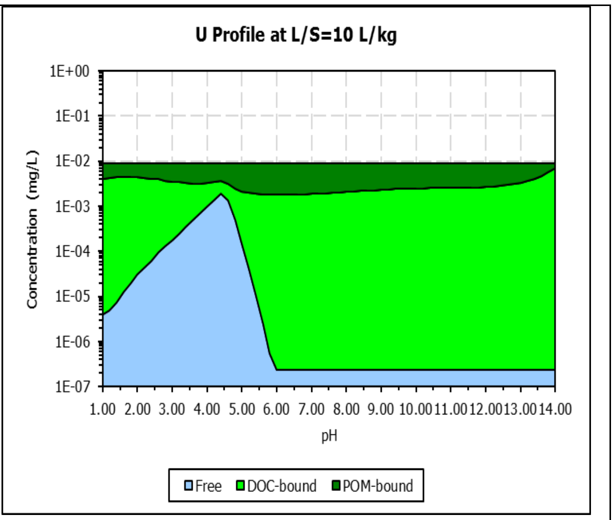

pH dependent concentration of Tin
Concentration (mg/L)
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

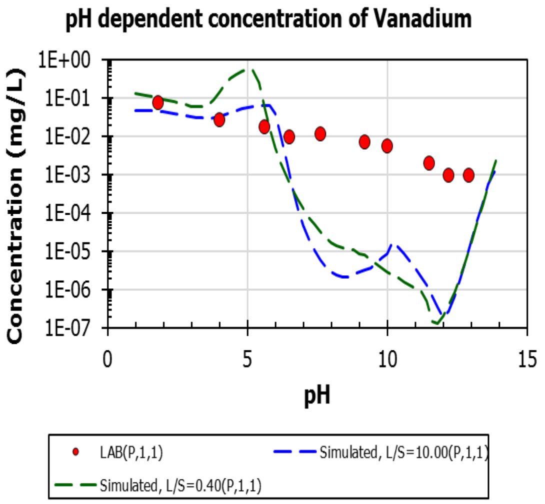

Sn Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

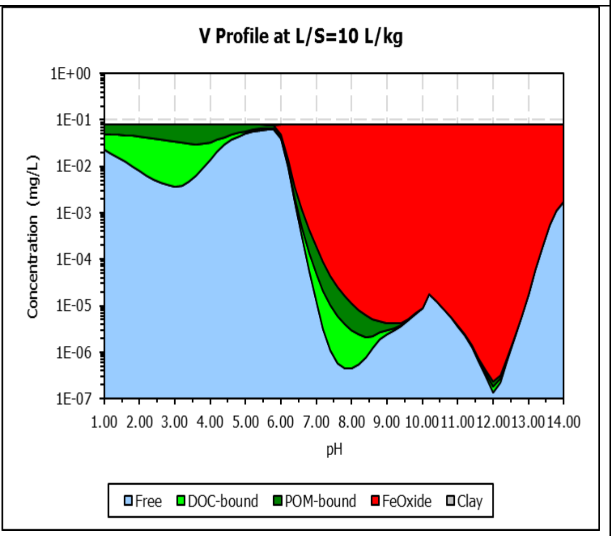

pH dependent concentration of Sulphate
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

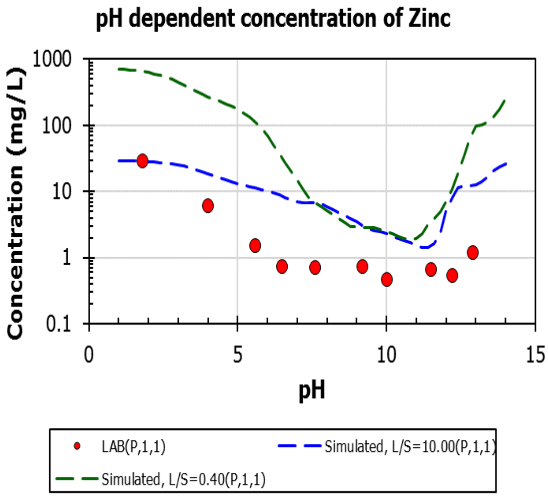

SO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite
Gypsum

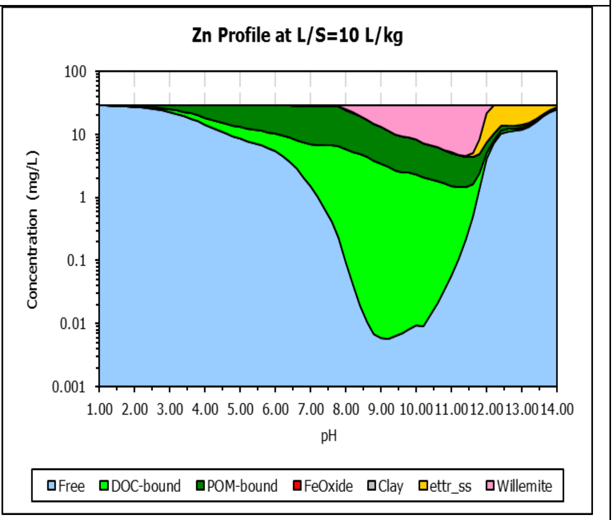

pH dependent concentration of Uranium
Concentration (mg/L)
0.1
0.01
0.001
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound

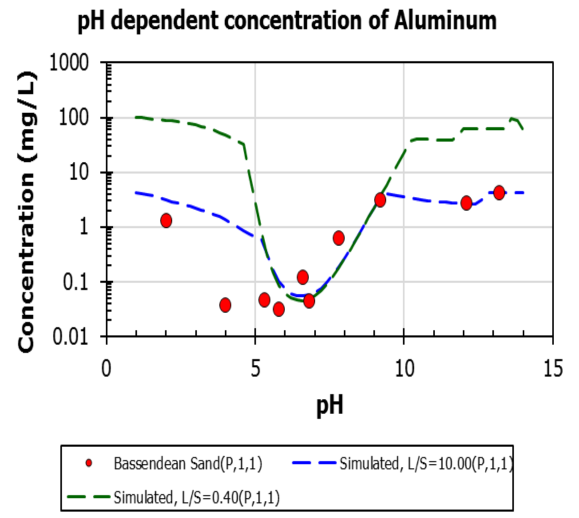

pH dependent concentration of Vanadium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

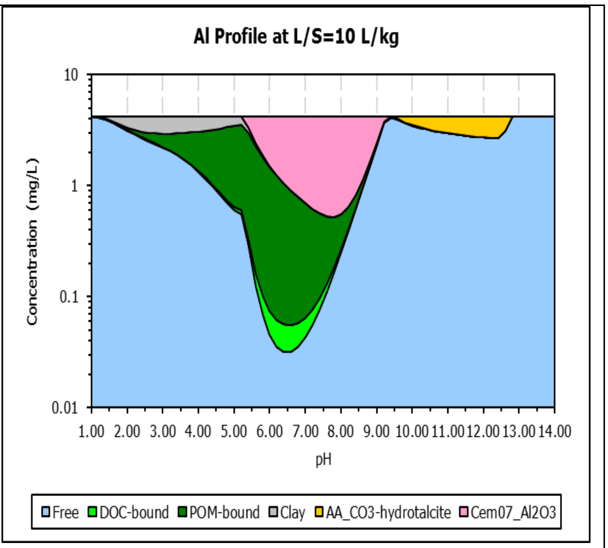

V Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

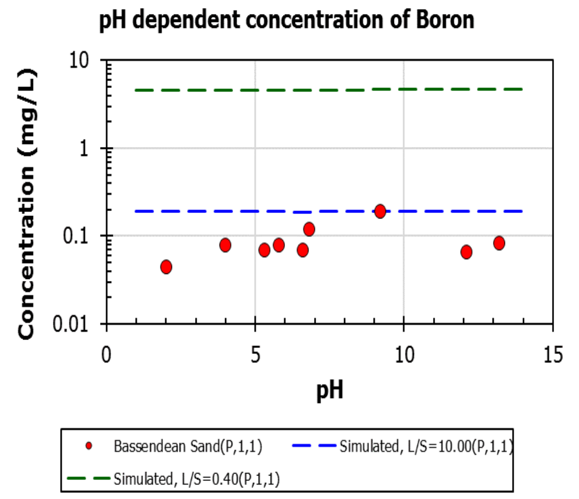

pH dependent concentration of Zinc
Concentration (mg/L)
1000
100
10
1
0.1
0
5
10
15
pH
LAB(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

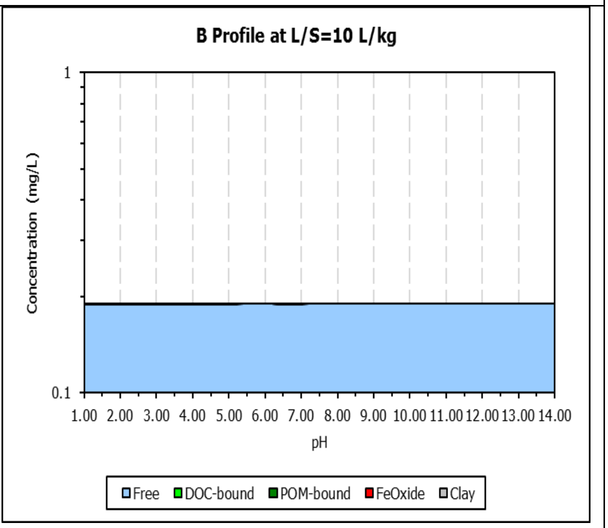

Zn Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Willemite

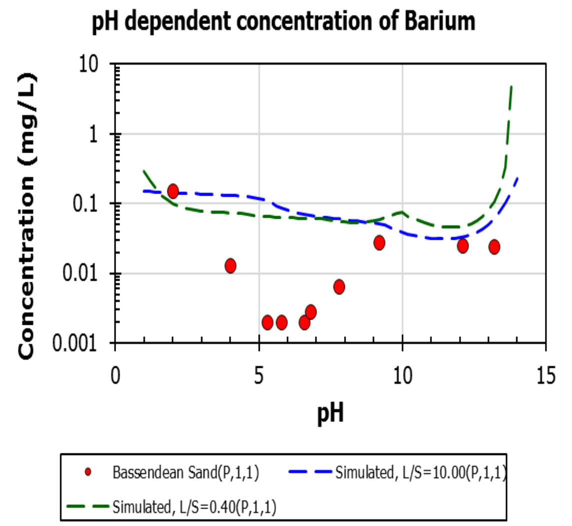
Appendix A9: Chemical Speciation Fingerprints for Bassendean Ellenbrook Soils.

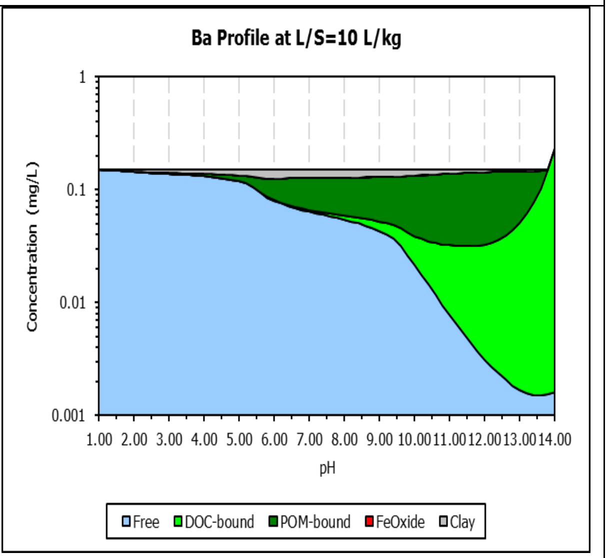

pH dependent concentration of Aluminum

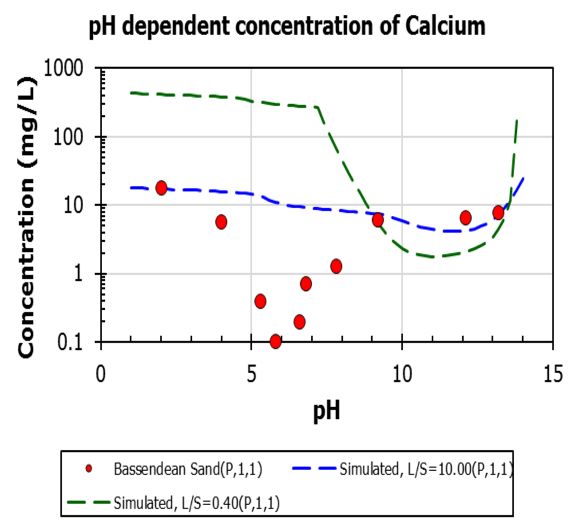

Al Profile at L/S=10 L/kg

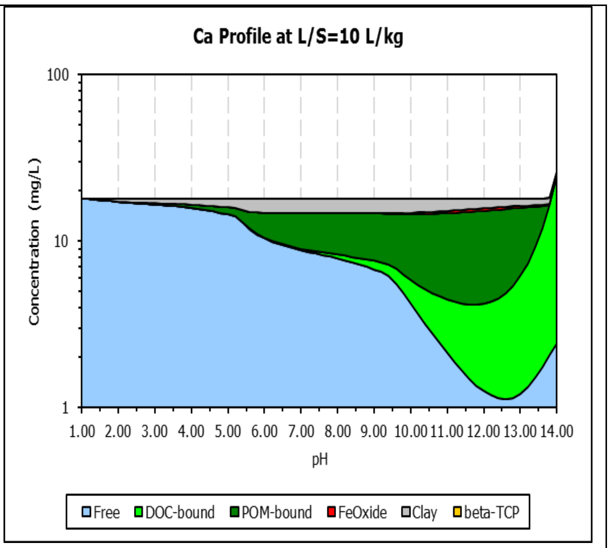

pH dependent concentration of Boron

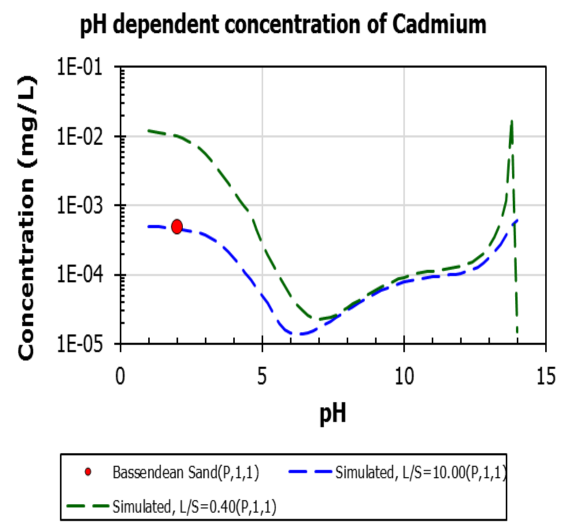

B Profile at L/S=10 L/kg

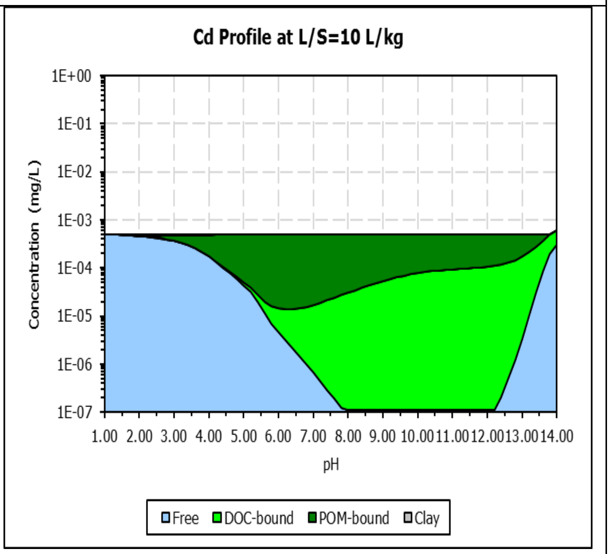

pH dependent concentration of Barium

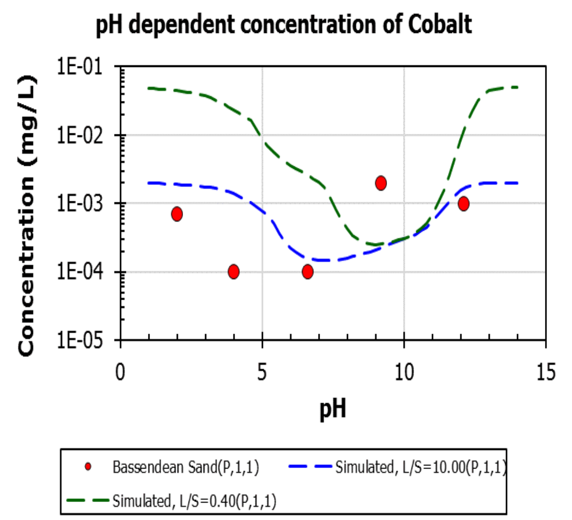

Ba Profile at L/S=10 L/kg

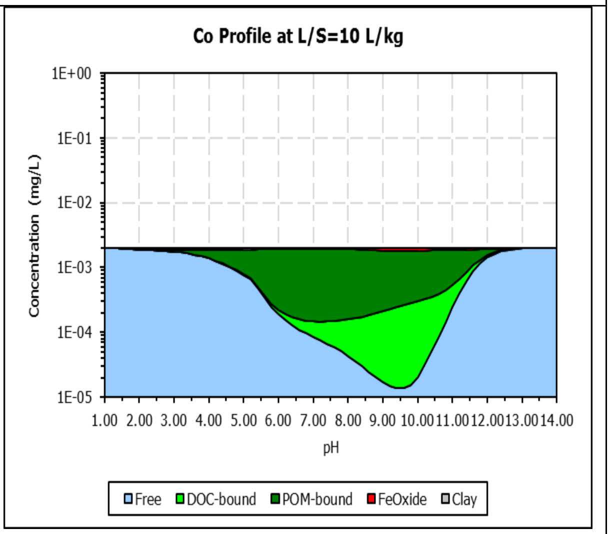

pH dependent concentration of Calcium
Concentration (mg/L)
1000
100
10
1
0.1
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

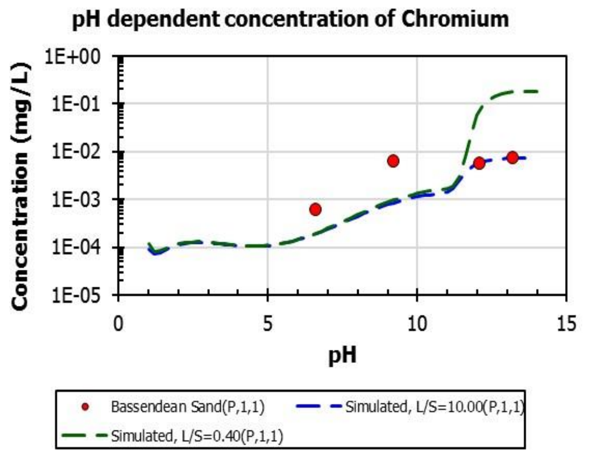

Ca Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
beta-TCP

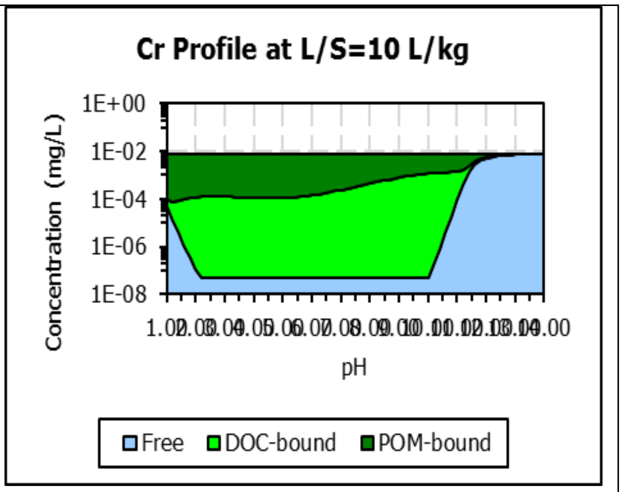

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

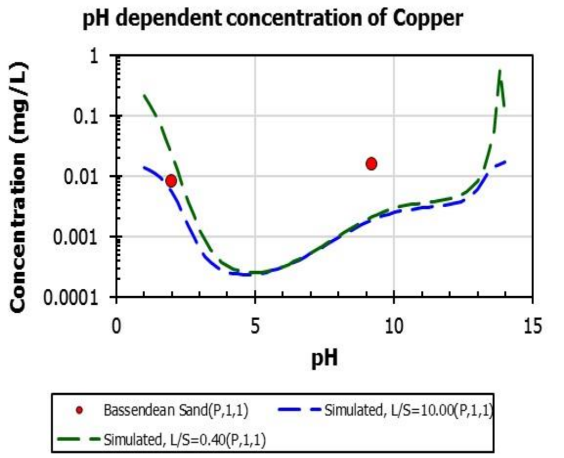

Cd Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

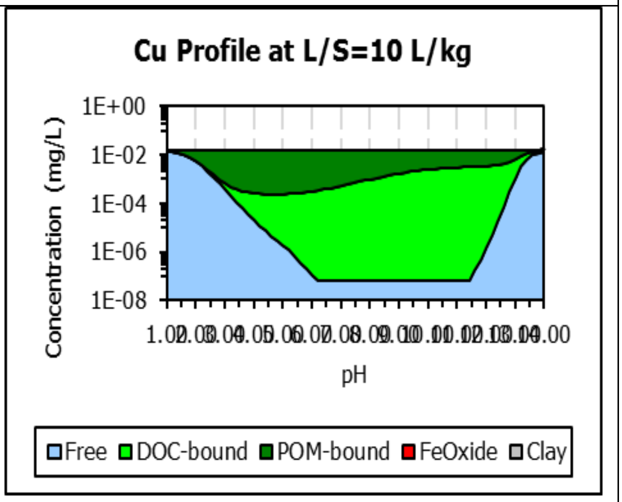

pH dependent concentration of Cobalt
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

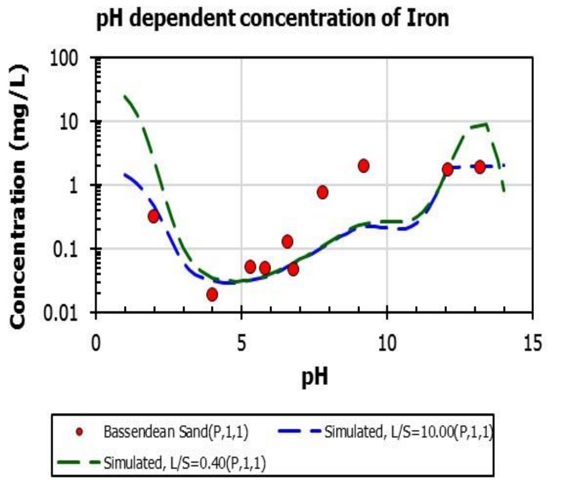

Co Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

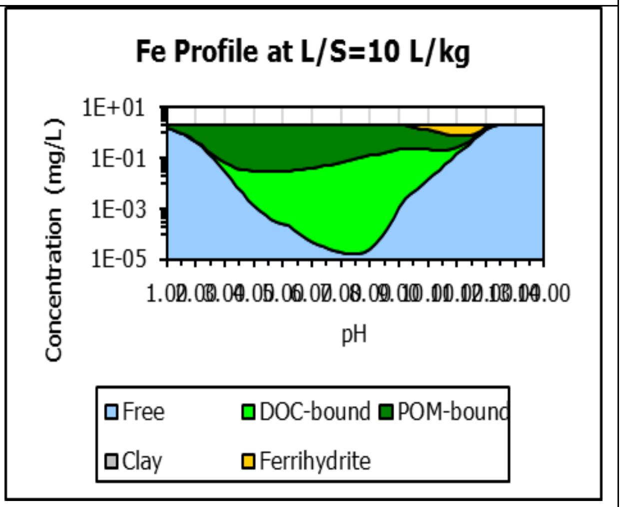

pH dependent concentration of Chromium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

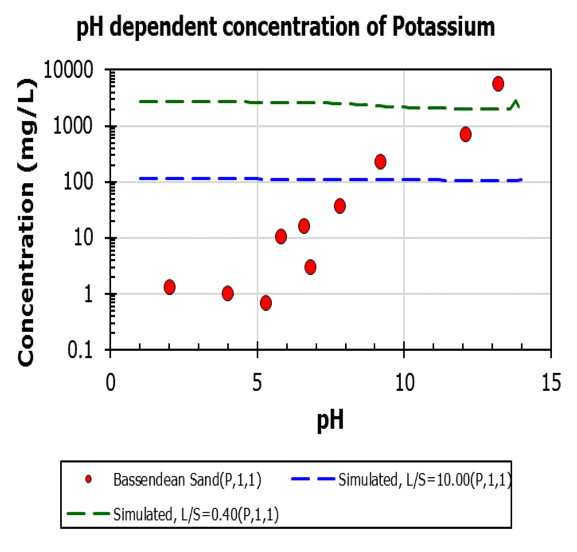

Cr Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-02
1E-04
1E-06
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound

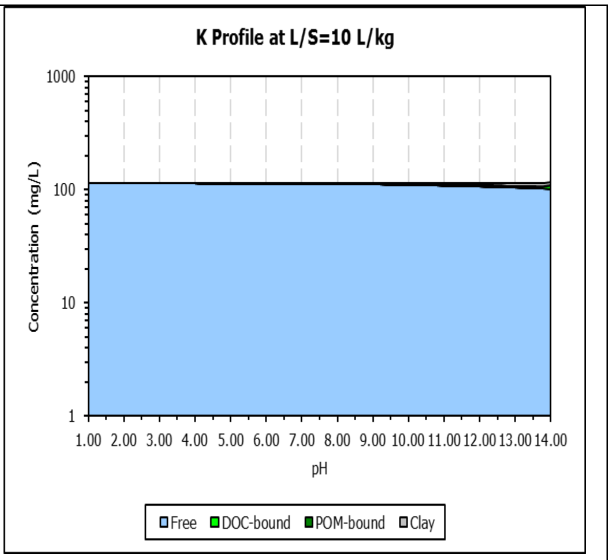

pH dependent concentration of Copper
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

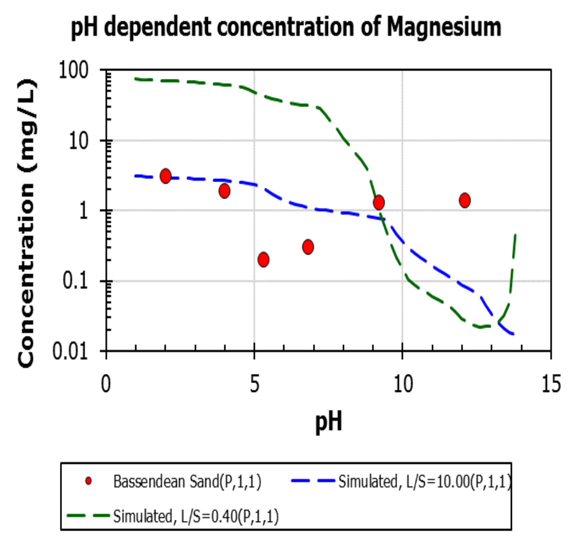

Cu Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-02
1E-04
1E-06
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

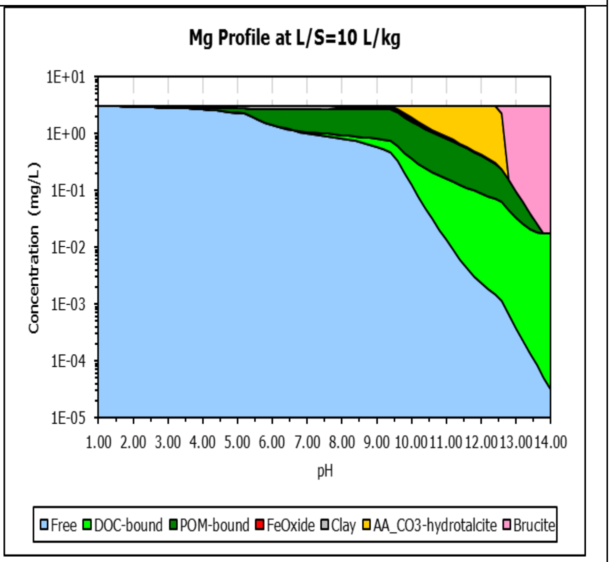

pH dependent concentration of Iron
Concentration (mg/L)
100
10
1
0.1
0.01
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

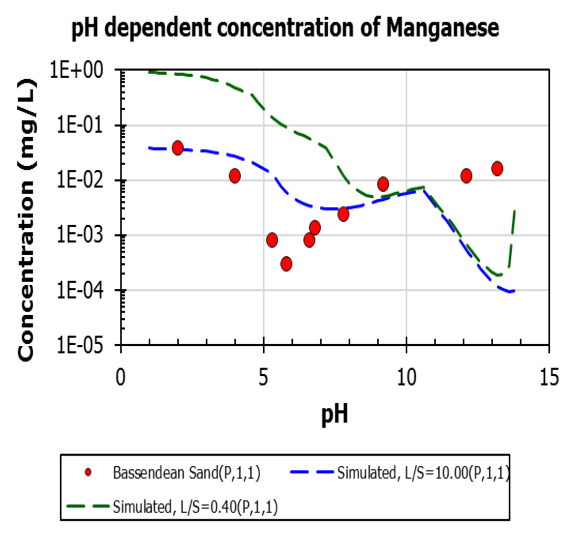

Fe Profile at L/S=10 L/kg
Concentration (mg/L)
1E+01
1E-01
1E-03
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Ferrihydrite

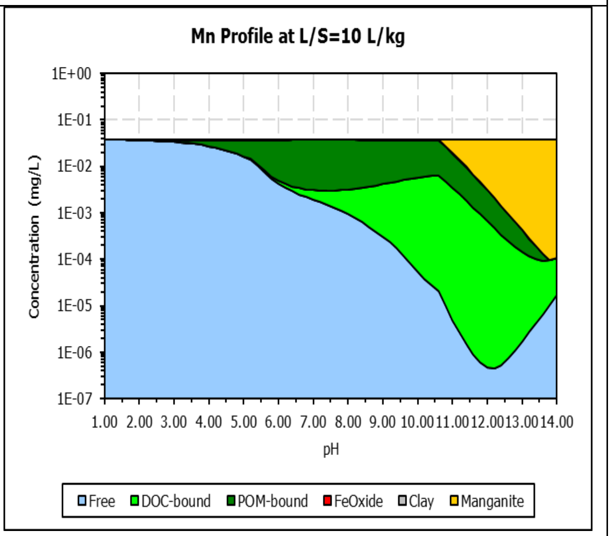

pH dependent concentration of Potassium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

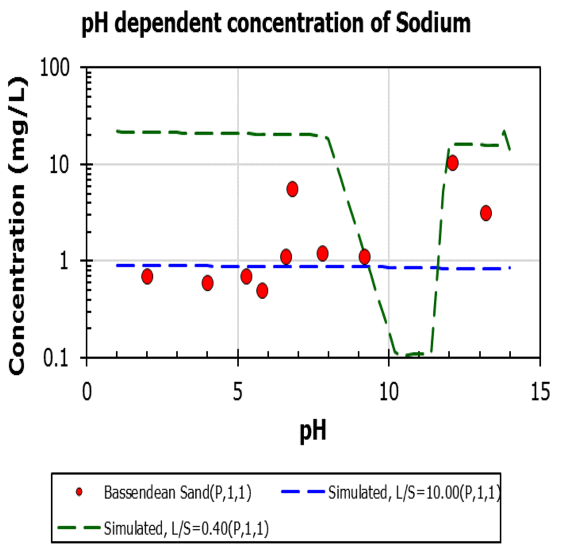

K Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

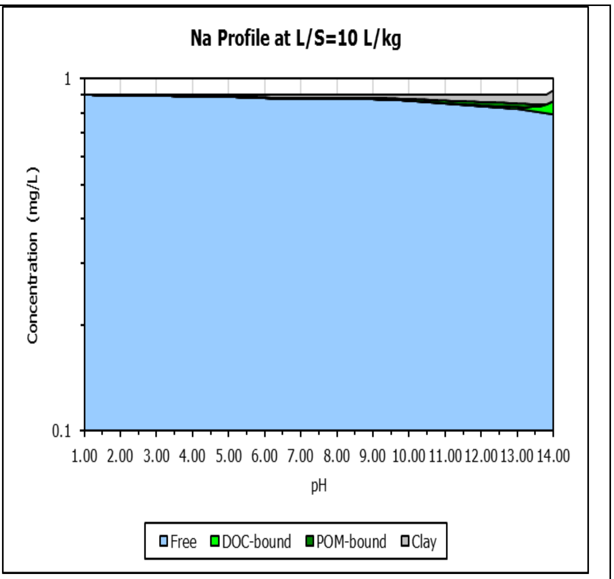

pH dependent concentration of Magnesium
Concentration (mg/L)
100
10
1
0.1
0.01
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

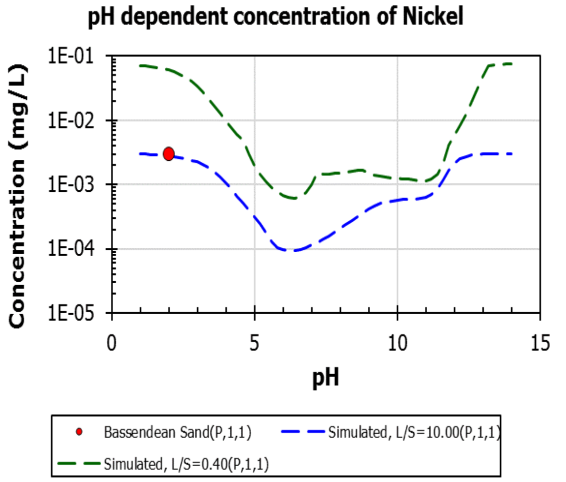

Mg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AA_CO3-hydrotalcite
Brucite

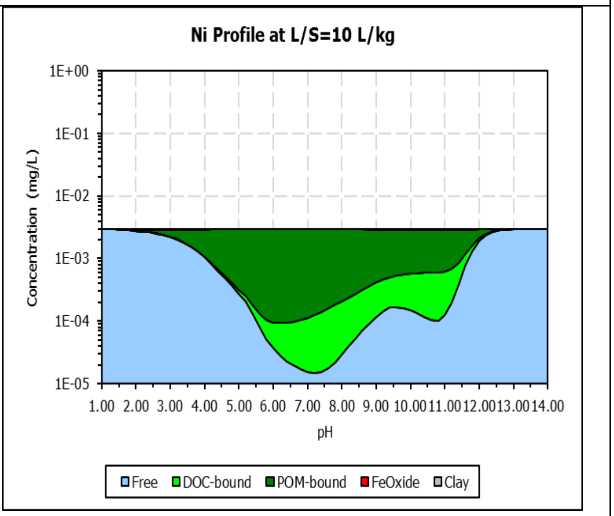

pH dependent concentration of Manganese
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

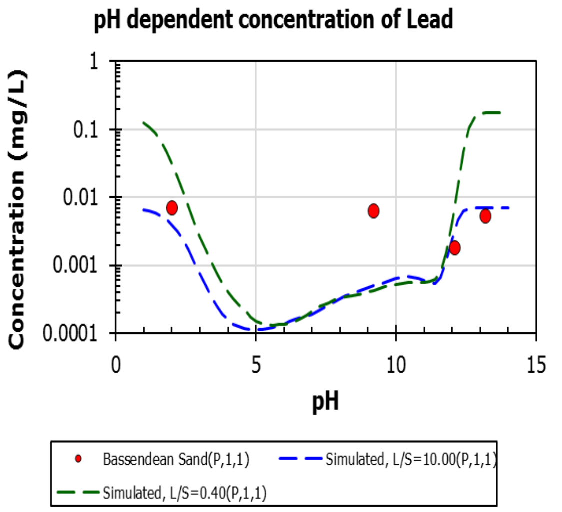

Mn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

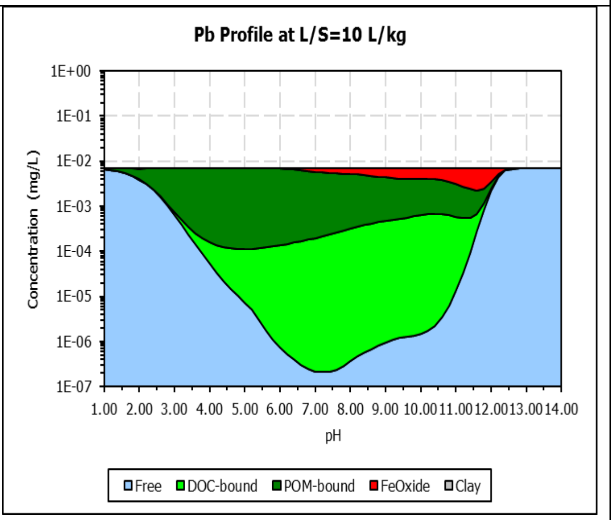

pH dependent concentration of Sodium
Concentration (mg/L)
100
10
1
0.1
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

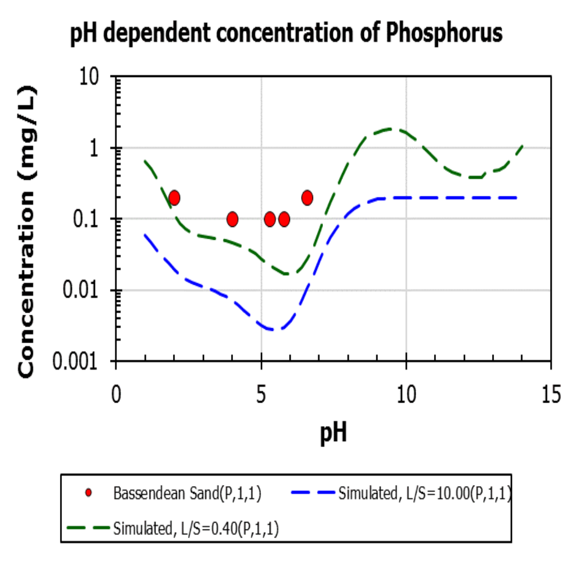

Na Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

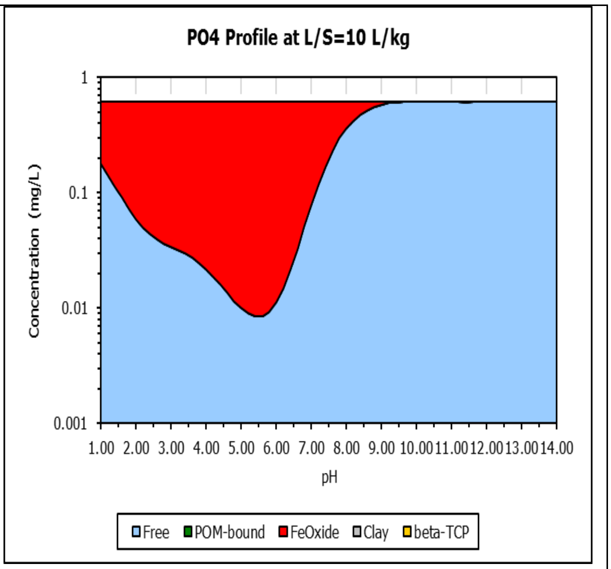

pH dependent concentration of Nickel
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

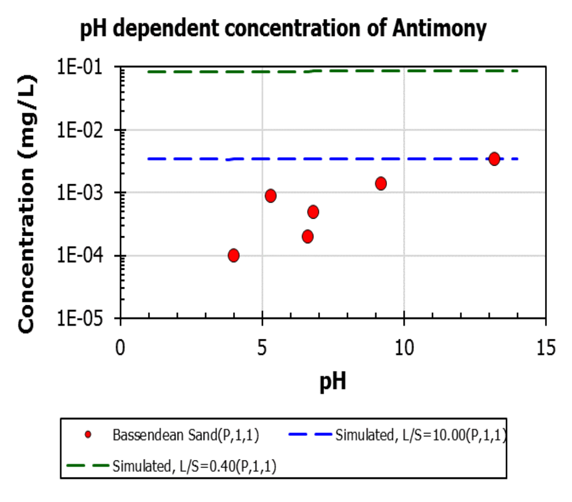

Ni Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

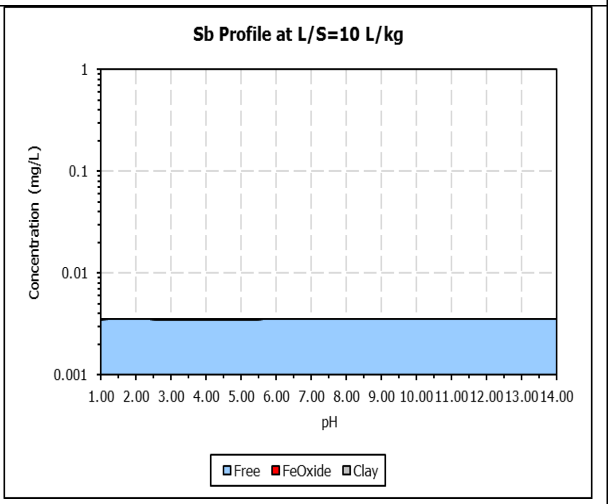

pH dependent concentration of Lead
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

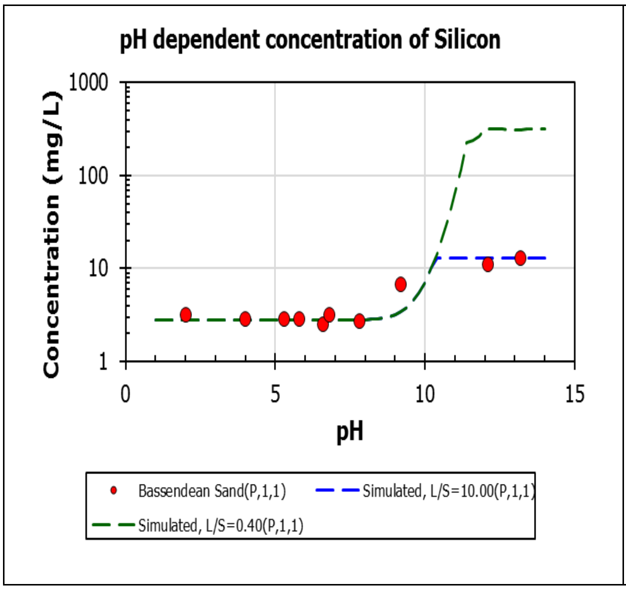

Pb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

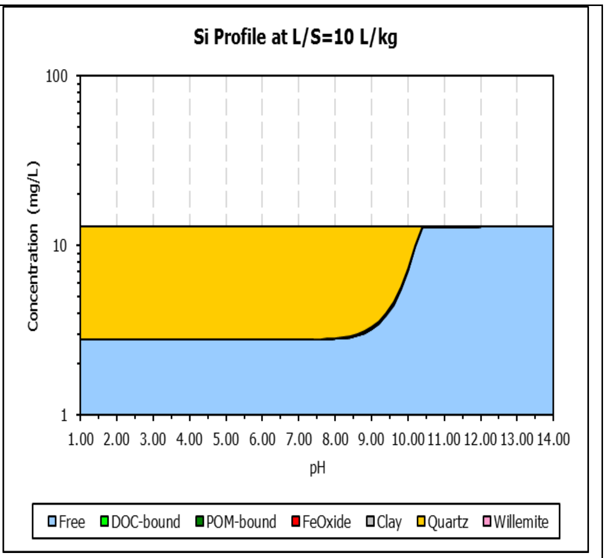

pH dependent concentration of Phosphorus
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

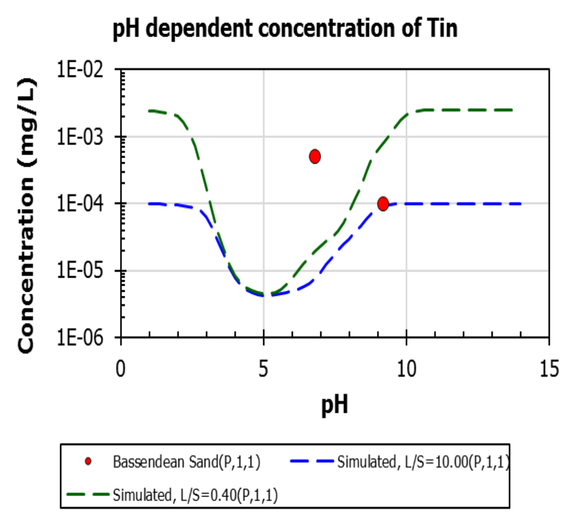

PO4 Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
POM-bound
FeOxide
Clay
beta-TCP

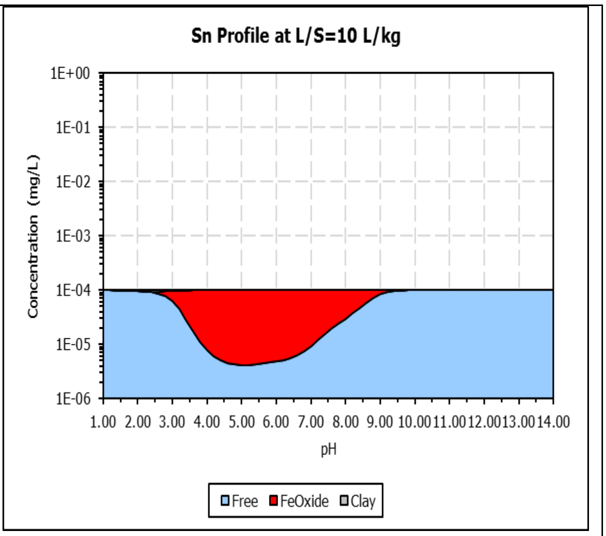

pH dependent concentration of Antimony
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

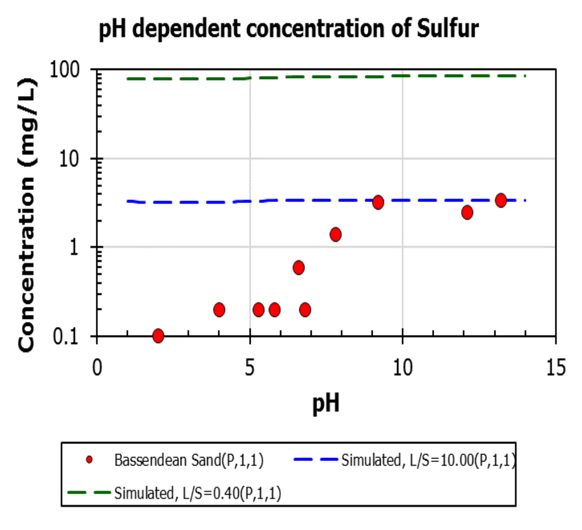

Sb Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

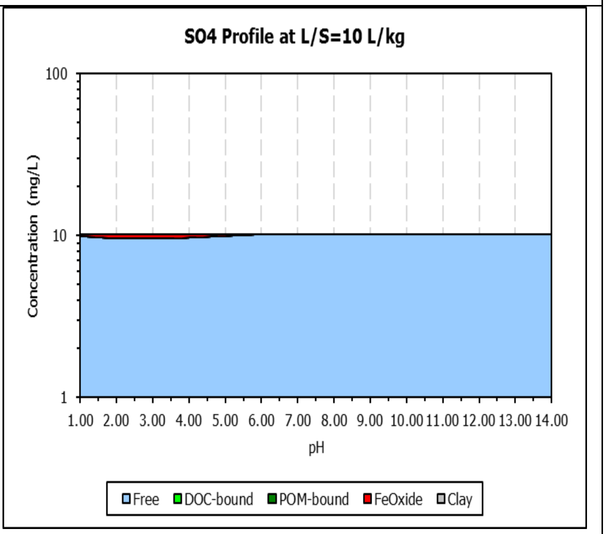

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

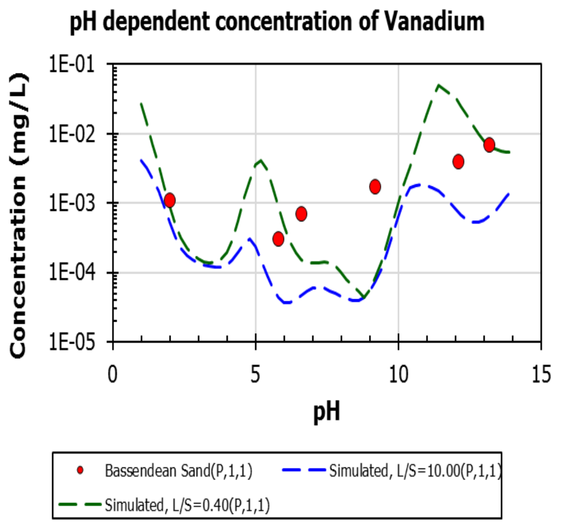

Si Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Quartz
Willemite

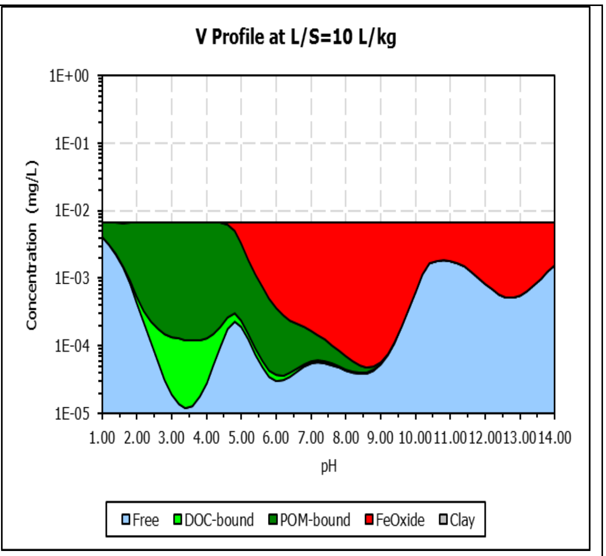

pH dependent concentration of Tin
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

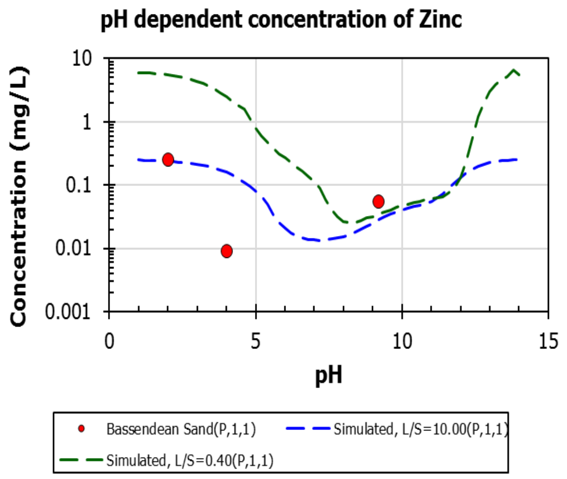

Sn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

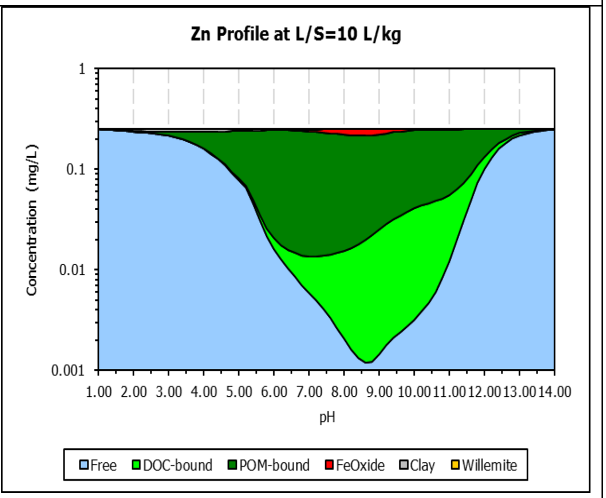

pH dependent concentration of Sulfur
Concentration (mg/L)
100
10
1
0.1
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)


SO4 Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay


pH dependent concentration of Vanadium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

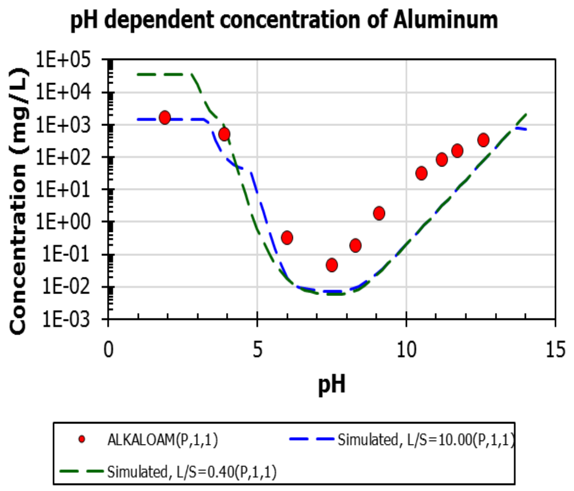

V Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

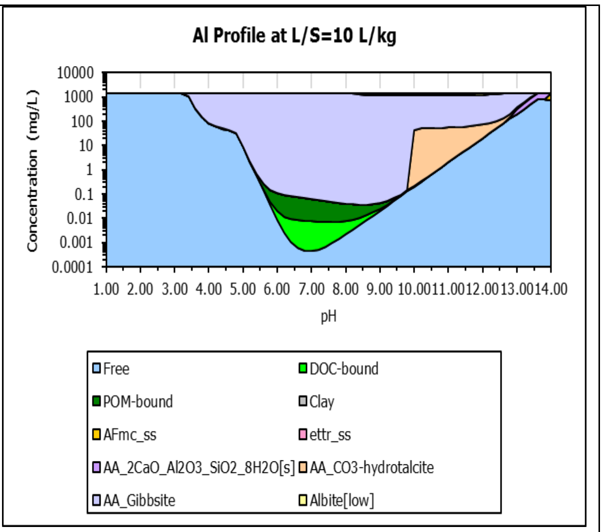

pH dependent concentration of Zinc
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
Bassendean Sand(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

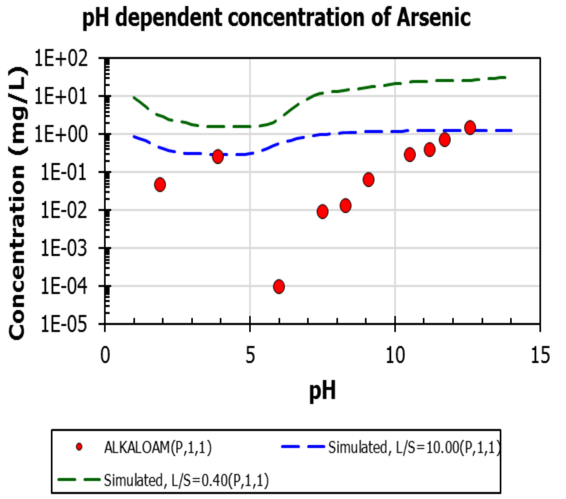

Zn Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Willemite

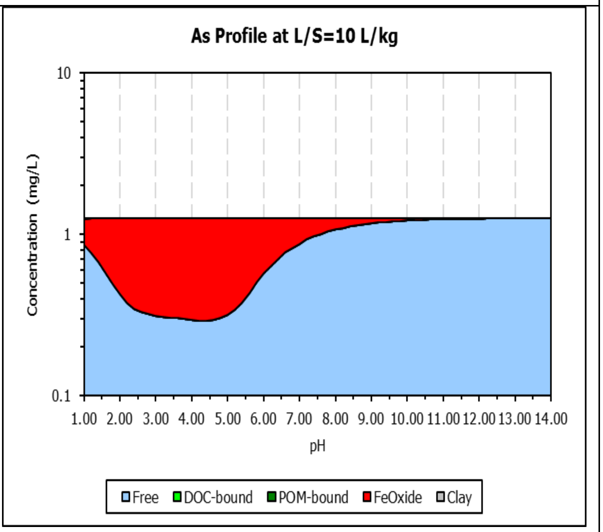
Appendix A 10: Chemical Speciation Fingerprints for Virtual Material

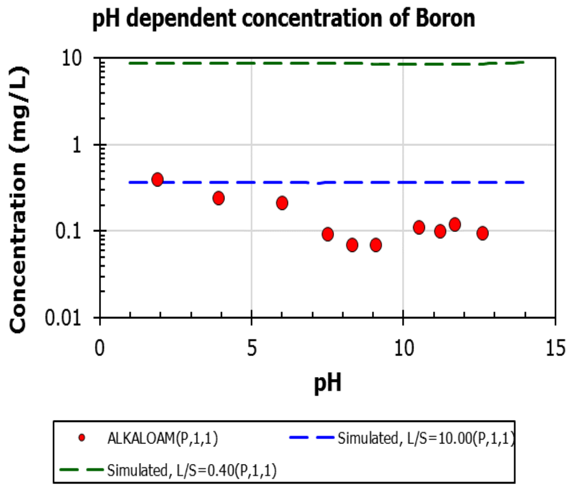
A10-1: Alkaloam 5% and Bassendean sand 95%

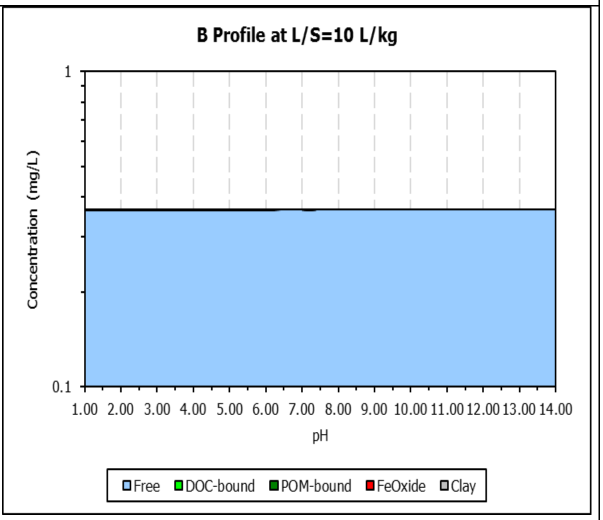

pH dependent concentration of Aluminum

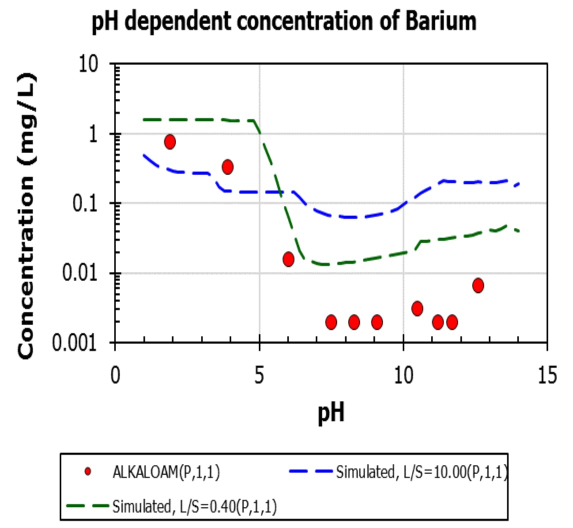

Al Profile at L/S=10 L/kg

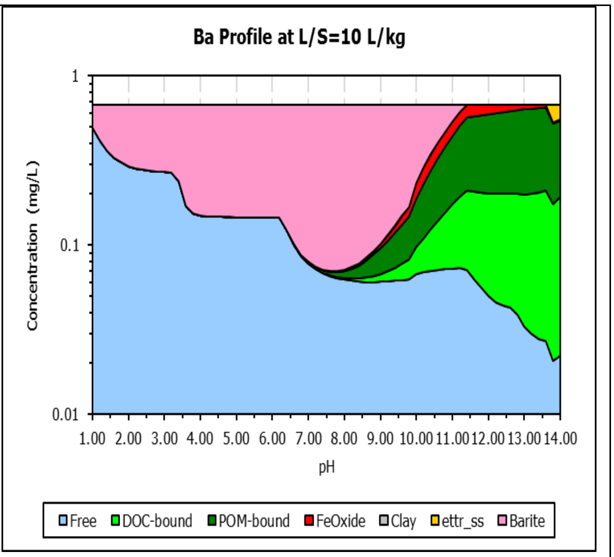

pH dependent concentration of Arsenic

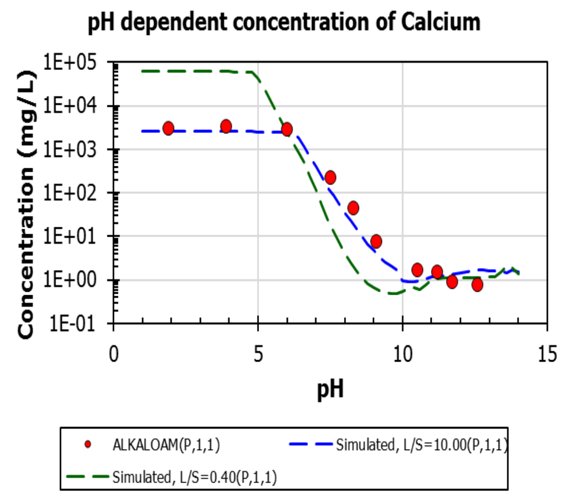

As Profile at L/S=10 L/kg

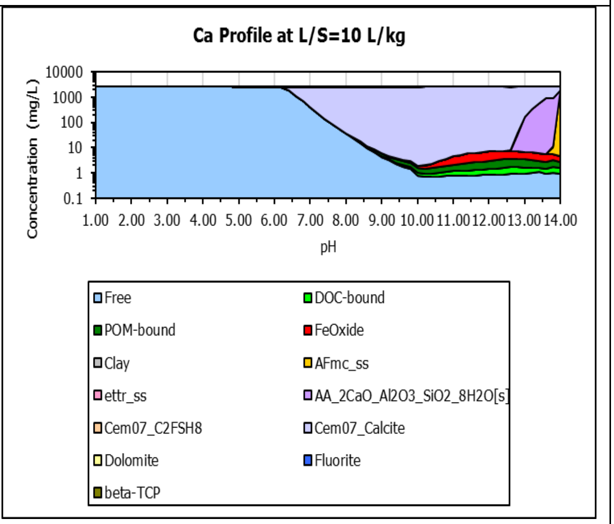

pH dependent concentration of Boron

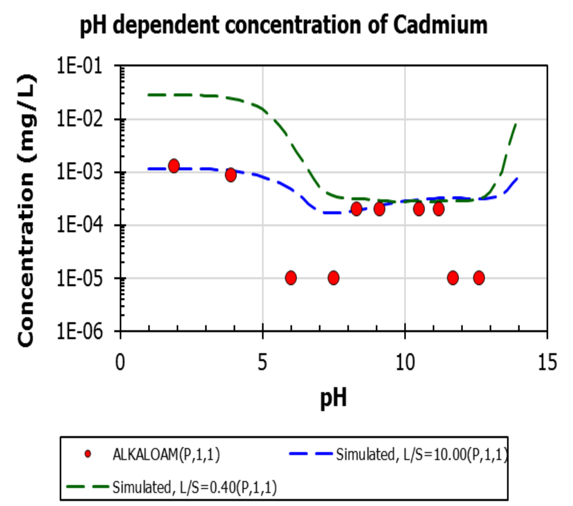

B Profile at L/S=10 L/kg

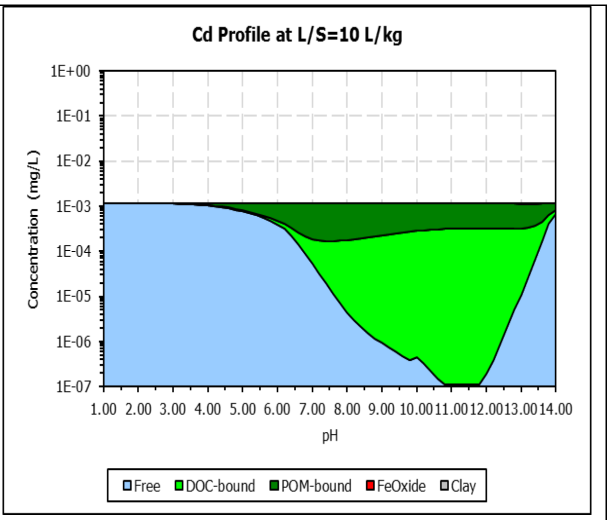

pH dependent concentration of Barium
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

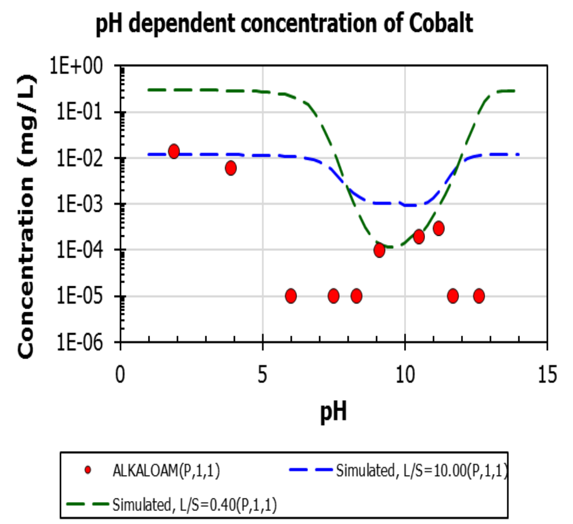

Ba Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
Barite

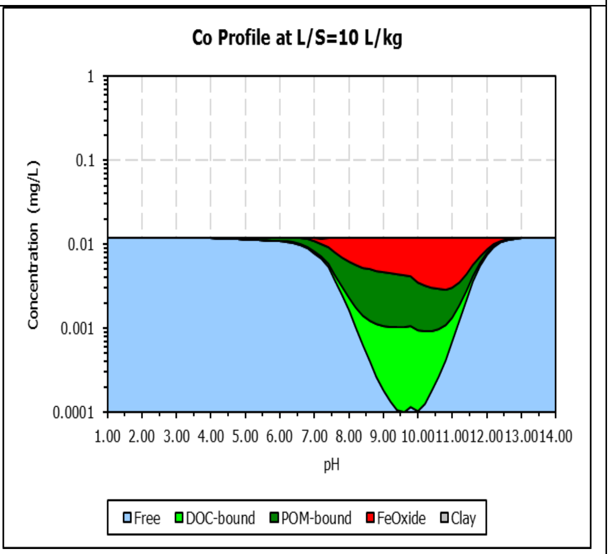

pH dependent concentration of Calcium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

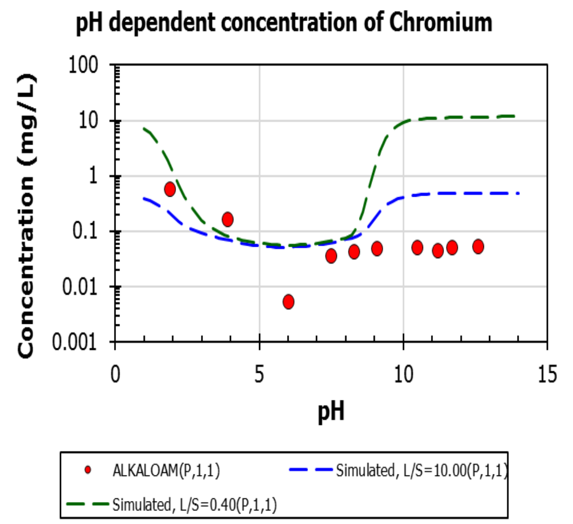

Ca Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
0.1
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AFmc_ss
ettr_ss
AA_2CaO_Al2O3_SiO2_8H2O[s]
Cem07_C2FSH8
Cem07_Calcite
Dolomite
Fluorite
beta-TCP

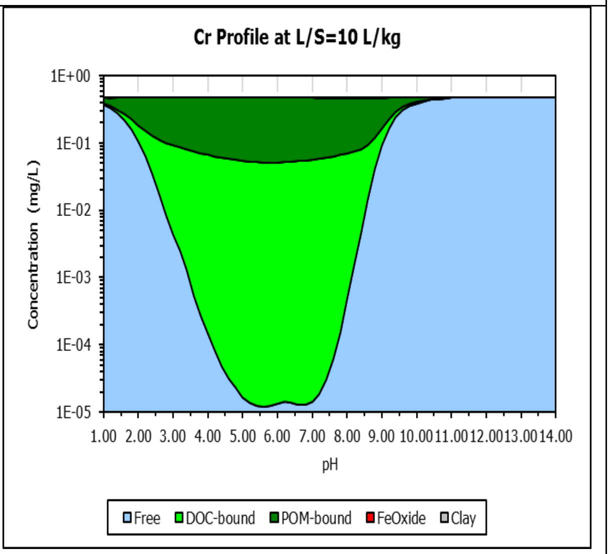

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

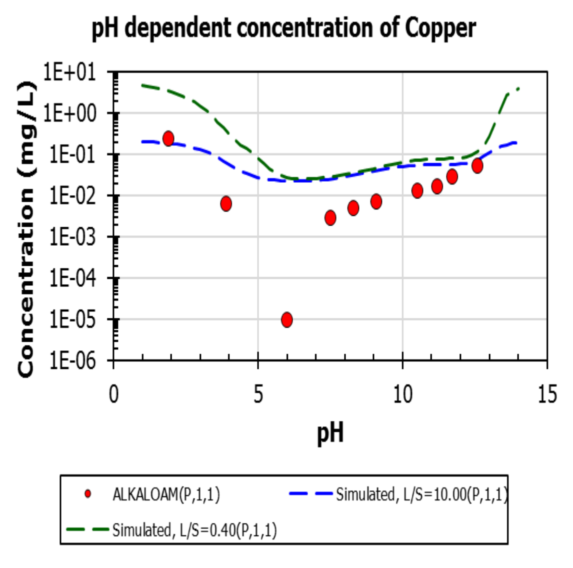

Cd Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

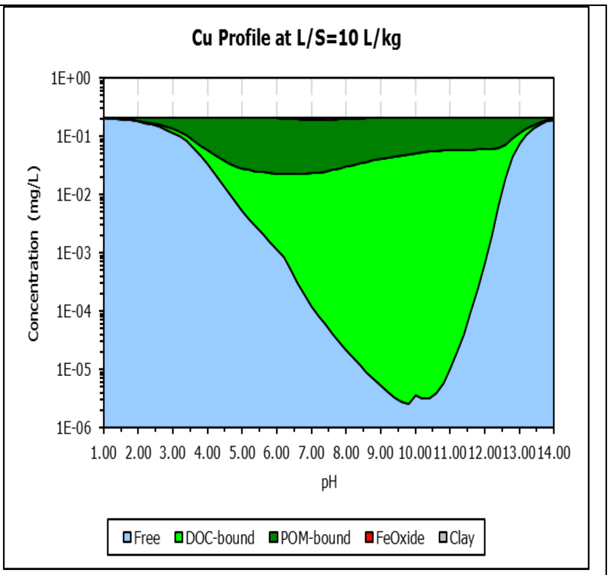

pH dependent concentration of Cobalt
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

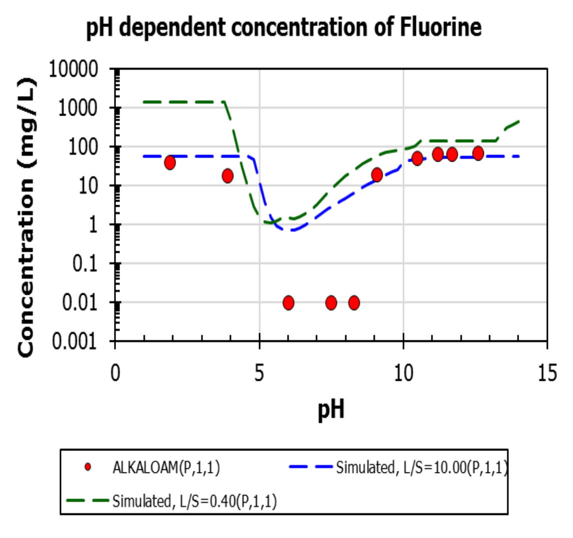

Co Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

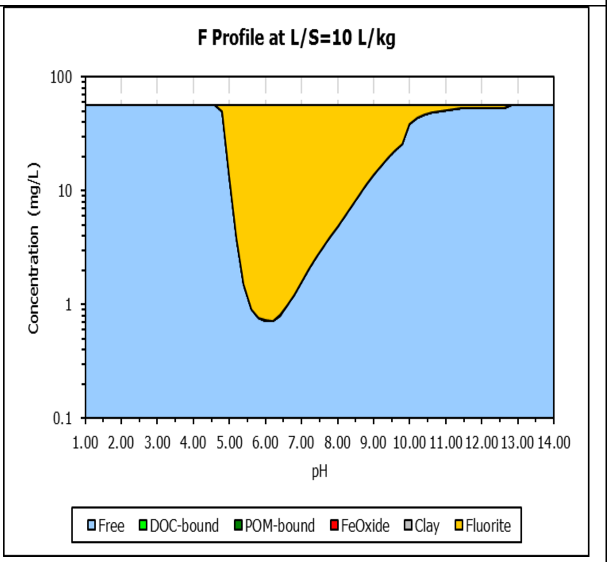

pH dependent concentration of Chromium
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

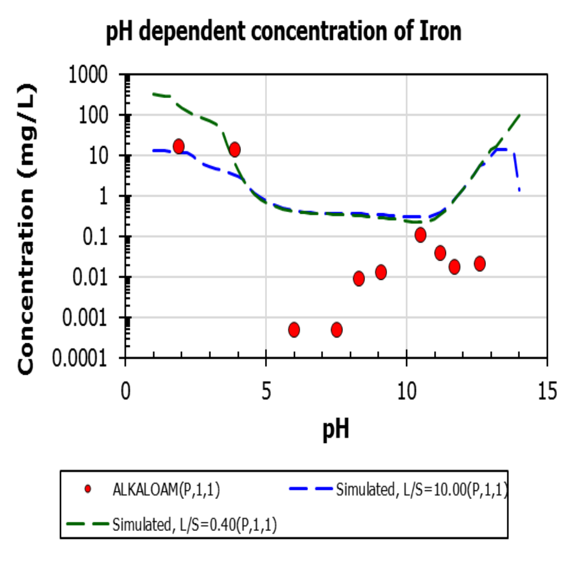

Cr Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

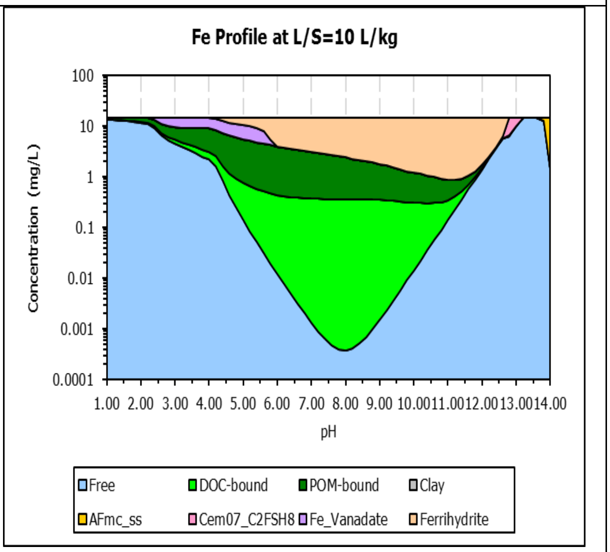

pH dependent concentration of Copper
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

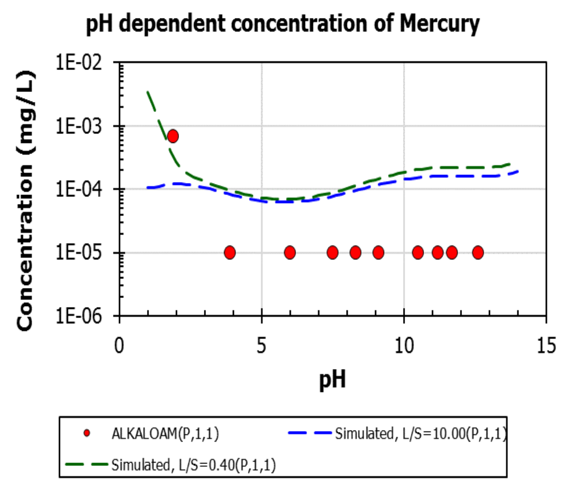

Cu Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

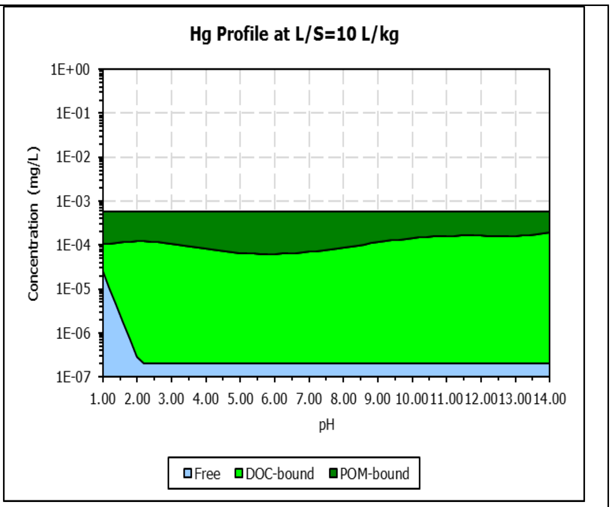

pH dependent concentration of Fluorine
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

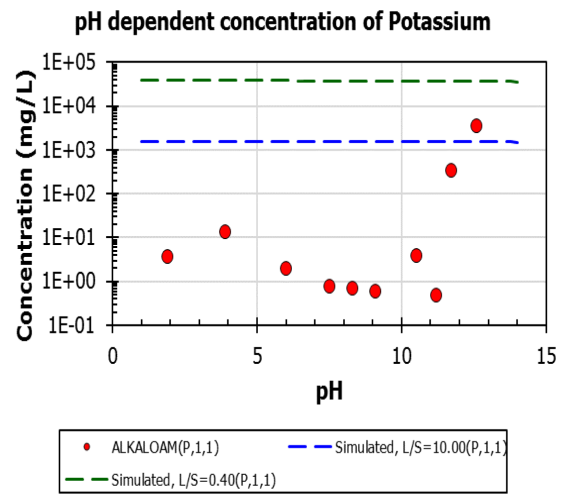

F Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Fluorite

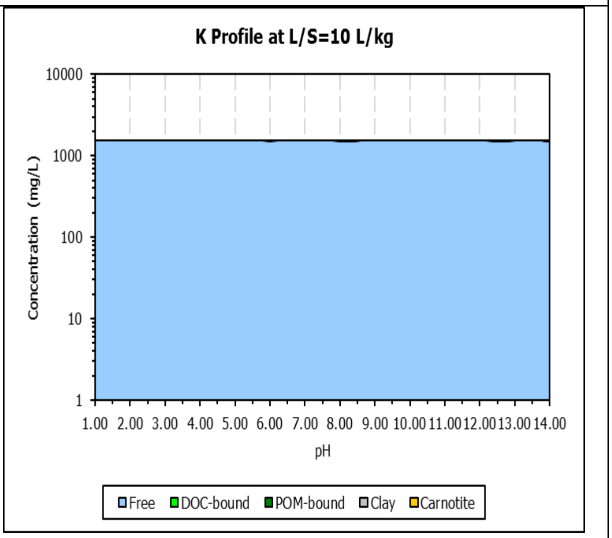

pH dependent concentration of Iron
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

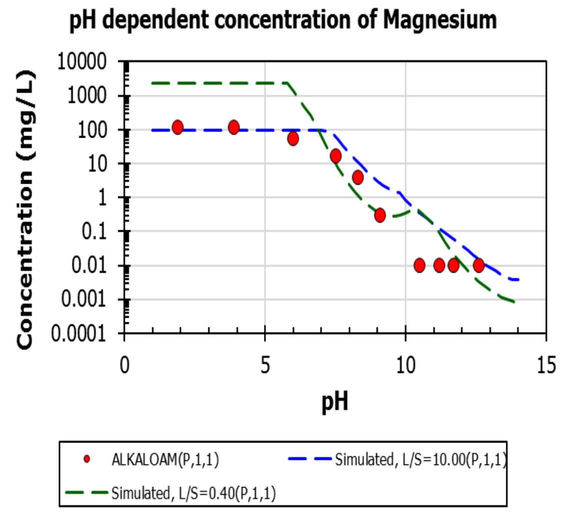

Fe Profile at L/S=10 L/kg
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
AFmc_ss
Cem07_C2FSH8
Fe_Vanadate
Ferrihydrite

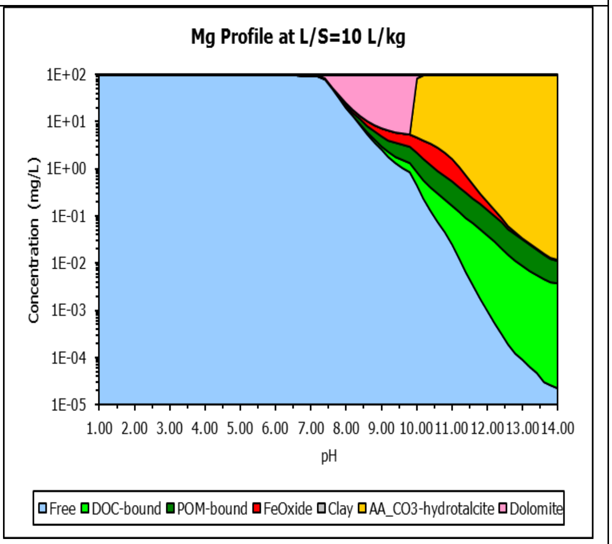

pH dependent concentration of Mercury
Concentration (mg/L)
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

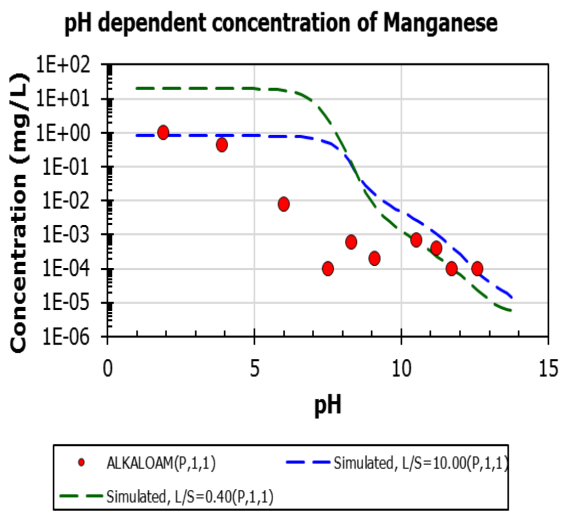

Hg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound

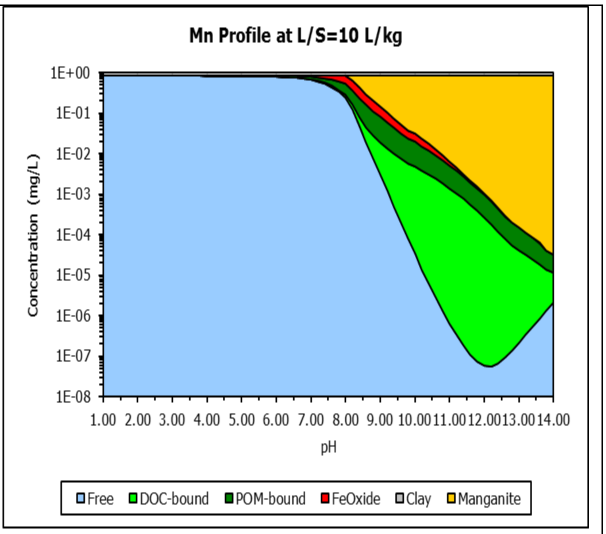

pH dependent concentration of Potassium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

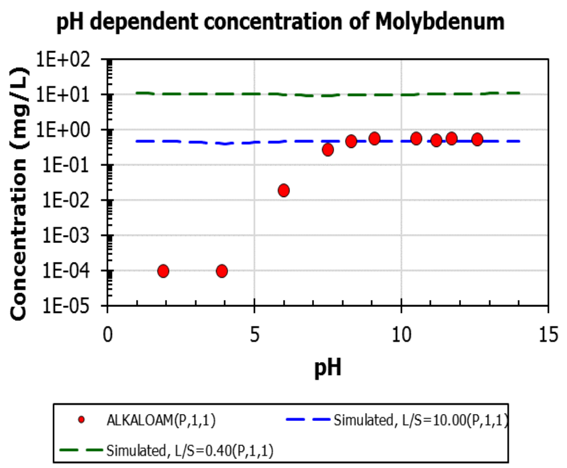

K Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Carnotite

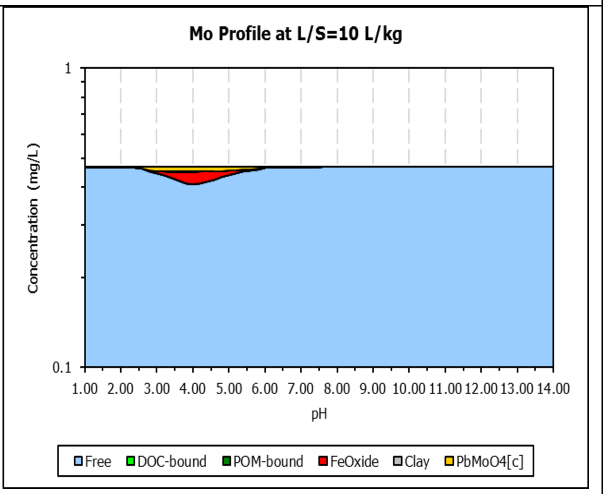

pH dependent concentration of Magnesium
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

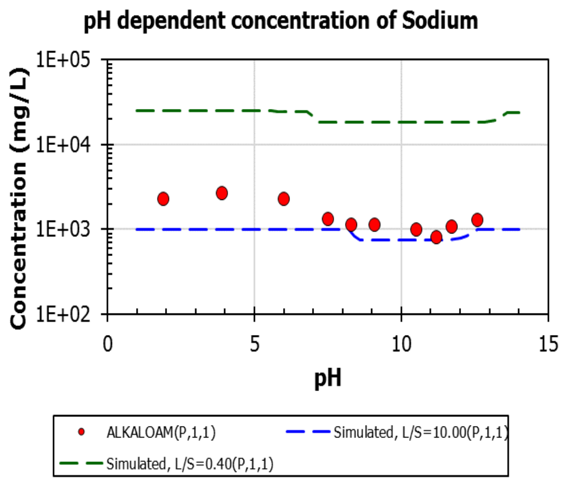

Mg Profile at L/S=10 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AA_CO3-hydrotalcite
Dolomite

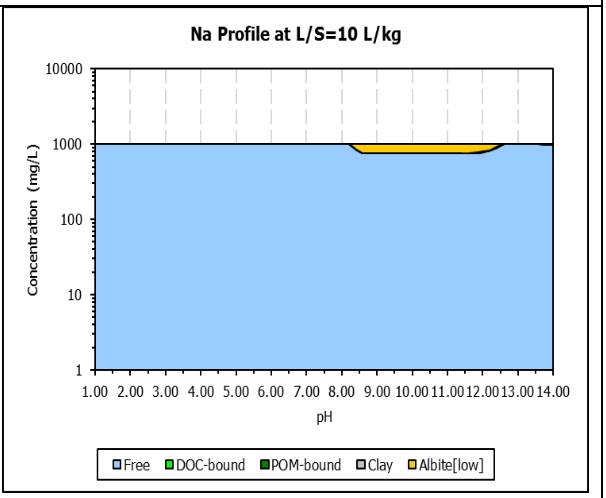

pH dependent concentration of Manganese
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

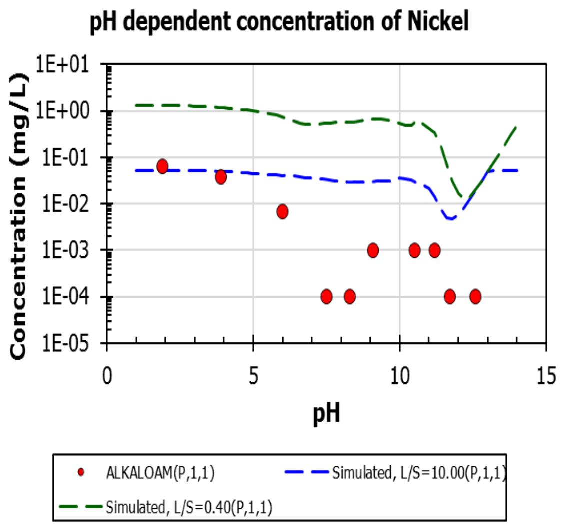

Mn Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Manganite

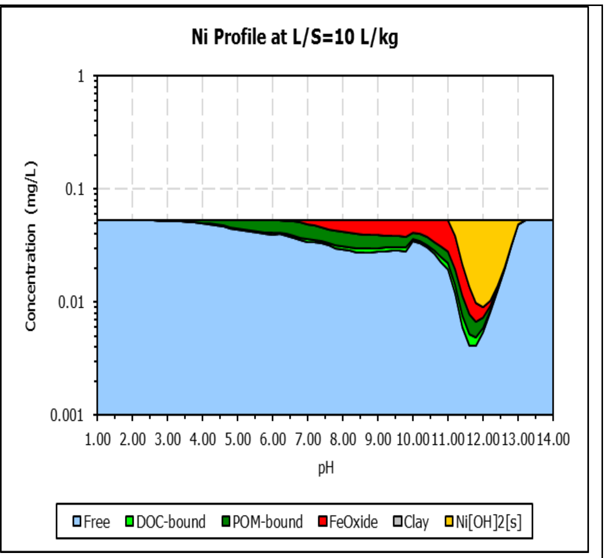

pH dependent concentration of Molybdenum
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

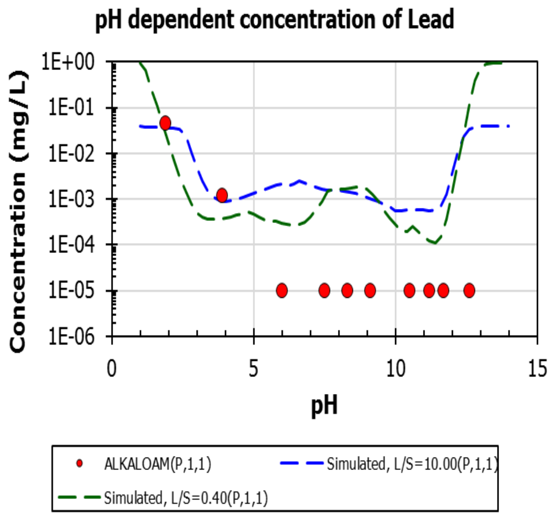

Mo Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
PbMoO4[c]

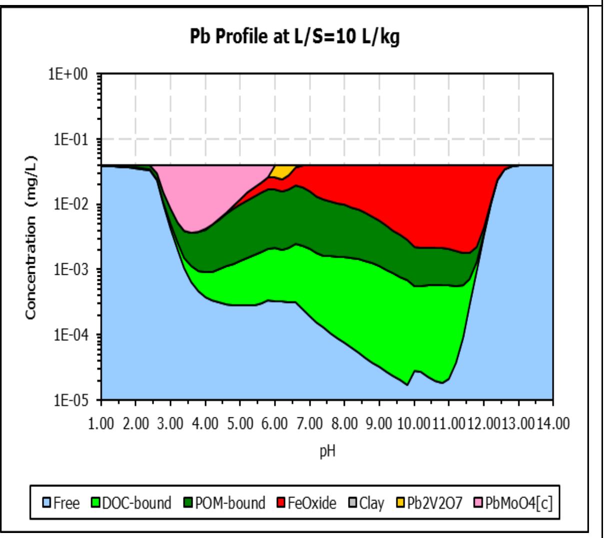

pH dependent concentration of Sodium
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

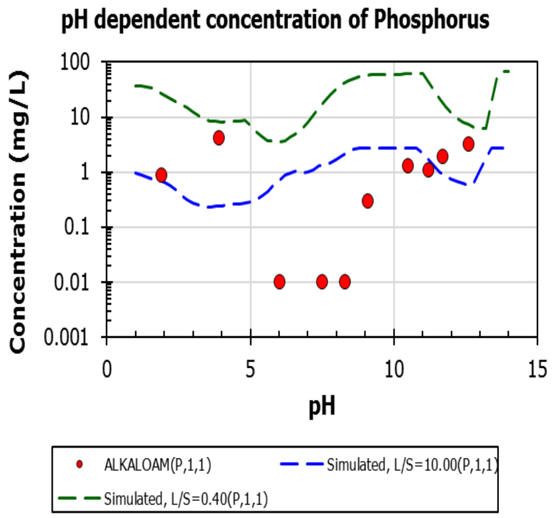

Na Profile at L/S=10 L/kg
Concentration (mg/L)
10000
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
Albite[low]

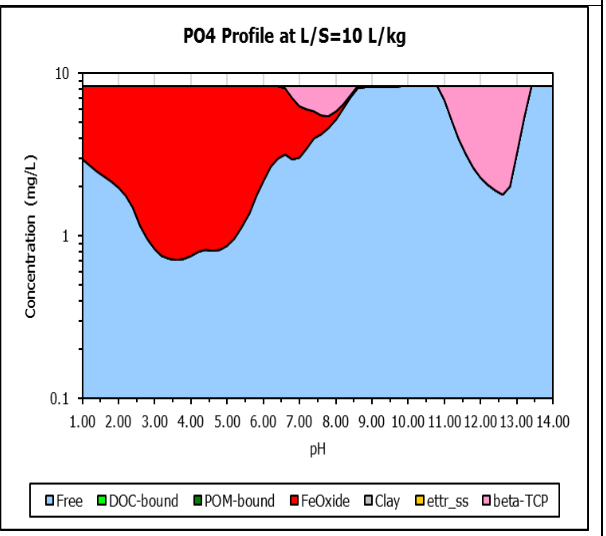

pH dependent concentration of Nickel
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

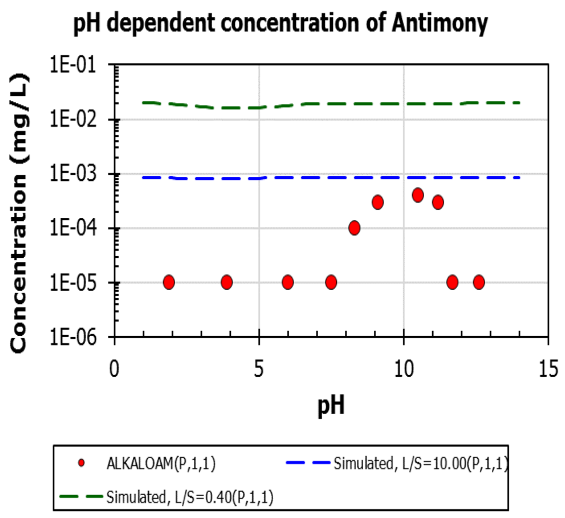

Ni Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Ni[OH]2[s]

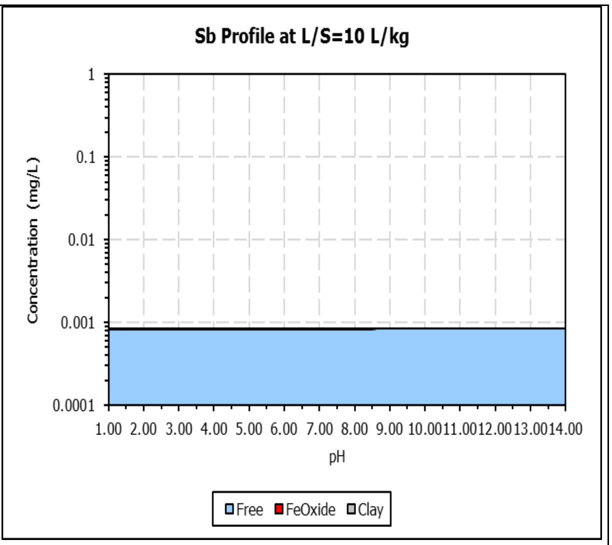

pH dependent concentration of Lead
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

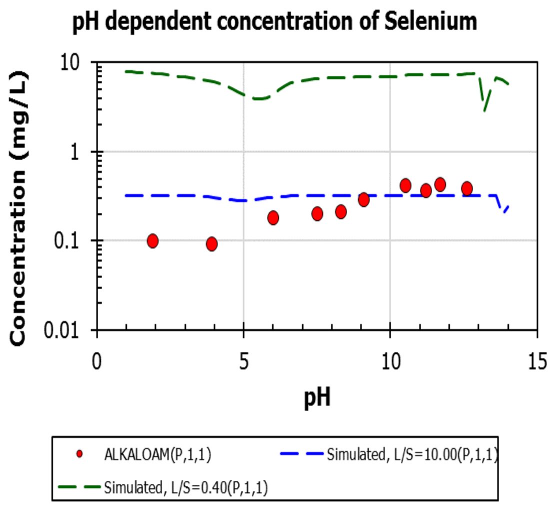

Pb Profile at L/S=10 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Pb2V2O7
PbMoO4[c]

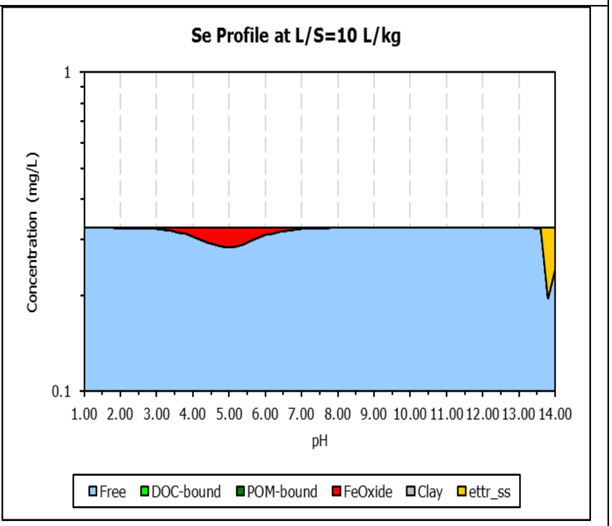

pH dependent concentration of Phosphorus
Concentration (mg/L)
100
10
1
0.1
0.01
0.001
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

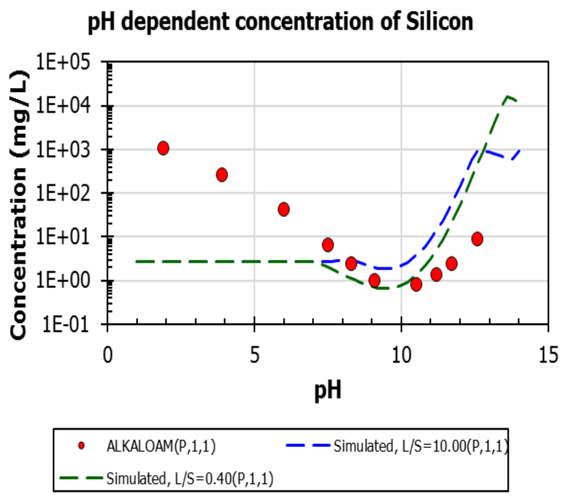

PO4 Profile at L/S=10 L/kg
Concentration (mg/L)
10
1
0.1
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss
beta-TCP

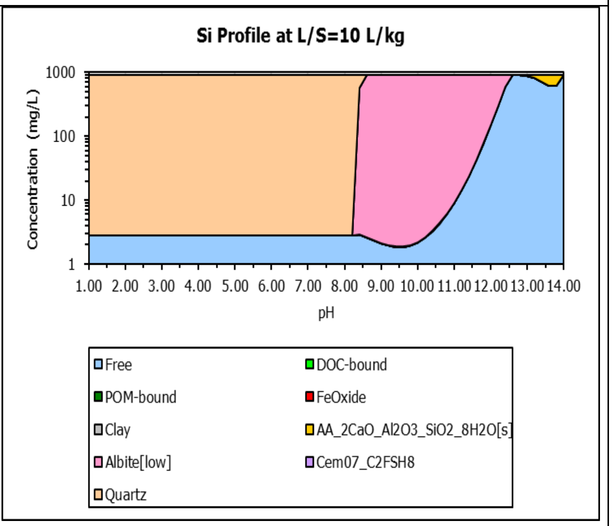

pH dependent concentration of Antimony
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

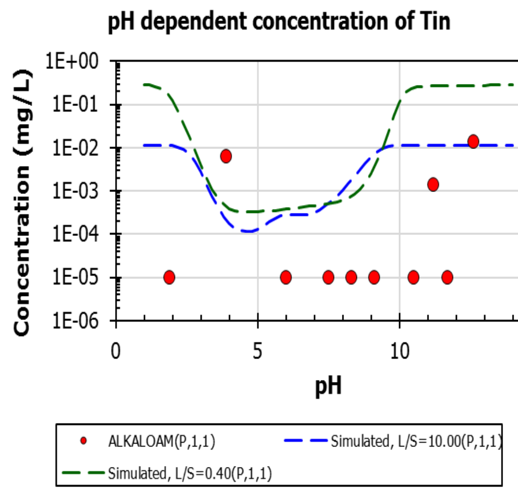

Sb Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
FeOxide
Clay

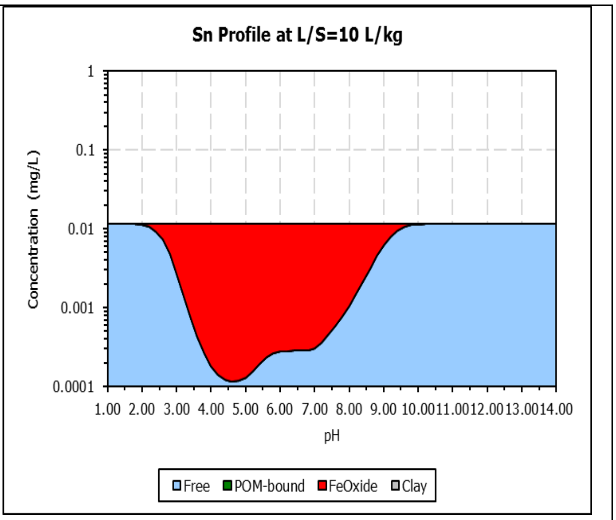

pH dependent concentration of Selenium
Concentration (mg/L)
10
1
0.1
0.01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

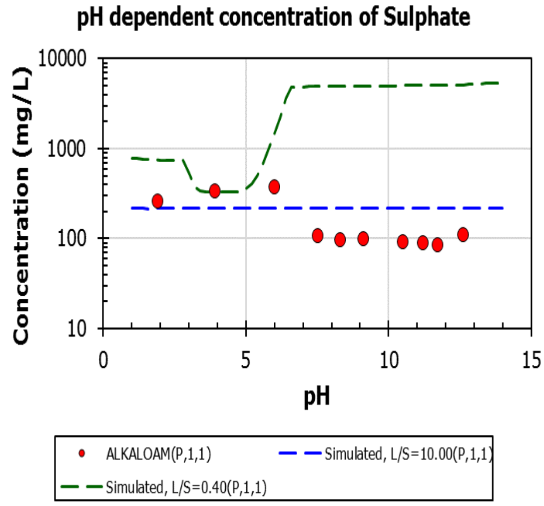

Se Profile at L/S=10 L/kg
Concentration (mg/L)
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
ettr_ss

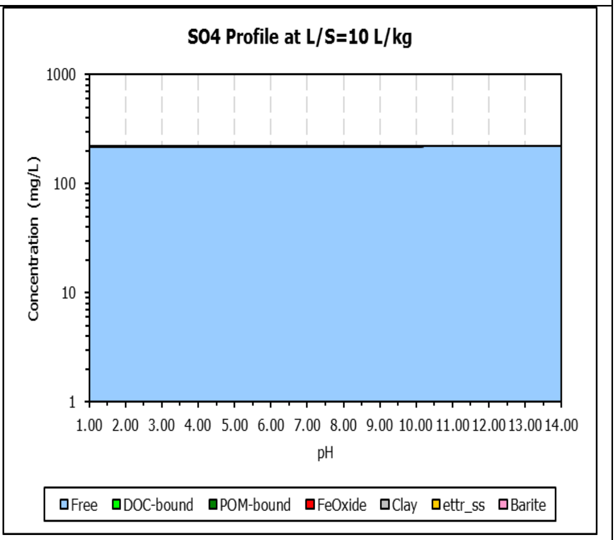

pH dependent concentration of Silicon
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
0
5
10
15
pH
ALKALOAM(P,1,1)
Simulated, L/S=10.00(P,1,1)
Simulated, L/S=0.40(P,1,1)

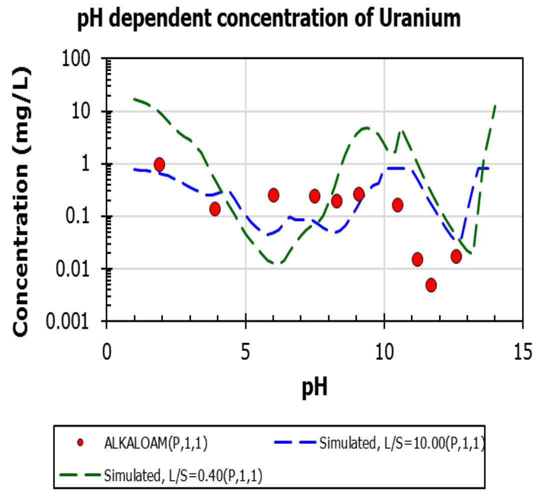

Si Profile at L/S=10 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AA_2CaO_Al2O3_SiO2_8H2O[s]
Albite[low]
Cem07_C2FSH8
Quartz

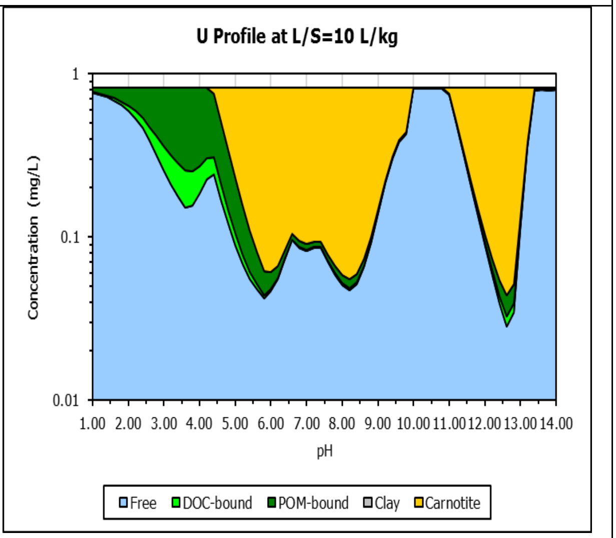

pH dependent concentration of Tin

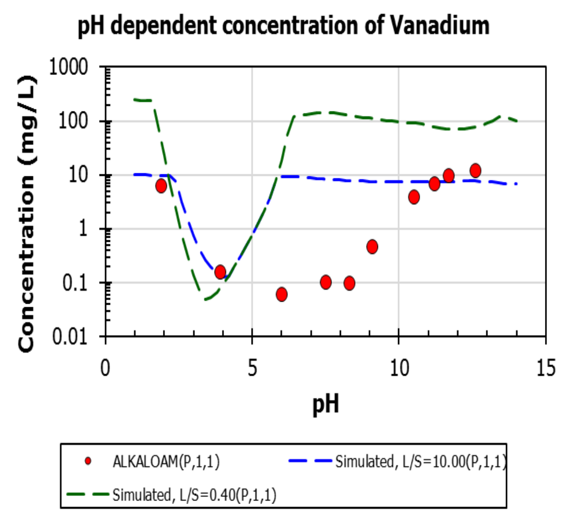

Sn Profile at L/S=10 L/kg

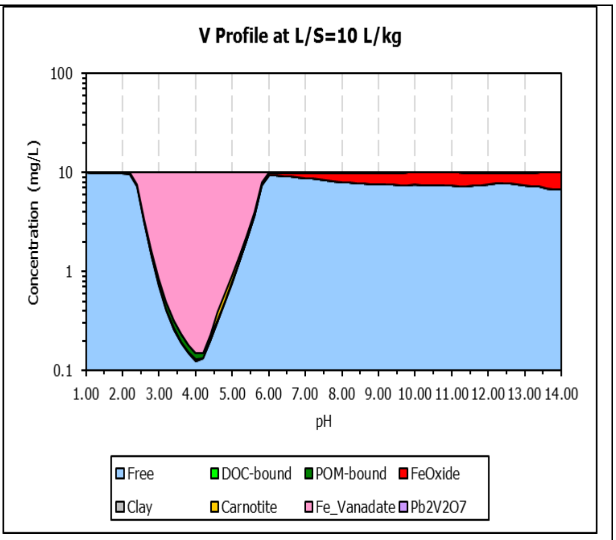

pH dependent concentration of Sulphate

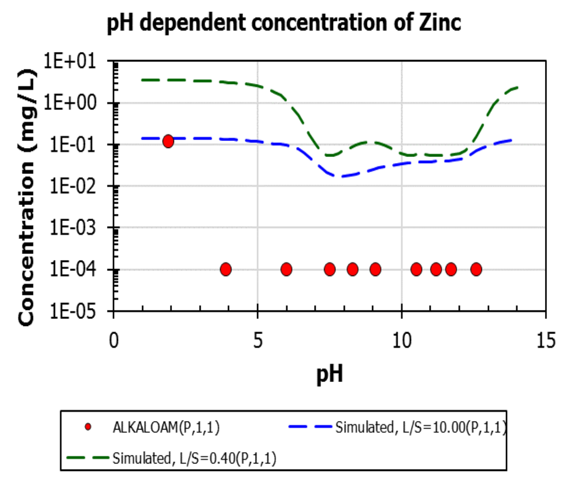

SO4 Profile at L/S=10 L/kg

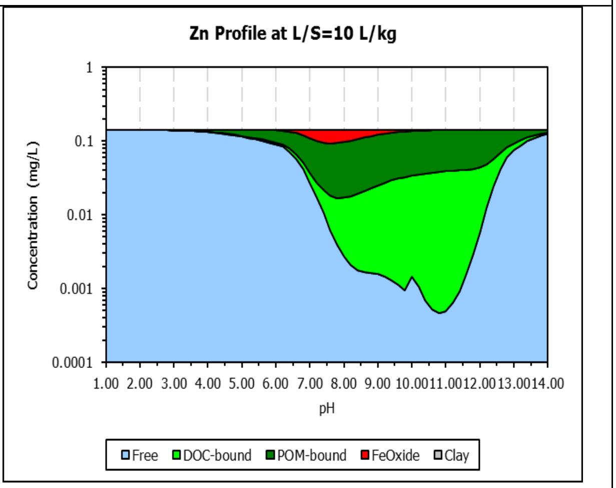

pH dependent concentration of Uranium


U Profile at L/S=10 L/kg

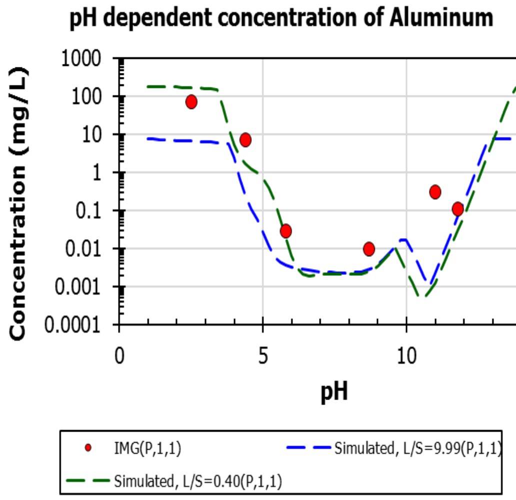

pH dependent concentration of Vanadium

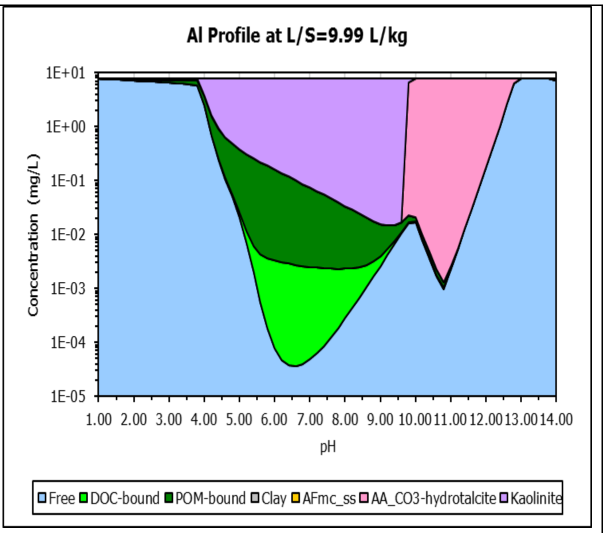

V Profile at L/S=10 L/kg

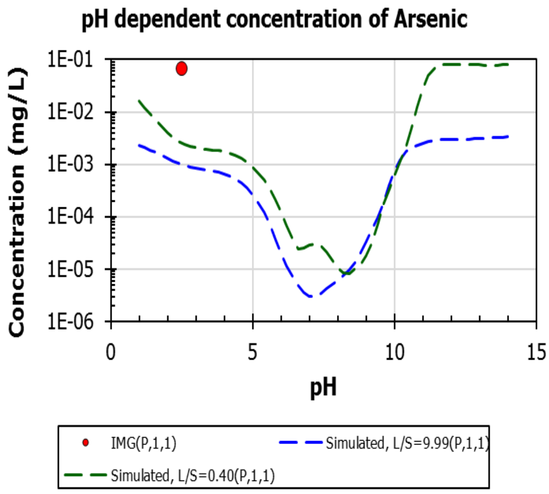

pH dependent concentration of Zinc

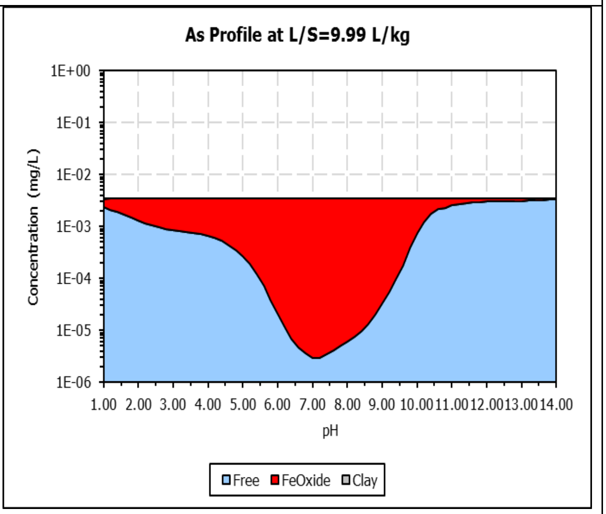

Zn Profile at L/S=10 L/kg

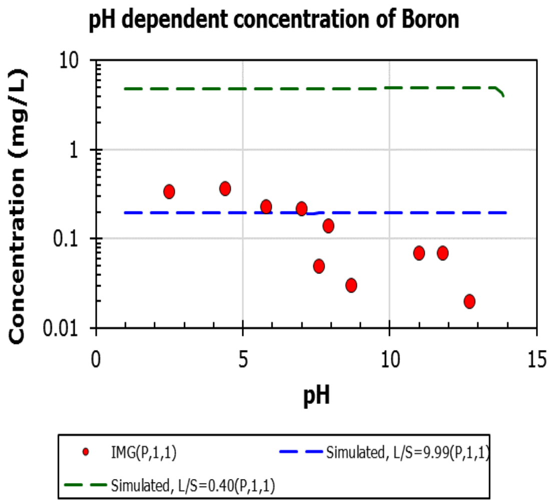
A10-2: Ironman Gypsum (IMG) 5% and Bassendean Sand 95%

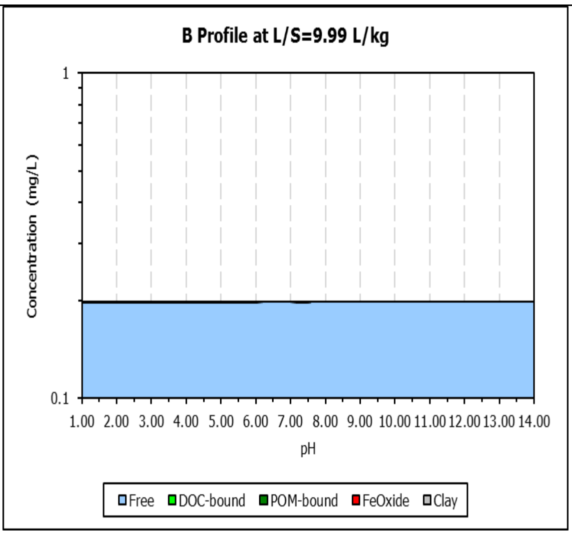


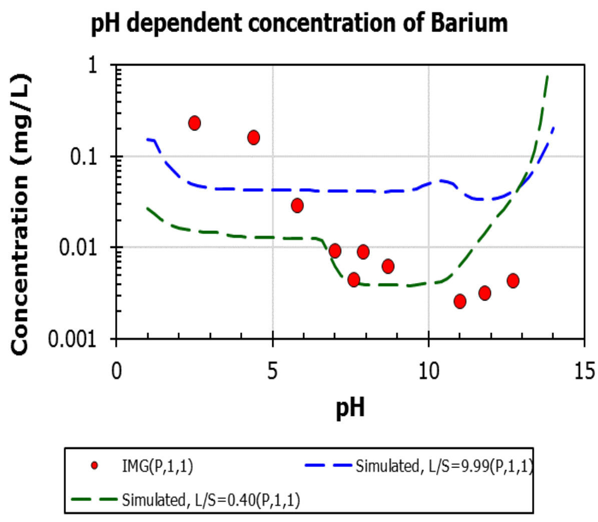


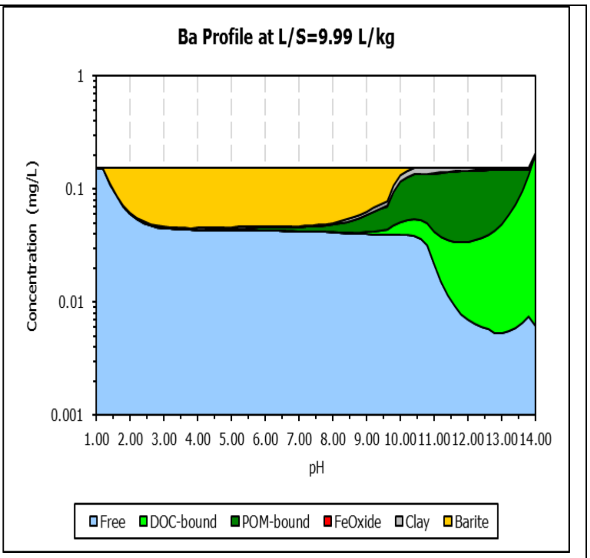


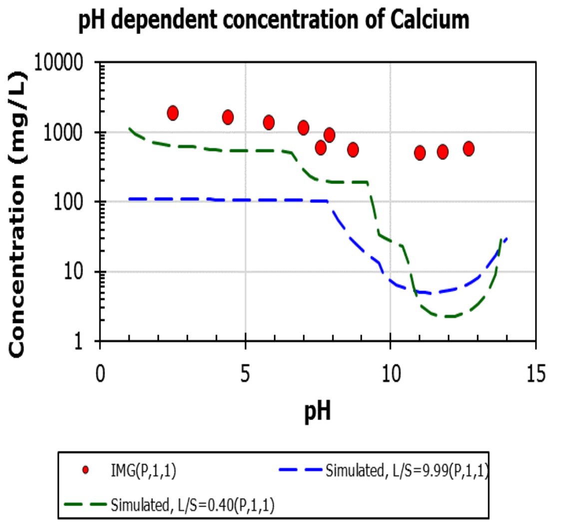


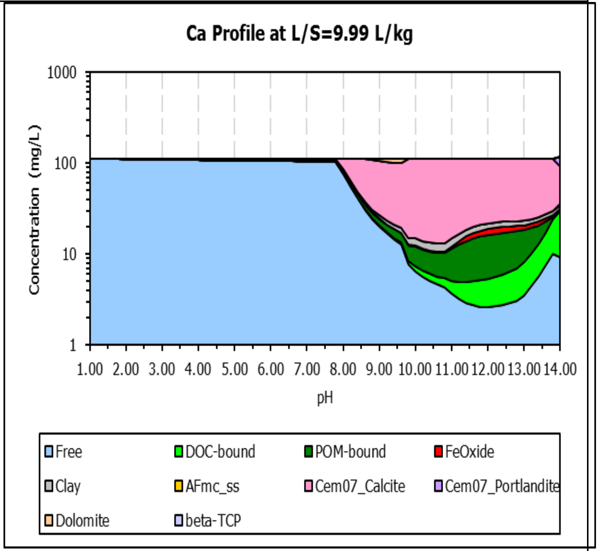


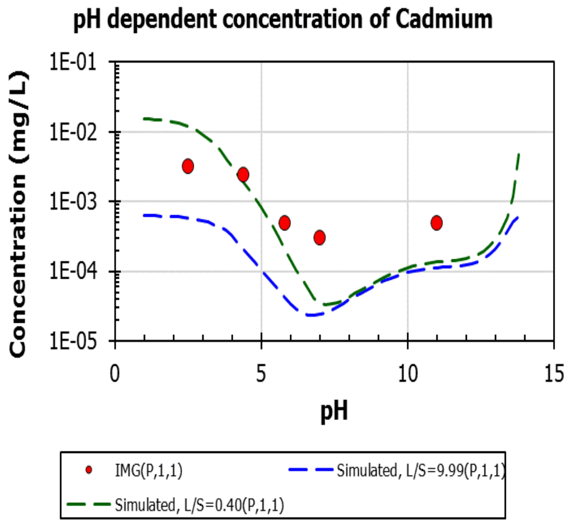


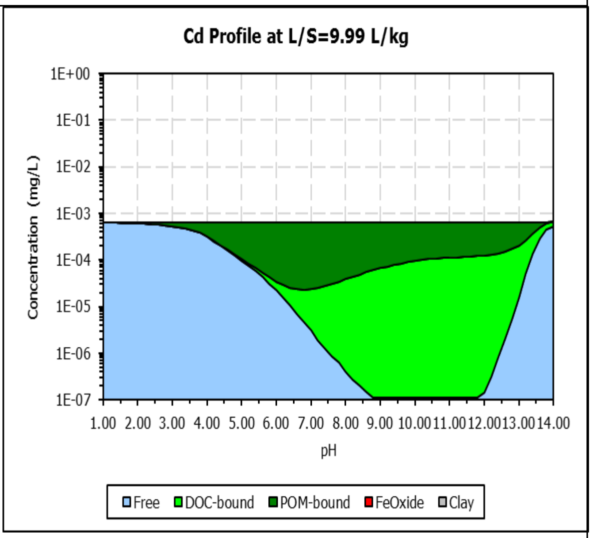

pH dependent concentration of Barium
Concentration (mg/L)
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

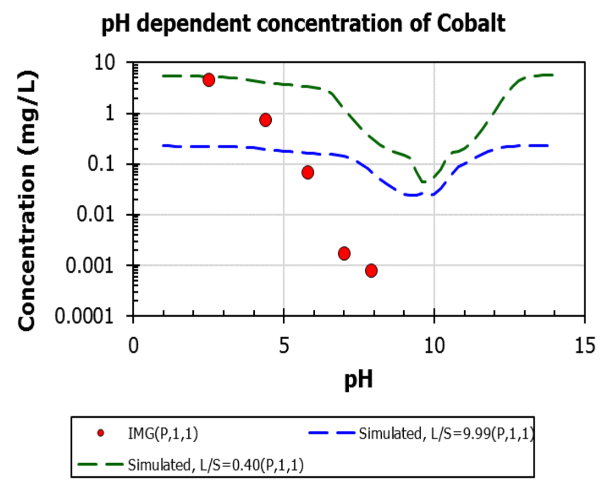

Ba Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite

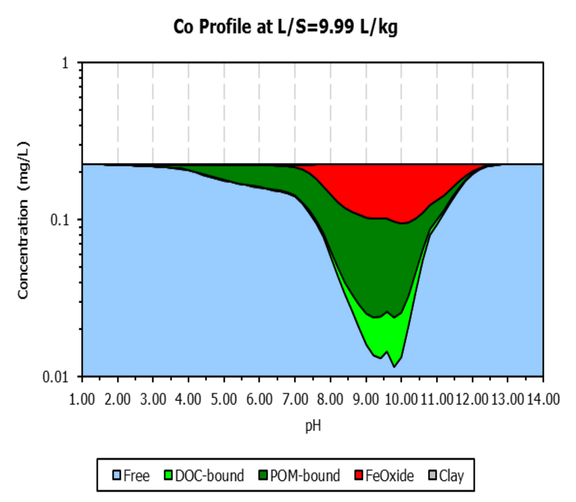

pH dependent concentration of Calcium
Concentration (mg/L)
10000
1000
100
10
1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

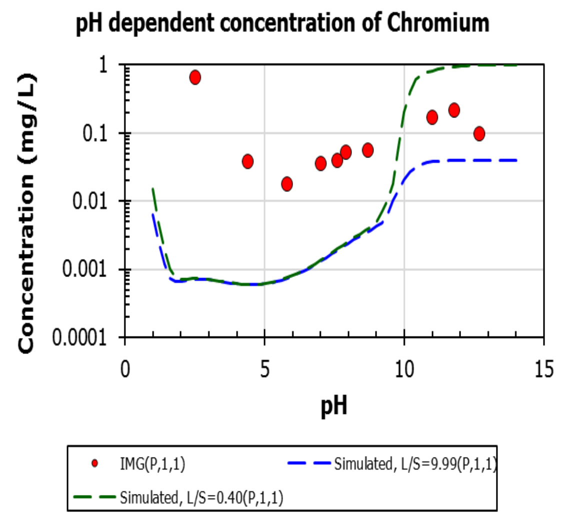

Ca Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
AFmc_ss
Cem07_Calcite
Cem07_Portlandite
Dolomite
beta-TCP

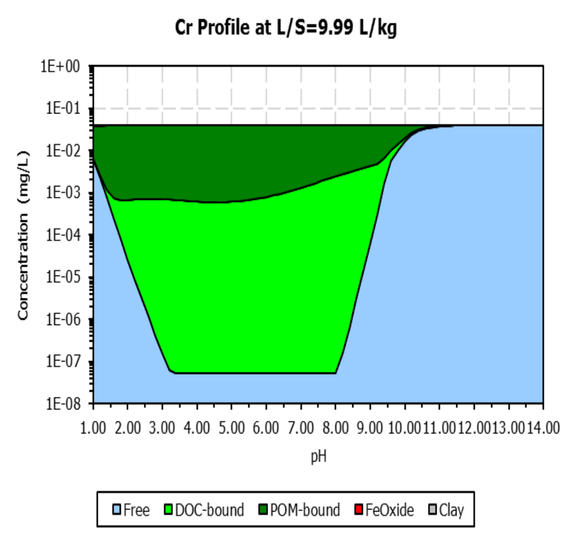

pH dependent concentration of Cadmium
Concentration (mg/L)
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

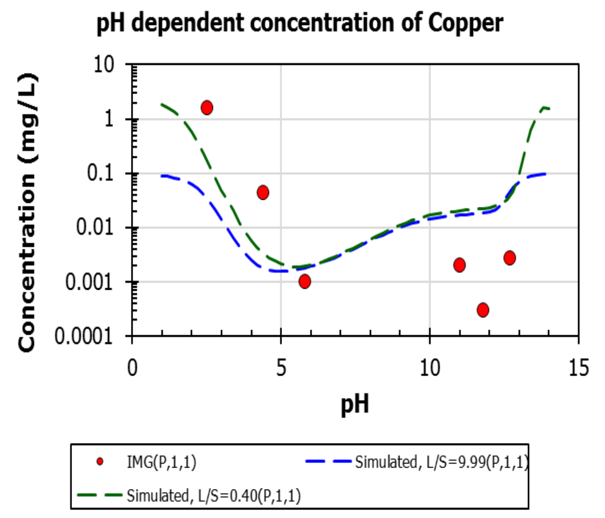

Cd Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

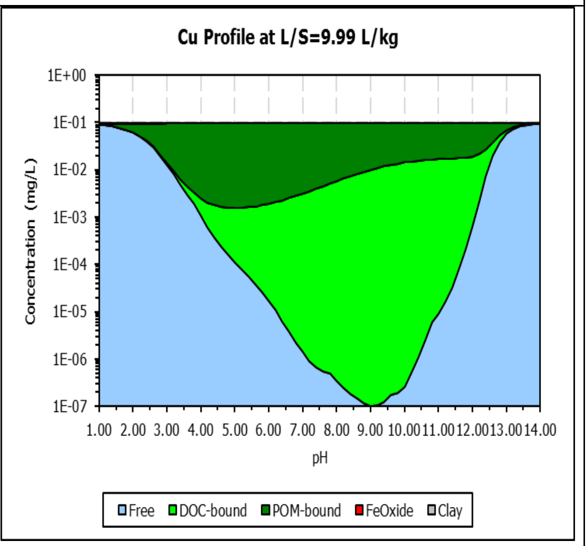

pH dependent concentration of Cobalt

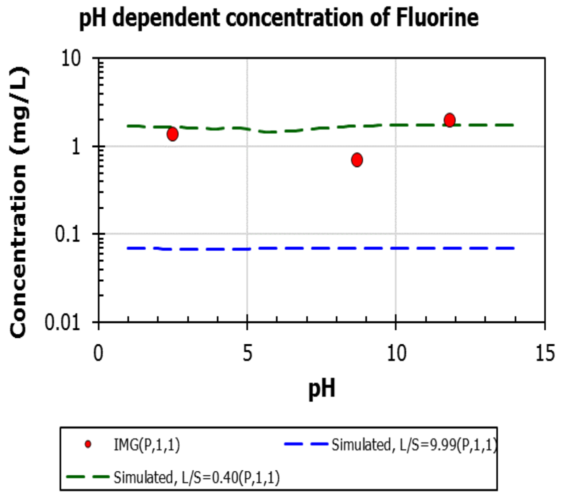

Co Profile at L/S=9.99 L/kg

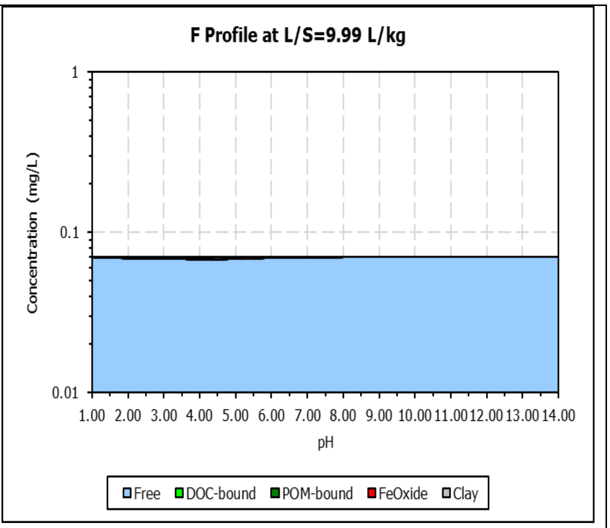

pH dependent concentration of Chromium

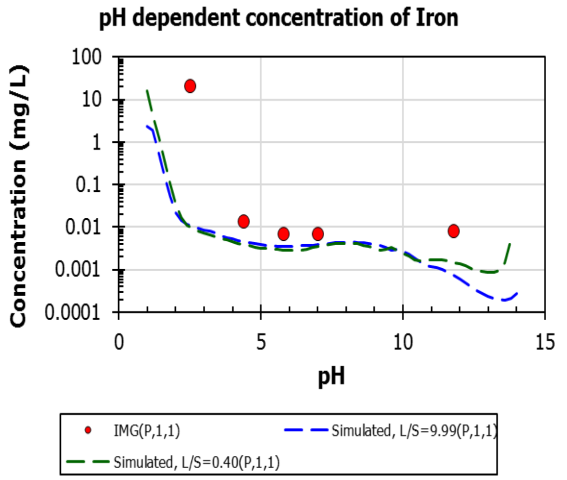

Cr Profile at L/S=9.99 L/kg

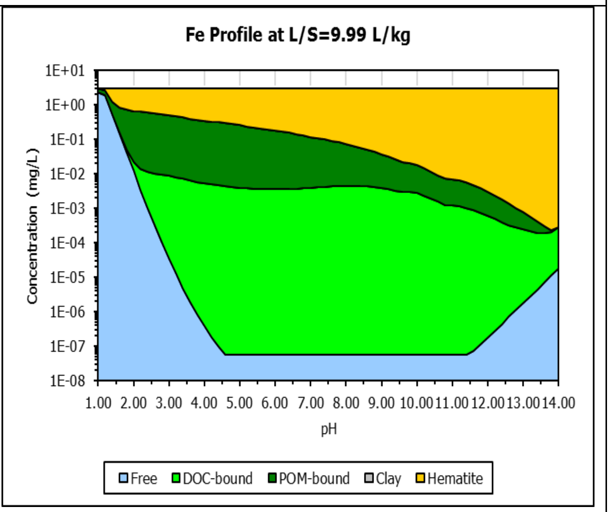

pH dependent concentration of Copper

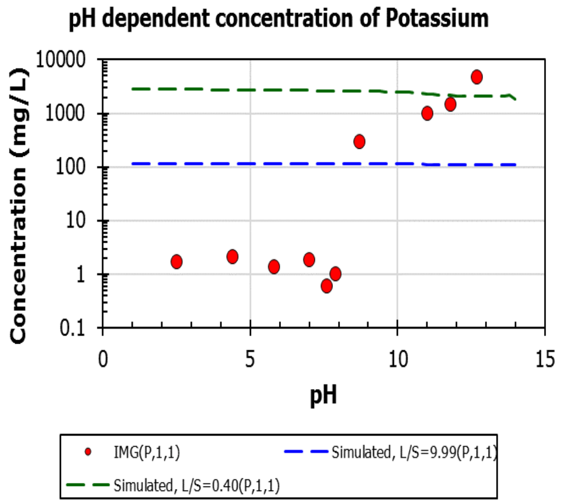

Cu Profile at L/S=9.99 L/kg

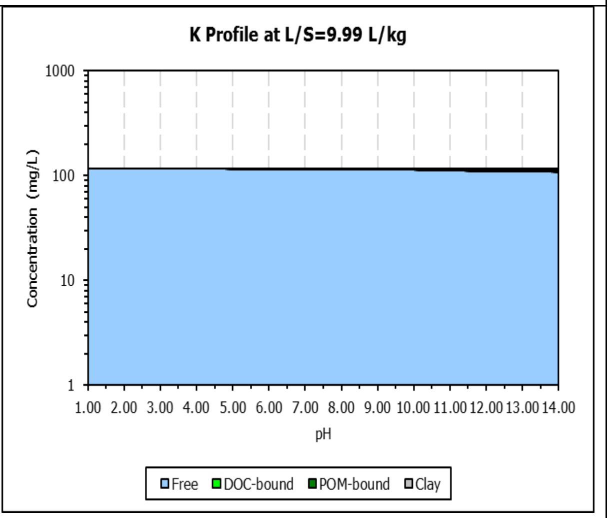

pH dependent concentration of Fluorine

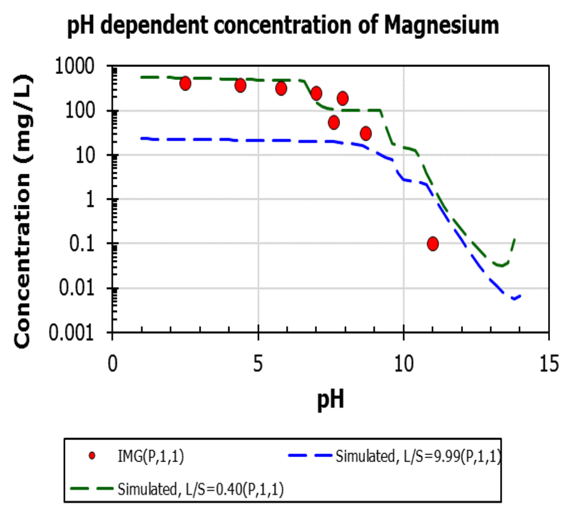

F Profile at L/S=9.99 L/kg

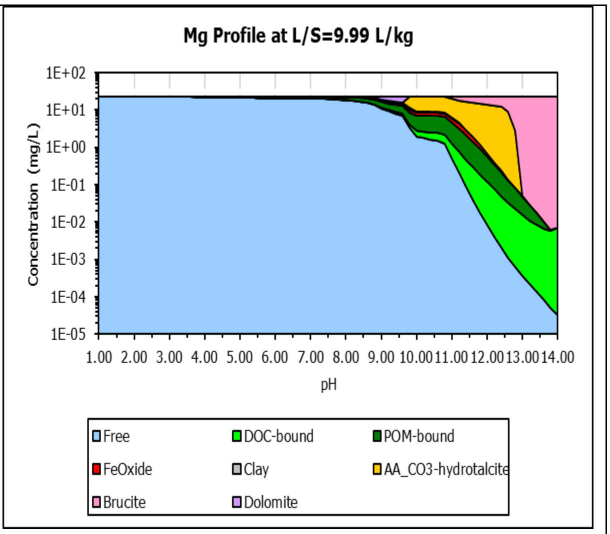

pH dependent concentration of Iron

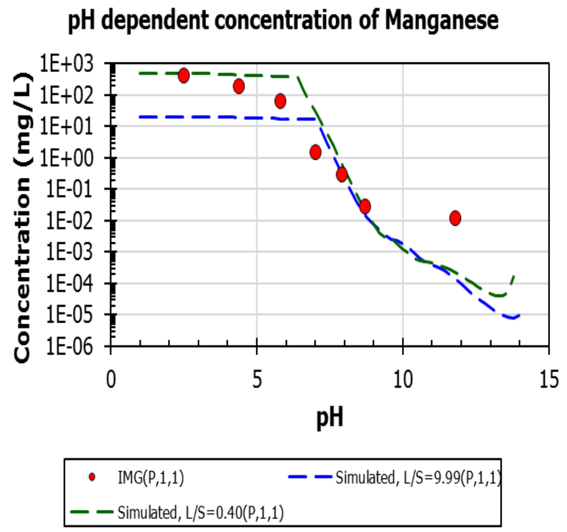

Fe Profile at L/S=9.99 L/kg

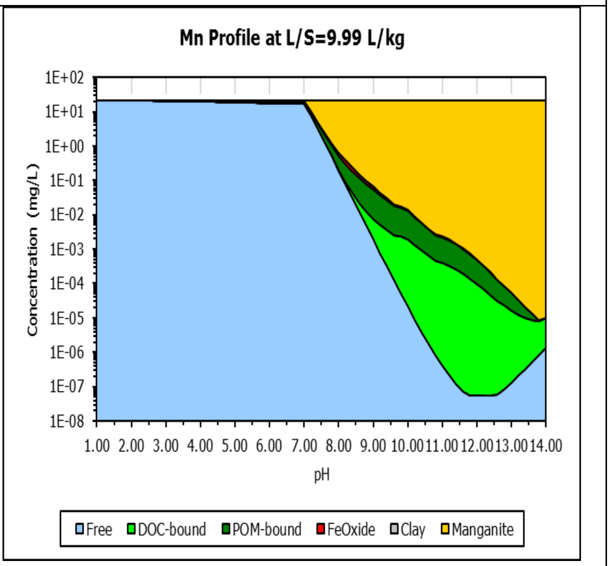

pH dependent concentration of Potassium

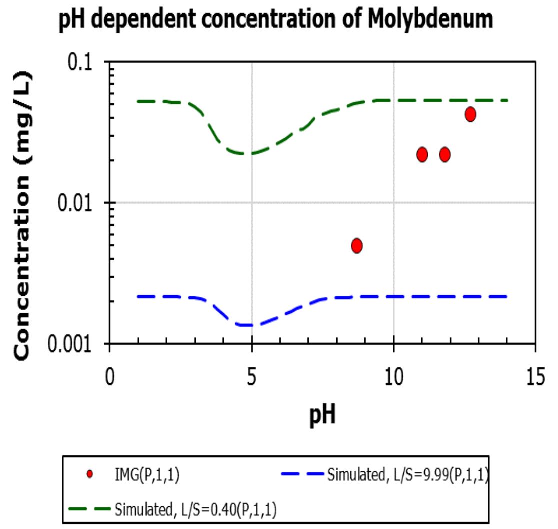

K Profile at L/S=9.99 L/kg

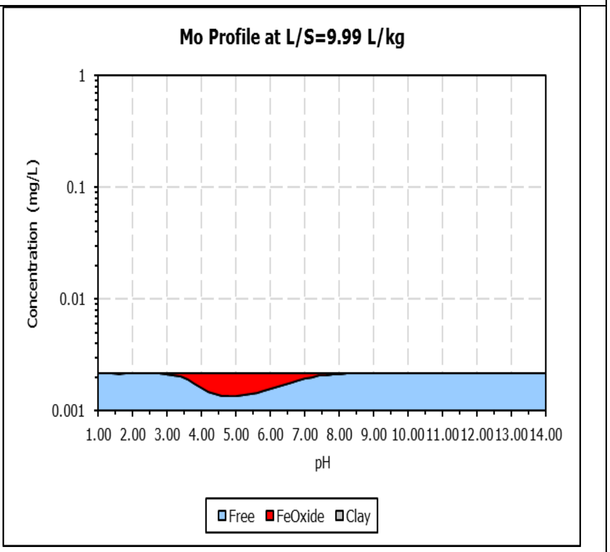

pH dependent concentration of Magnesium

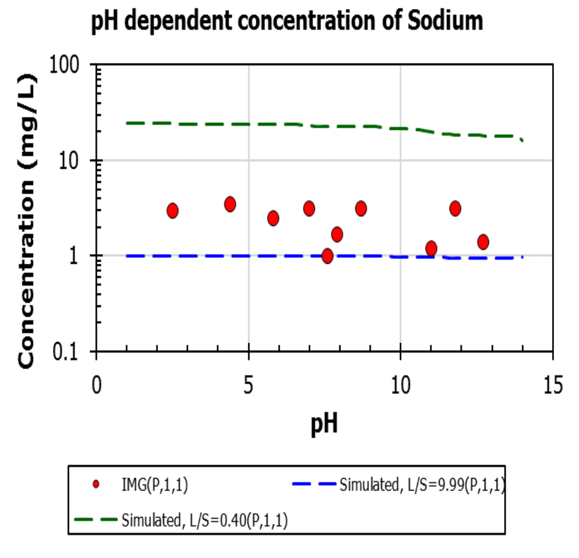

Mg Profile at L/S=9.99 L/kg

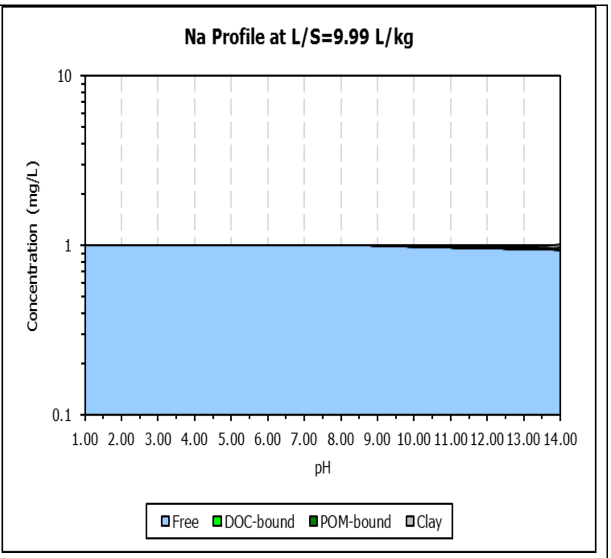

pH dependent concentration of Manganese

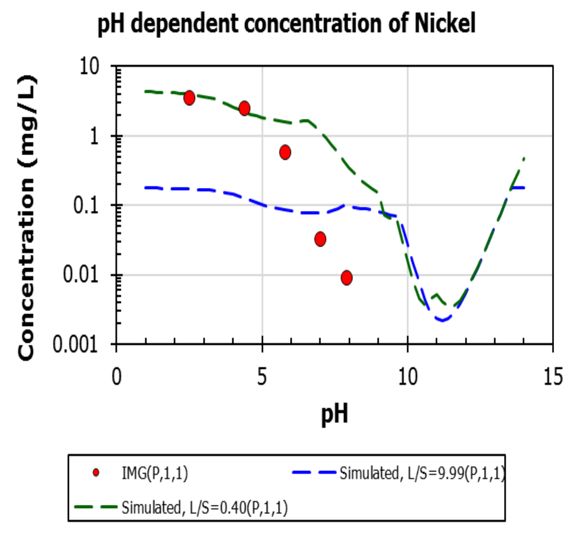

Mn Profile at L/S=9.99 L/kg

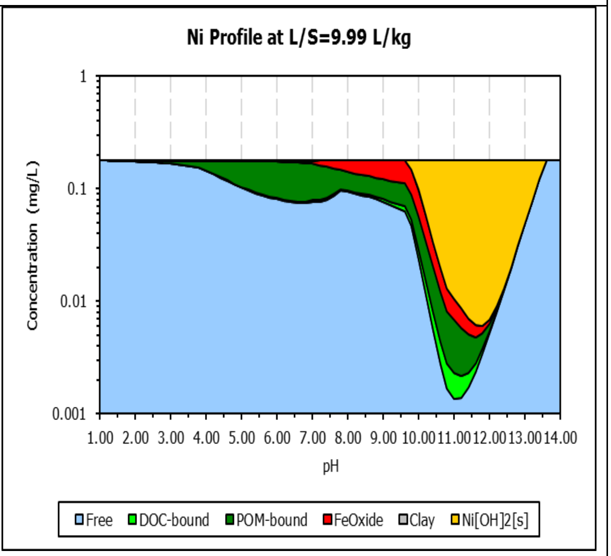

pH dependent concentration of Molybdenum

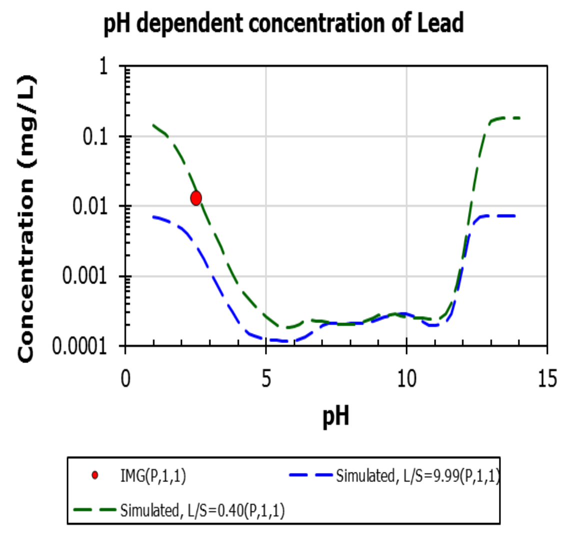

Mo Profile at L/S=9.99 L/kg

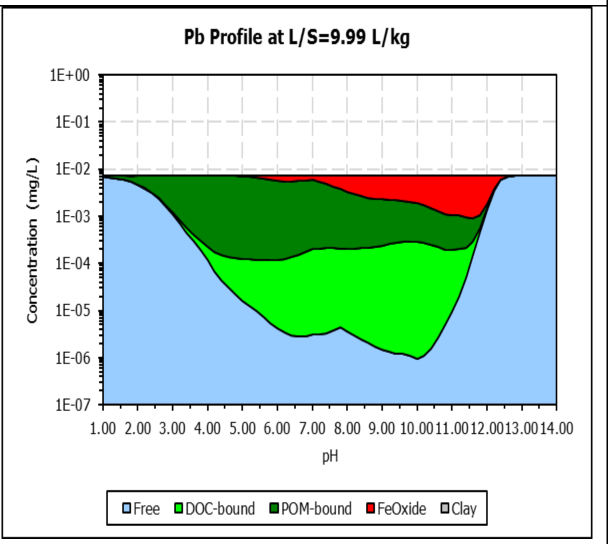

pH dependent concentration of Sodium
Concentration (mg/L)
100
10
1
0.1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

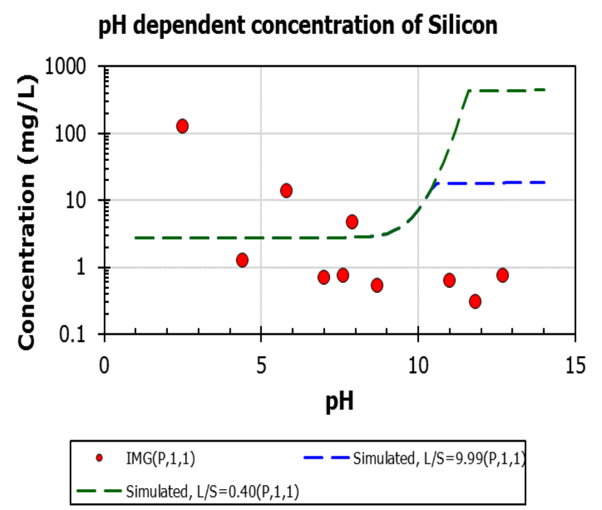

Na Profile at L/S=9.99 L/kg
Concentration (mg/L)
10
1
0.1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay

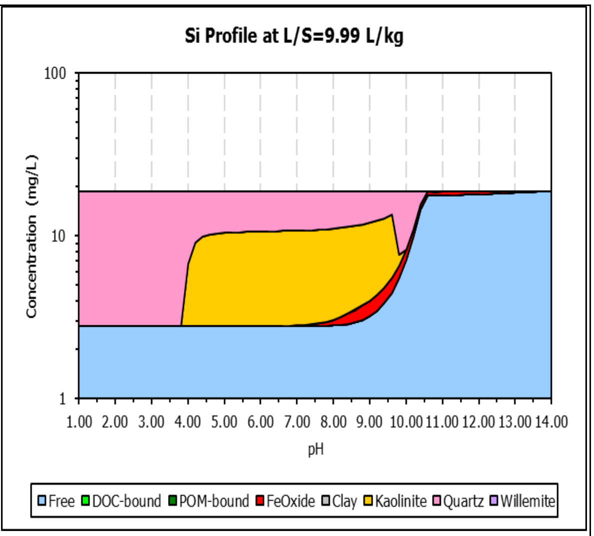

pH dependent concentration of Nickel
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

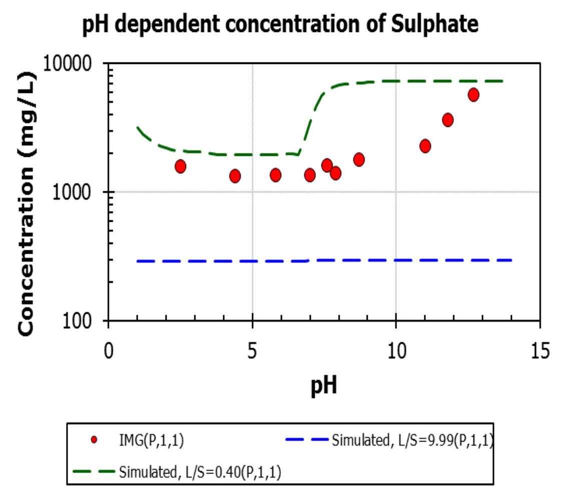

Ni Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Ni[OH]2[s]

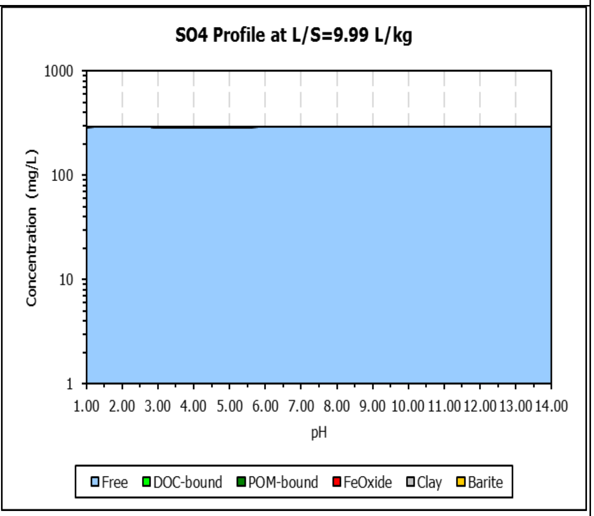

pH dependent concentration of Lead
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

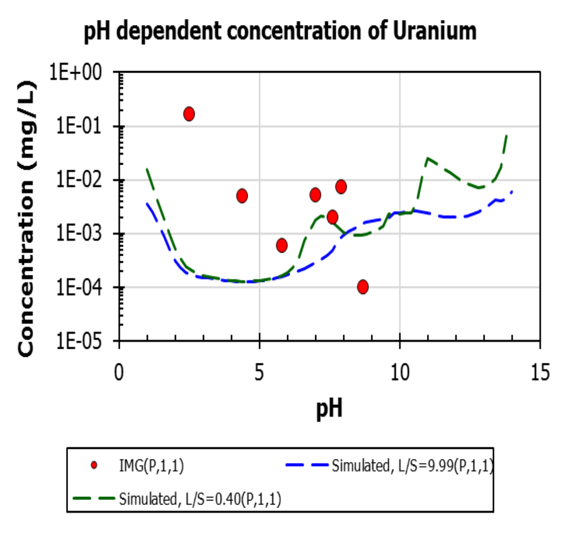

Pb Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay

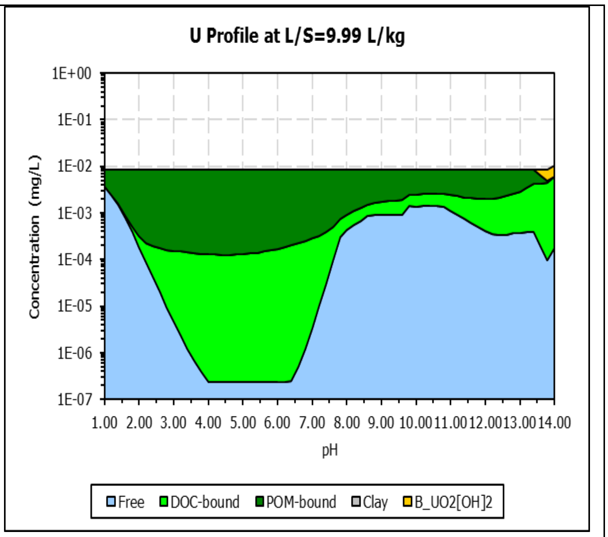

pH dependent concentration of Silicon
Concentration (mg/L)
1000
100
10
1
0.1
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)

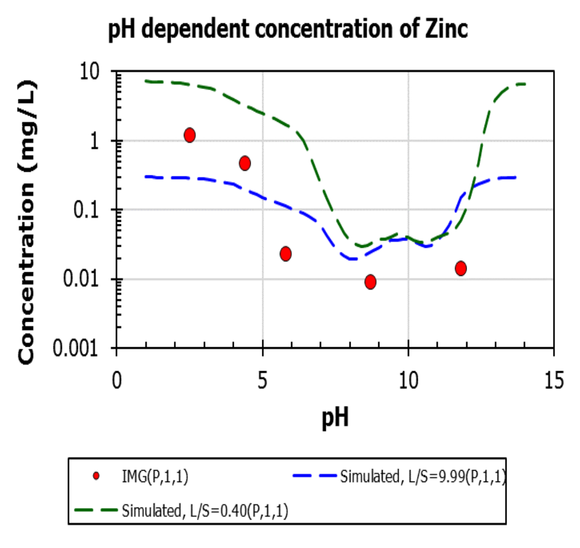

Si Profile at L/S=9.99 L/kg
Concentration (mg/L)
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Kaolinite
Quartz
Willemite

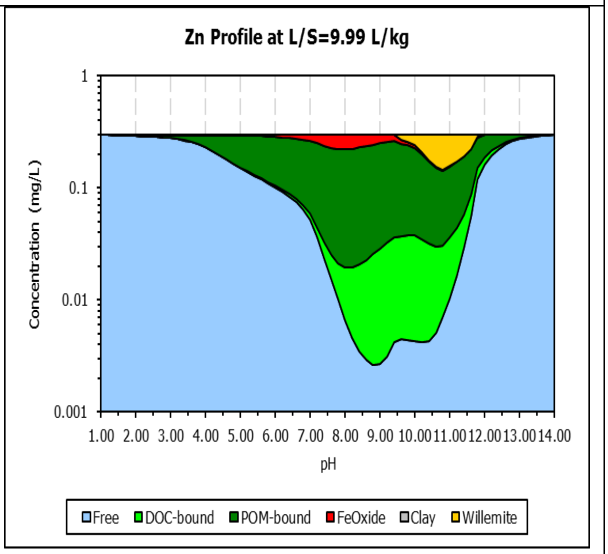

pH dependent concentration of Sulphate
Concentration (mg/L)
10000
1000
100
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)


SO4 Profile at L/S=9.99 L/kg
Concentration (mg/L)
1000
100
10
1
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Barite


pH dependent concentration of Uranium
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)


U Profile at L/S=9.99 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
Clay
B_UO2[OH]2


pH dependent concentration of Zinc
Concentration (mg/L)
10
1
0.1
0.01
0.001
0
5
10
15
pH
IMG(P,1,1)
Simulated, L/S=9.99(P,1,1)
Simulated, L/S=0.40(P,1,1)


Zn Profile at L/S=9.99 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
pH
Free
DOC-bound
POM-bound
FeOxide
Clay
Willemite

Appendix A11: Laboratory Tall Column Leaching Data – By-product Materials

Table A1-1 Tall Column Leachate Data. Note: Amended = 1st leach (Figure 8), soil = 2nd leach, bottom = 3rd leach.

Soil Type	**Amendment**	**Leachate**	**Time**	**pH**	**EC**	**Eh**	**DOC**	**Ag**	**Al**	**As**	**B**	**Ba**	**Be**
					mS/m	**mV**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Bassendean Ellenbrook	Control	Amended	1	6.2	4.4	523	14	<0.0001	0.072	<0.001	0.15	0.0011	<0.0001
Bassendean Ellenbrook	Control	Amended	2	6.3	2.6	565	13	<0.0001	0.069	<0.001	0.33	0.11	<0.0001
Bassendean Ellenbrook	Control	Amended	3	6.3	9.8	408	11	<0.0001	0.013	<0.001		0.13	<0.0001
Bassendean Ellenbrook	Control	Soil	1	6.1	25	363	110	0.0001	0.56	<0.001	0.7	0.021	<0.0001
Bassendean Ellenbrook	Control	Soil	2	6.0	43.7	406	150	0.0001	0.82	0.001	1.5	0.20	<0.0001
Bassendean Ellenbrook	Control	Soil	3	6.3	27.6	389	65	<0.0001	0.33	<0.001		0.19	<0.0001
Bassendean Ellenbrook	Control	Bottom	1	6.3	13.4	431	50	<0.0001	0.29	<0.001	0.41	0.18	<0.0001
Bassendean Ellenbrook	Control	Bottom	2	5.6	53.8	437	47	<0.0001	0.22	<0.001	0.62	0.19	<0.0001
Bassendean Ellenbrook	Control	Bottom	3	5.5	37.5	398	31	<0.0001	0.10	<0.001		0.21	<0.0001
Bassendean Ellenbrook	Alkaloam	Amended	1	7.9	156	403	320	<0.0002	3.4	0.025	0.35	0.15	<0.0002
Bassendean Ellenbrook	Alkaloam	Amended	2	8.1	69	517	87	<0.0001	1.7	0.008	0.78	0.27	<0.0001
Bassendean Ellenbrook	Alkaloam	Amended	3	8.1	21.8	390	13	<0.0001	0.36	0.004		0.0093	<0.0001
Bassendean Ellenbrook	Alkaloam	Soil	1	6.0	26.7	340	100	<0.0001	0.52	<0.001	0.45	0.13	<0.0001
Bassendean Ellenbrook	Alkaloam	Soil	2	5.9	60.5	361	270	<0.0001	1.8	0.004	0.92	0.24	0.0001
Bassendean Ellenbrook	Alkaloam	Soil	3	6.2	48.7	392	290	<0.0001	2.3	0.005		0.24	<0.0001
Bassendean Ellenbrook	Alkaloam	Bottom	1	6.1	26.8	440	110	<0.0002	1.5	0.007	0.16	0.16	<0.0002
Bassendean Ellenbrook	Alkaloam	Bottom	2	5.7	70.9	454	220	<0.0001	1.8	0.003	0.58	0.23	<0.0001
Bassendean Ellenbrook	Alkaloam	Bottom	3	6.2	37.3	415	130	<0.0001	1.1	0.003		0.20	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Amended	1	7.3	265	452	5.4	<0.0001	0.029	0.001	0.1	0.057	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Amended	2	7.2	180	509	3.1	<0.0001	0.007	0.001	0.39	0.022	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Amended	3	7.0	137	428	3.2	<0.0001	0.016	<0.001		0.035	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Soil	1	5.8	21.7	381	92	<0.0001	0.53	<0.001	0.34	0.015	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Soil	2	6.6	153	361	67	<0.0001	0.16	0.004	0.68	0.24	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Ironman Gypsum	Soil	3	6.6	188	412	37	<0.0001	0.045	0.002		0.32	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Bottom	1	5.1	160	411	46	<0.0001	0.26	<0.001	0.15	0.29	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Bottom	2	6.4	212	387	28	<0.0001	0.027	0.002	0.52	0.30	<0.0001
Bassendean Ellenbrook	Ironman Gypsum	Bottom	3	6.9	184	404	21	<0.0001	0.013	0.002		0.29	<0.0001
Bassendean Ellenbrook	NRP	Amended	1	7.4	272	437	23	<0.0001	0.15	0.002	0.30	0.091	<0.0001
Bassendean Ellenbrook	NRP	Amended	2	7.2	36.1	516	7.8	<0.0001	0.049	<0.001	0.35	0.015	<0.0001
Bassendean Ellenbrook	NRP	Amended	3	7.1	21.2	408	6.3	<0.0001	0.074	<0.001		0.13	<0.0001
Bassendean Ellenbrook	NRP	Soil	1	5.9	29.1	372	120	<0.0001	0.60	<0.001	0.48	0.021	<0.0001
Bassendean Ellenbrook	NRP	Soil	2	6.4	105	316	180	<0.0001	0.89	0.005	1.2	0.19	<0.0001
Bassendean Ellenbrook	NRP	Soil	3	6.7	57.9	392	59	<0.0001	0.19	0.002		0.18	<0.0001
Bassendean Ellenbrook	NRP	Bottom	1	5.5	110	420	41	<0.0001	0.21	<0.001	0.13	0.13	<0.0001
Bassendean Ellenbrook	NRP	Bottom	2	6.7	108	378	49	<0.0001	0.22	0.001	0.52	0.076	<0.0001
Bassendean Ellenbrook	NRP	Bottom	3	6.9	54.6	381	30	<0.0001	0.11	<0.001		0.17	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Amended	1	6.7	91	454	19	<0.0001	0.029	<0.001	0.06	0.36	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Amended	2	7.3	82.6	451	9.5	<0.0001	0.032	<0.001	0.83	0.11	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Amended	3	7.2	51.1	418	7.7	<0.0001	<0.005	<0.001		0.078	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Soil	1	5.8	20.4	404	93	<0.0010	5.3	<0.010	4.4	0.10	<0.0010
Bassendean Ellenbrook	Wanneroo Sediment	Soil	2	5.9	91.1	393	100	<0.0001	0.45	0.002	0.8	0.19	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Soil	3	6.1	66.3	388	64	<0.0001	0.28	0.001		0.20	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	1	5.9	67.6	397	31	<0.0001	0.13	<0.001	0.17	0.057	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	2	5.7	89.9	382	36	<0.0001	0.11	<0.001	0.48	0.19	<0.0001
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	3	5.9	65.3	392	29	<0.0001	0.059	<0.001		0.20	<0.0001
Bassendean Ellenbrook	Jandakot Sediment	Amended	1	6.8	1080	358	93	<0.0005	1.9	<0.005	0.67	0.57	<0.0005
Bassendean Ellenbrook	Jandakot Sediment	Amended	2	7.3	212	466	35	<0.0001	0.78	<0.001	0.60	0.15	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Jandakot Sediment	Amended	3	7.3	81.6	418	17	<0.0001	0.027	<0.001		0.18	<0.0001
Bassendean Ellenbrook	Jandakot Sediment	Soil	1	5.8	24.8	389	110	0.0012	6.3	<0.010	3.9	0.11	<0.0010
Bassendean Ellenbrook	Jandakot Sediment	Soil	2	6.1	391	357	290	<0.0001	1.5	0.003	1.0	0.21	<0.0001
Bassendean Ellenbrook	Jandakot Sediment	Soil	3	6.7	133	374	180	<0.0001	1.3	0.002		0.19	<0.0001
Bassendean Ellenbrook	Jandakot Sediment	Bottom	1	4.6	687	419	75	<0.0002	0.20	<0.002	0.10	0.42	<0.0002
Bassendean Ellenbrook	Jandakot Sediment	Bottom	2	6.2	242	389	130	<0.0001	0.60	0.001	0.56	0.15	<0.0001
Bassendean Ellenbrook	Jandakot Sediment	Bottom	3	7.0	112	383	62	<0.0001	0.24	0.001		0.17	<0.0001
Bassendean Joel	Control	Amended	1	6.9	2.0	417	6.8	<0.0001	0.011	<0.001	0.08	<0.0001	<0.0001
Bassendean Joel	Control	Amended	2	7.2	140	460	96	<0.0001	0.1	0.003	1.5	0.10	<0.0001
Bassendean Joel	Control	Amended	3	6.5	4.4	403	3.8	<0.0001	0.008	<0.001		0.0049	<0.0001
Bassendean Joel	Control	Soil	1	7.3	159	390	190	<0.0001	0.28	0.011	0.59	0.20	<0.0001
Bassendean Joel	Control	Soil	2	6.7	4.4	508	7.9	<0.0001	0.036	<0.001	0.19	0.11	<0.0001
Bassendean Joel	Control	Soil	3	7.3	99.2	355	64	<0.0001	0.053	0.004		0.08	<0.0001
Bassendean Joel	Control	Bottom	1	7.6	77.8	437	84	<0.0001	0.12	0.008	0.33	0.10	<0.0001
Bassendean Joel	Control	Bottom	2	7.4	129	432	55	<0.0001	0.039	0.003	0.76	0.09	<0.0001
Bassendean Joel	Control	Bottom	3	7.5	121	345	54	<0.0001	0.021	0.003		0.091	<0.0001
Bassendean Joel	Alkaloam	Amended	1	9.1	32.3	391	33	<0.0001	1.2	0.012	0.063	0.09	<0.0001
Bassendean Joel	Alkaloam	Amended	2	7.3	176	459	150	<0.0001	0.36	0.006	1.8	0.10	<0.0001
Bassendean Joel	Alkaloam	Amended	3	8.6	16.1	395	15	<0.0001	0.31	0.003		0.098	<0.0001
Bassendean Joel	Alkaloam	Soil	1	7.3	159	399	180	0.0001	0.30	0.010	0.70	0.069	<0.0001
Bassendean Joel	Alkaloam	Soil	2	8.5	40.8	489	34	<0.0001	0.58	0.003	0.43	0.12	<0.0001
Bassendean Joel	Alkaloam	Soil	3	7.5	137	360	81	<0.0001	0.095	0.007		0.091	<0.0001
Bassendean Joel	Alkaloam	Bottom	1	7.8	143	435	170	<0.0001	0.67	0.015	0.31	0.095	<0.0001
Bassendean Joel	Alkaloam	Bottom	2	7.4	141	448	110	<0.0001	0.35	0.006	0.89	0.092	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Alkaloam	Bottom	3	7.6	116	349	62	<0.0001	0.051	0.007		0.081	<0.0001
Bassendean Joel	Ironman Gypsum	Amended	1	7.3	192	459	2.4	<0.0001	0.012	<0.001	0.12	0.098	<0.0001
Bassendean Joel	Ironman Gypsum	Amended	2	7.5	276	433	76	<0.0001	0.093	0.005	2.3	0.18	<0.0001
Bassendean Joel	Ironman Gypsum	Amended	3	7.6	175	434	4.2	<0.0001	<0.005	0.002		0.031	<0.0001
Bassendean Joel	Ironman Gypsum	Soil	1	7.4	157	406	160	<0.0001	0.29	0.011	0.58	0.075	<0.0001
Bassendean Joel	Ironman Gypsum	Soil	2	7.5	106	538	2.9	<0.0001	<0.005	<0.001	0.32	0.019	<0.0001
Bassendean Joel	Ironman Gypsum	Soil	3	7.5	236	380	37	<0.0001	0.007	0.005	0	0.16	<0.0001
Bassendean Joel	Ironman Gypsum	Bottom	1	7.6	253	444	73	<0.0001	0.06	0.007	0.32	0.14	<0.0001
Bassendean Joel	Ironman Gypsum	Bottom	2	7.5	267	460	49	<0.0001	0.018	0.004	1.0	0.094	<0.0001
Bassendean Joel	Ironman Gypsum	Bottom	3	7.5	267	419	39	<0.0001	0.007	0.004		0.15	<0.0001
Bassendean Joel	NRP	Amended	1	7.8	66.3	433	4.5	<0.0001	0.18	0.001	0.06	0.11	<0.0001
Bassendean Joel	NRP	Amended	2	7.5	185	441	100	<0.0001	0.11	0.006	2.2	0.077	<0.0001
Bassendean Joel	NRP	Amended	3	7.3	9.8	412	6.4	<0.0001	0.067	<0.001		0.098	<0.0001
Bassendean Joel	NRP	Soil	1	7.5	141	402	180	<0.0001	0.37	0.011	0.37	0.078	<0.0001
Bassendean Joel	NRP	Soil	2	7.7	28.4	512	5.3	<0.0001	0.078	<0.001	0.35	0.14	<0.0001
Bassendean Joel	NRP	Soil	3	7.4	160	372	53	<0.0001	0.03	0.004		0.11	<0.0001
Bassendean Joel	NRP	Bottom	1	7.5	218	442	77	<0.0001	0.088	0.007	0.26	0.13	<0.0001
Bassendean Joel	NRP	Bottom	2	7.4	175	454	58	<0.0001	0.048	0.004	0.99	0.093	<0.0001
Bassendean Joel	NRP	Bottom	3	7.5	96.8	357	40	<0.0001	0.015	0.003		0.088	<0.0001
Bassendean Joel	Wanneroo Sediment	Amended	1	7.0	44.6	457	8.9	<0.0001	0.006	<0.001	0.09	0.18	<0.0001
Bassendean Joel	Wanneroo Sediment	Amended	2	7.4	195	421	86	<0.0001	0.16	0.004	2.8	0.099	<0.0001
Bassendean Joel	Wanneroo Sediment	Amended	3	7.3	33.7	427	4.1	<0.0001	0.012	<0.001		0.069	<0.0001
Bassendean Joel	Wanneroo Sediment	Soil	1	7.3	137	410	150	<0.0001	0.25	0.01	0.64	0.070	<0.0001
Bassendean Joel	Wanneroo Sediment	Soil	2	7.2	46.3	532	6.3	<0.0001	<0.005	<0.001	0.20	0.089	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Wanneroo Sediment	Soil	3	7.6	149	380	56	<0.0001	0.028	0.004		0.13	<0.0001
Bassendean Joel	Wanneroo Sediment	Bottom	1	7.5	97.6	438	51	<0.0001	0.054	0.004	0.28	0.12	<0.0001
Bassendean Joel	Wanneroo Sediment	Bottom	2	7.5	135	454	43	<0.0001	0.028	0.002	0.93	0.084	<0.0001
Bassendean Joel	Wanneroo Sediment	Bottom	3	7.6	96.3	412	37	<0.0001	0.019	0.003		0.1	<0.0001
Bassendean Joel	Jandakot Sediment	Amended	1	7.2	203	449	42	<0.0001	0.04	<0.001	0.12	0.075	<0.0001
Bassendean Joel	Jandakot Sediment	Amended	2	7.6	612	408	160	<0.0002	0.22	0.005	2.9	0.087	<0.0002
Bassendean Joel	Jandakot Sediment	Amended	3	7.7	63.6	427	13	<0.0001	0.022	<0.001		0.029	<0.0001
Bassendean Joel	Jandakot Sediment	Soil	1	7.5	386	423	150	<0.0001	0.16	0.009	0.55	0.079	<0.0001
Bassendean Joel	Jandakot Sediment	Soil	2	7.5	99.1	522	17	<0.0001	0.059	<0.001	0.67	0.024	<0.0001
Bassendean Joel	Jandakot Sediment	Soil	3	7.5	247	380	93	<0.0001	0.072	0.006		0.094	<0.0001
Bassendean Joel	Jandakot Sediment	Bottom	1	7.4	839	456	130	<0.0001	0.079	0.008	0.28	0.12	<0.0001
Bassendean Joel	Jandakot Sediment	Bottom	2	7.6	342	454	88	<0.0001	0.069	0.006	1.5	0.077	<0.0001
Bassendean Joel	Jandakot Sediment	Bottom	3	7.6	168	413	59	<0.0001	0.041	0.004		0.09	<0.0001
Fairbridge Duplex	Control	Amended	1	7.0	12.1	401	43	<0.0001	0.42	<0.001	0.22	<0.0001	<0.0001
Fairbridge Duplex	Control	Amended	2	6.5	78.9	460	21	<0.0001	0.026	<0.001	1.3	0.073	<0.0001
Fairbridge Duplex	Control	Amended	3	6.7	18.8	407	9.3	<0.0001	0.029	<0.001		0.019	<0.0001
Fairbridge Duplex	Control	Soil	1	6.9	322	344	460	<0.0001	0.90	0.004	0.41	0.16	<0.0001
Fairbridge Duplex	Control	Soil	2	7.1	252	288	400	<0.0001	0.11	0.005	0.66	0.061	<0.0001
Fairbridge Duplex	Control	Soil	3	7.5	202	403	170	<0.0001	0.11	0.006		0.13	<0.0001
Fairbridge Duplex	Control	Bottom	1	7.4	81.5	405	260	<0.0001	1.1	0.004	0.23	0.038	<0.0001
Fairbridge Duplex	Control	Bottom	2	7.7	205	384	180	<0.0001	0.11	0.003	0.37	0.045	<0.0001
Fairbridge Duplex	Control	Bottom	3	8.2	174	381	110	<0.0001	0.037	0.003		0.087	<0.0001
Fairbridge Duplex	Alkaloam	Amended	1	8.0	90.5	405	75	<0.0001	2.5	0.011	0.12	0.13	<0.0001
Fairbridge Duplex	Alkaloam	Amended	2	7.3	33.4	457	9.6	<0.0001	0.073	<0.001	0.27	0.012	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	Alkaloam	Amended	3	7.0	11.3	403	5.6	<0.0001	0.15	<0.001		0.0043	<0.0001
Fairbridge Duplex	Alkaloam	Soil	1	6.9	325	338	450	<0.0001	0.81	0.004	0.46	0.15	<0.0001
Fairbridge Duplex	Alkaloam	Soil	2	7.0	274	178	430	<0.0001	0.098	0.005	0.68	0.065	<0.0001
Fairbridge Duplex	Alkaloam	Soil	3	7.6	222	396	300	<0.0001	0.38	0.009		0.11	<0.0001
Fairbridge Duplex	Alkaloam	Bottom	1	7.3	81	316	280	<0.0001	1.2	0.004	0.25	0.035	0.0001
Fairbridge Duplex	Alkaloam	Bottom	2	7.3	266	384	270	<0.0001	0.2	0.005	0.31	0.088	<0.0001
Fairbridge Duplex	Alkaloam	Bottom	3	7.4	224	381	160	<0.0001	0.2	0.004		0.13	<0.0001
Fairbridge Duplex	Ironman Gypsum	Amended	1	7.5	242	453	11	<0.0001	0.006	0.001	0.18	0.056	<0.0001
Fairbridge Duplex	Ironman Gypsum	Amended	2	7.1	72.1	490	3.8	<0.0001	<0.005	<0.001	0.27	0.027	<0.0001
Fairbridge Duplex	Ironman Gypsum	Amended	3	7.2	70.6	420	4.6	<0.0001	<0.005	<0.001		0.036	<0.0001
Fairbridge Duplex	Ironman Gypsum	Soil	1	6.9	332	320	470	<0.0001	0.93	0.004	0.51	0.16	<0.0001
Fairbridge Duplex	Ironman Gypsum	Soil	2	7.0	295	171	450	<0.0001	0.065	0.005	0.80	0.068	<0.0001
Fairbridge Duplex	Ironman Gypsum	Soil	3	7.2	182	356	150	<0.0001	0.078	0.004		0.16	<0.0001
Fairbridge Duplex	Ironman Gypsum	Bottom	1	7.4	88	363	300	<0.0001	1.2	0.004	0.25	0.036	0.0002
Fairbridge Duplex	Ironman Gypsum	Bottom	2	7.0	323	300	180	<0.0001	0.03	0.003	0.30	0.079	<0.0001
Fairbridge Duplex	Ironman Gypsum	Bottom	3	7.2	224	385	81	<0.0001	0.03	0.002		0.14	<0.0001
Fairbridge Duplex	NRP	Amended	1	7.5	68.8	433	21	<0.0001	0.12	0.001	0.10	0.0052	<0.0001
Fairbridge Duplex	NRP	Amended	2	6.8	23.9	475	4.7	<0.0001	0.014	<0.001	0.17	0.014	<0.0001
Fairbridge Duplex	NRP	Amended	3	6.8	30.8	419	9.3	<0.0001	0.064	<0.001		0.028	<0.0001
Fairbridge Duplex	NRP	Soil	1	6.9	297	344	450	<0.0001	0.93	0.004	0.42	0.14	<0.0001
Fairbridge Duplex	NRP	Soil	2	7.1	293	148	480	<0.0001	0.12	0.005	0.44	0.066	<0.0001
Fairbridge Duplex	NRP	Soil	3	7.5	210	395	200	<0.0001	0.17	0.006		0.13	<0.0001
Fairbridge Duplex	NRP	Bottom	1	7.3	77.2	318	290	<0.0001	1.3	0.004	0.26	0.034	<0.0001
Fairbridge Duplex	NRP	Bottom	2	7.4	251	399	210	<0.0001	0.091	0.004	0.30	0.13	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	NRP	Bottom	3	7.5	191	376	140	<0.0001	0.067	0.005		0.19	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Amended	1	7.1	47.5	450	11	<0.0001	<0.005	<0.001	0.15	0.21	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Amended	2	7.1	53.1	488	7.3	<0.0001	<0.005	<0.001	0.62	0.083	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Amended	3	7.5	57	415	8.4	<0.0001	0.011	<0.001		0.12	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Soil	1	6.8	92.6	244	370	<0.0001	1.5	0.004	0.22	0.043	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Soil	2	7.1	269	154	330	<0.0001	0.064	0.004	0.81	0.075	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Soil	3	7.0	179	371	150	<0.0001	0.11	0.006		0.31	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Bottom	1	7.3	71.4	387	210	<0.0001	1.1	0.004	0.22	0.027	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Bottom	2	7.1	236	324	160	<0.0001	0.058	0.003	0.28	0.08	<0.0001
Fairbridge Duplex	Wanneroo Sediment	Bottom	3	7.1	162	384	93	<0.0001	0.071	0.003		0.31	<0.0001
Fairbridge Duplex	Jandakot Sediment	Amended	1	7.1	470	452	58	<0.0001	0.019	<0.001	0.11	0.16	<0.0001
Fairbridge Duplex	Jandakot Sediment	Amended	2	6.8	323	472	89	<0.0001	0.087	0.002	4.1	0.26	<0.0001
Fairbridge Duplex	Jandakot Sediment	Amended	3	7.4	134	419	28	<0.0001	0.02	<0.001		0.29	<0.0001
Fairbridge Duplex	Jandakot Sediment	Soil	1	6.9	262	298	440	<0.0001	1.2	0.004	0.41	0.13	<0.0001
Fairbridge Duplex	Jandakot Sediment	Soil	2	7.1	922	194	410	<0.0002	0.063	0.007	0.85	0.18	<0.0002
Fairbridge Duplex	Jandakot Sediment	Soil	3	7.4	261	368	310	<0.0001	0.73	0.004		0.28	<0.0001
Fairbridge Duplex	Jandakot Sediment	Bottom	1	7.2	288	404	180	<0.0001	0.87	0.004	0.2	0.12	<0.0001
Fairbridge Duplex	Jandakot Sediment	Bottom	2	7.0	545	161	470	<0.0002	0.55	0.006	0.29	0.15	<0.0002
Fairbridge Duplex	Jandakot Sediment	Bottom	3	7.3	231	348	200	<0.0001	0.51	0.004		0.17	<0.0001
Spearwood	Control	Amended	1	8	13.9	477	19	<0.0001	0.47	<0.001	0.11	0.0049	<0.0001
Spearwood	Control	Amended	2	8.2	11.3	448	9.2	<0.0001	0.46	<0.001	0.71	0.014	<0.0001
Spearwood	Control	Amended	3	8.3	11.7	395	7.4	<0.0001	0.79	<0.001	0	0.18	<0.0001
Spearwood	Control	Soil	1	7.8	106	450	170	<0.0001	0.14	0.003	0.77	0.056	<0.0001
Spearwood	Control	Soil	2	8.3	75.4	416	91	<0.0001	0.07	0.008	8.1	0.14	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Control	Soil	3	8.6	60.3	360	61	<0.0001	0.025	0.007	0	0.15	<0.0001
Spearwood	Control	Bottom	1	8.1	42.3	449	75	<0.0001	0.094	0.002	0.15	0.005	<0.0001
Spearwood	Control	Bottom	2	8.1	63.5	471	37	<0.0001	0.023	0.004	0.98	0.069	<0.0001
Spearwood	Control	Bottom	3	8.2	53.8	391	36	<0.0001	<0.005	0.004	0	0.17	<0.0001
Spearwood	Alkaloam	Amended	1	10.2	106	371	76	<0.0001	39	0.054	0.17	0.089	0.0001
Spearwood	Alkaloam	Amended	2	9.3	38.3	417	12	<0.0001	8.1	0.021	1.3	0.11	<0.0001
Spearwood	Alkaloam	Amended	3	9.1	29.6	375	8.3	<0.0001	0.83	0.008	0	0.13	<0.0001
Spearwood	Alkaloam	Soil	1	7.8	101	455	170	<0.0001	0.13	0.004	1	0.065	<0.0001
Spearwood	Alkaloam	Soil	2	8.3	124	405	160	<0.0001	0.19	0.011	10	0.19	<0.0001
Spearwood	Alkaloam	Soil	3	8.7	133	351	170	<0.0001	0.43	0.01	0	0.21	<0.0001
Spearwood	Alkaloam	Bottom	1	8.1	41.3	447	71	<0.0001	0.083	0.002	0.17	0.0054	<0.0001
Spearwood	Alkaloam	Bottom	2	8.1	120	463	110	<0.0001	0.41	0.007	1	0.096	<0.0001
Spearwood	Alkaloam	Bottom	3	8.4	96.7	382	74	<0.0001	0.15	0.006	0	0.18	<0.0001
Spearwood	Ironman Gypsum	Amended	1	7.7	237	485	4.5	<0.0001	0.006	0.002	0.18	0.024	<0.0001
Spearwood	Ironman Gypsum	Amended	2	7.7	216	488	3.2	<0.0001	0.015	0.002	0.72	0.03	<0.0001
Spearwood	Ironman Gypsum	Amended	3	7.8	221	420	4.1	<0.0001	0.013	0.002	0	0.045	<0.0001
Spearwood	Ironman Gypsum	Soil	1	7.9	92.4	446	160	<0.0001	0.12	0.003	0.99	0.055	<0.0001
Spearwood	Ironman Gypsum	Soil	2	8.2	201	427	70	<0.0001	0.039	0.01	12	0.26	<0.0001
Spearwood	Ironman Gypsum	Soil	3	8.3	252	387	49	<0.0001	0.017	0.01	0	0.3	<0.0001
Spearwood	Ironman Gypsum	Bottom	1	8.1	42	447	76	<0.0001	0.092	0.002	0.2	0.0055	<0.0001
Spearwood	Ironman Gypsum	Bottom	2	7.8	217	472	40	<0.0001	0.16	0.004	2	0.15	<0.0001
Spearwood	Ironman Gypsum	Bottom	3	7.9	249	405	38	<0.0001	0.01	0.005	0	0.19	<0.0001
Spearwood	NRP	Amended	1	7.9	168	477	11	<0.0001	0.049	0.001	0.18	0.0099	<0.0001
Spearwood	NRP	Amended	2	8.3	24.3	462	6.9	<0.0001	0.82	0.001	0.84	0.12	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	NRP	Amended	3	8.3	29.3	397	12	<0.0001	0.11	0.001		0.16	<0.0001
Spearwood	NRP	Soil	1	7.8	91.9	456	160	<0.0001	0.15	0.003	0.46	0.037	<0.0001
Spearwood	NRP	Soil	2	8.0	221	424	89	<0.0001	0.057	0.011	6.7	0.21	<0.0001
Spearwood	NRP	Soil	3	8.3	138	369	58	<0.0001	0.058	0.008		0.23	<0.0001
Spearwood	NRP	Bottom	1	8.1	40.4	448	72	<0.0001	0.095	0.002	0.14	0.0027	<0.0001
Spearwood	NRP	Bottom	2	8	170	470	39	<0.0001	0.02	0.003	0.87	0.094	<0.0001
Spearwood	NRP	Bottom	3	8.1	93.8	395	42	<0.0001	0.035	0.005		0.19	<0.0001
Spearwood	Wanneroo Sediment	Amended	1	7.3	82.1	481	14	<0.0001	0.012	<0.001	0.13	0.33	<0.0001
Spearwood	Wanneroo Sediment	Amended	2	7.5	65.9	487	8.2	<0.0001	0.014	<0.001	0.64	0.07	<0.0001
Spearwood	Wanneroo Sediment	Amended	3	7.6	56	411	8.6	0.0004	<0.005	<0.001		0.076	<0.0001
Spearwood	Wanneroo Sediment	Soil	1	7.9	83.4	454	140	<0.0001	0.14	0.003	0.52	0.035	<0.0001
Spearwood	Wanneroo Sediment	Soil	2	8.0	129	425	82	<0.0001	0.069	0.009	8.4	0.16	<0.0001
Spearwood	Wanneroo Sediment	Soil	3	8.1	111	382	52	<0.0001	<0.005	0.006		0.19	<0.0001
Spearwood	Wanneroo Sediment	Bottom	1	8.1	57.3	440	64	<0.0001	0.35	0.002	0.17	0.022	<0.0001
Spearwood	Wanneroo Sediment	Bottom	2	7.9	119	463	37	<0.0001	0.019	0.004	0.99	0.079	<0.0001
Spearwood	Wanneroo Sediment	Bottom	3	7.9	95.3	400	33	<0.0001	0.019	0.005		0.089	<0.0001
Spearwood	Jandakot Sediment	Amended	1	7.4	655	487	67	<0.0001	0.046	<0.001	0.18	0.19	<0.0001
Spearwood	Jandakot Sediment	Amended	2	7.8	228	481	36	<0.0001	0.12	<0.001	4.2	0.03	<0.0001
Spearwood	Jandakot Sediment	Amended	3	7.9	132	410	31	<0.0001	0.13	<0.001		0.18	<0.0001
Spearwood	Jandakot Sediment	Soil	1	8.0	80.2	442	140	<0.0001	0.17	0.003	0.4	0.031	<0.0001
Spearwood	Jandakot Sediment	Soil	2	7.9	852	438	130	<0.0002	0.059	0.014	8.7	0.36	0.0004
Spearwood	Jandakot Sediment	Soil	3	8.1	240	384	83	<0.0001	0.039	0.006		0.14	<0.0001
Spearwood	Jandakot Sediment	Bottom	1	7.9	355	429	76	<0.0001	0.085	0.003	0.15	0.16	<0.0001
Spearwood	Jandakot Sediment	Bottom	2	8.0	413	462	72	<0.0001	0.049	0.005	1.2	0.11	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Jandakot Sediment	Bottom	3	8.0	177	401	52	<0.0001	0.026	0.004		0.088	<0.0001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean	Control	Amended	1	0.9	<0.0001	<0.0001	<0.0005	0.0012	0.081	<0.0001	2.6	0.5	0.0004	<0.001
Bassendean	Control	Amended	2	1.4	<0.0001	<0.0001	<0.0005	0.0011	0.11	<0.0001	1.5	0.7	0.002	<0.001
Bassendean	Control	Amended	3	7.4	<0.0001	<0.0001	<0.0005	0.0008	<0.005	<0.0001	2.8	3.5	0.0046	<0.001
Bassendean	Control	Soil	1	10.4	<0.0001	0.0007	0.0016	0.030	0.31	<0.0001	10.6	5.4	0.018	<0.001
Bassendean	Control	Soil	2	26	<0.0001	0.0013	0.0059	0.0088	5.6	<0.0001	14.1	12.7	0.049	0.001
Bassendean	Control	Soil	3	19	<0.0001	0.0007	0.0018	0.0035	2.7	<0.0001	7.0	9.9	0.034	<0.001
Bassendean	Control	Bottom	1	4.4	<0.0001	0.0004	0.0009	0.0048	0.22	<0.0001	5.8	2.2	0.0089	<0.001
Bassendean	Control	Bottom	2	34.7	<0.0001	0.0009	0.0011	0.0024	5.9	<0.0001	10.8	18.4	0.072	<0.001
Bassendean	Control	Bottom	3	27.1	<0.0001	0.0005	0.0006	0.0019	1.3	<0.0001	5.6	15.3	0.05	<0.001
Bassendean	Alkaloam	Amended	1	25.8	0.0003	0.0016	0.018	0.044	4.4	<0.0002	2.1	3.0	0.0079	0.1
Bassendean	Alkaloam	Amended	2	15.2	<0.0001	0.0005	0.0073	0.012	2.1	<0.0001	1.6	2.0	0.003	0.007
Bassendean	Alkaloam	Amended	3	4.2	<0.0001	<0.0001	0.0006	0.0014	0.17	<0.0001	0.7	0.8	0.0006	0.001
Bassendean	Alkaloam	Soil	1	11	<0.0001	0.0009	0.002	0.024	0.43	<0.0001	10.9	5.2	0.025	0.004
Bassendean	Alkaloam	Soil	2	30.9	0.0004	0.0049	0.019	0.041	10	0.0002	13.6	13.7	0.076	0.005
Bassendean	Alkaloam	Soil	3	21.8	<0.0001	0.0028	0.012	0.015	8.7	<0.0001	6.1	7.7	0.045	0.003
Bassendean	Alkaloam	Bottom	1	15.3	<0.0002	0.0011	0.0088	0.010	1.7	<0.0002	8.7	6.6	0.036	0.007
Bassendean	Alkaloam	Bottom	2	34.1	<0.0001	0.0031	0.0082	0.017	11	<0.0001	8.4	15	0.074	0.002
Bassendean	Alkaloam	Bottom	3	13.2	<0.0001	0.0013	0.0044	0.012	5.2	<0.0001	3.3	5.0	0.026	0.003
Bassendean	Ironman Gypsum	Amended	1	554	0.0002	0.0017	0.0055	0.009	<0.005	<0.0001	8.5	106	0.56	<0.001
Bassendean	Ironman Gypsum	Amended	2	404	<0.0001	0.0003	0.0011	0.0001	0.24	<0.0001	2.1	37.3	0.039	<0.001
Bassendean	Ironman Gypsum	Amended	3	306	<0.0001	0.0002	0.0016	0.0005	0.11	<0.0001	1.4	11.3	0.019	<0.001
Bassendean	Ironman Gypsum	Soil	1	8.6	<0.0001	0.0012	0.0022	0.016	0.28	<0.0001	8.9	4.2	0.019	0.003
Bassendean	Ironman Gypsum	Soil	2	141	<0.0001	0.0005	0.0038	0.0004	1.7	<0.0001	23.3	85.9	0.15	<0.001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean	Ironman Gypsum	Soil	3	366	<0.0001	0.0002	0.0009	0.0004	1.4	<0.0001	6.8	61.3	0.32	<0.001
Bassendean	Ironman Gypsum	Bottom	1	167	0.0003	0.0024	0.0010	0.0024	2.1	<0.0001	20.8	92.4	0.35	<0.001
Bassendean	Ironman Gypsum	Bottom	2	310	<0.0001	0.0005	0.0007	0.0003	0.84	<0.0001	11.8	107	0.31	0.001
Bassendean	Ironman Gypsum	Bottom	3	371	<0.0001	0.0002	<0.0005	0.0003	0.28	<0.0001	3.8	41.8	0.34	<0.001
Bassendean	NRP	Amended	1	259	0.0001	0.0004	<0.0005	0.0023	0.04	<0.0001	8.2	33.8	0.039	0.009
Bassendean	NRP	Amended	2	33.7	<0.0001	<0.0001	<0.0005	0.0034	0.034	<0.0001	1.1	1.1	0.0007	0.004
Bassendean	NRP	Amended	3	21.5	<0.0001	<0.0001	<0.0005	0.0008	0.037	<0.0001	0.8	0.7	0.0006	0.002
Bassendean	NRP	Soil	1	11.5	<0.0001	0.0008	0.0016	0.015	0.31	<0.0001	11	6.3	0.022	0.003
Bassendean	NRP	Soil	2	37.6	<0.0001	0.0013	0.0081	0.0053	3.0	<0.0001	18.2	22.5	0.051	0.001
Bassendean	NRP	Soil	3	34.6	<0.0001	0.0004	0.0022	0.0017	1.8	<0.0001	6.8	21.4	0.04	<0.001
Bassendean	NRP	Bottom	1	70.9	0.0001	0.0010	<0.0005	0.0022	1.0	<0.0001	16.5	38.9	0.14	<0.001
Bassendean	NRP	Bottom	2	56.8	<0.0001	0.0004	0.0013	0.0014	4.1	<0.0001	12.1	35.3	0.076	<0.001
Bassendean	NRP	Bottom	3	35.7	<0.0001	0.0002	0.0015	0.0033	1.8	<0.0001	4.4	21.8	0.042	<0.001
Bassendean	Wanneroo Sediment	Amended	1	57.0	<0.0001	<0.0001	<0.0005	0.0005	0.006	<0.0001	8.2	12.3	0.51	<0.001
Bassendean	Wanneroo Sediment	Amended	2	59.3	<0.0001	<0.0001	<0.0005	0.0004	0.025	<0.0001	10.5	15.5	0.33	<0.001
Bassendean	Wanneroo Sediment	Amended	3	41.8	<0.0001	<0.0001	<0.0005	0.0004	<0.005	<0.0001	7.7	10.5	0.053	<0.001
Bassendean	Wanneroo Sediment	Soil	1	79.7	<0.0010	0.0081	0.016	0.21	2.7	<0.0010	87.9	40	0.17	0.016
Bassendean	Wanneroo Sediment	Soil	2	36.3	<0.0001	0.0024	0.0050	0.0022	6.9	<0.0001	16.2	19.7	0.086	<0.001
Bassendean	Wanneroo Sediment	Soil	3	32.0	<0.0001	0.0013	0.0028	0.0017	5.4	<0.0001	9.6	17.1	0.072	<0.001
Bassendean	Wanneroo Sediment	Bottom	1	28.3	<0.0001	0.0007	<0.0005	0.0013	0.4	<0.0001	15.5	16.9	0.069	<0.001
Bassendean	Wanneroo Sediment	Bottom	2	44.4	<0.0001	0.0018	0.0006	0.0007	6.9	<0.0001	11.7	24.4	0.10	<0.001
Bassendean	Wanneroo Sediment	Bottom	3	36.3	<0.0001	0.0010	0.0006	0.0005	4.7	<0.0001	9.1	18.2	0.075	<0.001
Bassendean	Jandakot Sediment	Amended	1	170	<0.0005	<0.0005	<0.0025	0.0018	0.47	<0.0005	53.3	69.2	0.69	<0.005
Bassendean	Jandakot Sediment	Amended	2	72.6	<0.0001	0.0001	0.0005	0.0010	0.17	<0.0001	21.2	32.4	0.54	<0.001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean	Jandakot Sediment	Amended	3	54.3	<0.0001	<0.0001	<0.0005	0.001	<0.005	<0.0001	10.5	22.1	0.066	<0.001
Bassendean	Jandakot Sediment	Soil	1	101	0.0017	0.0085	0.019	0.36	3.6	<0.0010	96.2	52.5	0.22	0.018
Bassendean	Jandakot Sediment	Soil	2	35.2	<0.0001	0.0031	0.0096	0.0053	5.5	<0.0001	27.9	13.0	0.061	0.002
Bassendean	Jandakot Sediment	Soil	3	12.6	<0.0001	0.0019	0.0077	0.0067	4.3	<0.0001	17.1	4.3	0.024	0.002
Bassendean	Jandakot Sediment	Bottom	1	206	0.0014	0.0025	<0.0010	0.0031	2.4	<0.0002	35.3	98.7	0.41	<0.002
Bassendean	Jandakot Sediment	Bottom	2	15.6	<0.0001	0.0015	0.0030	0.0041	3.1	<0.0001	20.1	5.7	0.031	0.001
Bassendean	Jandakot Sediment	Bottom	3	12.0	<0.0001	0.0006	0.0014	0.0027	0.78	<0.0001	16.3	5.7	0.018	0.001
Bassendean Joel	Control	Amended	1	3.5	<0.0001	<0.0001	<0.0005	0.0047	0.023	<0.0001	4.7	2	0.0013	<0.001
Bassendean Joel	Control	Amended	2	118	<0.0001	0.0019	0.0043	0.0058	3.3	<0.0001	68	65.2	0.11	0.002
Bassendean Joel	Control	Amended	3	5.7	<0.0001	<0.0001	<0.0005	0.0012	0.006	<0.0001	1.3	2.7	0.0009	<0.001
Bassendean Joel	Control	Soil	1	75.6	0.0009	0.0020	0.0040	0.12	0.75	<0.0001	119	44.2	0.029	0.021
Bassendean Joel	Control	Soil	2	3.1	<0.0001	<0.0001	0.0018	0.0034	0.046	<0.0001	2.0	1.5	0.0015	<0.001
Bassendean Joel	Control	Soil	3	96.4	<0.0001	0.0011	0.0017	0.0072	1.6	<0.0001	32.4	50.7	0.076	0.002
Bassendean Joel	Control	Bottom	1	32.8	<0.0001	0.001	0.0024	0.026	0.53	<0.0001	66.5	20.2	0.020	0.010
Bassendean Joel	Control	Bottom	2	107	<0.0001	0.001	0.0013	0.0065	1.0	<0.0001	41.4	61.2	0.052	0.002
Bassendean Joel	Control	Bottom	3	114	<0.0001	0.0007	0.0010	0.0082	0.38	<0.0001	23.6	57.9	0.057	0.001
Bassendean Joel	Alkaloam	Amended	1	4.5	<0.0001	0.0003	0.0043	0.028	0.78	<0.0001	1.5	0.80	0.0026	0.005
Bassendean Joel	Alkaloam	Amended	2	104	0.0004	0.0023	0.0081	0.029	3.5	<0.0001	59.6	56.3	0.071	0.017
Bassendean Joel	Alkaloam	Amended	3	2.4	<0.0001	<0.0001	<0.0005	0.0066	0.021	<0.0001	1.1	0.7	0.0003	<0.001
Bassendean Joel	Alkaloam	Soil	1	71.4	0.0012	0.0021	0.0041	0.13	0.62	<0.0001	115	41.6	0.030	0.021
Bassendean Joel	Alkaloam	Soil	2	5.7	<0.0001	0.0002	0.0030	0.018	0.58	<0.0001	2.2	1.6	0.002	0.002
Bassendean Joel	Alkaloam	Soil	3	72.4	<0.0001	0.0007	0.0021	0.028	0.39	<0.0001	29.5	38.1	0.018	0.056
Bassendean Joel	Alkaloam	Bottom	1	76.5	0.0004	0.0021	0.0085	0.074	2.4	<0.0001	103	46.0	0.044	0.11
Bassendean Joel	Alkaloam	Bottom	2	73.5	<0.0001	0.0013	0.0047	0.024	2.2	<0.0001	36.3	40.1	0.039	0.014

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Alkaloam	Bottom	3	66.3	<0.0001	0.0004	0.0014	0.018	0.25	<0.0001	19.3	34.4	0.0053	0.016
Bassendean Joel	Ironman Gypsum	Amended	1	436	<0.0001	<0.0001	0.0072	0.0009	<0.005	<0.0001	6.3	24.6	0.0098	<0.001
Bassendean Joel	Ironman Gypsum	Amended	2	317	<0.0001	0.0006	0.0030	0.0027	0.35	<0.0001	96.3	182	0.15	0.002
Bassendean Joel	Ironman Gypsum	Amended	3	394	<0.0001	0.0001	0.0084	0.0014	0.01	<0.0001	3.5	16.7	0.0031	<0.001
Bassendean Joel	Ironman Gypsum	Soil	1	66.2	0.0007	0.0018	0.0035	0.11	0.55	<0.0001	124	37.5	0.033	0.019
Bassendean Joel	Ironman Gypsum	Soil	2	215	<0.0001	<0.0001	0.0016	0.0008	0.006	<0.0001	3.2	17.8	0.0025	<0.001
Bassendean Joel	Ironman Gypsum	Soil	3	361	<0.0001	0.0004	0.0011	0.0045	0.14	<0.0001	36.1	124	0.024	0.005
Bassendean Joel	Ironman Gypsum	Bottom	1	224	0.0002	0.001	0.0022	0.018	0.25	<0.0001	120	129	0.083	0.010
Bassendean Joel	Ironman Gypsum	Bottom	2	356	<0.0001	0.0005	0.0010	0.0027	0.27	<0.0001	55.9	172	0.12	0.003
Bassendean Joel	Ironman Gypsum	Bottom	3	473	0.0001	0.0005	0.0007	0.0041	0.092	<0.0001	28.3	118	0.042	0.003
Bassendean Joel	NRP	Amended	1	66.4	<0.0001	<0.0001	0.0005	0.0019	0.056	<0.0001	3.3	10.1	0.0005	0.006
Bassendean Joel	NRP	Amended	2	122	<0.0001	0.0008	0.0037	0.0034	0.15	<0.0001	71	70	0.045	0.002
Bassendean Joel	NRP	Amended	3	8.3	<0.0001	<0.0001	<0.0005	0.0025	0.023	<0.0001	1.1	1.0	0.0002	<0.001
Bassendean Joel	NRP	Soil	1	57.2	0.0014	0.0021	0.0041	0.15	0.68	<0.0001	114	33.2	0.033	0.019
Bassendean Joel	NRP	Soil	2	23.1	<0.0001	<0.0001	<0.0005	0.0021	0.03	<0.0001	1.4	1.8	0.0004	0.002
Bassendean Joel	NRP	Soil	3	162	<0.0001	0.0007	0.0009	0.0085	0.26	<0.0001	35.3	78.1	0.047	0.007
Bassendean Joel	NRP	Bottom	1	121	0.0002	0.0010	0.0015	0.016	0.42	<0.0001	116	73.7	0.056	0.018
Bassendean Joel	NRP	Bottom	2	138	<0.0001	0.0010	0.0019	0.035	0.14	<0.0001	49	87.6	0.013	0.005
Bassendean Joel	NRP	Bottom	3	90.6	<0.0001	0.0006	0.0006	0.0069	0.25	<0.0001	18.9	41.1	0.027	0.003
Bassendean Joel	Wanneroo Sediment	Amended	1	38.5	<0.0001	<0.0001	<0.0005	0.0009	<0.005	<0.0001	4.7	7.3	0.3	<0.001
Bassendean Joel	Wanneroo Sediment	Amended	2	143	<0.0001	0.0009	0.0022	0.0043	1.4	<0.0001	70.1	79.9	0.11	0.002
Bassendean Joel	Wanneroo Sediment	Amended	3	37.9	<0.0001	<0.0001	0.0005	0.0015	0.01	<0.0001	4.8	7.3	0.19	<0.001
Bassendean Joel	Wanneroo Sediment	Soil	1	54.7	0.0007	0.0017	0.0031	0.12	0.54	<0.0001	105	30.8	0.021	0.018
Bassendean Joel	Wanneroo Sediment	Soil	2	46.3	<0.0001	<0.0001	<0.0005	0.0004	<0.005	<0.0001	6.7	10.3	0.36	<0.001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Wanneroo Sediment	Soil	3	126	<0.0001	0.0006	0.0034	0.004	0.99	<0.0001	37.4	62.0	0.08	0.002
Bassendean Joel	Wanneroo Sediment	Bottom	1	37.3	0.0001	0.0005	0.0018	0.015	0.18	<0.0001	61.0	23.2	0.013	0.005
Bassendean Joel	Wanneroo Sediment	Bottom	2	94.3	<0.0001	0.0004	0.0007	0.0028	0.73	<0.0001	42.7	51.4	0.057	0.002
Bassendean Joel	Wanneroo Sediment	Bottom	3	89.3	<0.0001	0.0003	<0.0005	0.0033	0.55	<0.0001	21.6	39.5	0.028	<0.001
Bassendean Joel	Jandakot Sediment	Amended	1	43.0	<0.0001	<0.0001	<0.0005	0.001	0.013	<0.0001	16.2	16.1	0.20	<0.001
Bassendean Joel	Jandakot Sediment	Amended	2	184	<0.0002	0.0016	0.0051	0.0056	1.4	<0.0002	94.5	90.9	0.13	0.004
Bassendean Joel	Jandakot Sediment	Amended	3	44.4	<0.0001	<0.0001	<0.0005	0.0007	<0.005	<0.0001	8.4	17.4	0.0014	<0.001
Bassendean Joel	Jandakot Sediment	Soil	1	145	0.0003	0.0016	0.0030	0.092	0.44	<0.0001	138	81.9	0.041	0.019
Bassendean Joel	Jandakot Sediment	Soil	2	50.6	<0.0001	<0.0001	<0.0005	0.0007	0.013	<0.0001	11.8	21.2	0.0062	<0.001
Bassendean Joel	Jandakot Sediment	Soil	3	126	<0.0001	0.0006	0.0027	0.0041	0.48	<0.0001	37.3	57.4	0.067	0.003
Bassendean Joel	Jandakot Sediment	Bottom	1	232	0.001	0.0012	0.0059	0.027	0.28	<0.0005	158	130	0.074	0.010
Bassendean Joel	Jandakot Sediment	Bottom	2	111	<0.0001	0.0008	0.0025	0.0066	0.67	<0.0001	50.8	55.3	0.068	0.004
Bassendean Joel	Jandakot Sediment	Bottom	3	97.6	<0.0001	0.0003	0.0011	0.0037	0.32	<0.0001	24.5	42.7	0.026	0.002
Fairbridge Duplex	Control	Amended	1	11.2	<0.0001	0.0007	0.0011	0.0065	0.44	<0.0001	14.7	2.5	0.0097	0.002
Fairbridge Duplex	Control	Amended	2	93.4	<0.0001	0.0003	<0.0005	0.0016	0.1	<0.0001	22.7	19.9	0.042	<0.001
Fairbridge Duplex	Control	Amended	3	21	<0.0001	<0.0001	<0.0005	0.0012	0.075	<0.0001	4.5	3.6	0.01	<0.001
Fairbridge Duplex	Control	Soil	1	363	0.0007	0.010	0.0081	0.027	1.4	<0.0001	167	81.9	0.83	0.007
Fairbridge Duplex	Control	Soil	2	152	<0.0001	0.011	0.0028	0.001	8.1	<0.0001	150	62.8	0.39	0.003
Fairbridge Duplex	Control	Soil	3	159	<0.0001	0.0078	0.0028	0.003	6.9	<0.0001	93.1	35.8	1.0	0.002
Fairbridge Duplex	Control	Bottom	1	80.6	0.0006	0.0087	0.0060	0.017	1.9	<0.0001	82.5	17.5	0.27	0.008
Fairbridge Duplex	Control	Bottom	2	139	<0.0001	0.0077	0.0014	0.0006	3.1	<0.0001	110	40.8	0.30	0.003
Fairbridge Duplex	Control	Bottom	3	137	<0.0001	0.0054	0.0013	0.0015	1.6	<0.0001	72	31.2	0.64	0.002
Fairbridge Duplex	Alkaloam	Amended	1	13	0.0002	0.0013	0.0047	0.027	1.5	<0.0001	7.8	1.5	0.0037	0.03
Fairbridge Duplex	Alkaloam	Amended	2	10.8	<0.0001	<0.0001	<0.0005	0.0017	0.041	<0.0001	3.5	2.1	0.0018	0.002

Soil Type	**Amendment**	**Leachate**	**Time**	**Ca**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**K**	**Mg**	**Mn**	**Mo**
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Fairbridge Duplex	Alkaloam	Amended	3	3.8	<0.0001	<0.0001	<0.0005	0.0011	0.051	<0.0001	1.5	0.6	0.0019	<0.001
Fairbridge Duplex	Alkaloam	Soil	1	346	0.0007	0.0092	0.007	0.027	1.4	<0.0001	159	77.2	0.83	0.007
Fairbridge Duplex	Alkaloam	Soil	2	190	<0.0001	0.012	0.0027	0.0009	8.3	<0.0001	153	63.4	0.95	0.002
Fairbridge Duplex	Alkaloam	Soil	3	150	<0.0001	0.0093	0.0055	0.0021	32	<0.0001	87	31.4	1.1	0.002
Fairbridge Duplex	Alkaloam	Bottom	1	79.7	0.0007	0.0097	0.0070	0.02	2.3	<0.0001	85.8	16.5	0.24	0.009
Fairbridge Duplex	Alkaloam	Bottom	2	136	<0.0001	0.0092	0.0021	0.0008	7.0	<0.0001	131	50.6	0.56	0.002
Fairbridge Duplex	Alkaloam	Bottom	3	127	<0.0001	0.0058	0.0026	0.001	19	<0.0001	69.7	26.2	0.86	0.002
Fairbridge Duplex	Ironman Gypsum	Amended	1	501	0.0002	0.0004	0.0048	0.0036	0.019	<0.0001	35.3	62.5	0.045	<0.001
Fairbridge Duplex	Ironman Gypsum	Amended	2	116	<0.0001	<0.0001	<0.0005	0.0006	0.006	<0.0001	2.5	10.7	0.005	<0.001
Fairbridge Duplex	Ironman Gypsum	Amended	3	131	0.0007	<0.0001	<0.0005	0.0007	0.008	<0.0001	2.2	10.1	0.0026	<0.001
Fairbridge Duplex	Ironman Gypsum	Soil	1	368	0.0008	0.0098	0.0060	0.027	1.5	<0.0001	161	82.4	0.8	0.007
Fairbridge Duplex	Ironman Gypsum	Soil	2	134	<0.0001	0.0058	0.0025	0.0009	4.0	<0.0001	154	63.2	0.28	<0.001
Fairbridge Duplex	Ironman Gypsum	Soil	3	201	0.0002	0.0041	0.0024	0.0019	8.1	<0.0001	93.5	52.1	1.3	<0.001
Fairbridge Duplex	Ironman Gypsum	Bottom	1	87.6	0.0007	0.0093	0.0072	0.021	1.8	<0.0001	87.2	18.3	0.26	0.009
Fairbridge Duplex	Ironman Gypsum	Bottom	2	222	<0.0001	0.0045	0.0011	0.0005	2.1	<0.0001	159	84	0.70	<0.001
Fairbridge Duplex	Ironman Gypsum	Bottom	3	267	<0.0001	0.0020	0.0012	0.0004	2.3	<0.0001	80.4	66.7	1.4	<0.001
Fairbridge Duplex	NRP	Amended	1	66.8	<0.0001	0.0004	<0.0005	0.0032	0.12	<0.0001	11.6	8	0.0039	0.005
Fairbridge Duplex	NRP	Amended	2	26.7	<0.0001	<0.0001	<0.0005	0.0022	0.014	<0.0001	2.7	1.8	0.0009	<0.001
Fairbridge Duplex	NRP	Amended	3	34	<0.0001	<0.0001	<0.0005	0.0018	0.18	<0.0001	3.8	2.7	0.0037	<0.001
Fairbridge Duplex	NRP	Soil	1	326	0.0008	0.0095	0.0063	0.028	1.5	<0.0001	152	71.7	0.76	0.007
Fairbridge Duplex	NRP	Soil	2	171	<0.0001	0.0059	0.0027	0.001	7.1	<0.0001	163	71.3	0.68	<0.001
Fairbridge Duplex	NRP	Soil	3	155	<0.0001	0.0042	0.0033	0.0012	8.2	<0.0001	86.2	35.7	0.92	0.001
Fairbridge Duplex	NRP	Bottom	1	78.1	0.0007	0.010	0.0068	0.018	2.2	<0.0001	83.6	16	0.29	0.009
Fairbridge Duplex	NRP	Bottom	2	150	<0.0001	0.0041	0.0019	0.0005	5.3	<0.0001	122	48.7	0.39	<0.001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	NRP	Bottom	3	151	<0.0001	0.003	0.0022	0.001	3.6	<0.0001	75.4	34.4	0.85	<0.001
Fairbridge Duplex	Wanneroo Sediment	Amended	1	43.5	<0.0001	<0.0001	<0.0005	0.0005	<0.005	<0.0001	5.5	8.5	0.35	<0.001
Fairbridge Duplex	Wanneroo Sediment	Amended	2	44.5	<0.0001	<0.0001	<0.0005	0.0004	<0.005	<0.0001	8.4	11.3	0.4	<0.001
Fairbridge Duplex	Wanneroo Sediment	Amended	3	50.4	0.0003	<0.0001	<0.0005	0.0013	0.011	<0.0001	8.8	13.4	0.31	<0.001
Fairbridge Duplex	Wanneroo Sediment	Soil	1	98.4	0.001	0.011	0.0072	0.023	1.7	<0.0001	93.5	20	0.38	0.009
Fairbridge Duplex	Wanneroo Sediment	Soil	2	167	<0.0001	0.011	0.0025	0.0012	5.9	<0.0001	135	60.5	0.67	0.001
Fairbridge Duplex	Wanneroo Sediment	Soil	3	136	0.0002	0.0064	0.0033	0.0023	9.6	<0.0001	63.4	27.8	0.87	<0.001
Fairbridge Duplex	Wanneroo Sediment	Bottom	1	64.7	0.0006	0.0075	0.0052	0.012	1.6	<0.0001	75.4	13.6	0.17	0.012
Fairbridge Duplex	Wanneroo Sediment	Bottom	2	150	<0.0001	0.0072	0.0014	0.0005	4.4	<0.0001	104	43.3	0.47	0.002
Fairbridge Duplex	Wanneroo Sediment	Bottom	3	114	<0.0001	0.004	0.0022	0.001	6.5	<0.0001	46.5	22.9	0.77	<0.001
Fairbridge Duplex	Jandakot Sediment	Amended	1	87.9	<0.0001	0.0001	<0.0005	0.0032	0.006	<0.0001	30.1	33.2	0.42	<0.001
Fairbridge Duplex	Jandakot Sediment	Amended	2	106	<0.0001	0.0008	0.0007	0.001	5	<0.0001	37.2	61.9	1.9	0.001
Fairbridge Duplex	Jandakot Sediment	Amended	3	71	0.0003	0.0001	<0.0005	0.0061	0.018	<0.0001	16.9	28.6	0.77	<0.001
Fairbridge Duplex	Jandakot Sediment	Soil	1	284	0.0008	0.0094	0.0068	0.027	1.6	<0.0001	141	61.6	0.47	0.007
Fairbridge Duplex	Jandakot Sediment	Soil	2	508	<0.0002	0.012	0.0023	0.0006	4.1	<0.0002	191	123	2	<0.002
Fairbridge Duplex	Jandakot Sediment	Soil	3	127	0.0001	0.0081	0.0079	0.0033	39	<0.0001	50.2	21.1	1.1	0.002
Fairbridge Duplex	Jandakot Sediment	Bottom	1	281	0.0008	0.0079	0.0054	0.013	1.3	<0.0001	122	66.9	1.1	0.009
Fairbridge Duplex	Jandakot Sediment	Bottom	2	236	<0.0002	0.0097	0.0056	0.0056	37	<0.0002	101	46.4	1.6	0.003
Fairbridge Duplex	Jandakot Sediment	Bottom	3	86.7	<0.0001	0.0051	0.0044	0.0024	19	<0.0001	41.6	14	0.69	0.003
Spearwood	Control	Amended	1	23.5	<0.0001	0.0002	0.001	0.0027	0.25	<0.0001	4.2	1.9	0.0003	0.003
Spearwood	Control	Amended	2	20	<0.0001	<0.0001	<0.0005	<0.0001	0.22	<0.0001	3.6	2.3	<0.0001	0.002
Spearwood	Control	Amended	3	12.3	<0.0001	<0.0001	0.0012	0.0011	0.35	<0.0001	2.9	1.7	0.0014	0.002
Spearwood	Control	Soil	1	131	<0.0001	0.0031	0.0035	0.014	0.076	<0.0001	17.3	11.4	0.0013	0.022
Spearwood	Control	Soil	2	84.1	<0.0001	0.0006	<0.0005	0.0004	0.5	<0.0001	25.1	20.3	0.012	0.016

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Control	Soil	3	61.3	<0.0001	0.0003	0.0013	0.0006	0.1	<0.0001	20.4	13.1	0.0044	0.01
Spearwood	Control	Bottom	1	62.6	<0.0001	0.001	0.0027	0.0058	0.051	<0.0001	10.5	5.7	<0.0001	0.011
Spearwood	Control	Bottom	2	88.4	<0.0001	0.0003	0.0007	<0.0001	0.52	<0.0001	13.2	17.9	<0.0001	0.005
Spearwood	Control	Bottom	3	71.2	<0.0001	0.0002	0.0005	0.0004	0.14	<0.0001	13	12.5	0.0051	0.006
Spearwood	Alkaloam	Amended	1	9.2	<0.0001	0.0015	0.029	0.015	14	0.0002	1.4	0.5	0.0068	0.029
Spearwood	Alkaloam	Amended	2	3.7	<0.0001	0.0003	0.0063	<0.0001	3.5	<0.0001	2.0	0.5	<0.0001	0.001
Spearwood	Alkaloam	Amended	3	2.1	<0.0001	<0.0001	0.0016	0.0016	0.29	<0.0001	2.4	0.4	0.0004	0.001
Spearwood	Alkaloam	Soil	1	128	<0.0001	0.0034	0.0040	0.012	0.075	<0.0001	17.7	11.3	0.0014	0.024
Spearwood	Alkaloam	Soil	2	76.4	<0.0001	0.0007	0.0017	0.0003	0.65	<0.0001	35.1	23.7	0.011	0.054
Spearwood	Alkaloam	Soil	3	37	<0.0001	0.0005	0.0073	0.0016	0.67	0.0001	26.4	13.8	0.0042	0.056
Spearwood	Alkaloam	Bottom	1	60.7	<0.0001	0.0009	0.0010	0.0054	0.036	<0.0001	10.4	5.6	<0.0001	0.011
Spearwood	Alkaloam	Bottom	2	82.7	<0.0001	0.0005	0.0033	<0.0001	1.6	<0.0001	17.5	18.6	<0.0001	0.044
Spearwood	Alkaloam	Bottom	3	39.1	<0.0001	0.0002	0.0025	0.0006	0.29	<0.0001	16.5	10.7	0.0018	0.033
Spearwood	Ironman Gypsum	Amended	1	592	<0.0001	0.0001	0.026	0.0006	<0.005	<0.0001	6.4	27.9	0.0044	<0.001
Spearwood	Ironman Gypsum	Amended	2	594	<0.0001	<0.0001	0.0065	<0.0001	<0.005	<0.0001	2.7	18.2	<0.0001	<0.001
Spearwood	Ironman Gypsum	Amended	3	570	<0.0001	0.0001	0.027	0.0009	0.05	<0.0001	3.8	13	0.0031	0.001
Spearwood	Ironman Gypsum	Soil	1	118	0.0001	0.0034	0.0039	0.012	0.076	<0.0001	17.3	10.5	0.001	0.022
Spearwood	Ironman Gypsum	Soil	2	325	<0.0001	0.0005	<0.0005	<0.0001	0.45	<0.0001	41.3	60.3	0.028	0.015
Spearwood	Ironman Gypsum	Soil	3	471	<0.0001	0.0002	0.0007	0.0003	0.21	<0.0001	37.4	53.3	0.028	0.01
Spearwood	Ironman Gypsum	Bottom	1	66.8	<0.0001	0.001	0.0010	0.0066	0.039	<0.0001	11	5.8	<0.0001	0.011
Spearwood	Ironman Gypsum	Bottom	2	452	<0.0001	0.0003	0.0009	<0.0001	0.16	<0.0001	24.6	56.5	0.079	0.006
Spearwood	Ironman Gypsum	Bottom	3	532	<0.0001	0.0002	<0.0005	0.0004	0.16	<0.0001	24.1	49.9	0.086	0.006
Spearwood	NRP	Amended	1	318	<0.0001	0.0001	0.0014	0.0019	<0.005	<0.0001	3.4	6.0	0.0002	0.012
Spearwood	NRP	Amended	2	27.8	<0.0001	<0.0001	0.0011	<0.0001	0.6	<0.0001	2.0	0.9	<0.0001	0.006

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	NRP	Amended	3	23.8	<0.0001	0.0001	0.0008	0.0021	0.055	<0.0001	3.7	1.3	0.0004	0.007
Spearwood	NRP	Soil	1	122	<0.0001	0.0030	0.0031	0.012	0.07	<0.0001	16.8	10.3	0.001	0.021
Spearwood	NRP	Soil	2	252	<0.0001	0.0006	<0.0005	0.0003	0.82	<0.0001	38.6	45.8	0.037	0.016
Spearwood	NRP	Soil	3	164	<0.0001	0.0005	0.0011	0.0014	0.059	<0.0001	25.9	26	0.0066	0.012
Spearwood	NRP	Bottom	1	59.8	<0.0001	0.0009	0.0009	0.0059	0.034	<0.0001	10.9	5.3	<0.0001	0.011
Spearwood	NRP	Bottom	2	261	<0.0001	0.0003	<0.0005	<0.0001	0.23	<0.0001	20.4	34.9	0.019	0.007
Spearwood	NRP	Bottom	3	125	<0.0001	0.0003	0.0007	0.0004	0.081	<0.0001	15.1	14.3	0.0087	0.007
Spearwood	Wanneroo Sediment	Amended	1	64.1	<0.0001	<0.0001	0.0007	0.0009	<0.005	<0.0001	7.2	11.6	0.46	<0.001
Spearwood	Wanneroo Sediment	Amended	1	55.3	<0.0001	<0.0001	<0.0005	<0.0001	<0.005	<0.0001	9.4	11.5	0.25	<0.001
Spearwood	Wanneroo Sediment	Amended	2	45.4	<0.0001	<0.0001	<0.0005	0.0005	<0.005	<0.0001	10.9	10.5	0.12	<0.001
Spearwood	Wanneroo Sediment	Soil	3	116	<0.0001	0.0021	0.0021	0.011	0.076	<0.0001	15.9	10.2	0.0014	0.017
Spearwood	Wanneroo Sediment	Soil	1	110	<0.0001	0.0006	<0.0005	0.0002	0.46	<0.0001	31.4	28.2	0.02	0.014
Spearwood	Wanneroo Sediment	Soil	2	101	<0.0001	0.0004	0.0010	0.0019	<0.005	<0.0001	23.3	20.2	0.0047	0.01
Spearwood	Wanneroo Sediment	Bottom	3	84.1	<0.0001	0.0008	0.0006	0.0066	0.14	<0.0001	12.2	7.7	<0.0001	0.009
Spearwood	Wanneroo Sediment	Bottom	1	132	<0.0001	0.0003	<0.0005	<0.0001	0.42	<0.0001	18.1	22.2	<0.0001	0.005
Spearwood	Wanneroo Sediment	Bottom	2	114	<0.0001	0.0003	0.0006	0.0007	0.11	<0.0001	14.8	17	0.015	0.005
Spearwood	Jandakot Sediment	Amended	3	138	0.0001	0.0001	0.0008	0.0014	0.012	0.0003	37.5	42.9	0.3	<0.001
Spearwood	Jandakot Sediment	Amended	1	57.6	<0.0001	<0.0001	<0.0005	<0.0001	<0.005	<0.0001	29.3	28.3	0.0013	0.001
Spearwood	Jandakot Sediment	Amended	2	43.2	<0.0001	<0.0001	<0.0005	0.0007	<0.005	<0.0001	23.7	22.8	0.028	0.001
Spearwood	Jandakot Sediment	Soil	3	111	<0.0001	0.0021	0.0044	0.012	0.095	<0.0001	16.2	9.7	0.0006	0.017
Spearwood	Jandakot Sediment	Soil	1	275	<0.0002	0.021	<0.0010	0.0002	0.51	<0.0002	59.6	49.4	0.04	0.013
Spearwood	Jandakot Sediment	Soil	2	99.1	<0.0001	0.0006	0.0016	0.0024	0.026	<0.0001	30.9	22.1	0.0052	0.013
Spearwood	Jandakot Sediment	Bottom	3	302	0.0001	0.0007	0.0006	0.0046	0.03	<0.0001	26.6	25.7	<0.0001	0.009
Spearwood	Jandakot Sediment	Bottom	1	132	<0.0001	0.0004	0.0011	<0.0001	0.51	<0.0001	29.3	20	0.0024	0.007

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Jandakot Sediment	Bottom	2	101	<0.0001	0.0003	0.0007	0.0009	0.043	<0.0001	21.1	19.4	0.011	0.005

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Control	Amended	1	4.3	<0.001	0.4	<0.0001	1.0	<0.0001	<0.001	<0.0001	<0.0001	0.0033
Bassendean Ellenbrook	Control	Amended	2	10.7	<0.001	0.3	0.0004	0.4	<0.0001	<0.001	<0.0001	<0.0001	0.0046
Bassendean Ellenbrook	Control	Amended	3	11.9	<0.001	0.2	0.0004	2.0	<0.0001	<0.001	<0.0001	<0.0001	0.0012
Bassendean Ellenbrook	Control	Soil	1	21	0.004	4.1	0.0022	6.4	0.0001	<0.001	0.0058	0.0003	0.023
Bassendean Ellenbrook	Control	Soil	2	22.9	0.003	4.4	0.0037	4.2	0.0003	<0.001	0.0019	0.0005	0.063
Bassendean Ellenbrook	Control	Soil	3	10.4	0.002	1.1	0.0007	3.5	0.0002	<0.001	0.0004	0.0001	0.024
Bassendean Ellenbrook	Control	Bottom	1	10.8	0.001	1.5	<0.0001	3.1	<0.0001	<0.001	0.0005	0.0002	0.0098
Bassendean Ellenbrook	Control	Bottom	2	16	0.001	1.6	0.0003	4.1	<0.0001	<0.001	0.0002	<0.0001	0.0093
Bassendean Ellenbrook	Control	Bottom	3	8.2	<0.001	0.3	0.0003	4.6	0.0001	<0.001	<0.0001	<0.0001	0.0036
Bassendean Ellenbrook	Alkaloam	Amended	1	419	0.004	0.6	0.0005	9.7	<0.0002	0.02	0.0015	0.0099	0.25
Bassendean Ellenbrook	Alkaloam	Amended	2	142	0.002	0.2	0.0014	9.8	<0.0001	0.002	0.0005	0.0075	0.18
Bassendean Ellenbrook	Alkaloam	Amended	3	42.3	<0.001	<0.1	0.0002	2.0	<0.0001	<0.001	<0.0001	0.0007	0.014
Bassendean Ellenbrook	Alkaloam	Soil	1	21.4	0.003	3.3	0.0023	6.6	0.0002	<0.001	0.0016	0.0005	0.021
Bassendean Ellenbrook	Alkaloam	Soil	2	57.9	0.006	4.6	0.022	8.9	0.0005	0.009	0.0025	0.0036	0.17
Bassendean Ellenbrook	Alkaloam	Soil	3	83.1	0.005	1.9	0.0064	12	0.0004	0.004	0.0076	0.0025	0.16
Bassendean Ellenbrook	Alkaloam	Bottom	1	30.5	0.003	1.7	0.0045	12	<0.0002	0.047	0.0008	0.003	0.069
Bassendean Ellenbrook	Alkaloam	Bottom	2	85.3	0.005	2.0	0.0050	12	0.0001	0.003	0.0006	0.003	0.12
Bassendean Ellenbrook	Alkaloam	Bottom	3	60.5	0.003	0.9	0.0038	8.0	0.0002	0.002	0.001	0.0009	0.058
Bassendean Ellenbrook	Ironman Gypsum	Amended	1	10.2	<0.001	<0.1	<0.0001	560	<0.0001	<0.001	0.0005	<0.0001	0.0007
Bassendean Ellenbrook	Ironman Gypsum	Amended	2	4.4	<0.001	<0.1	<0.0001	370	<0.0001	<0.001	0.0004	0.0002	0.0013
Bassendean Ellenbrook	Ironman Gypsum	Amended	3	3.8	<0.001	<0.1	0.0002	240	<0.0001	<0.001	0.0009	<0.0001	0.0006
Bassendean Ellenbrook	Ironman Gypsum	Soil	1	17.5	0.004	3.1	0.0017	5.7	0.0001	<0.001	0.0002	0.0004	0.019
Bassendean Ellenbrook	Ironman Gypsum	Soil	2	22.9	0.002	2.3	0.0001	200	0.0003	<0.001	0.0003	0.0001	0.013

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Ironman Gypsum	Soil	3	7.8	<0.001	1.2	<0.0001	340	0.0001	<0.001	<0.0001	<0.0001	0.0041
Bassendean Ellenbrook	Ironman Gypsum	Bottom	1	25.9	0.003	1.4	0.0008	280	<0.0001	<0.001	0.0005	<0.0001	0.0059
Bassendean Ellenbrook	Ironman Gypsum	Bottom	2	11.2	<0.001	0.3	<0.0001	340	<0.0001	<0.001	<0.0001	<0.0001	0.0018
Bassendean Ellenbrook	Ironman Gypsum	Bottom	3	5.4	<0.001	0.3	<0.0001	310	<0.0001	<0.001	<0.0001	<0.0001	0.0013
Bassendean Ellenbrook	NRP	Amended	1	376	<0.001	<0.1	<0.0001	460	<0.0001	0.03	<0.0001	<0.0001	0.0031
Bassendean Ellenbrook	NRP	Amended	2	33.5	<0.001	<0.1	0.0003	38	<0.0001	<0.001	0.0004	<0.0001	0.002
Bassendean Ellenbrook	NRP	Amended	3	15.5	<0.001	<0.1	<0.0001	19	<0.0001	<0.001	<0.0001	<0.0001	0.0021
Bassendean Ellenbrook	NRP	Soil	1	25.4	0.002	3.6	0.0018	8.4	0.0001	<0.001	0.0002	0.0006	0.021
Bassendean Ellenbrook	NRP	Soil	2	127	0.006	4.6	0.0084	60	0.0004	0.001	0.0012	0.0008	0.11
Bassendean Ellenbrook	NRP	Soil	3	36.1	0.002	1.9	0.0009	33	0.0001	<0.001	<0.0001	0.0001	0.019
Bassendean Ellenbrook	NRP	Bottom	1	76.5	0.001	1.2	<0.0001	170	<0.0001	0.009	0.0004	<0.0001	0.006
Bassendean Ellenbrook	NRP	Bottom	2	78.8	0.001	1.8	0.0016	94	<0.0001	<0.001	0.0001	0.0002	0.018
Bassendean Ellenbrook	NRP	Bottom	3	24.9	0.002	1.3	0.0008	36	<0.0001	<0.001	0.0014	<0.0001	0.0056
Bassendean Ellenbrook	Wanneroo Sediment	Amended	1	82.9	<0.001	<0.1	0.0001	35	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Bassendean Ellenbrook	Wanneroo Sediment	Amended	2	65.8	<0.001	<0.1	<0.0001	44	<0.0001	<0.001	0.0007	<0.0001	0.0006
Bassendean Ellenbrook	Wanneroo Sediment	Amended	3	30.5	<0.001	<0.1	<0.0001	38	<0.0001	<0.001	0.0006	<0.0001	<0.0005
Bassendean Ellenbrook	Wanneroo Sediment	Soil	1	168	0.022	31	0.016	54	0.0018	<0.010	0.0012	0.003	0.19
Bassendean Ellenbrook	Wanneroo Sediment	Soil	2	65.7	0.002	3.9	0.0016	13	0.0002	<0.001	0.0011	0.0003	0.032
Bassendean Ellenbrook	Wanneroo Sediment	Soil	3	53.5	0.002	1.7	0.0009	25	0.0001	<0.001	0.0004	0.0001	0.025
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	1	44.9	0.001	0.9	0.0016	29	<0.0001	<0.001	0.0005	<0.0001	0.0033
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	2	60.4	<0.001	1.3	0.0002	38	<0.0001	<0.001	<0.0001	<0.0001	0.005
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	3	44.8	<0.001	0.8	0.0002	41	<0.0001	<0.001	<0.0001	<0.0001	0.0035
Bassendean Ellenbrook	Jandakot Sediment	Amended	1	1920	<0.005	<0.1	<0.0005	64	<0.0005	<0.005	<0.0005	<0.0005	<0.0025
Bassendean Ellenbrook	Jandakot Sediment	Amended	2	273	<0.001	<0.1	<0.0001	73	<0.0001	<0.001	<0.0001	<0.0001	0.0023

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Jandakot Sediment	Amended	3	59.7	<0.001	<0.1	<0.0001	54	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Ellenbrook	Jandakot Sediment	Soil	1	206	0.024	37	0.018	61	0.0013	<0.010	0.0015	0.0035	0.23
Bassendean Ellenbrook	Jandakot Sediment	Soil	2	705	0.006	5.2	0.0037	14	0.0005	0.001	0.0026	0.0012	0.14
Bassendean Ellenbrook	Jandakot Sediment	Soil	3	224	0.005	2.1	0.0079	36	0.0004	<0.001	0.0023	0.0008	0.14
Bassendean Ellenbrook	Jandakot Sediment	Bottom	1	1050	0.003	1.3	<0.0002	46	<0.0002	<0.002	0.0004	<0.0002	0.0055
Bassendean Ellenbrook	Jandakot Sediment	Bottom	2	393	0.002	2.2	0.0014	55	0.0001	<0.001	0.0009	0.0004	0.039
Bassendean Ellenbrook	Jandakot Sediment	Bottom	3	172	0.001	0.4	0.0018	64	0.0001	<0.001	0.0003	<0.0001	0.025
Bassendean Joel	Control	Amended	1	10.5	<0.001	0.2	<0.0001	1.5	<0.0001	<0.001	0.0002	<0.0001	<0.0005
Bassendean Joel	Control	Amended	2	42.1	0.008	7.1	<0.0001	15	0.0001	<0.001	0.001	0.0001	0.018
Bassendean Joel	Control	Amended	3	1.7	<0.001	<0.1	<0.0001	3	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Joel	Control	Soil	1	146	0.005	5.6	<0.0001	55	0.0003	0.002	0.0003	0.0006	0.026
Bassendean Joel	Control	Soil	2	2.2	0.001	0.3	<0.0001	0.7	<0.0001	<0.001	0.0002	<0.0001	0.0008
Bassendean Joel	Control	Soil	3	18.9	0.002	3	0.0003	18	0.0001	<0.001	<0.0001	<0.0001	0.0073
Bassendean Joel	Control	Bottom	1	67.5	0.002	3.3	<0.0001	15	0.0002	<0.001	0.0003	0.0004	0.0089
Bassendean Joel	Control	Bottom	2	23.9	0.005	2	<0.0001	20	<0.0001	<0.001	0.0002	<0.0001	0.003
Bassendean Joel	Control	Bottom	3	10.9	0.001	1.4	0.0002	26	0.0001	<0.001	0.0002	<0.0001	0.0032
Bassendean Joel	Alkaloam	Amended	1	72.8	0.001	0.4	0.0081	1.8	<0.0001	0.002	0.0003	0.0019	0.035
Bassendean Joel	Alkaloam	Amended	2	194	0.008	8	0.0026	18	0.0002	0.004	0.001	0.0011	0.052
Bassendean Joel	Alkaloam	Amended	3	32.5	<0.001	0.1	<0.0001	1.8	<0.0001	<0.001	<0.0001	0.0002	0.0016
Bassendean Joel	Alkaloam	Soil	1	140	0.005	5.1	<0.0001	52	0.0003	0.002	0.0003	0.0007	0.027
Bassendean Joel	Alkaloam	Soil	2	81.5	0.001	0.2	<0.0001	7.4	<0.0001	<0.001	0.0008	0.002	0.043
Bassendean Joel	Alkaloam	Soil	3	160	0.002	1.3	0.0001	43	0.0003	0.001	0.0004	0.0002	0.008
Bassendean Joel	Alkaloam	Bottom	1	125	0.005	3.8	<0.0001	37	0.0002	0.11	0.0007	0.003	0.057
Bassendean Joel	Alkaloam	Bottom	2	148	0.003	3.1	<0.0001	25	0.0001	0.001	0.0007	0.0011	0.032

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Alkaloam	Bottom	3	105	0.001	1.5	<0.0001	28	0.0002	<0.001	0.0003	<0.0001	0.0038
Bassendean Joel	Ironman Gypsum	Amended	1	6.3	<0.001	<0.1	<0.0001	370	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Bassendean Joel	Ironman Gypsum	Amended	2	73.4	0.002	4.5	<0.0001	330	0.0001	<0.001	0.0044	<0.0001	0.0079
Bassendean Joel	Ironman Gypsum	Amended	3	9.6	<0.001	<0.1	0.0002	320	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Joel	Ironman Gypsum	Soil	1	140	0.004	4.9	<0.0001	57	0.0003	0.001	0.0002	0.0007	0.023
Bassendean Joel	Ironman Gypsum	Soil	2	4.4	<0.001	<0.1	<0.0001	180	<0.0001	<0.001	0.0014	<0.0001	<0.0005
Bassendean Joel	Ironman Gypsum	Soil	3	33.5	0.001	1.1	0.0002	370	<0.0001	<0.001	0.0005	<0.0001	0.0019
Bassendean Joel	Ironman Gypsum	Bottom	1	100	0.003	1.9	<0.0001	350	0.0002	<0.001	0.0003	0.0003	0.0066
Bassendean Joel	Ironman Gypsum	Bottom	2	41.3	0.001	2	<0.0001	330	0.0001	<0.001	0.0003	<0.0001	0.0029
Bassendean Joel	Ironman Gypsum	Bottom	3	16	<0.001	1	0.0001	410	<0.0001	<0.001	0.0004	<0.0001	0.0012
Bassendean Joel	NRP	Amended	1	44.6	<0.001	<0.1	<0.0001	84	<0.0001	0.002	0.0002	0.0001	0.0034
Bassendean Joel	NRP	Amended	2	160	0.004	6.4	<0.0001	50	0.0001	<0.001	0.0004	0.0002	0.022
Bassendean Joel	NRP	Amended	3	7.4	<0.001	<0.1	0.0004	7.2	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Joel	NRP	Soil	1	127	0.005	6	<0.0001	43	0.0002	0.002	0.0003	0.0009	0.031
Bassendean Joel	NRP	Soil	2	25.5	0.013	<0.1	<0.0001	22	<0.0001	<0.001	0.0002	<0.0001	0.0019
Bassendean Joel	NRP	Soil	3	49.4	0.001	1.2	0.0002	130	0.0002	<0.001	0.0003	<0.0001	0.0034
Bassendean Joel	NRP	Bottom	1	184	0.002	2.3	<0.0001	250	0.0002	0.015	0.0002	0.0003	0.0081
Bassendean Joel	NRP	Bottom	2	154	0.005	2.7	<0.0001	84	0.0002	<0.001	<0.0001	<0.0001	0.004
Bassendean Joel	NRP	Bottom	3	26.4	<0.001	1.3	0.0002	58	0.0001	<0.001	0.0004	<0.0001	0.0022
Bassendean Joel	Wanneroo Sediment	Amended	1	32.1	<0.001	<0.1	<0.0001	36	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Bassendean Joel	Wanneroo Sediment	Amended	2	125	0.002	4.9	0.0002	30	0.0004	<0.001	0.0012	0.0001	0.011
Bassendean Joel	Wanneroo Sediment	Amended	3	12.1	<0.001	<0.1	0.0003	31	<0.0001	<0.001	0.0002	<0.0001	<0.0005
Bassendean Joel	Wanneroo Sediment	Soil	1	119	0.004	4.3	<0.0001	41	0.0041	0.001	0.0002	0.0007	0.021
Bassendean Joel	Wanneroo Sediment	Soil	2	28	<0.001	<0.1	<0.0001	34	<0.0001	<0.001	<0.0001	<0.0001	<0.0005

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Wanneroo Sediment	Soil	3	76.9	0.002	2.2	0.0003	61	0.0002	<0.001	0.0002	<0.0001	0.0066
Bassendean Joel	Wanneroo Sediment	Bottom	1	76.5	0.001	1.6	<0.0001	39	0.0011	<0.001	0.0003	0.0002	0.004
Bassendean Joel	Wanneroo Sediment	Bottom	2	75.4	0.001	1.9	0.0001	45	0.0004	<0.001	0.0004	<0.0001	0.0017
Bassendean Joel	Wanneroo Sediment	Bottom	3	50.9	<0.001	1.5	0.0001	56	0.0003	<0.001	0.0005	<0.0001	0.0021
Bassendean Joel	Jandakot Sediment	Amended	1	312	<0.001	<0.1	0.0038	47	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Joel	Jandakot Sediment	Amended	2	1030	0.003	6.6	0.0003	36	0.0006	<0.002	0.0010	0.0004	0.029
Bassendean Joel	Jandakot Sediment	Amended	3	44.2	<0.001	<0.1	<0.0001	46	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Bassendean Joel	Jandakot Sediment	Soil	1	429	0.004	2.9	<0.0001	56	0.0024	0.001	0.0001	0.0005	0.014
Bassendean Joel	Jandakot Sediment	Soil	2	105	<0.001	<0.1	<0.0001	51	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Bassendean Joel	Jandakot Sediment	Soil	3	314	0.002	4.5	0.0003	49	0.0004	<0.001	0.0002	0.0002	0.019
Bassendean Joel	Jandakot Sediment	Bottom	1	1270	0.003	2.2	<0.0005	82	<0.0005	0.001	<0.0005	<0.0005	0.0075
Bassendean Joel	Jandakot Sediment	Bottom	2	529	0.002	2.9	0.0008	67	0.0004	<0.001	0.0001	0.0001	0.0093
Bassendean Joel	Jandakot Sediment	Bottom	3	182	0.001	2.5	0.0002	67	0.0003	<0.001	0.0001	<0.0001	0.0053
Fairbridge Duplex	Control	Amended	1	6.7	<0.001	1.2	<0.0001	2.6	<0.0001	<0.001	<0.0001	0.0005	0.0011
Fairbridge Duplex	Control	Amended	2	27	<0.001	0.4	<0.0001	5.8	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Fairbridge Duplex	Control	Amended	3	2.1	<0.001	0.2	0.0002	2.2	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Fairbridge Duplex	Control	Soil	1	112	0.007	2.0	0.0008	63	0.0001	0.002	<0.0001	0.0031	0.0055
Fairbridge Duplex	Control	Soil	2	44.2	0.006	0.9	<0.0001	8.5	0.0002	0.001	0.0002	<0.0001	0.0025
Fairbridge Duplex	Control	Soil	3	21.6	0.004	1.1	0.0004	3.8	<0.0001	<0.001	<0.0001	0.0001	0.0029
Fairbridge Duplex	Control	Bottom	1	50.0	0.005	1.8	<0.0001	11	0.0001	0.002	0.0006	0.0032	0.0055
Fairbridge Duplex	Control	Bottom	2	22.3	0.004	0.5	<0.0001	12	0.0001	<0.001	0.0006	<0.0001	0.0011
Fairbridge Duplex	Control	Bottom	3	17.6	0.003	0.3	0.0002	13	<0.0001	<0.001	0.0002	<0.0001	0.001
Fairbridge Duplex	Alkaloam	Amended	1	212	0.002	1.0	0.0002	5.6	<0.0001	0.01	0.0002	0.003	0.045
Fairbridge Duplex	Alkaloam	Amended	2	51.6	<0.001	0.1	<0.0001	4.9	<0.0001	<0.001	0.0006	<0.0001	0.0012

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	Alkaloam	Amended	3	16.1	<0.001	<0.1	<0.0001	1.7	<0.0001	<0.001	<0.0001	<0.0001	0.0023
Fairbridge Duplex	Alkaloam	Soil	1	108	0.006	2	0.0007	61	0.0001	0.002	<0.0001	0.0029	0.0048
Fairbridge Duplex	Alkaloam	Soil	2	44.1	0.006	0.8	<0.0001	6.6	0.0002	0.002	0.0002	0.0001	0.0031
Fairbridge Duplex	Alkaloam	Soil	3	167	0.007	6.1	0.0009	6.4	0.0001	0.002	0.0002	0.0005	0.011
Fairbridge Duplex	Alkaloam	Bottom	1	37.2	0.006	1.8	<0.0001	9.7	0.0001	0.004	0.0004	0.0039	0.0066
Fairbridge Duplex	Alkaloam	Bottom	2	76.1	0.005	0.7	0.0003	17	0.0002	0.001	0.0003	<0.0001	0.0023
Fairbridge Duplex	Alkaloam	Bottom	3	158	0.003	4	0.0005	21	<0.0001	<0.001	0.0003	0.0003	0.0054
Fairbridge Duplex	Ironman Gypsum	Amended	1	7.9	0.001	0.1	<0.0001	470	<0.0001	<0.001	0.0003	<0.0001	<0.0005
Fairbridge Duplex	Ironman Gypsum	Amended	2	2.3	<0.001	<0.1	<0.0001	83	<0.0001	<0.001	0.0003	<0.0001	<0.0005
Fairbridge Duplex	Ironman Gypsum	Amended	3	1.7	<0.001	<0.1	<0.0001	92	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Fairbridge Duplex	Ironman Gypsum	Soil	1	114	0.006	2	<0.0001	64	0.0001	0.002	0.0003	0.0031	0.0056
Fairbridge Duplex	Ironman Gypsum	Soil	2	46.2	0.004	0.5	<0.0001	6.1	0.0002	0.001	0.0004	0.0001	0.0022
Fairbridge Duplex	Ironman Gypsum	Soil	3	17.5	0.003	0.4	<0.0001	11	<0.0001	<0.001	<0.0001	<0.0001	0.0019
Fairbridge Duplex	Ironman Gypsum	Bottom	1	39.6	0.006	1.7	<0.0001	13	0.0001	0.002	0.0005	0.0039	0.0057
Fairbridge Duplex	Ironman Gypsum	Bottom	2	32.2	0.002	0.2	<0.0001	160	0.0001	<0.001	0.0038	<0.0001	0.0009
Fairbridge Duplex	Ironman Gypsum	Bottom	3	12.1	0.001	0.2	<0.0001	170	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Fairbridge Duplex	NRP	Amended	1	52.6	<0.001	0.5	<0.0001	82	<0.0001	0.002	<0.0001	0.0002	0.0023
Fairbridge Duplex	NRP	Amended	2	11.7	<0.001	<0.1	<0.0001	13	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Fairbridge Duplex	NRP	Amended	3	11.6	<0.001	0.1	0.0001	11	<0.0001	<0.001	<0.0001	<0.0001	0.0007
Fairbridge Duplex	NRP	Soil	1	104	0.005	1.9	<0.0001	57	0.0001	0.002	<0.0001	0.0033	0.0072
Fairbridge Duplex	NRP	Soil	2	91.2	0.004	1	<0.0001	7.4	0.0002	0.001	0.0003	0.0001	0.0036
Fairbridge Duplex	NRP	Soil	3	102	0.003	2.7	0.0003	4.4	<0.0001	<0.001	0.0002	0.0002	0.0058
Fairbridge Duplex	NRP	Bottom	1	33.6	0.006	1.8	<0.0001	11	0.0001	0.002	0.0004	0.0038	0.0058
Fairbridge Duplex	NRP	Bottom	2	111	0.003	0.8	<0.0001	50	0.0001	0.001	0.0003	<0.0001	0.0017

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	NRP	Bottom	3	66.4	0.002	1.0	<0.0001	17	<0.0001	<0.001	<0.0001	<0.0001	0.0021
Fairbridge Duplex	Wanneroo Sediment	Amended	1	35.9	<0.001	<0.1	0.0004	43	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Fairbridge Duplex	Wanneroo Sediment	Amended	2	35.1	<0.001	<0.1	<0.0001	32	<0.0001	<0.001	0.001	<0.0001	<0.0005
Fairbridge Duplex	Wanneroo Sediment	Amended	3	34.8	<0.001	<0.1	0.0003	37	<0.0001	<0.001	0.0003	<0.0001	<0.0005
Fairbridge Duplex	Wanneroo Sediment	Soil	1	46.7	0.006	2.2	<0.0001	17	0.0002	0.002	0.0001	0.0044	0.0071
Fairbridge Duplex	Wanneroo Sediment	Soil	2	36.8	0.005	0.6	<0.0001	5.8	0.0002	0.001	0.0002	0.0001	0.0019
Fairbridge Duplex	Wanneroo Sediment	Soil	3	58.1	0.004	1.2	0.0002	4.0	0.0001	<0.001	0.0002	0.0001	0.0028
Fairbridge Duplex	Wanneroo Sediment	Bottom	1	27.5	0.005	1.9	<0.0001	11	0.0001	0.002	0.0003	0.0030	0.0047
Fairbridge Duplex	Wanneroo Sediment	Bottom	2	41.7	0.003	0.4	0.0005	29	0.0001	<0.001	0.001	<0.0001	0.0017
Fairbridge Duplex	Wanneroo Sediment	Bottom	3	50.9	0.002	1.3	<0.0001	35	<0.0001	<0.001	<0.0001	<0.0001	0.0014
Fairbridge Duplex	Jandakot Sediment	Amended	1	780	<0.001	<0.1	<0.0001	48	<0.0001	<0.001	0.0002	<0.0001	<0.0005
Fairbridge Duplex	Jandakot Sediment	Amended	2	453	<0.001	<0.1	<0.0001	120	<0.0001	<0.001	0.0005	<0.0001	0.0007
Fairbridge Duplex	Jandakot Sediment	Amended	3	149	<0.001	<0.1	<0.0001	69	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Fairbridge Duplex	Jandakot Sediment	Soil	1	91.3	0.006	2.1	<0.0001	48	0.0001	0.002	0.0002	0.0037	0.0066
Fairbridge Duplex	Jandakot Sediment	Soil	2	1150	0.005	0.6	<0.0002	9.2	0.0003	<0.002	<0.0002	<0.0002	0.0027
Fairbridge Duplex	Jandakot Sediment	Soil	3	392	0.007	8.7	0.0029	8.3	0.0002	0.001	0.0005	0.0011	0.017
Fairbridge Duplex	Jandakot Sediment	Bottom	1	62.3	0.004	1.3	<0.0001	13	0.0001	0.001	0.0003	0.0024	0.0038
Fairbridge Duplex	Jandakot Sediment	Bottom	2	809	0.006	4.9	<0.0002	39	0.0003	0.002	0.0009	0.0007	0.0094
Fairbridge Duplex	Jandakot Sediment	Bottom	3	294	0.004	4.9	0.0012	29	0.0002	0.001	0.0001	0.0007	0.010
Spearwood	Control	Amended	1	2.8	0.001	<0.1	0.0003	1.3	<0.0001	<0.001	0.0002	0.0001	0.0029
Spearwood	Control	Amended	2	34.7	<0.001	<0.1	0.0002	1.1	<0.0001	<0.001	<0.0001	<0.0001	0.0085
Spearwood	Control	Amended	3	9.7	<0.001	<0.1	0.0002	0.9	<0.0001	<0.001	0.0001	<0.0001	0.0053
Spearwood	Control	Soil	1	79.9	0.011	<0.1	0.0009	25	0.0002	0.005	0.0003	0.0006	0.0035
Spearwood	Control	Soil	2	62	0.002	<0.1	0.0003	2.6	<0.0001	0.002	0.0003	0.0003	0.0029

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Control	Soil	3	49.8	0.001	<0.1	0.0004	1.6	<0.0001	0.001	<0.0001	0.0001	0.0034
Spearwood	Control	Bottom	1	22	0.002	<0.1	0.002	6.5	0.0001	0.002	0.0003	0.0003	0.0012
Spearwood	Control	Bottom	2	16.8	<0.001	<0.1	<0.0001	4.8	<0.0001	<0.001	<0.0001	0.0001	0.0007
Spearwood	Control	Bottom	3	20.5	<0.001	<0.1	<0.0001	3.2	<0.0001	<0.001	<0.0001	<0.0001	0.0007
Spearwood	Alkaloam	Amended	1	240	0.01	0.8	0.0033	3	0.0002	0.018	0.0012	0.0074	0.23
Spearwood	Alkaloam	Amended	2	83.2	0.002	0.2	0.0007	0.7	<0.0001	0.003	0.0001	0.0022	0.076
Spearwood	Alkaloam	Amended	3	62.3	<0.001	<0.1	0.0003	2.8	<0.0001	0.001	0.0002	0.0004	0.012
Spearwood	Alkaloam	Soil	1	78.3	0.012	<0.1	0.001	25	0.0002	0.005	0.0001	0.0006	0.0046
Spearwood	Alkaloam	Soil	2	183	0.002	<0.1	<0.0001	3.8	<0.0001	0.004	0.0002	0.0006	0.0062
Spearwood	Alkaloam	Soil	3	281	0.003	0.1	0.001	4.6	<0.0001	0.004	0.0005	0.001	0.016
Spearwood	Alkaloam	Bottom	1	19.8	0.002	<0.1	0.0003	5.9	0.0001	0.002	0.0004	0.0003	0.0014
Spearwood	Alkaloam	Bottom	2	190	0.001	<0.1	0.0001	10	0.0001	0.004	<0.0001	0.0007	0.01
Spearwood	Alkaloam	Bottom	3	173	<0.001	<0.1	0.0002	2.6	<0.0001	0.002	<0.0001	0.0004	0.0037
Spearwood	Ironman Gypsum	Amended	1	3.6	0.001	<0.1	<0.0001	490	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	Ironman Gypsum	Amended	2	3.3	<0.001	<0.1	<0.0001	470	<0.0001	<0.001	<0.0001	<0.0001	0.0009
Spearwood	Ironman Gypsum	Amended	3	9.6	<0.001	<0.1	<0.0001	440	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Spearwood	Ironman Gypsum	Soil	1	67.7	0.01	<0.1	0.0011	21	0.0002	0.004	0.0002	0.0006	0.0042
Spearwood	Ironman Gypsum	Soil	2	93	0.001	<0.1	<0.0001	330	<0.0001	0.002	0.0008	0.0001	0.0011
Spearwood	Ironman Gypsum	Soil	3	80.2	0.001	<0.1	0.0002	440	<0.0001	0.001	<0.0001	<0.0001	0.0008
Spearwood	Ironman Gypsum	Bottom	1	21	0.002	<0.1	0.0017	6.4	0.0001	0.002	0.0004	0.0003	0.0016
Spearwood	Ironman Gypsum	Bottom	2	26.8	<0.001	<0.1	<0.0001	380	<0.0001	0.001	0.0003	<0.0001	0.0013
Spearwood	Ironman Gypsum	Bottom	3	28.3	<0.001	<0.1	0.0001	440	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	NRP	Amended	1	85	0.003	<0.1	<0.0001	290	<0.0001	0.003	0.0001	0.0001	<0.0005
Spearwood	NRP	Amended	2	21.2	<0.001	<0.1	0.0002	16	<0.0001	<0.001	0.0001	0.0005	0.025

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	NRP	Amended	3	32.8	<0.001	<0.1	0.0002	17	0.0004	0.001	0.0007	<0.0001	0.0018
Spearwood	NRP	Soil	1	66.3	0.008	<0.1	0.0008	23	0.0002	0.005	<0.0001	0.0005	0.0025
Spearwood	NRP	Soil	2	219	0.001	<0.1	<0.0001	310	<0.0001	0.002	0.0002	0.0002	0.0019
Spearwood	NRP	Soil	3	108	0.002	<0.1	0.0026	150	<0.0001	0.002	<0.0001	<0.0001	0.0011
Spearwood	NRP	Bottom	1	19.8	0.001	<0.1	<0.0001	5.3	<0.0001	0.002	0.0003	0.0003	0.0013
Spearwood	NRP	Bottom	2	96.8	<0.001	<0.1	<0.0001	240	<0.0001	0.001	<0.0001	<0.0001	<0.0005
Spearwood	NRP	Bottom	3	60.6	<0.001	<0.1	0.0003	70	<0.0001	0.001	<0.0001	0.0001	0.01
Spearwood	Wanneroo Sediment	Amended	1	68.7	<0.001	<0.1	<0.0001	42	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	Wanneroo Sediment	Amended	1	54.4	<0.001	<0.1	<0.0001	46	<0.0001	<0.001	0.0002	<0.0001	<0.0005
Spearwood	Wanneroo Sediment	Amended	2	39.6	<0.001	<0.1	<0.0001	45	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	Wanneroo Sediment	Soil	3	57.0	0.005	<0.1	0.015	19	0.0001	0.004	<0.0001	0.0005	0.0028
Spearwood	Wanneroo Sediment	Soil	1	115	0.001	<0.1	0.0005	19	<0.0001	0.002	0.0003	0.0002	0.0013
Spearwood	Wanneroo Sediment	Soil	2	107	0.001	<0.1	0.0005	39	<0.0001	0.002	<0.0001	<0.0001	0.0009
Spearwood	Wanneroo Sediment	Bottom	3	18.0	0.001	<0.1	<0.0001	6.6	<0.0001	0.002	0.0004	0.0003	0.0039
Spearwood	Wanneroo Sediment	Bottom	1	68.4	<0.001	<0.1	<0.0001	38	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Spearwood	Wanneroo Sediment	Bottom	2	56.2	<0.001	<0.1	0.0005	40	<0.0001	<0.001	<0.0001	<0.0001	0.0007
Spearwood	Jandakot Sediment	Amended	3	1120	<0.001	<0.1	<0.0001	59	0.0001	<0.001	0.0002	<0.0001	<0.0005
Spearwood	Jandakot Sediment	Amended	1	333	<0.001	<0.1	<0.0001	66	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	Jandakot Sediment	Amended	2	157	<0.001	<0.1	<0.0001	67	<0.0001	<0.001	<0.0001	<0.0001	<0.0005
Spearwood	Jandakot Sediment	Soil	3	53.1	0.005	<0.1	0.019	17	0.0011	0.004	0.0007	0.0005	0.0025
Spearwood	Jandakot Sediment	Soil	1	1510	0.041	<0.1	<0.0002	49	0.0002	0.003	<0.0002	0.0008	0.0026
Spearwood	Jandakot Sediment	Soil	2	375	0.002	<0.1	0.0007	60	0.0001	0.003	0.0005	0.0001	0.0016
Spearwood	Jandakot Sediment	Bottom	3	343	0.001	<0.1	<0.0001	11	0.0005	0.002	0.0003	0.0003	0.0009
Spearwood	Jandakot Sediment	Bottom	1	694	<0.001	<0.1	0.0003	49	0.0001	0.002	0.0002	0.0002	0.0011

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Spearwood	Jandakot Sediment	Bottom	2	228	<0.001	<0.1	0.0004	61	<0.0001	0.001	<0.0001	<0.0001	0.0006

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Control	Amended	1	<0.0001	<0.0001	0.0001	0.008	0.47	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Amended	2	<0.0001	<0.0001	0.0005	0.042	0.97	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Amended	3	<0.0001	<0.0001	0.0004	0.036	1.1	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Soil	1	<0.0001	0.0002	0.0017	0.13	2.4	<20	<50	<10	10.9
Bassendean Ellenbrook	Control	Soil	2	<0.0001	0.0003	0.0038	0.19	23	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Soil	3	<0.0001	<0.0001	0.0014	0.097	16	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Bottom	1	<0.0001	<0.0001	0.0005	0.13	1.5	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Bottom	2	<0.0001	<0.0001	0.0008	0.13	8.8	<20	<50	<10	<10.0
Bassendean Ellenbrook	Control	Bottom	3	<0.0001	<0.0001	0.0007	0.13	4.7	<20	<50	<10	<10.0
Bassendean Ellenbrook	Alkaloam	Amended	1	<0.0002	0.08	0.28	0.069	3.3	<20	<50	<10	<10.0
Bassendean Ellenbrook	Alkaloam	Amended	2	<0.0001	0.033	0.12	0.063	2.4	<20	<50	<10	23.2
Bassendean Ellenbrook	Alkaloam	Amended	3	0.0002	0.0050	0.08	0.008	1.7	<20	<50	<10	<10.0
Bassendean Ellenbrook	Alkaloam	Soil	1	<0.0001	0.0002	0.0017	0.22	2.7	<20	<50	<10	11.3
Bassendean Ellenbrook	Alkaloam	Soil	2	<0.0001	0.0014	0.011	0.16	21	<20	<50	<10	13.5
Bassendean Ellenbrook	Alkaloam	Soil	3	<0.0001	0.0012	0.011	0.10	19	<20	<50	<10	17.4
Bassendean Ellenbrook	Alkaloam	Bottom	1	<0.0002	0.0024	0.0056	0.24	2.6	<20	<50	<10	20.8
Bassendean Ellenbrook	Alkaloam	Bottom	2	<0.0001	0.0021	0.0073	0.18	11	<20	<50	<10	22.8
Bassendean Ellenbrook	Alkaloam	Bottom	3	<0.0001	0.0008	0.0049	0.097	7.7	<20	<50	<10	13.3
Bassendean Ellenbrook	Ironman Gypsum	Amended	1	<0.0001	0.0005	<0.0001	0.004	2.1	<20	<50	<10	1650
Bassendean Ellenbrook	Ironman Gypsum	Amended	2	<0.0001	0.0001	0.0002	0.01	1.7	<20	<50	<10	1020
Bassendean Ellenbrook	Ironman Gypsum	Amended	3	<0.0001	<0.0001	0.0001	0.012	1.7	<20	<50	<10	674
Bassendean Ellenbrook	Ironman Gypsum	Soil	1	<0.0001	0.0002	0.0012	0.13	2.4	<20	<50	<10	<10.0
Bassendean Ellenbrook	Ironman Gypsum	Soil	2	<0.0001	<0.0001	0.002	0.02	19	<20	<50	<10	596

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Ironman Gypsum	Soil	3	<0.0001	<0.0001	0.0007	0.032	18	<20	<50	<10	1140
Bassendean Ellenbrook	Ironman Gypsum	Bottom	1	0.0001	<0.0001	0.0009	0.45	2.3	<20	<50	<10	823
Bassendean Ellenbrook	Ironman Gypsum	Bottom	2	<0.0001	<0.0001	0.0007	0.024	8.8	<20	<50	<10	1010
Bassendean Ellenbrook	Ironman Gypsum	Bottom	3	<0.0001	<0.0001	0.0004	0.033	7.8	<20	<50	<10	913
Bassendean Ellenbrook	NRP	Amended	1	<0.0001	0.0020	0.0088	0.015	8.0	<20	<50	<10	1350
Bassendean Ellenbrook	NRP	Amended	2	<0.0001	0.0002	0.011	0.01	2.7	<20	<50	<10	101
Bassendean Ellenbrook	NRP	Amended	3	<0.0001	0.0001	0.0095	0.029	1.8	<20	<50	<10	46.5
Bassendean Ellenbrook	NRP	Soil	1	<0.0001	0.0002	0.0017	0.14	2.6	<20	<50	<10	11.8
Bassendean Ellenbrook	NRP	Soil	2	<0.0001	0.0005	0.006	0.035	21	<20	<50	<10	186
Bassendean Ellenbrook	NRP	Soil	3	<0.0001	<0.0001	0.0009	0.045	16	<20	<50	<10	86.2
Bassendean Ellenbrook	NRP	Bottom	1	<0.0001	<0.0001	0.0004	0.23	2.6	<20	<50	<10	462
Bassendean Ellenbrook	NRP	Bottom	2	<0.0001	0.0001	0.0007	0.01	9.2	<20	<50	<10	299
Bassendean Ellenbrook	NRP	Bottom	3	<0.0001	<0.0001	0.0003	0.036	7.0	<20	<50	<10	82.9
Bassendean Ellenbrook	Wanneroo Sediment	Amended	1	<0.0001	<0.0001	<0.0001	0.007	2.1	22	160	<10	79.6
Bassendean Ellenbrook	Wanneroo Sediment	Amended	2	<0.0001	<0.0001	<0.0001	0.013	3.6	31	93	<10	96.6
Bassendean Ellenbrook	Wanneroo Sediment	Amended	3	<0.0001	<0.0001	<0.0001	0.005	2.1	<20	<50	<10	88.8
Bassendean Ellenbrook	Wanneroo Sediment	Soil	1	<0.0010	0.0015	0.014	1.2	23	<20	<50	<10	<10.0
Bassendean Ellenbrook	Wanneroo Sediment	Soil	2	<0.0001	0.0002	0.0023	0.042	21	30	160	<10	30.9
Bassendean Ellenbrook	Wanneroo Sediment	Soil	3	<0.0001	<0.0001	0.0012	0.041	18	21	68	<10	52.4
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	1	<0.0001	<0.0001	0.0003	0.11	2.4	<20	120	<10	65.1
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	2	<0.0001	<0.0001	0.0004	0.038	7.0	30	100	<10	97.3
Bassendean Ellenbrook	Wanneroo Sediment	Bottom	3	<0.0001	<0.0001	0.0003	0.043	6.5	<20	<50	<10	87.2
Bassendean Ellenbrook	Jandakot Sediment	Amended	1	<0.0005	<0.0005	0.0007	0.069	3.3	510	3300	<10	149
Bassendean Ellenbrook	Jandakot Sediment	Amended	2	0.0001	<0.0001	0.0005	0.007	2.7	59	370	<10	192

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Jandakot Sediment	Amended	3	<0.0001	<0.0001	0.0001	0.036	1.5	21	<50	<10	122
Bassendean Ellenbrook	Jandakot Sediment	Soil	1	<0.0010	0.0018	0.014	1.1	23	<20	64	<10	11.1
Bassendean Ellenbrook	Jandakot Sediment	Soil	2	<0.0001	0.0006	0.0085	0.056	28	88	1100	<10	20.7
Bassendean Ellenbrook	Jandakot Sediment	Soil	3	<0.0001	0.0005	0.0081	0.054	23	30	210	<10	83.4
Bassendean Ellenbrook	Jandakot Sediment	Bottom	1	<0.0002	<0.0002	0.0005	0.56	1.5	280	2100	<10	141
Bassendean Ellenbrook	Jandakot Sediment	Bottom	2	<0.0001	0.0002	0.0027	0.038	11	57	510	<10	141
Bassendean Ellenbrook	Jandakot Sediment	Bottom	3	<0.0001	0.0001	0.0018	0.044	9.7	25	95	<10	161
Bassendean Joel	Control	Amended	1	<0.0001	<0.0001	0.0022	0.012	0.37	<20	<50	<10	<10.0
Bassendean Joel	Control	Amended	2	<0.0001	0.0003	0.003	0.048	22	<20	<50	<10	30.1
Bassendean Joel	Control	Amended	3	<0.0001	<0.0001	0.0006	0.005	0.4	<20	<50	<10	<10.0
Bassendean Joel	Control	Soil	1	<0.0001	0.0012	0.014	0.16	12	<20	190	<10	149
Bassendean Joel	Control	Soil	2	<0.0001	<0.0001	0.0029	0.033	0.67	<20	<50	<10	<10.0
Bassendean Joel	Control	Soil	3	<0.0001	0.0002	0.0036	0.043	19	<20	<50	<10	42.5
Bassendean Joel	Control	Bottom	1	<0.0001	0.0005	0.0083	0.048	8.5	<20	<50	<10	28.5
Bassendean Joel	Control	Bottom	2	<0.0001	0.0001	0.0019	0.032	9	<20	<50	<10	48
Bassendean Joel	Control	Bottom	3	<0.0001	0.0001	0.0061	0.038	12	<20	<50	<10	50.4
Bassendean Joel	Alkaloam	Amended	1	<0.0001	0.032	0.19	0.026	0.82	<20	<50	<10	<10.0
Bassendean Joel	Alkaloam	Amended	2	<0.0001	0.0013	0.01	0.061	23	25	<50	<10	36.5
Bassendean Joel	Alkaloam	Amended	3	<0.0001	0.0032	0.06	0.022	0.91	<20	<50	<10	<10.0
Bassendean Joel	Alkaloam	Soil	1	<0.0001	0.0012	0.015	0.062	12	<20	170	<10	128
Bassendean Joel	Alkaloam	Soil	2	<0.0001	0.019	0.072	0.025	1.4	<20	<50	<10	22.5
Bassendean Joel	Alkaloam	Soil	3	<0.0001	0.0009	0.02	0.045	15	<20	<50	<10	98.4
Bassendean Joel	Alkaloam	Bottom	1	<0.0001	0.0033	0.016	0.075	9.7	<20	66	<10	76.2
Bassendean Joel	Alkaloam	Bottom	2	<0.0001	0.001	0.012	0.038	9.9	<20	<50	<10	57.6

Soil Type	**Amendment**	**Leachate**	**Time**	**Tl**	**U**	**V**	**Zn**	**Si**	**Br**	**Cl**	**F**	**SO_4**
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Bassendean Joel	Alkaloam	Bottom	3	<0.0001	0.0004	0.036	0.041	8.8	<20	<50	<10	57.2
Bassendean Joel	Ironman Gypsum	Amended	1	<0.0001	0.0005	<0.0001	0.028	0.72	<20	<50	<10	1070
Bassendean Joel	Ironman Gypsum	Amended	2	<0.0001	0.0011	0.0019	0.087	25	<20	<50	<10	907
Bassendean Joel	Ironman Gypsum	Amended	3	<0.0001	0.0013	<0.0001	0.008	2.8	<10	<50	<10	972
Bassendean Joel	Ironman Gypsum	Soil	1	<0.0001	0.0011	0.014	0.052	11	<20	190	<10	156
Bassendean Joel	Ironman Gypsum	Soil	2	<0.0001	<0.0001	<0.0001	0.025	0.84	<20	<50	<10	501
Bassendean Joel	Ironman Gypsum	Soil	3	<0.0001	0.0008	0.0041	0.046	23	<10	<50	<10	1150
Bassendean Joel	Ironman Gypsum	Bottom	1	<0.0001	0.0004	0.0054	0.042	8.3	<20	72	<10	1030
Bassendean Joel	Ironman Gypsum	Bottom	2	<0.0001	0.0003	0.0029	0.049	15	<20	<50	<10	973
Bassendean Joel	Ironman Gypsum	Bottom	3	<0.0001	0.0001	0.0048	0.033	16	<10	<50	<10	1210
Bassendean Joel	NRP	Amended	1	<0.0001	0.0044	0.016	0.023	0.64	<20	<50	<10	241
Bassendean Joel	NRP	Amended	2	<0.0001	0.0003	0.0043	0.026	22	<20	<50	<10	125
Bassendean Joel	NRP	Amended	3	<0.0001	0.0001	0.0083	0.024	0.38	<20	<50	<10	16.9
Bassendean Joel	NRP	Soil	1	<0.0001	0.0011	0.017	0.061	11	<20	160	<10	106
Bassendean Joel	NRP	Soil	2	<0.0001	0.0009	0.0093	0.026	0.82	<20	<50	<10	62.2
Bassendean Joel	NRP	Soil	3	<0.0001	0.0006	0.0061	0.036	17	<20	<50	<10	413
Bassendean Joel	NRP	Bottom	1	<0.0001	0.0004	0.0066	0.041	7.8	<20	70	<10	763
Bassendean Joel	NRP	Bottom	2	<0.0001	0.0001	0.004	0.029	10	<20	<50	<10	220
Bassendean Joel	NRP	Bottom	3	<0.0001	<0.0001	0.011	0.036	9.4	<20	<50	<10	166
Bassendean Joel	Wanneroo Sediment	Amended	1	<0.0001	<0.0001	0.0001	0.015	1.7	<20	<50	<10	80
Bassendean Joel	Wanneroo Sediment	Amended	2	<0.0001	0.0005	0.0019	0.057	24	36	170	<10	61.3
Bassendean Joel	Wanneroo Sediment	Amended	3	<0.0001	<0.0001	<0.0001	0.015	2.0	21	<50	<10	71.5
Bassendean Joel	Wanneroo Sediment	Soil	1	<0.0001	0.001	0.015	0.051	10	<20	140	<10	90.6
Bassendean Joel	Wanneroo Sediment	Soil	2	<0.0001	<0.0001	<0.0001	0.023	2.7	31	<50	<10	78.6

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Wanneroo Sediment	Soil	3	<0.0001	0.0002	0.001	0.035	21	30	83	<10	165
Bassendean Joel	Wanneroo Sediment	Bottom	1	<0.0001	0.0001	0.0073	0.04	5.3	<20	120	<10	92.5
Bassendean Joel	Wanneroo Sediment	Bottom	2	<0.0001	<0.0001	0.0009	0.047	9.1	37	160	<10	124
Bassendean Joel	Wanneroo Sediment	Bottom	3	<0.0001	<0.0001	0.0011	0.04	11	26	<50	<10	120
Bassendean Joel	Jandakot Sediment	Amended	1	<0.0001	<0.0001	<0.0001	0.007	0.64	35	470	<10	119
Bassendean Joel	Jandakot Sediment	Amended	2	<0.0002	0.0017	0.0085	0.053	25	180	1600	<10	91.9
Bassendean Joel	Jandakot Sediment	Amended	3	<0.0001	<0.0001	<0.0001	0.008	1.4	25	<50	<10	133
Bassendean Joel	Jandakot Sediment	Soil	1	<0.0001	0.0011	0.016	0.04	10	130	870	<10	129
Bassendean Joel	Jandakot Sediment	Soil	2	<0.0001	<0.0001	0.0001	0.014	2.1	38	130	<10	137
Bassendean Joel	Jandakot Sediment	Soil	3	<0.0001	0.0006	0.0054	0.034	24	36	270	<10	105
Bassendean Joel	Jandakot Sediment	Bottom	1	<0.0005	<0.0005	0.013	0.039	7.0	340	2300	<10	222
Bassendean Joel	Jandakot Sediment	Bottom	2	<0.0001	0.0005	0.0084	0.043	13	79	630	<10	163
Bassendean Joel	Jandakot Sediment	Bottom	3	<0.0001	0.0002	0.0042	0.031	13	34	150	<10	179
Fairbridge Duplex	Control	Amended	1	<0.0001	0.0003	0.0085	0.009	2.5	<20	<50	<10	<10.0
Fairbridge Duplex	Control	Amended	2	<0.0001	<0.0001	0.0028	0.016	4.4	<20	<50	<10	17.3
Fairbridge Duplex	Control	Amended	3	<0.0001	<0.0001	0.0015	0.008	1	<20	<50	<10	<10.0
Fairbridge Duplex	Control	Soil	1	0.0002	0.0022	0.035	0.017	13	<20	150	<10	173
Fairbridge Duplex	Control	Soil	2	<0.0001	0.0002	0.005	0.029	15	28	<50	<10	15.1
Fairbridge Duplex	Control	Soil	3	<0.0001	0.0002	0.0039	0.12	15	<20	<50	<10	<10.0
Fairbridge Duplex	Control	Bottom	1	0.0001	0.0016	0.026	0.028	11	<20	<50	<10	<10.0
Fairbridge Duplex	Control	Bottom	2	<0.0001	0.0003	0.0024	0.016	11	26	<50	<10	25.5
Fairbridge Duplex	Control	Bottom	3	<0.0001	0.0004	0.0021	0.055	12	<20	<50	<10	24.9
Fairbridge Duplex	Alkaloam	Amended	1	<0.0001	0.062	0.12	0.037	4.1	<20	<50	<10	20.2
Fairbridge Duplex	Alkaloam	Amended	2	<0.0001	0.0007	0.013	0.013	1.5	<20	<50	<10	14.6

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	Alkaloam	Amended	3	<0.0001	<0.0001	0.0073	0.01	0.81	<20	<50	<10	<10.0
Fairbridge Duplex	Alkaloam	Soil	1	0.0002	0.002	0.032	0.018	12	<20	150	<10	172
Fairbridge Duplex	Alkaloam	Soil	2	<0.0001	0.0002	0.0049	0.045	14	28	<50	<10	21.4
Fairbridge Duplex	Alkaloam	Soil	3	<0.0001	0.0005	0.017	0.037	16	<20	<50	<10	<10.0
Fairbridge Duplex	Alkaloam	Bottom	1	0.0005	0.0018	0.029	0.03	11	<20	<50	<10	<10.0
Fairbridge Duplex	Alkaloam	Bottom	2	<0.0001	0.0004	0.0034	0.04	12	26	<50	<10	34.7
Fairbridge Duplex	Alkaloam	Bottom	3	<0.0001	0.0004	0.0084	0.041	14	<20	<50	<10	48.4
Fairbridge Duplex	Ironman Gypsum	Amended	1	<0.0001	0.0008	0.0014	0.01	1.8	<20	<50	<10	1420
Fairbridge Duplex	Ironman Gypsum	Amended	2	<0.0001	<0.0001	0.0003	0.014	1.1	25	<50	<10	260
Fairbridge Duplex	Ironman Gypsum	Amended	3	0.0003	<0.0001	0.0003	0.007	1	<20	<50	<10	229
Fairbridge Duplex	Ironman Gypsum	Soil	1	<0.0001	0.0022	0.035	0.028	12	<20	140	<10	161
Fairbridge Duplex	Ironman Gypsum	Soil	2	<0.0001	0.0002	0.0044	0.027	14	27	<50	<10	87.2
Fairbridge Duplex	Ironman Gypsum	Soil	3	<0.0001	0.0012	0.0045	0.06	16	<20	<50	<10	17.7
Fairbridge Duplex	Ironman Gypsum	Bottom	1	0.0002	0.0019	0.03	0.029	12	<20	<50	<10	13.7
Fairbridge Duplex	Ironman Gypsum	Bottom	2	<0.0001	0.0002	0.0015	0.021	13	26	<50	<10	584
Fairbridge Duplex	Ironman Gypsum	Bottom	3	<0.0001	0.0003	0.0011	0.031	13	<20	<50	<10	473
Fairbridge Duplex	NRP	Amended	1	<0.0001	0.0029	0.013	0.003	2	<20	<50	<10	261
Fairbridge Duplex	NRP	Amended	2	<0.0001	<0.0001	0.0027	0.013	0.77	<20	<50	<10	39.5
Fairbridge Duplex	NRP	Amended	3	<0.0001	<0.0001	0.0035	0.008	1.5	<20	<50	<10	24.5
Fairbridge Duplex	NRP	Soil	1	<0.0001	0.0023	0.033	0.019	12	<20	130	<10	156
Fairbridge Duplex	NRP	Soil	2	<0.0001	0.0002	0.0062	0.037	15	28	<50	<10	15.9
Fairbridge Duplex	NRP	Soil	3	<0.0001	0.0002	0.0083	0.06	17	<20	<50	<10	<10.0
Fairbridge Duplex	NRP	Bottom	1	0.0002	0.0018	0.03	0.03	11	<20	<50	<10	11.7
Fairbridge Duplex	NRP	Bottom	2	<0.0001	0.0003	0.0037	0.033	13	25	<50	<10	143

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	NRP	Bottom	3	<0.0001	0.0002	0.0048	0.13	16	<20	<50	<10	42.8
Fairbridge Duplex	Wanneroo Sediment	Amended	1	<0.0001	<0.0001	<0.0001	0.006	1.9	<20	70	<10	102
Fairbridge Duplex	Wanneroo Sediment	Amended	2	<0.0001	<0.0001	<0.0001	0.009	3.1	32	62	<10	89.6
Fairbridge Duplex	Wanneroo Sediment	Amended	3	0.0003	<0.0001	<0.0001	0.011	3.6	<20	<50	<10	79.8
Fairbridge Duplex	Wanneroo Sediment	Soil	1	<0.0001	0.0022	0.039	0.027	12	<20	<50	<10	21.8
Fairbridge Duplex	Wanneroo Sediment	Soil	2	<0.0001	0.0001	0.0035	0.037	15	37	96	<10	11.8
Fairbridge Duplex	Wanneroo Sediment	Soil	3	<0.0001	0.0001	0.0042	0.15	17	<20	64	<10	<10.0
Fairbridge Duplex	Wanneroo Sediment	Bottom	1	0.0001	0.0013	0.027	0.028	9.9	<20	<50	<10	17.7
Fairbridge Duplex	Wanneroo Sediment	Bottom	2	<0.0001	0.0002	0.0021	0.023	12	36	140	<10	82.4
Fairbridge Duplex	Wanneroo Sediment	Bottom	3	<0.0001	<0.0001	0.0018	0.16	13	<20	64	<10	87.8
Fairbridge Duplex	Jandakot Sediment	Amended	1	<0.0001	<0.0001	<0.0001	0.005	0.63	93	1200	<10	113
Fairbridge Duplex	Jandakot Sediment	Amended	2	<0.0001	0.0001	0.0009	0.047	5.7	94	660	<10	329
Fairbridge Duplex	Jandakot Sediment	Amended	3	0.0002	<0.0001	0.0002	0.058	2.7	34	140	<10	174
Fairbridge Duplex	Jandakot Sediment	Soil	1	<0.0001	0.0020	0.035	0.029	13	<20	78	<10	90.3
Fairbridge Duplex	Jandakot Sediment	Soil	2	<0.0002	0.0003	0.0035	0.04	13	390	2900	<10	<10.0
Fairbridge Duplex	Jandakot Sediment	Soil	3	<0.0001	0.0012	0.024	0.19	18	35	240	<10	<10.0
Fairbridge Duplex	Jandakot Sediment	Bottom	1	0.0002	0.0011	0.021	0.027	9.9	140	860	<10	25.2
Fairbridge Duplex	Jandakot Sediment	Bottom	2	<0.0002	0.0008	0.017	0.054	14	130	1000	<10	88.1
Fairbridge Duplex	Jandakot Sediment	Bottom	3	<0.0001	0.0014	0.021	0.096	14	29	180	<10	54.2
Spearwood	Control	Amended	1	<0.0001	0.0004	0.0009	0.007	0.93	<20	<50	<10	<10.0
Spearwood	Control	Amended	2	<0.0001	0.0002	0.0018	0.002	1.3	<20	<50	<10	<10.0
Spearwood	Control	Amended	3	<0.0001	0.0002	0.0023	0.017	1.2	<20	<50	<10	<10.0
Spearwood	Control	Soil	1	<0.0001	0.0017	0.0017	0.012	6.5	<20	120	<10	63.2
Spearwood	Control	Soil	2	<0.0001	0.0003	0.013	0.008	12	<20	<50	<10	<10.0

Soil Type	**Amendment**	**Leachate**	**Time**	**Tl**	**U**	**V**	**Zn**	**Si**	**Br**	**Cl**	**F**	**SO_4**
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Spearwood	Control	Soil	3	<0.0001	0.0003	0.0082	0.019	14	<20	<50	<10	<10.0
Spearwood	Control	Bottom	1	<0.0001	0.0009	0.0009	0.011	2	<20	<50	<10	16.9
Spearwood	Control	Bottom	2	0.0001	0.0001	0.0017	0.002	5	<20	<50	<10	<10.0
Spearwood	Control	Bottom	3	<0.0001	0.0001	0.0028	0.017	5.6	<20	<50	<10	<10.0
Spearwood	Alkaloam	Amended	1	<0.0001	0.025	1.2	0.018	18	<20	<50	14	<10.0
Spearwood	Alkaloam	Amended	2	<0.0001	0.032	0.28	0.014	6.2	<20	<50	<10	<10.0
Spearwood	Alkaloam	Amended	3	<0.0001	0.015	0.11	0.015	2.4	<20	<50	<10	<10.0
Spearwood	Alkaloam	Soil	1	<0.0001	0.0017	0.002	0.016	8.3	<20	97	<10	60.1
Spearwood	Alkaloam	Soil	2	<0.0001	0.0006	0.027	0.004	13	<20	<50	<10	<10.0
Spearwood	Alkaloam	Soil	3	<0.0001	0.0013	0.046	0.025	18	<20	<50	<10	<10.0
Spearwood	Alkaloam	Bottom	1	<0.0001	0.001	0.001	0.013	2.3	<20	<50	<10	14
Spearwood	Alkaloam	Bottom	2	<0.0001	0.0005	0.0089	0.002	5.1	<20	<50	<10	20.1
Spearwood	Alkaloam	Bottom	3	<0.0001	0.0004	0.013	0.018	5.8	<20	<50	<10	<10.0
Spearwood	Ironman Gypsum	Amended	1	<0.0001	0.0019	<0.0001	0.007	0.88	<20	<50	<10	1450
Spearwood	Ironman Gypsum	Amended	2	<0.0001	0.0028	<0.0001	0.008	1.3	<20	<50	<10	1490
Spearwood	Ironman Gypsum	Amended	3	<0.0001	0.0011	<0.0001	0.006	1.3	<20	<50	<10	1310
Spearwood	Ironman Gypsum	Soil	1	<0.0001	0.0016	0.0019	0.010	7.4	<20	82	<10	53
Spearwood	Ironman Gypsum	Soil	2	<0.0001	0.0008	0.0073	0.002	15	22	<50	<10	1020
Spearwood	Ironman Gypsum	Soil	3	<0.0001	0.0005	0.0045	0.004	18	<20	<50	<10	1400
Spearwood	Ironman Gypsum	Bottom	1	<0.0001	0.0010	0.0011	0.01	2.5	<20	<50	<10	24.2
Spearwood	Ironman Gypsum	Bottom	2	<0.0001	0.0011	0.0009	0.003	5.2	<20	<50	<10	1190
Spearwood	Ironman Gypsum	Bottom	3	<0.0001	0.0006	0.0012	0.005	5.7	<20	<50	<10	1280
Spearwood	NRP	Amended	1	0.0003	0.0082	0.0019	0.019	0.88	<20	<50	<10	885
Spearwood	NRP	Amended	2	<0.0001	0.0018	0.013	0.017	2.3	<20	<50	<10	38.4

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	NRP	Amended	3	<0.0001	0.0026	0.010	0.019	1.9	<20	<50	<10	36.8
Spearwood	NRP	Soil	1	<0.0001	0.0017	0.0023	0.008	4.1	<20	60	<10	52
Spearwood	NRP	Soil	2	<0.0001	0.0012	0.0095	<0.001	8.6	<20	<50	<10	1130
Spearwood	NRP	Soil	3	<0.0001	0.0017	0.0088	0.016	13	<20	<50	<10	475
Spearwood	NRP	Bottom	1	<0.0001	0.001	0.0009	0.010	1.9	<20	<50	<10	11.5
Spearwood	NRP	Bottom	2	<0.0001	0.0008	0.0012	0.001	4.6	<20	<50	<10	703
Spearwood	NRP	Bottom	3	0.0002	0.0005	0.0045	0.020	3.9	<20	<50	<10	197
Spearwood	Wanneroo Sediment	Amended	1	<0.0001	<0.0001	<0.0001	0.009	1.8	<20	140	<10	90.3
Spearwood	Wanneroo Sediment	Amended	1	<0.0001	<0.0001	0.0001	0.009	2.2	31	65	<10	94.4
Spearwood	Wanneroo Sediment	Amended	2	<0.0001	<0.0001	<0.0001	0.007	2.4	21	<50	<10	92.8
Spearwood	Wanneroo Sediment	Soil	3	<0.0001	0.0016	0.0015	0.008	4.2	<20	<50	<10	38.9
Spearwood	Wanneroo Sediment	Soil	1	<0.0001	0.0015	0.0089	0.002	10	36	180	<10	36.8
Spearwood	Wanneroo Sediment	Soil	2	<0.0001	0.0016	0.0089	0.022	13	25	84	<10	86.8
Spearwood	Wanneroo Sediment	Bottom	3	<0.0001	0.0011	0.011	0.008	2.2	<20	61	<10	25.2
Spearwood	Wanneroo Sediment	Bottom	1	<0.0001	0.0008	0.0012	0.002	4.3	34	870	<10	108
Spearwood	Wanneroo Sediment	Bottom	2	<0.0001	0.0006	0.0033	0.005	3.5	23	65	<10	85.6
Spearwood	Jandakot Sediment	Amended	3	0.0001	<0.0001	<0.0001	0.010	0.53	200	1800	<10	147
Spearwood	Jandakot Sediment	Amended	1	<0.0001	<0.0001	0.0005	0.003	3.6	71	450	<10	177
Spearwood	Jandakot Sediment	Amended	2	<0.0001	<0.0001	0.0008	0.024	4.7	32	120	<10	169
Spearwood	Jandakot Sediment	Soil	3	<0.0001	0.0016	0.0016	0.007	3.6	<20	<50	<10	37.4
Spearwood	Jandakot Sediment	Soil	1	<0.0002	0.0048	0.012	0.005	9.9	340	2600	<10	117
Spearwood	Jandakot Sediment	Soil	2	<0.0001	0.0026	0.012	0.01	12	50	390	<10	155
Spearwood	Jandakot Sediment	Bottom	3	0.0001	0.001	0.0008	0.008	2	160	930	<10	23
Spearwood	Jandakot Sediment	Bottom	1	<0.0001	0.0011	0.0047	0.002	3.9	110	1000	<10	128

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Jandakot Sediment	Bottom	2	<0.0001	0.001	0.005	0.006	4.2	34	220	<10	150

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Biosolids	Amended	1	6.3	11.8	392	21	<0.0001	0.036	0.001	0.13	0.18	<0.0001
Bassendean Ellenbrook	Biosolids	Amended	2	5.3	55.7	434	64	<0.0001	0.15	<0.001	0.67	0.22	<0.0001
Bassendean Ellenbrook	Biosolids	Amended	3	4.8	25.2	419	17	<0.0001	0.083	<0.001	0.55	0.24	<0.0001
Bassendean Ellenbrook	Biosolids	Soil	1	5.7	36.6	330	170	0.0001	0.63	<0.001	0.36	0.14	<0.0001
Bassendean Ellenbrook	Biosolids	Soil	2	6.2	42.1	372	160	<0.0001	1.0	0.001	0.68	0.16	<0.0001
Bassendean Ellenbrook	Biosolids	Soil	3	6.5	36.6	316	83	<0.0001	0.42	0.001	0.78	0.32	<0.0001
Bassendean Ellenbrook	Biosolids	Bottom	1	6.2	31.2	317	110	<0.0001	0.45	0.001	0.17	0.14	<0.0001
Bassendean Ellenbrook	Biosolids	Bottom	2	5.0	112	424	89	<0.0001	0.33	<0.001	0.52	0.28	<0.0001
Bassendean Ellenbrook	Biosolids	Bottom	3	6.1	55.4	389	43	<0.0001	0.13	<0.001	0.62	0.22	<0.0001
Bassendean Ellenbrook	LAB	Amended	1	6.8	30.7	310	210	<0.0001	0.078	0.002	0.11	0.13	<0.0001
Bassendean Ellenbrook	LAB	Amended	2	7.2	66.7	423	54	<0.0001	0.033	0.001	0.63	0.17	<0.0001
Bassendean Ellenbrook	LAB	Amended	3	7.1	39.5	383	14	<0.0001	0.016	<0.001	0.85	0.19	<0.0001
Bassendean Ellenbrook	LAB	Soil	1	5.5	35.6	344	170	0.0001	0.61	<0.001	0.27	0.13	<0.0001
Bassendean Ellenbrook	LAB	Soil	2	6.3	48.4	391	180	<0.0001	0.65	0.002	0.70	0.18	<0.0001
Bassendean Ellenbrook	LAB	Soil	3	6.7	34.1	320	79	<0.0001	0.36	0.001	0.64	0.21	<0.0001
Bassendean Ellenbrook	LAB	Bottom	1	6.2	29.2	315	160	<0.0001	0.43	0.001	0.10	0.14	<0.0001
Bassendean Ellenbrook	LAB	Bottom	2	5.8	107	410	62	<0.0001	0.19	<0.001	0.31	0.47	<0.0001
Bassendean Ellenbrook	LAB	Bottom	3	6.7	59.4	393	40	<0.0001	0.12	<0.001	0.40	0.23	<0.0001
Bassendean Joel	Biosolids	Amended	1	7.2	37.5	332	59	0.0001	0.13	0.006	0.21	0.12	<0.0001
Bassendean Joel	Biosolids	Amended	2	6.7	55.5	440	66	<0.0001	0.051	0.002	1.3	0.09	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	Biosolids	Amended	3	6.9	41.1	374	13	<0.0001	<0.005	0.001	1.5	0.17	<0.0001
Bassendean Joel	Biosolids	Soil	1	7.6	188	382	210	<0.0001	0.24	0.015	1.5	0.08	<0.0001
Bassendean Joel	Biosolids	Soil	2	7.7	153	355	240	<0.0001	0.13	0.004	6.8	0.066	<0.0001
Bassendean Joel	Biosolids	Soil	3	7.8	179	320	63	<0.0001	0.006	0.01	8.2	0.10	<0.0001
Bassendean Joel	Biosolids	Bottom	1	7.7	116	360	120	<0.0001	0.098	0.013	0.54	0.11	<0.0001
Bassendean Joel	Biosolids	Bottom	2	7.6	137	413	92	<0.0001	0.027	0.005	1.2	0.061	<0.0001
Bassendean Joel	Biosolids	Bottom	3	7.7	196	378	57	<0.0001	0.021	0.007	2.4	0.14	<0.0001
Bassendean Joel	LAB	Amended	1	7.3	62.8	243	260	<0.0001	0.17	0.004	0.18	0.11	<0.0001
Bassendean Joel	LAB	Amended	2	7.7	82.7	440	31	<0.0001	0.019	0.002	1.7	0.084	<0.0001
Bassendean Joel	LAB	Amended	3	7.2	36.6	374	6.3	<0.0001	<0.005	<0.001	1.1	0.17	<0.0001
Bassendean Joel	LAB	Soil	1	7.7	182	412	210	0.0001	0.37	0.015	1.8	0.085	<0.0001
Bassendean Joel	LAB	Soil	2	7.7	172	413	200	<0.0001	0.095	0.004	3.6	0.073	<0.0001
Bassendean Joel	LAB	Soil	3	7.8	126	333	63	<0.0001	0.025	0.006	6.3	0.10	<0.0001
Bassendean Joel	LAB	Bottom	1	7.7	124	286	170	<0.0001	0.11	0.011	0.5	0.11	<0.0001
Bassendean Joel	LAB	Bottom	2	7.6	228	426	110	<0.0001	0.026	0.004	1.5	0.08	<0.0001
Bassendean Joel	LAB	Bottom	3	7.6	142	384	50	<0.0001	0.009	0.003	2.1	0.15	<0.0001
Fairbridge Duplex	Biosolids	Amended	1	6.0	177	446	70	<0.0001	0.18	0.002	0.39	0.20	<0.0001
Fairbridge Duplex	Biosolids	Amended	2	5.9	216	449	51	<0.0001	0.18	0.001	0.81	0.26	<0.0001
Fairbridge Duplex	Biosolids	Amended	3	5.9	162	398	33	<0.0001	0.12	<0.001	1.4	0.32	<0.0001
Fairbridge Duplex	Biosolids	Soil	1	7.0	146	391	290	<0.0001	0.55	0.004	0.53	0.074	<0.0001
Fairbridge Duplex	Biosolids	Soil	2	7.1	183	257	360	<0.0001	0.11	0.004	0.68	0.36	<0.0001
Fairbridge Duplex	Biosolids	Soil	3	7.4	160	323	130	<0.0001	0.055	0.003	1.0	0.48	<0.0001
Fairbridge Duplex	Biosolids	Bottom	1	7.3	160	345	170	<0.0001	0.29	0.003	0.19	0.17	<0.0001
Fairbridge Duplex	Biosolids	Bottom	2	7.4	230	421	160	<0.0001	0.026	0.002	0.33	0.25	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	Biosolids	Bottom	3	7.5	130	386	77	<0.0001	0.036	0.002	0.52	0.37	<0.0001
Fairbridge Duplex	LAB	Amended	1	7.6	225	418	200	<0.0001	0.10	0.003	0.88	0.17	<0.0001
Fairbridge Duplex	LAB	Amended	2	7.4	25.7	432	15	<0.0001	0.034	<0.001	0.41	0.10	<0.0001
Fairbridge Duplex	LAB	Amended	3	7.3	68.3	382	18	<0.0001	0.022	<0.001	1.2	0.20	<0.0001
Fairbridge Duplex	LAB	Soil	1	7.0	176	358	370	<0.0001	0.64	0.005	0.71	0.18	<0.0001
Fairbridge Duplex	LAB	Soil	2	7.2	222	314	520	<0.0001	0.22	0.006	1.1	0.29	<0.0001
Fairbridge Duplex	LAB	Soil	3	7.4	172	323	130	<0.0001	0.077	0.004	1.7	0.40	<0.0001
Fairbridge Duplex	LAB	Bottom	1	8.1	158	354	370	<0.0001	0.62	0.007	0.17	0.21	<0.0001
Fairbridge Duplex	LAB	Bottom	2	7.5	202	410	300	<0.0001	0.13	0.003	0.34	0.25	<0.0001
Fairbridge Duplex	LAB	Bottom	3	7.4	170	386	86	<0.0001	0.016	0.002	0.59	0.48	<0.0001
Spearwood	Biosolids	Amended	1	8.3	47.2	368	52	0.0001	2.5	0.005	0.29	0.11	<0.0001
Spearwood	Biosolids	Amended	2	7.9	18.6	415	29	<0.0001	0.72	0.004	0.91	0.056	<0.0001
Spearwood	Biosolids	Amended	3	8.6	4.3	338	2.5	<0.0001	0.40	<0.001	0.24	0.21	<0.0001
Spearwood	Biosolids	Soil	1	7.7	92.0	392	150	<0.0001	0.081	0.004	0.63	0.16	<0.0001
Spearwood	Biosolids	Soil	2	8.3	90.1	373	170	<0.0001	0.27	0.006	7.0	0.20	<0.0001
Spearwood	Biosolids	Soil	3	8.2	79	289	43	<0.0001	0.018	0.002	5.1	0.21	<0.0001
Spearwood	Biosolids	Bottom	1	8.1	64.2	381	75	<0.0001	0.054	0.002	0.13	0.11	<0.0001
Spearwood	Biosolids	Bottom	2	8.2	95.2	399	96	<0.0001	0.023	0.003	1.1	0.13	<0.0001
Spearwood	Biosolids	Bottom	3	8.2	55.2	385	29	<0.0001	0.007	0.001	1.9	0.18	<0.0001
Spearwood	LAB	Amended	1	7.9	57.3	373	82	<0.0001	1.3	0.003	0.46	0.14	<0.0001
Spearwood	LAB	Amended	2	8.1	16.7	414	25	<0.0001	0.13	<0.001	0.71	0.14	<0.0001
Spearwood	LAB	Amended	3	9.1	3.3	331	1.5	<0.0001	0.33	<0.001	0.22	0.22	<0.0001
Spearwood	LAB	Soil	1	7.8	103	406	160	<0.0001	0.073	0.004	1.5	0.20	<0.0001
Spearwood	LAB	Soil	2	8.0	125	384	230	<0.0001	0.05	0.007	7.7	0.25	<0.0001

Soil Type	Amendment	Leachate	Time	pH	EC	Eh	DOC	Ag	Al	As	B	Ba	Be
					mS/m	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	LAB	Soil	3	8.3	91.4	296	50	<0.0001	0.007	0.005	10	0.27	<0.0001
Spearwood	LAB	Bottom	1	8.2	93.0	403	67	<0.0001	0.051	0.003	0.19	0.11	<0.0001
Spearwood	LAB	Bottom	2	8.1	129	410	95	<0.0001	0.020	0.002	1.1	0.15	<0.0001
Spearwood	LAB	Bottom	3	8.3	59.4	376	36	<0.0001	<0.005	0.002	2.3	0.18	<0.0001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/	mg/	mg/L	mg/L
Bassendean Ellenbrook	Biosolids	Amended	1	2.6	<0.0001	0.0008	0.0006	0.0055	0.058	<0.00	3.2	0.8	0.002	0.004
Bassendean Ellenbrook	Biosolids	Amended	2	33.6	0.0001	0.0006	0.0012	0.019	0.1	<0.00	4.9	15.2	0.066	0.001
Bassendean Ellenbrook	Biosolids	Amended	3	19.3	0.0001	0.0003	<0.0005	0.0084	0.046	<0.00	1.3	7.2	0.047	<0.001
Bassendean Ellenbrook	Biosolids	Soil	1	15.5	0.0001	0.0008	0.0021	0.02	0.65	<0.00	18.8	8.4	0.031	0.001
Bassendean Ellenbrook	Biosolids	Soil	2	27.0	<0.0001	0.0021	0.0048	0.0041	4.2	<0.00	13.9	14.9	0.043	0.001
Bassendean Ellenbrook	Biosolids	Soil	3	25.0	<0.0001	0.0012	0.0024	0.0042	3.5	<0.00	10.8	15.6	0.031	<0.001
Bassendean Ellenbrook	Biosolids	Bottom	1	13.5	<0.0001	0.0015	0.0045	0.014	0.63	<0.00	14.9	7.2	0.024	<0.001
Bassendean Ellenbrook	Biosolids	Bottom	2	84.8	<0.0001	0.0021	0.0013	0.0038	6.4	<0.00	17.1	48.8	0.11	<0.001
Bassendean Ellenbrook	Biosolids	Bottom	3	40.0	<0.0001	0.0007	0.0011	0.0024	1.7	<0.00	8.3	24.4	0.048	<0.001
Bassendean Ellenbrook	LAB	Amended	1	16.9	<0.0001	0.0020	0.0019	0.28	0.17	<0.00	8.6	7.6	0.011	0.012
Bassendean Ellenbrook	LAB	Amended	2	69.8	<0.0001	0.0008	<0.0005	0.036	0.058	<0.00	5.2	22.7	0.005	0.014
Bassendean Ellenbrook	LAB	Amended	3	40.4	<0.0001	0.0003	0.0005	0.011	0.031	<0.00	2.5	11.3	0.001	0.008
Bassendean Ellenbrook	LAB	Soil	1	15.6	0.0001	0.0010	0.0022	0.032	0.74	<0.00	16.6	8.4	0.032	0.001
Bassendean Ellenbrook	LAB	Soil	2	26.4	<0.0001	0.0024	0.0057	0.0047	3.5	<0.00	14.2	14.6	0.04	0.001
Bassendean Ellenbrook	LAB	Soil	3	22.5	<0.0001	0.0012	0.0021	0.0032	3.5	<0.00	11.4	13.9	0.028	<0.001
Bassendean Ellenbrook	LAB	Bottom	1	12.3	<0.0001	0.0016	0.0035	0.019	0.65	<0.00	13.4	6.4	0.022	<0.001
Bassendean Ellenbrook	LAB	Bottom	2	72.6	<0.0001	0.0017	0.0017	0.0035	3.7	<0.00	13.4	41.5	0.084	<0.001

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/	mg/	mg/L	mg/L
Bassendean Ellenbrook	LAB	Bottom	3	42.9	<0.0001	0.0009	0.0011	0.0026	2.9	<0.00	10.6	26.8	0.054	<0.001
Bassendean Joel	Biosolids	Amended	1	10.8	<0.0001	0.0023	0.001	0.04	0.16	<0.00	25.6	5.1	0.004	0.013
Bassendean Joel	Biosolids	Amended	2	47.1	<0.0001	0.0004	0.0007	0.035	0.065	<0.00	5.9	23.8	0.003	0.006
Bassendean Joel	Biosolids	Amended	3	32.9	<0.0001	0.0001	<0.0005	0.012	0.009	<0.00	2.7	12.4	0.008	0.002
Bassendean Joel	Biosolids	Soil	1	79.1	0.0002	0.0025	0.0068	0.12	0.65	<0.00	142	39.5	0.026	0.027
Bassendean Joel	Biosolids	Soil	2	112	<0.0001	0.0016	0.0044	0.0061	1.2	<0.00	90.1	60.8	0.072	0.007
Bassendean Joel	Biosolids	Soil	3	149	<0.0001	0.0007	0.0015	0.01	0.14	<0.00	60.4	78.3	0.045	0.012
Bassendean Joel	Biosolids	Bottom	1	45.8	<0.0001	0.0023	0.0030	0.051	0.51	<0.00	101	25.9	0.021	0.017
Bassendean Joel	Biosolids	Bottom	2	95.7	<0.0001	0.0007	0.0011	0.012	0.35	<0.00	50.7	51.9	0.06	0.007
Bassendean Joel	Biosolids	Bottom	3	185	<0.0001	0.0006	0.0021	0.012	0.10	<0.00	46.7	86.7	0.023	0.005
Bassendean Joel	LAB	Amended	1	37.5	0.0002	0.0033	0.0022	0.48	0.28	<0.00	28.6	17.1	0.007	0.021
Bassendean Joel	LAB	Amended	2	70.4	<0.0001	0.0007	<0.0005	0.015	0.019	<0.00	6.6	27.8	0.000	0.014
Bassendean Joel	LAB	Amended	3	30.9	<0.0001	0.0001	<0.0005	0.013	<0.005	<0.00	2.1	10.2	0.016	0.002
Bassendean Joel	LAB	Soil	1	78.0	0.0003	0.0023	0.0066	0.15	0.55	<0.00	133	38.4	0.012	0.025
Bassendean Joel	LAB	Soil	2	133	<0.0001	0.0015	0.0032	0.014	0.68	<0.00	76.5	74.3	0.031	0.007
Bassendean Joel	LAB	Soil	3	110	<0.0001	0.0010	0.0026	0.0097	0.94	<0.00	38.9	54.7	0.058	0.004
Bassendean Joel	LAB	Bottom	1	58.3	0.0002	0.0036	0.0035	0.22	0.37	<0.00	104	31.9	0.019	0.024
Bassendean Joel	LAB	Bottom	2	187	<0.0001	0.001	0.0014	0.015	0.39	<0.00	60.5	106	0.03	0.008
Bassendean Joel	LAB	Bottom	3	134	<0.0001	0.0007	0.0014	0.011	0.3	<0.00	27.6	63.3	0.034	0.003
Fairbridge Duplex	Biosolids	Amended	1	179	0.0003	0.0017	0.0015	0.015	0.16	<0.00	63.8	50.6	0.037	0.002
Fairbridge Duplex	Biosolids	Amended	2	266	0.0005	0.0009	0.0007	0.0099	0.16	0.000	28.9	60.2	0.1	<0.001
Fairbridge Duplex	Biosolids	Amended	3	204	0.0005	0.0006	0.0007	0.011	0.091	<0.00	12.1	36.3	0.085	<0.001
Fairbridge Duplex	Biosolids	Soil	1	146	0.0006	0.0092	0.0077	0.017	3.7	<0.00	97.5	33.8	0.66	0.009
Fairbridge Duplex	Biosolids	Soil	2	177	<0.0001	0.0092	0.0037	0.0032	19	<0.00	96.8	45.6	1.3	0.004

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/	mg/	mg/L	mg/L
Fairbridge Duplex	Biosolids	Soil	3	168	<0.0001	0.0058	0.0022	0.0025	4.7	<0.00	75.6	44	0.94	0.003
Fairbridge Duplex	Biosolids	Bottom	1	140	0.0004	0.0074	0.0032	0.015	4.5	0.000	92.5	33.2	0.8	0.008
Fairbridge Duplex	Biosolids	Bottom	2	223	<0.0001	0.0058	0.0013	0.0016	2	<0.00	96.9	55.8	1.4	0.003
Fairbridge Duplex	Biosolids	Bottom	3	130	<0.0001	0.0032	0.0014	0.0028	5.6	<0.00	56.2	33.2	0.58	0.003
Fairbridge Duplex	LAB	Amended	1	212	0.0001	0.0091	0.0019	0.14	0.41	<0.00	62.8	61.8	0.018	0.035
Fairbridge Duplex	LAB	Amended	2	27.6	<0.0001	0.0002	<0.0005	0.0027	0.049	<0.00	4.2	5.8	0.004	0.001
Fairbridge Duplex	LAB	Amended	3	79.9	<0.0001	0.0004	0.0007	0.013	0.043	<0.00	5.9	12.1	0.016	0.004
Fairbridge Duplex	LAB	Soil	1	177	0.0007	0.011	0.0077	0.015	5.5	<0.00	111	45.2	0.81	0.009
Fairbridge Duplex	LAB	Soil	2	195	<0.0001	0.012	0.0052	0.0037	26	<0.00	127	53.6	1.3	0.004
Fairbridge Duplex	LAB	Soil	3	171	<0.0001	0.0056	0.0027	0.0011	4.6	<0.00	81.1	47.9	0.98	0.002
Fairbridge Duplex	LAB	Bottom	1	174	0.0005	0.013	0.0064	0.01	14	<0.00	110	43	1	0.01
Fairbridge Duplex	LAB	Bottom	2	168	<0.0001	0.0078	0.0026	0.0015	14	<0.00	98.5	46.1	1.1	0.004
Fairbridge Duplex	LAB	Bottom	3	162	<0.0001	0.0041	0.0014	0.0015	1.5	<0.00	68.6	44.3	0.86	0.002
Spearwood	Biosolids	Amended	1	7.7	<0.0001	0.0021	0.0025	0.034	1.1	<0.00	9.8	1.3	0.001	0.027
Spearwood	Biosolids	Amended	2	22.4	<0.0001	0.0003	0.0008	0.018	0.42	<0.00	1.8	5.6	0.001	0.01
Spearwood	Biosolids	Amended	3	4.6	<0.0001	<0.0001	0.0006	0.0024	0.22	<0.00	0.1	0.4	0.000	<0.001
Spearwood	Biosolids	Soil	1	124	0.0001	0.0037	0.0058	0.016	0.056	<0.00	17.2	12.1	0.034	0.032
Spearwood	Biosolids	Soil	2	95.6	<0.0001	0.0047	0.0041	0.0007	0.28	<0.00	23.5	24.8	0.091	0.051
Spearwood	Biosolids	Soil	3	82.6	<0.0001	0.0014	0.0012	0.0029	0.038	<0.00	19.2	13.4	0.012	0.018
Spearwood	Biosolids	Bottom	1	99.9	<0.0001	0.0014	0.002	0.0077	0.037	<0.00	13.7	10.4	0.012	0.012
Spearwood	Biosolids	Bottom	2	122	<0.0001	0.0025	0.0013	0.0014	0.62	<0.00	14.8	20.1	0.15	0.013
Spearwood	Biosolids	Bottom	3	71.1	<0.0001	0.001	0.0008	0.0027	0.035	<0.00	12	7	0.017	0.01
Spearwood	LAB	Amended	1	15.2	<0.0001	0.0022	0.0022	0.19	0.6	<0.00	9.5	5.4	0.001	0.015
Spearwood	LAB	Amended	2	17.7	<0.0001	0.0003	<0.0005	0.015	0.078	<0.00	1.9	3.9	0.000	0.003

Soil Type	Amendment	Leachate	Time	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/	mg/	mg/L	mg/L
Spearwood	LAB	Amended	3	3.9	<0.0001	<0.0001	0.0006	0.0008	0.17	<0.00	<0.1	0.3	0.000	<0.001
Spearwood	LAB	Soil	1	137	0.0001	0.0031	0.0048	0.013	0.056	<0.00	19.9	14.3	0.018	0.03
Spearwood	LAB	Soil	2	130	<0.0001	0.0026	0.0083	0.0028	1.4	<0.00	33	35.7	0.087	0.019
Spearwood	LAB	Soil	3	76.6	<0.0001	0.0021	0.0017	0.0045	0.042	<0.00	27.5	18.7	0.006	0.033
Spearwood	LAB	Bottom	1	153	0.0001	0.001	0.0018	0.0055	0.019	<0.00	17.3	18	0.011	0.008
Spearwood	LAB	Bottom	2	162	<0.0001	0.0014	0.0013	0.0043	0.61	<0.00	23.2	25	0.097	0.007
Spearwood	LAB	Bottom	3	69.1	<0.0001	0.0008	0.0009	0.0056	0.037	<0.00	14.7	8.4	0.003	0.014

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean	Biosolids	Amended	1	5.0	0.006	8.2	0.0009	5.5	0.0001	<0.001	0.0004	<0.0001	0.0034
Bassendean	Biosolids	Amended	2	10.4	0.003	18	0.0008	12	<0.0001	<0.001	<0.0001	<0.0001	0.0027
Bassendean	Biosolids	Amended	3	11.2	0.001	10	0.0003	2.9	<0.0001	<0.001	<0.0001	<0.0001	0.0012
Bassendean	Biosolids	Soil	1	27.1	0.003	5.9	0.0033	8.8	0.0002	<0.001	0.0003	0.0009	0.030
Bassendean	Biosolids	Soil	2	17.2	0.005	6.6	0.0024	4.1	0.0002	<0.001	0.0020	0.0003	0.050
Bassendean	Biosolids	Soil	3	13.4	0.003	11	0.0021	4.2	0.0001	<0.001	0.0004	<0.0001	0.031
Bassendean	Biosolids	Bottom	1	18.1	0.005	12	0.0030	15	0.0001	<0.001	0.0002	<0.0001	0.020
Bassendean	Biosolids	Bottom	2	16.7	0.002	8.0	0.0015	11	<0.0001	<0.001	0.0002	<0.0001	0.013
Bassendean	Biosolids	Bottom	3	10.0	0.001	7.2	0.0009	5.2	<0.0001	<0.001	0.0015	<0.0001	0.0079
Bassendean	LAB	Amended	1	10.0	0.008	2.0	0.0009	11	0.0003	<0.001	0.0005	<0.0001	0.0083
Bassendean	LAB	Amended	2	11.3	0.002	2.3	0.0005	20	0.0003	<0.001	<0.0001	<0.0001	0.0019
Bassendean	LAB	Amended	3	6.3	<0.001	2.1	0.0001	4.9	0.0002	<0.001	<0.0001	<0.0001	0.0009
Bassendean	LAB	Soil	1	24.9	0.004	6.0	0.0045	8.7	0.0002	<0.001	0.0003	0.0006	0.028
Bassendean	LAB	Soil	2	19.6	0.005	2.1	0.0027	4.7	0.0003	<0.001	0.0010	0.0004	0.061

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean	LAB	Soil	3	13.4	0.002	3.4	0.0017	5.2	0.0001	<0.001	0.0005	<0.0001	0.032
Bassendean	LAB	Bottom	1	17.1	0.004	3.8	0.0034	13	0.0001	<0.001	0.0004	<0.0001	0.022
Bassendean	LAB	Bottom	2	18.9	0.002	0.9	0.0018	8.4	0.0001	<0.001	0.0003	0.0004	0.012
Bassendean	LAB	Bottom	3	9.1	0.001	1.9	0.0007	7.5	<0.0001	<0.001	0.0004	0.0023	0.0080
Bassendean Joel	Biosolids	Amended	1	19.9	0.009	14	<0.0001	17	0.0002	<0.001	<0.0001	0.0002	0.010
Bassendean Joel	Biosolids	Amended	2	14.4	0.002	13	0.0002	11	0.0002	<0.001	<0.0001	<0.0001	0.0034
Bassendean Joel	Biosolids	Amended	3	19.1	<0.001	5	<0.0001	6.3	<0.0001	<0.001	0.0003	<0.0001	0.0009
Bassendean Joel	Biosolids	Soil	1	181	0.007	3.6	0.0072	59	0.0004	0.002	0.0034	0.0014	0.034
Bassendean Joel	Biosolids	Soil	2	123	0.004	7.1	0.0019	17	0.0002	<0.001	0.0005	0.0001	0.022
Bassendean Joel	Biosolids	Soil	3	91.3	0.002	2.4	0.0003	40	0.0004	<0.001	<0.0001	<0.0001	0.0028
Bassendean Joel	Biosolids	Bottom	1	95.0	0.008	5.4	0.0042	36	0.0003	0.001	<0.0001	0.0007	0.0084
Bassendean Joel	Biosolids	Bottom	2	38.0	0.002	4.4	0.0004	20	0.0002	<0.001	<0.0001	<0.0001	0.0044
Bassendean Joel	Biosolids	Bottom	3	43.8	0.002	2.8	0.0004	36	0.0002	<0.001	0.0002	<0.0001	0.0025
Bassendean Joel	LAB	Amended	1	25.9	0.016	2.0	0.0002	19	0.0004	0.002	0.0005	<0.0001	0.0047
Bassendean Joel	LAB	Amended	2	30.5	0.002	1.5	<0.0001	17	0.0001	<0.001	<0.0001	<0.0001	0.0011
Bassendean Joel	LAB	Amended	3	13.8	<0.001	0.5	0.0002	4.5	<0.0001	<0.001	0.0007	<0.0001	<0.0005
Bassendean Joel	LAB	Soil	1	177	0.007	3.7	0.0044	57	0.0004	0.002	<0.0001	0.0013	0.027
Bassendean Joel	LAB	Soil	2	81.5	0.004	3.6	0.0008	23	<0.0001	<0.001	<0.0001	<0.0001	0.0077
Bassendean Joel	LAB	Soil	3	71.4	0.002	3.9	0.0002	23	0.0001	<0.001	<0.0001	<0.0001	0.0068
Bassendean Joel	LAB	Bottom	1	92.3	0.010	2.9	0.0041	31	0.0004	0.002	<0.0001	0.0006	0.011
Bassendean Joel	LAB	Bottom	2	52.5	0.002	2.3	0.0003	35	0.0001	<0.001	<0.0001	<0.0001	0.0039
Bassendean Joel	LAB	Bottom	3	30.0	0.002	1.8	0.0003	25	0.0001	<0.001	0.0004	<0.0001	0.0027
Fairbridge Duplex	Biosolids	Amended	1	32.3	0.005	5.5	0.0002	28	0.0002	<0.001	<0.0001	0.0005	0.0027
Fairbridge Duplex	Biosolids	Amended	2	15.6	0.002	2.6	0.0004	30	<0.0001	<0.001	<0.0001	<0.0001	0.0023

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fairbridge Duplex	Biosolids	Amended	3	22.1	0.002	2.0	0.0002	21	<0.0001	<0.001	0.0001	<0.0001	<0.0005
Fairbridge Duplex	Biosolids	Soil	1	59.1	0.006	1.6	0.0055	30	0.0003	0.002	0.0007	0.0034	0.0095
Fairbridge Duplex	Biosolids	Soil	2	48.1	0.005	0.5	0.0007	12	<0.0001	0.001	0.0007	0.0002	0.0022
Fairbridge Duplex	Biosolids	Soil	3	30.4	0.003	0.3	0.0002	8.5	<0.0001	<0.001	<0.0001	<0.0001	0.0016
Fairbridge Duplex	Biosolids	Bottom	1	50.9	0.005	1.0	0.0024	29	0.0001	0.001	<0.0001	0.0030	0.0041
Fairbridge Duplex	Biosolids	Bottom	2	36.9	0.002	0.1	0.0001	25	<0.0001	<0.001	<0.0001	<0.0001	0.0006
Fairbridge Duplex	Biosolids	Bottom	3	19.3	0.002	0.5	0.0003	18	<0.0001	<0.001	0.0003	<0.0001	0.0013
Fairbridge Duplex	LAB	Amended	1	51	0.011	0.8	0.0004	61	0.0008	0.002	<0.0001	0.0004	<0.0005
Fairbridge Duplex	LAB	Amended	2	4.8	<0.001	0.3	0.0001	2.9	<0.0001	<0.001	<0.0001	<0.0001	0.0008
Fairbridge Duplex	LAB	Amended	3	14.2	<0.001	0.6	0.0002	7.9	<0.0001	<0.001	0.0004	<0.0001	0.0008
Fairbridge Duplex	LAB	Soil	1	69.9	0.007	1.8	0.0046	35	0.0002	0.002	<0.0001	0.0041	0.010
Fairbridge Duplex	LAB	Soil	2	49.2	0.006	1.2	0.0009	9.5	<0.0001	0.002	0.0002	0.0004	0.0049
Fairbridge Duplex	LAB	Soil	3	34.9	0.003	0.3	0.0002	3.5	<0.0001	<0.001	<0.0001	<0.0001	0.0021
Fairbridge Duplex	LAB	Bottom	1	60.3	0.007	1.9	0.0044	30	0.0002	0.002	0.0004	0.0035	0.0063
Fairbridge Duplex	LAB	Bottom	2	31.8	0.004	0.8	0.0003	20	<0.0001	<0.001	<0.0001	0.0003	0.0021
Fairbridge Duplex	LAB	Bottom	3	25.1	0.002	0.1	0.0001	18	<0.0001	<0.001	0.0002	<0.0001	0.0008
Spearwood	Biosolids	Amended	1	11.0	0.008	6.0	0.0007	9.7	0.0004	0.002	0.0002	0.0002	0.036
Spearwood	Biosolids	Amended	2	10.7	0.002	4.1	0.0001	2.3	0.0005	<0.001	<0.0001	<0.0001	0.013
Spearwood	Biosolids	Amended	3	2.3	<0.001	0.5	0.0001	0.1	<0.0001	<0.001	<0.0001	<0.0001	0.0074
Spearwood	Biosolids	Soil	1	59.4	0.031	<0.1	0.060	22	0.0003	0.006	0.0008	0.0005	0.013
Spearwood	Biosolids	Soil	2	64.0	0.014	0.9	0.0011	17	<0.0001	0.002	0.0002	<0.0001	0.0041
Spearwood	Biosolids	Soil	3	64.2	0.004	<0.1	0.0003	15	0.0003	0.002	<0.0001	<0.0001	<0.0005
Spearwood	Biosolids	Bottom	1	23.3	0.008	<0.1	0.024	6.6	0.0002	0.002	0.0074	0.0002	0.0016
Spearwood	Biosolids	Bottom	2	28.7	0.004	0.3	0.0005	11	<0.0001	0.001	<0.0001	<0.0001	0.0007

Soil Type	Amendment	Leachate	Time	Na	Ni	P	Pb	S	Sb	Se	Sn	Th	Ti
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Spearwood	Biosolids	Bottom	3	33.0	0.001	<0.1	0.0003	5.9	0.0001	<0.001	0.0002	0.0003	<0.0005
Spearwood	LAB	Amended	1	16.0	0.009	0.6	0.0006	11	0.0005	0.001	0.0010	0.0001	0.024
Spearwood	LAB	Amended	2	9.3	0.001	0.2	0.0004	2.1	0.0001	<0.001	0.0004	<0.0001	0.0018
Spearwood	LAB	Amended	3	1.5	<0.001	<0.1	0.0001	<0.1	<0.0001	<0.001	<0.0001	<0.0001	0.0066
Spearwood	LAB	Soil	1	71.5	0.027	<0.1	0.053	25	0.0004	0.006	0.0004	0.0004	0.0056
Spearwood	LAB	Soil	2	81.5	0.006	<0.1	0.0014	8.6	<0.0001	0.002	0.0003	<0.0001	0.0048
Spearwood	LAB	Soil	3	87.5	0.007	<0.1	0.0004	30	0.0006	0.002	<0.0001	<0.0001	0.0005
Spearwood	LAB	Bottom	1	24.6	0.005	<0.1	0.018	6.0	0.0002	0.002	0.0070	0.0001	0.0034
Spearwood	LAB	Bottom	2	31.2	0.003	<0.1	<0.0001	13	<0.0001	0.001	<0.0001	<0.0001	<0.0005
Spearwood	LAB	Bottom	3	40.8	0.002	<0.1	0.0003	11	0.0001	0.001	0.0001	0.0001	0.0005

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	Biosolids	Amended	1	<0.0001	<0.0001	0.0006	0.11	0.47	<20	<50	<10	<10.0
Bassendean Ellenbrook	Biosolids	Amended	2	<0.0001	<0.0001	0.0036	0.25	2.1	<20	<50	<10	25.2
Bassendean Ellenbrook	Biosolids	Amended	3	<0.0001	<0.0001	0.0008	0.19	1.3	<20	<50	<10	<10.0
Bassendean Ellenbrook	Biosolids	Soil	1	<0.0001	0.0002	0.0019	0.14	1.4	<20	<50	<10	13.2
Bassendean Ellenbrook	Biosolids	Soil	2	<0.0001	0.0002	0.0037	0.11	20	<20	<50	<10	<10.0
Bassendean Ellenbrook	Biosolids	Soil	3	<0.0001	<0.0001	0.0033	0.081	18	<20	<50	<10	<10.0
Bassendean Ellenbrook	Biosolids	Bottom	1	<0.0001	0.0001	0.0013	0.12	2.0	<20	<50	<10	27.7
Bassendean Ellenbrook	Biosolids	Bottom	2	<0.0001	0.0001	0.0044	0.19	12	<20	<50	<10	18.4
Bassendean Ellenbrook	Biosolids	Bottom	3	<0.0001	<0.0001	0.0015	0.059	8.9	<20	<50	<10	12.6

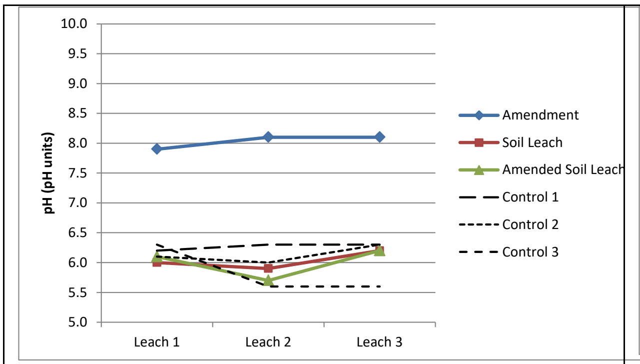
Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Ellenbrook	LAB	Amended	1	<0.0001	0.0001	0.0049	0.13	0.73	<20	<50	<10	14.6
Bassendean Ellenbrook	LAB	Amended	2	<0.0001	<0.0001	0.0009	0.073	3.6	<20	<50	<10	40.4
Bassendean Ellenbrook	LAB	Amended	3	<0.0001	<0.0001	0.0006	0.053	3.1	<20	<50	<10	12.7
Bassendean Ellenbrook	LAB	Soil	1	<0.0001	0.0002	0.0021	0.14	1.5	<20	<50	<10	11.4
Bassendean Ellenbrook	LAB	Soil	2	<0.0001	0.0003	0.0039	0.092	19	<20	<50	<10	<10.0
Bassendean Ellenbrook	LAB	Soil	3	<0.0001	<0.0001	0.0016	0.056	19	<20	<50	<10	<10.0
Bassendean Ellenbrook	LAB	Bottom	1	<0.0001	0.0001	0.0014	0.13	2.1	<20	<50	<10	18.5
Bassendean Ellenbrook	LAB	Bottom	2	0.0001	<0.0001	0.0017	0.20	11	<20	<50	<10	14.7
Bassendean Ellenbrook	LAB	Bottom	3	0.0004	<0.0001	0.0005	0.044	10	<20	<50	<10	17.9
Bassendean Joel	Biosolids	Amended	1	<0.0001	0.0004	0.014	0.04	1.3	<20	<50	<10	26.7
Bassendean Joel	Biosolids	Amended	2	<0.0001	<0.0001	0.0096	0.055	4.5	<20	<50	<10	17
Bassendean Joel	Biosolids	Amended	3	<0.0001	<0.0001	0.004	0.034	2.0	<20	<50	<10	14.4
Bassendean Joel	Biosolids	Soil	1	<0.0001	0.0018	0.018	0.079	19	<20	200	<10	133
Bassendean Joel	Biosolids	Soil	2	<0.0001	0.0011	0.010	0.068	27	<20	<50	<10	21.2
Bassendean Joel	Biosolids	Soil	3	<0.0001	0.0061	0.0038	0.045	26	<20	<50	<10	85.6
Bassendean Joel	Biosolids	Bottom	1	<0.0001	0.0008	0.012	0.046	10	<20	81	<10	68.7
Bassendean Joel	Biosolids	Bottom	2	<0.0001	0.0003	0.016	0.029	6.5	<20	<50	<10	44.4
Bassendean Joel	Biosolids	Bottom	3	<0.0001	0.0014	0.007	0.028	11	<20	<50	<10	80.5
Bassendean Joel	LAB	Amended	1	<0.0001	0.0025	0.0084	0.14	1.6	<20	<50	<10	23.9
Bassendean Joel	LAB	Amended	2	<0.0001	0.0006	0.0079	0.033	3.1	<20	<50	<10	41.8
Bassendean Joel	LAB	Amended	3	<0.0001	<0.0001	0.0030	0.029	1.1	<20	<50	<10	11.1
Bassendean Joel	LAB	Soil	1	<0.0001	0.0021	0.019	0.085	21	<20	190	<10	128
Bassendean Joel	LAB	Soil	2	<0.0001	0.0011	0.0066	0.058	21	<20	<50	<10	40.4
Bassendean Joel	LAB	Soil	3	<0.0001	0.0012	0.006	0.039	25	<20	<50	<10	46.2

Soil Type	Amendment	Leachate	Time	Tl	U	V	Zn	Si	Br	Cl	F	SO_4
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bassendean Joel	LAB	Bottom	1	<0.0001	0.0013	0.010	0.091	11	<20	59	<10	52.7
Bassendean Joel	LAB	Bottom	2	<0.0001	0.0001	0.0072	0.033	10	<20	<50	<10	87.4
Bassendean Joel	LAB	Bottom	3	<0.0001	0.0002	0.0076	0.032	10	<20	<50	<10	56.9
Fairbridge Duplex	Biosolids	Amended	1	<0.0001	0.0002	0.0061	0.063	12	<20	<50	<10	51.5
Fairbridge Duplex	Biosolids	Amended	2	<0.0001	<0.0001	0.0045	0.12	11	<20	<50	<10	57.3
Fairbridge Duplex	Biosolids	Amended	3	<0.0001	<0.0001	0.0040	0.15	7.8	<20	<50	<10	48.4
Fairbridge Duplex	Biosolids	Soil	1	0.0002	0.0034	0.024	0.13	11	<20	<50	<10	48.7
Fairbridge Duplex	Biosolids	Soil	2	<0.0001	0.0002	0.0052	0.12	11	<20	<50	<10	19.1
Fairbridge Duplex	Biosolids	Soil	3	<0.0001	0.0001	0.0026	0.10	12	<20	<50	<10	13.0
Fairbridge Duplex	Biosolids	Bottom	1	0.0003	0.0020	0.013	0.04	9.3	<20	<50	<10	50.5
Fairbridge Duplex	Biosolids	Bottom	2	<0.0001	0.0001	0.0015	0.06	9.7	<20	<50	<10	51.1
Fairbridge Duplex	Biosolids	Bottom	3	<0.0001	0.0002	0.0014	0.055	8.8	<20	<50	<10	37.4
Fairbridge Duplex	LAB	Amended	1	<0.0001	0.028	0.012	0.045	5.3	<20	<50	<10	137
Fairbridge Duplex	LAB	Amended	2	<0.0001	<0.0001	0.0022	0.03	0.73	<20	<50	<10	<10.0
Fairbridge Duplex	LAB	Amended	3	<0.0001	<0.0001	0.0050	0.035	2.4	<20	<50	<10	20.6
Fairbridge Duplex	LAB	Soil	1	0.0002	0.0046	0.032	0.056	11	<20	53	<10	53.8
Fairbridge Duplex	LAB	Soil	2	<0.0001	0.0004	0.010	0.21	12	<20	<50	<10	11.9
Fairbridge Duplex	LAB	Soil	3	<0.0001	0.0002	0.0028	0.11	14	<20	<50	<10	<10.0
Fairbridge Duplex	LAB	Bottom	1	0.0002	0.0067	0.032	0.037	9.3	<20	<50	<10	39.9
Fairbridge Duplex	LAB	Bottom	2	<0.0001	0.0002	0.0041	0.15	8.8	<20	<50	<10	43.9
Fairbridge Duplex	LAB	Bottom	3	<0.0001	0.0002	0.0010	0.094	9.2	<20	<50	<10	36.8
Spearwood	Biosolids	Amended	1	<0.0001	0.0009	0.010	0.023	2.4	<20	<50	<10	17.7
Spearwood	Biosolids	Amended	2	<0.0001	<0.0001	0.0066	0.027	2.2	<20	<50	<10	<10.0
Spearwood	Biosolids	Amended	3	<0.0001	<0.0001	0.0011	0.008	0.45	<20	<50	<10	<10.0

Soil Type	**Amendment**	**Leachate**	**Time**	**Tl**	**U**	**V**	**Zn**	**Si**	**Br**	**Cl**	**F**	**SO_4**
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Spearwood	Biosolids	Soil	1	0.0001	0.0030	0.0047	0.092	8.8	<20	62	<10	39.7
Spearwood	Biosolids	Soil	2	<0.0001	0.0018	0.0074	0.030	19	<20	<50	<10	33.6
Spearwood	Biosolids	Soil	3	<0.0001	0.0031	0.0032	0.019	9.7	<20	<50	<10	31.7
Spearwood	Biosolids	Bottom	1	<0.0001	0.0017	0.0012	0.027	3.6	<20	<50	<10	10.7
Spearwood	Biosolids	Bottom	2	<0.0001	0.0009	0.0024	0.026	4.6	<20	<50	<10	19.4
Spearwood	Biosolids	Bottom	3	0.0001	0.0013	0.0015	0.018	3.8	<20	<50	<10	15.1
Spearwood	LAB	Amended	1	<0.0001	0.0016	0.0039	0.055	1.8	<20	<50	<10	17.1
Spearwood	LAB	Amended	2	<0.0001	0.0003	0.0019	0.030	1.3	<20	<50	<10	<10.0
Spearwood	LAB	Amended	3	<0.0001	<0.0001	0.0006	0.004	0.33	<20	<50	<10	<10.0
Spearwood	LAB	Soil	1	0.0001	0.0030	0.0030	0.061	13	<20	51	<10	43.7
Spearwood	LAB	Soil	2	<0.0001	0.0008	0.0087	0.033	21	<20	<50	<10	12.6
Spearwood	LAB	Soil	3	<0.0001	0.0051	0.0043	0.021	21	<20	<50	<10	67.8
Spearwood	LAB	Bottom	1	<0.0001	0.0020	0.0020	0.029	4.6	<20	<50	<10	<10.0
Spearwood	LAB	Bottom	2	<0.0001	0.0004	0.0010	0.023	4.2	<20	<50	<10	27.2
Spearwood	LAB	Bottom	3	<0.0001	0.0020	0.0018	0.020	4.7	<20	<50	<10	25.1

Appendix 12: Tall column chart.

A12-1. Alkaloam



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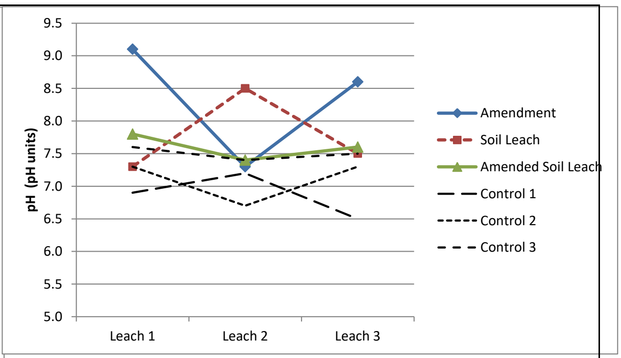

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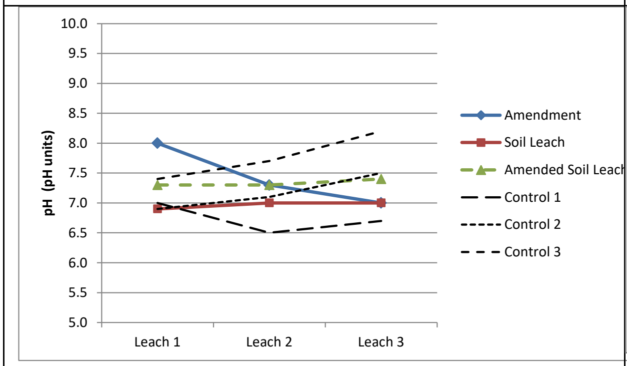

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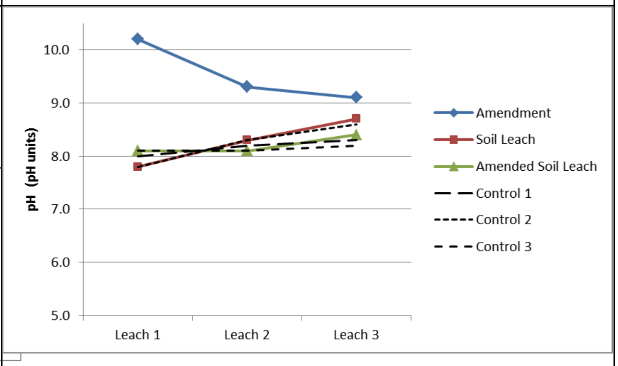

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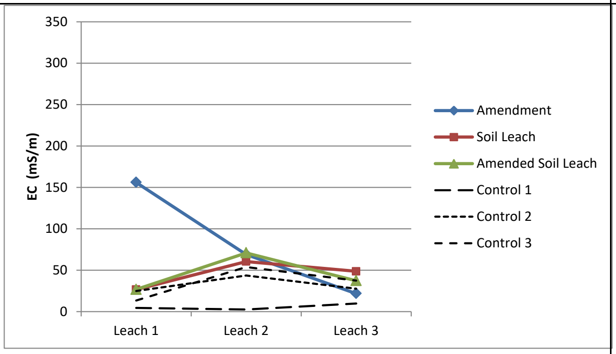

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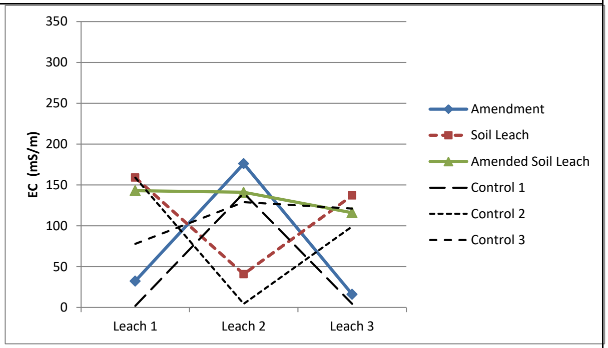

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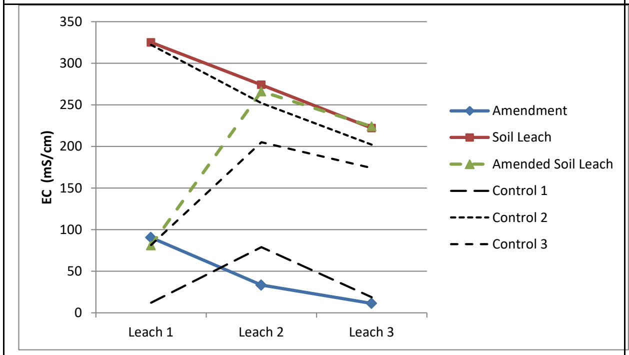

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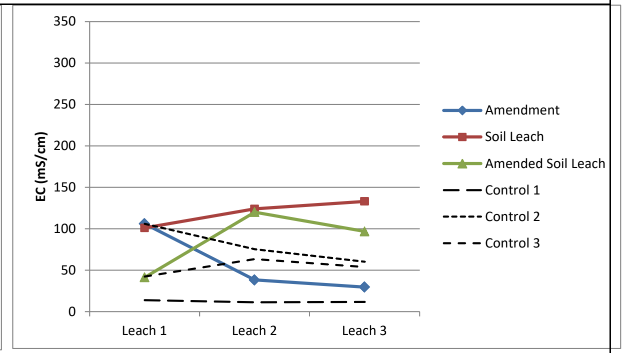
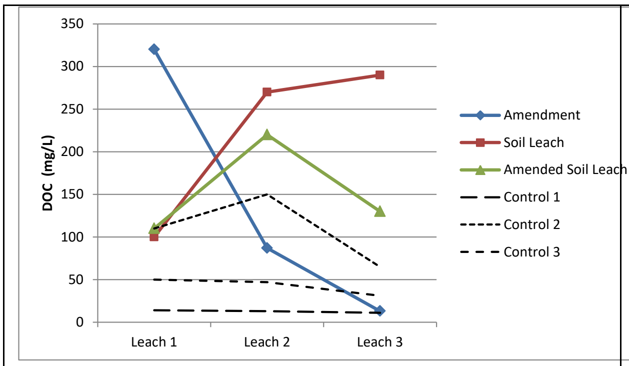


Spearwood

A12-1. Alkaloam



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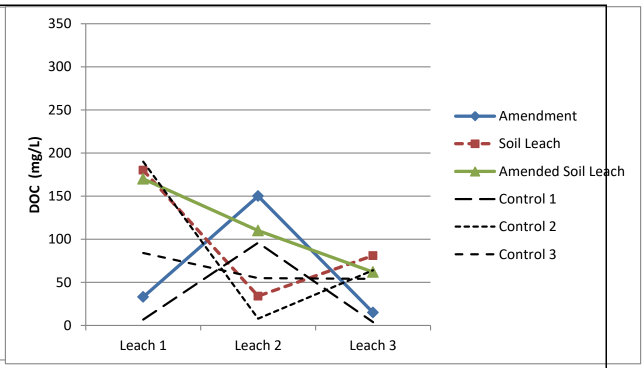

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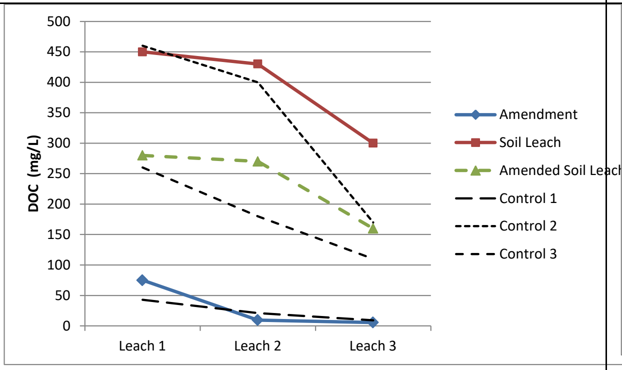

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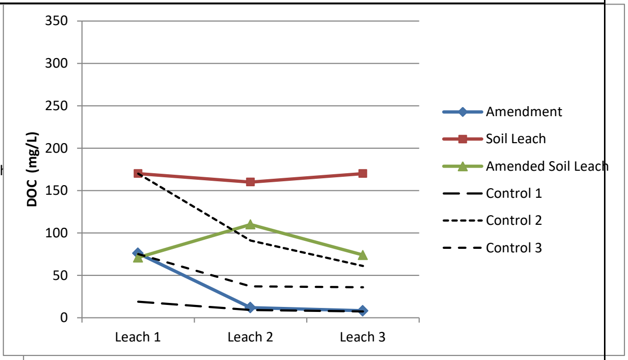

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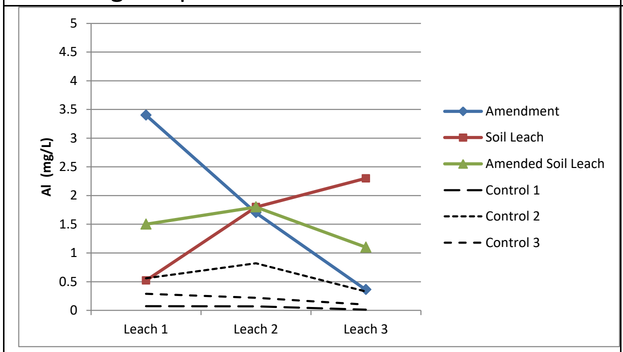

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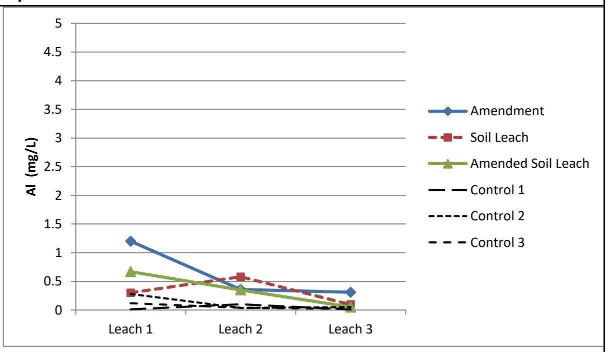

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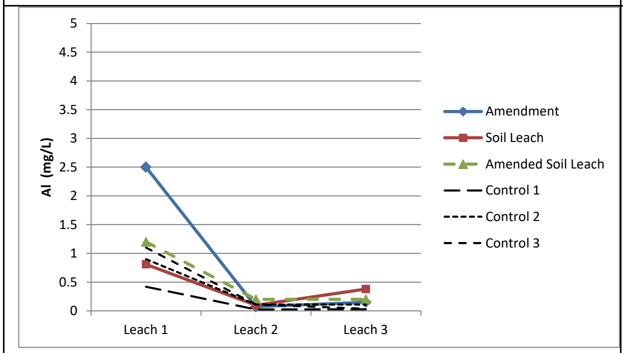

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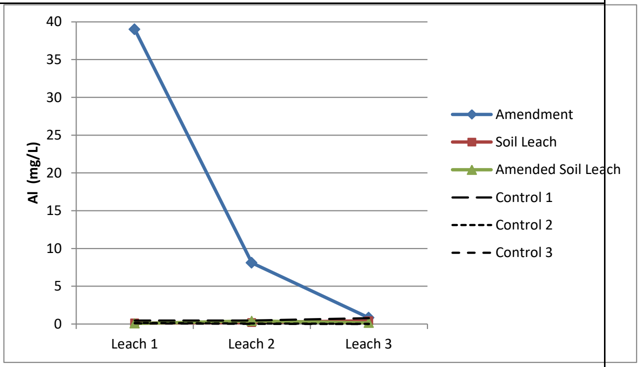

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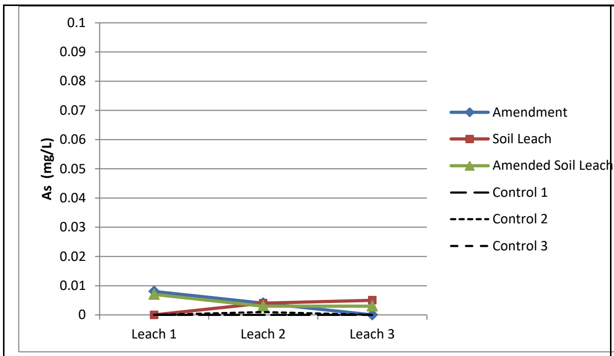
A12-1. Alkaloam



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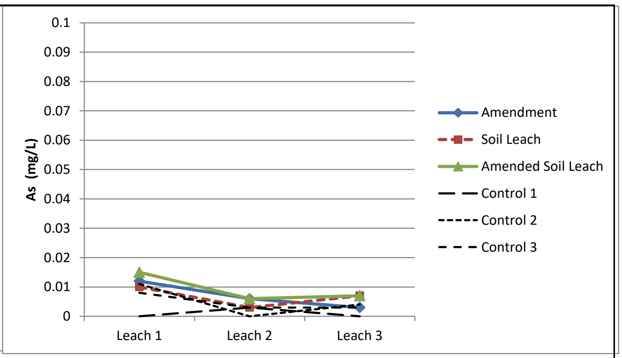

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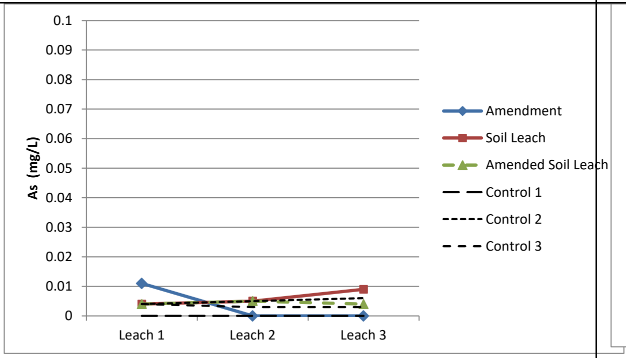

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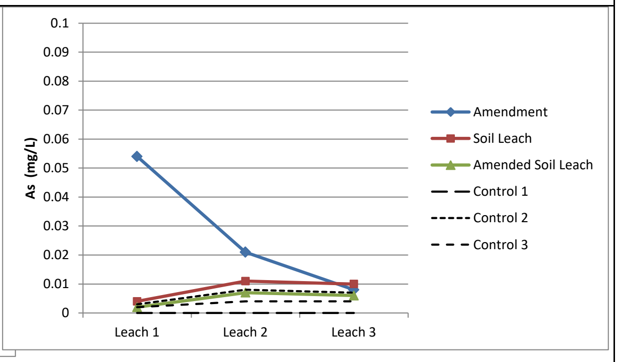

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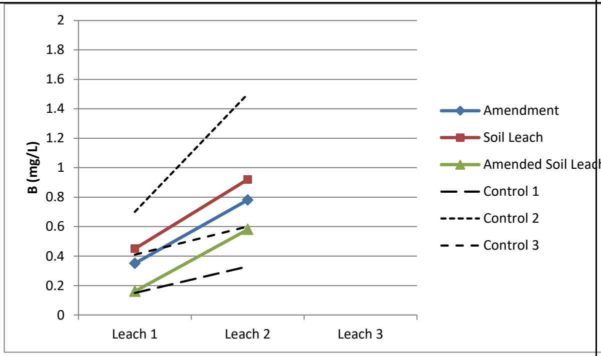

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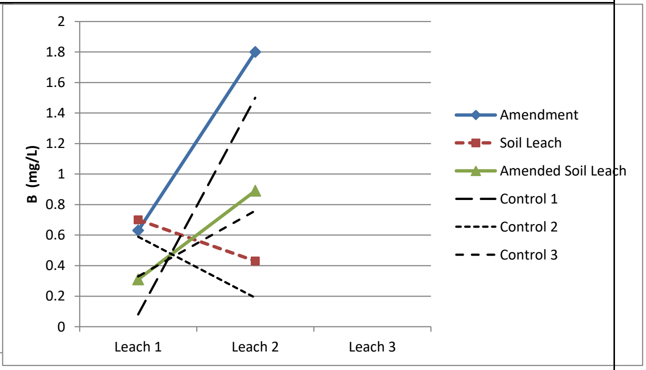

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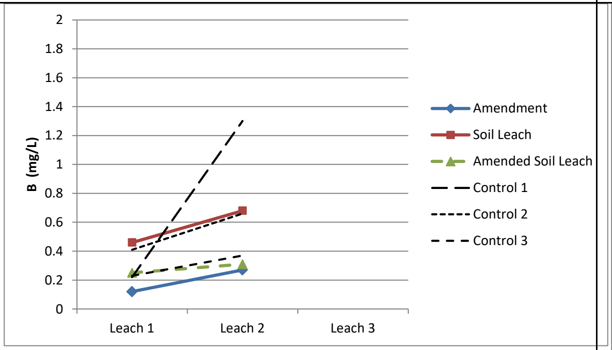

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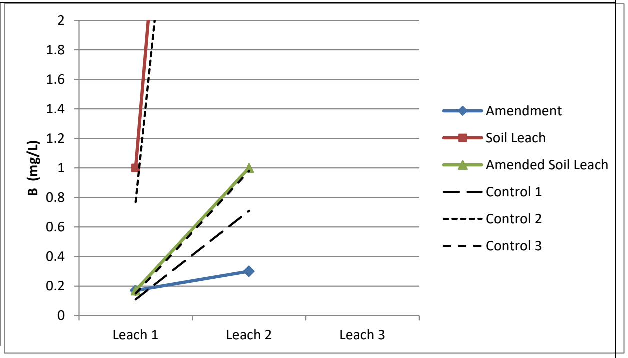

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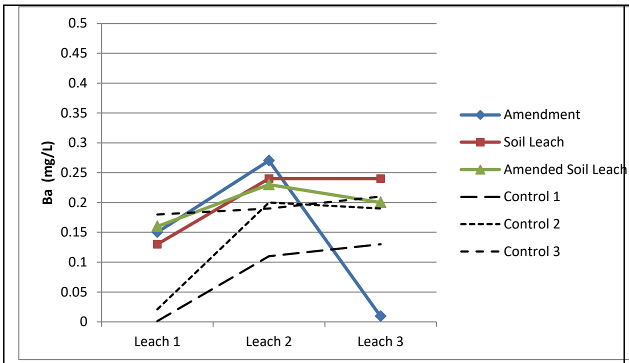
A12-1. Alkaloam



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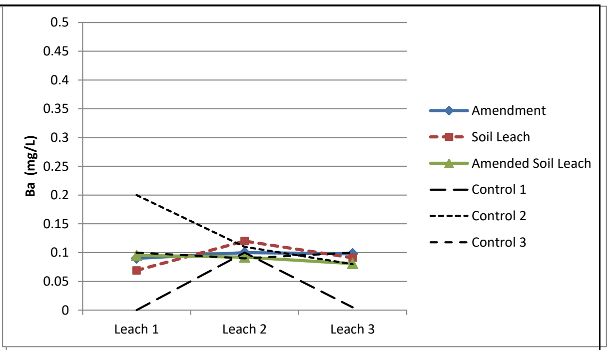

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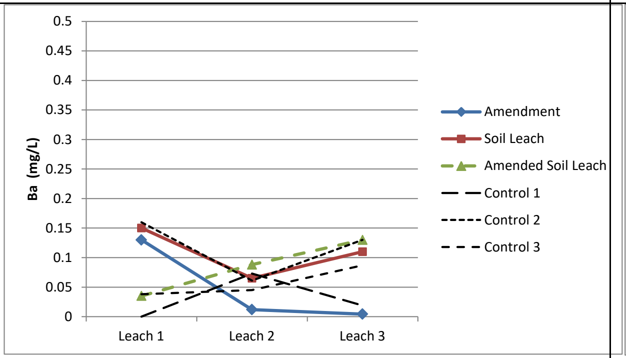

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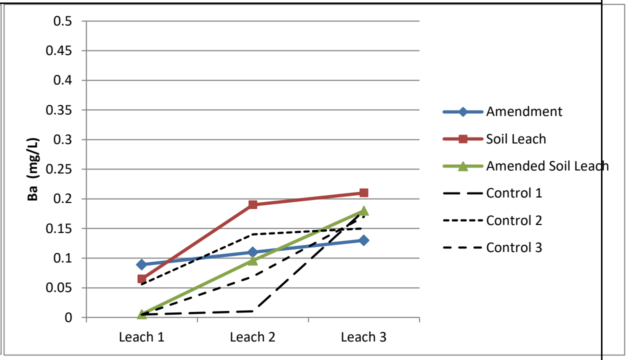

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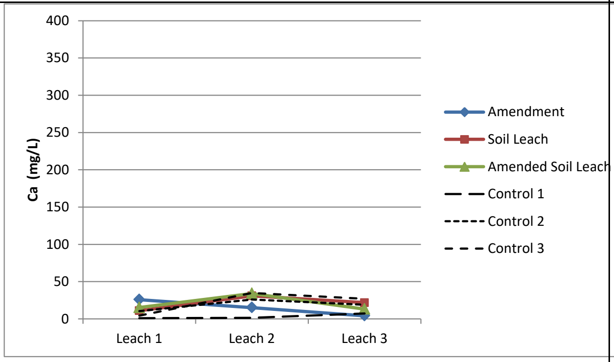

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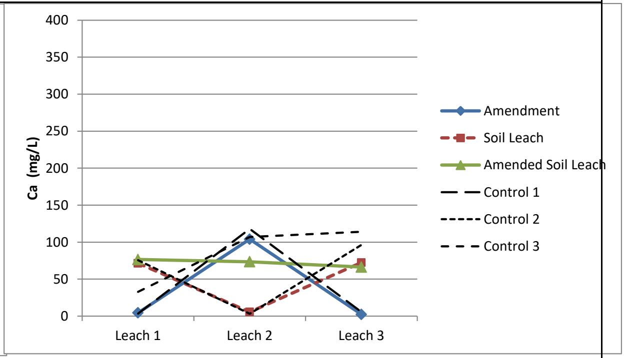

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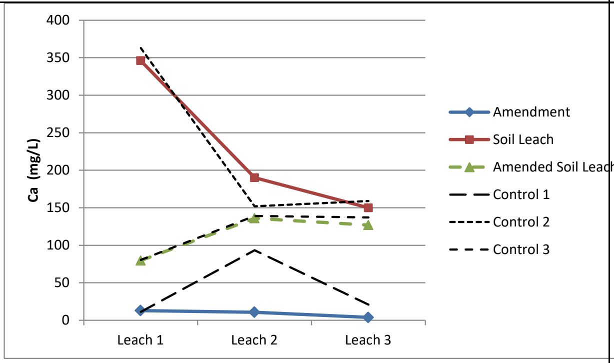

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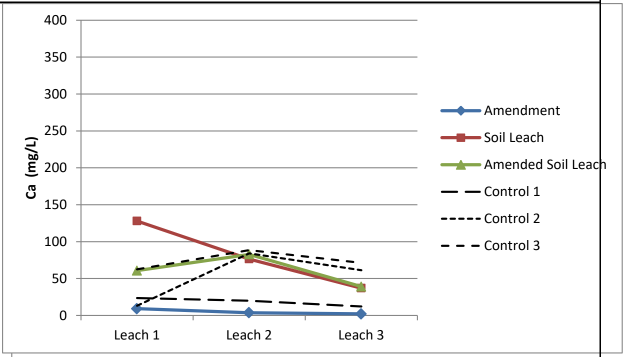

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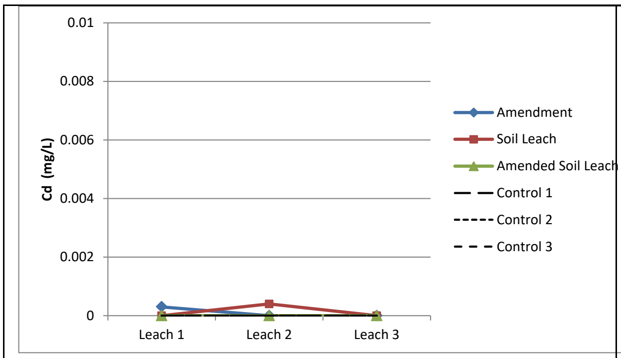

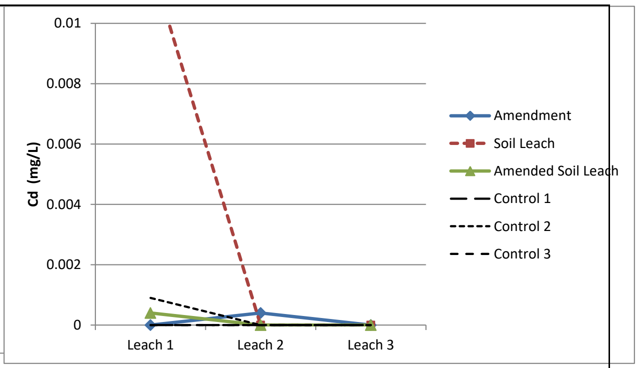

Bassendean Ellenbrook

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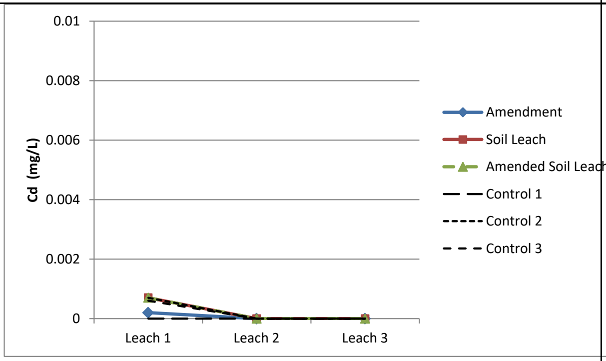

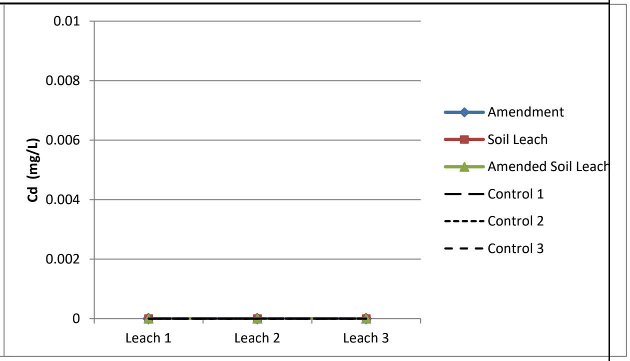

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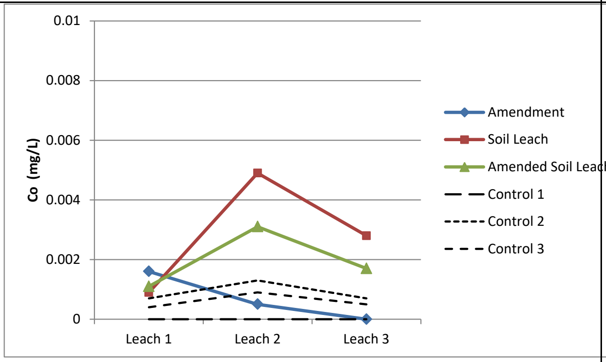
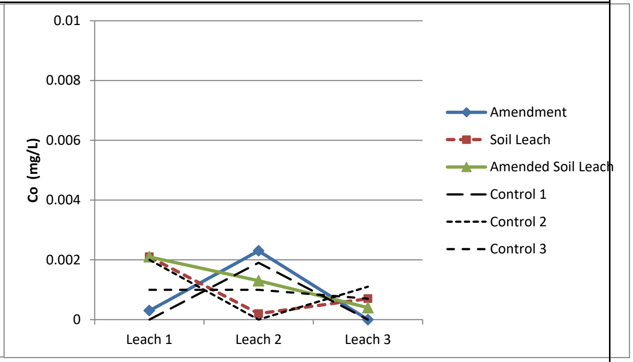
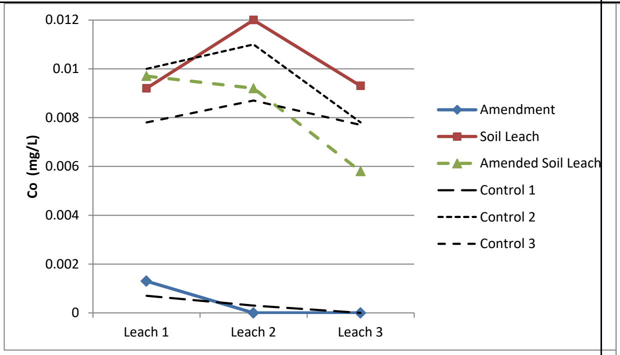
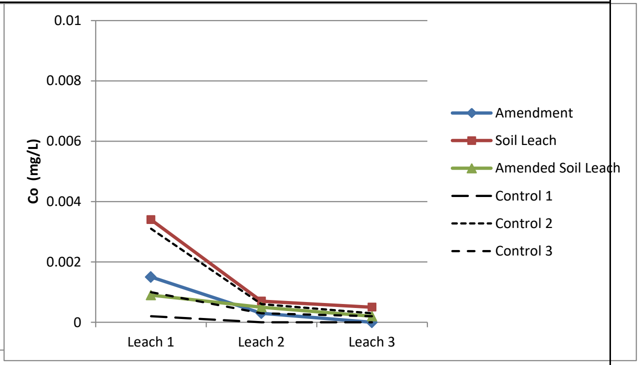




Bassendean Ellenbrook

Bassendean Joel

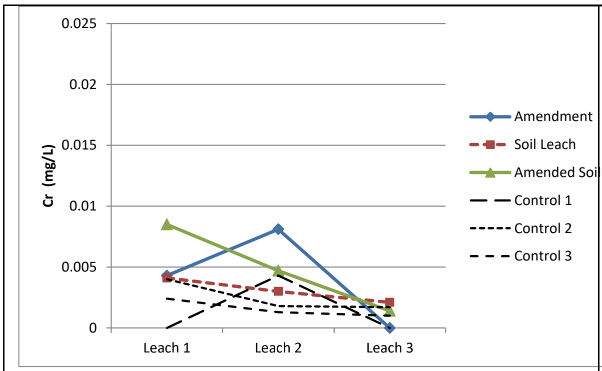




Fairbridge Duplex

Spearwood

A12-1. Alkaloam



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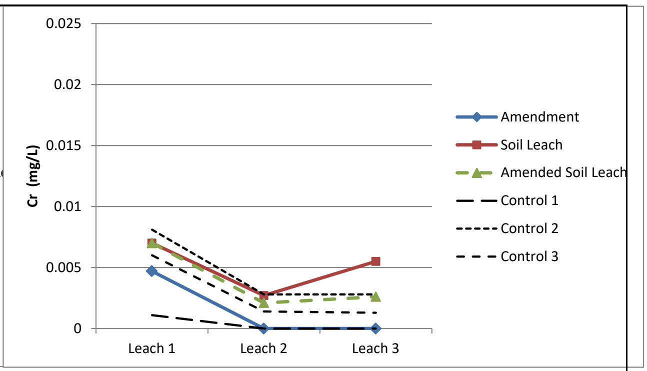

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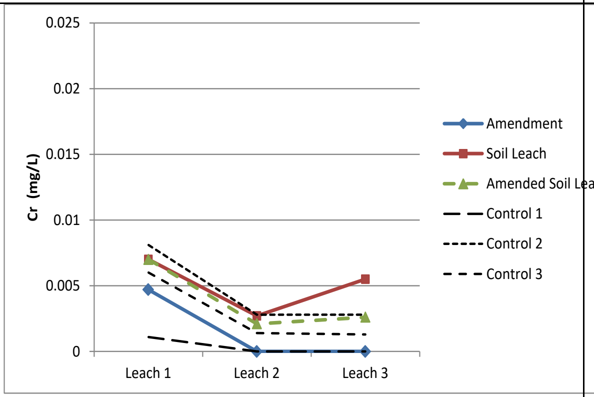

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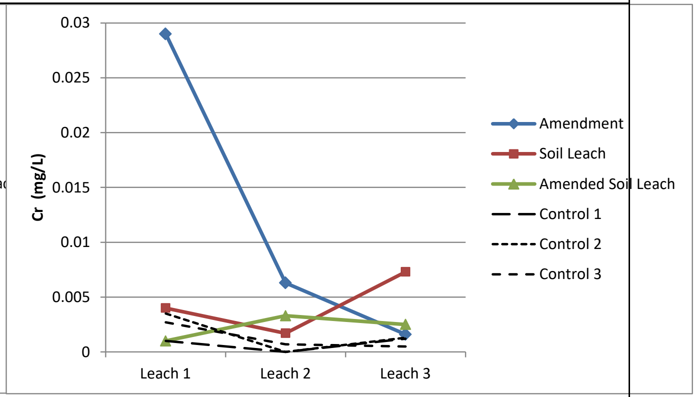

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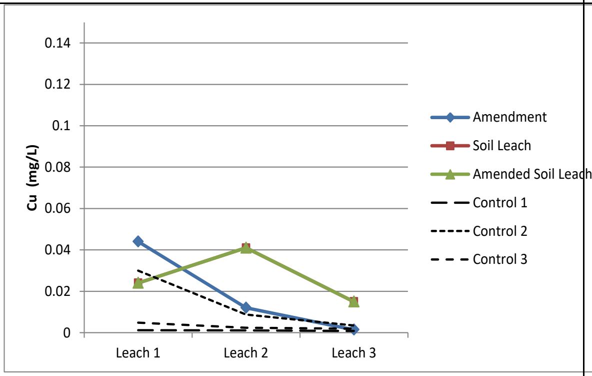

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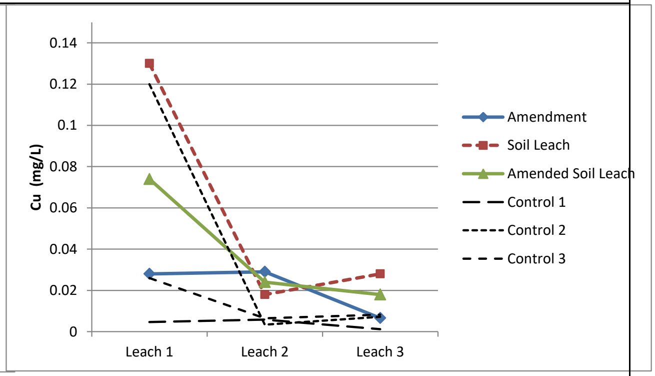

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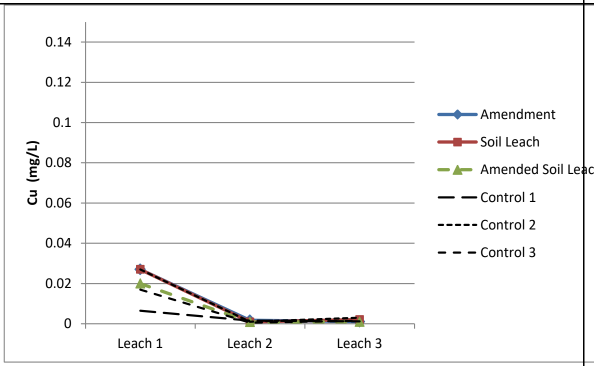

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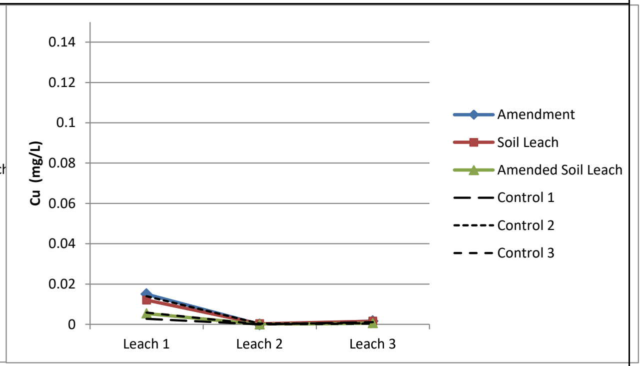
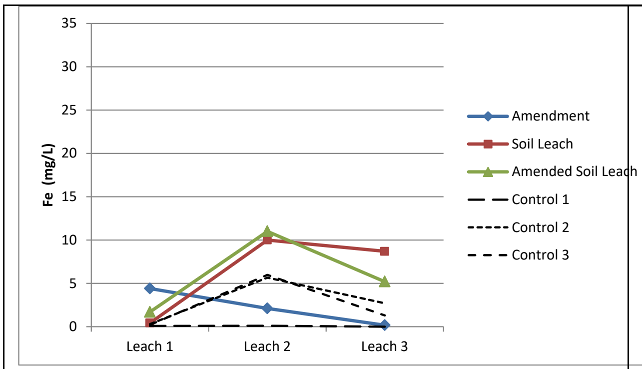


Spearwood

A12-1. Alkaloam



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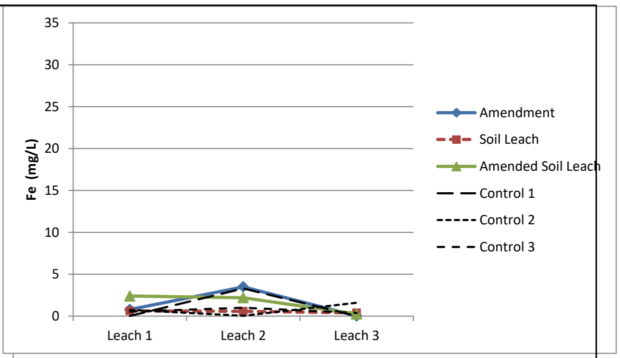

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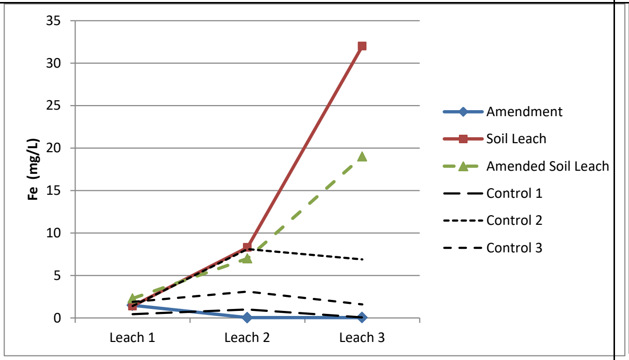
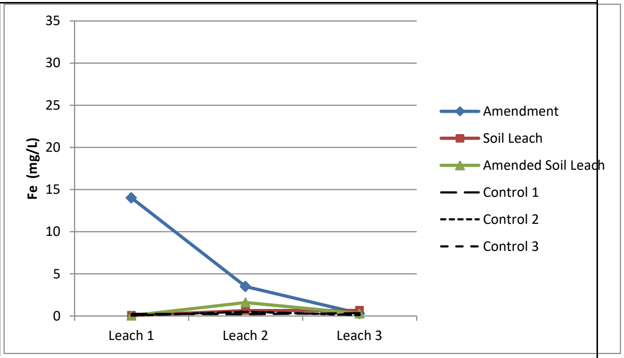
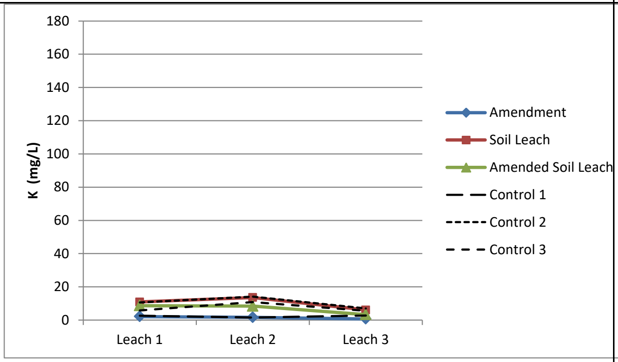


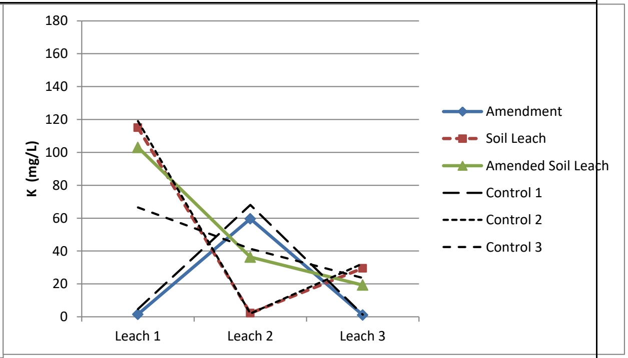
Fairbridge Duplex



Spearwood



Bassendean Ellenbrook



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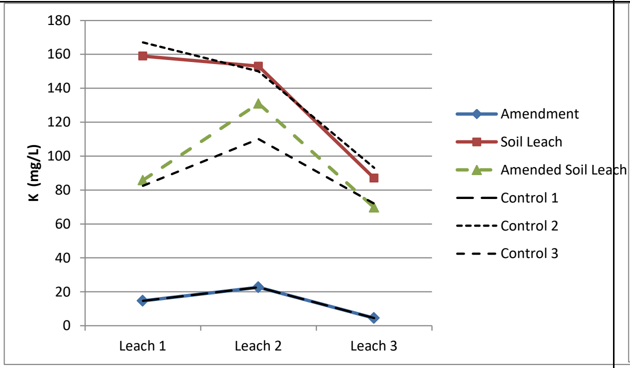

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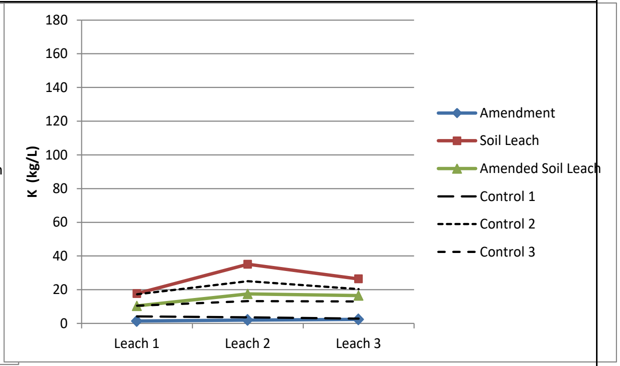

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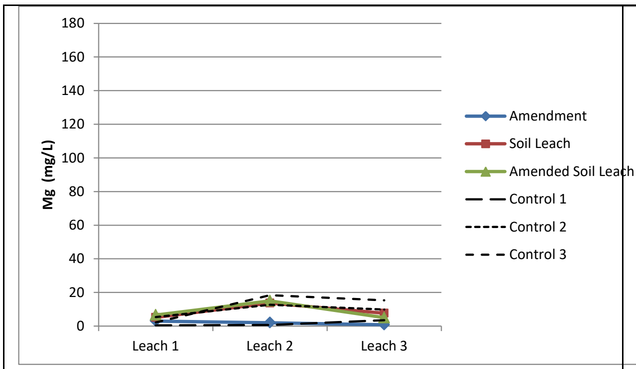
A12-1. Alkaloam



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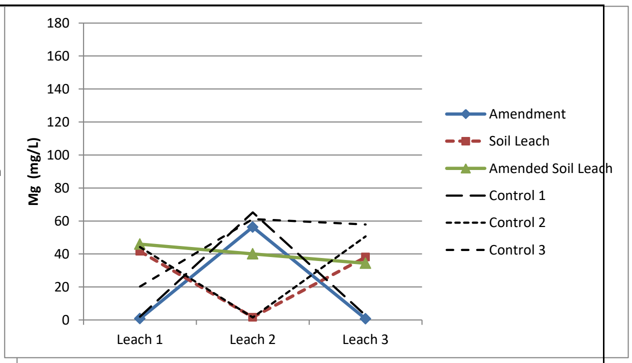

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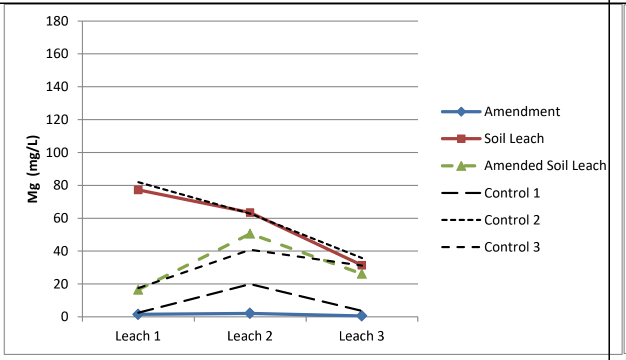

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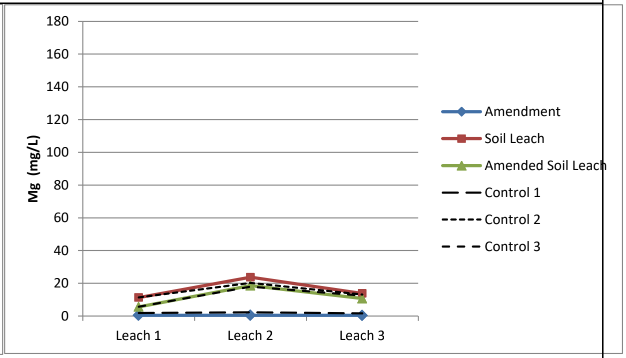

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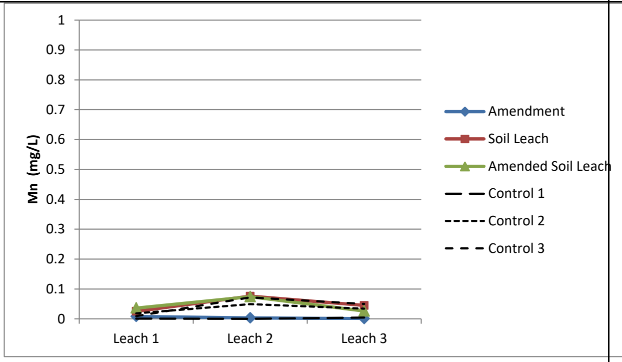

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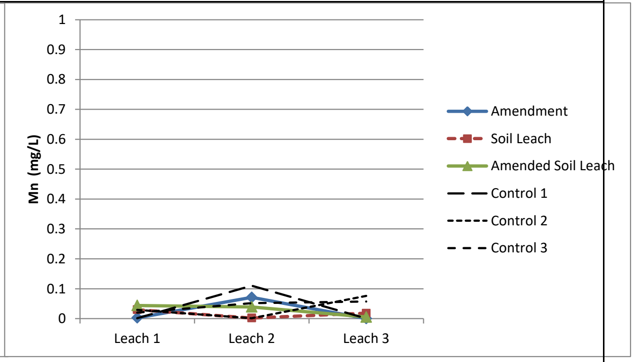

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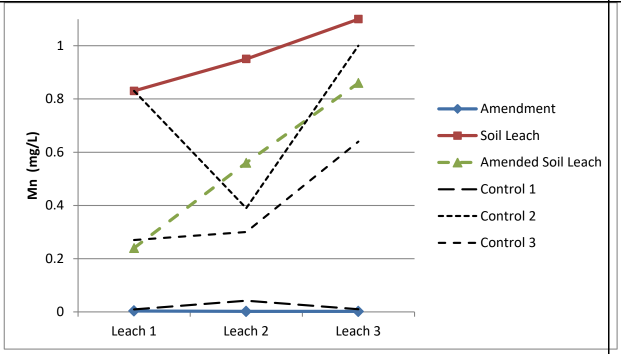

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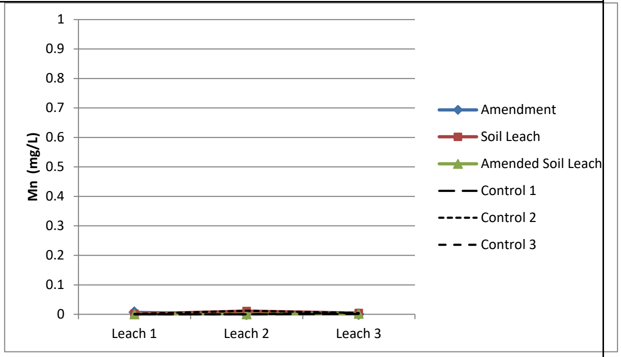
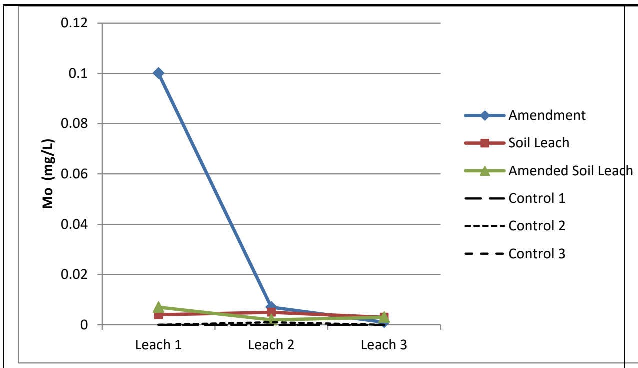


Spearwood

A12-1. Alkaloam



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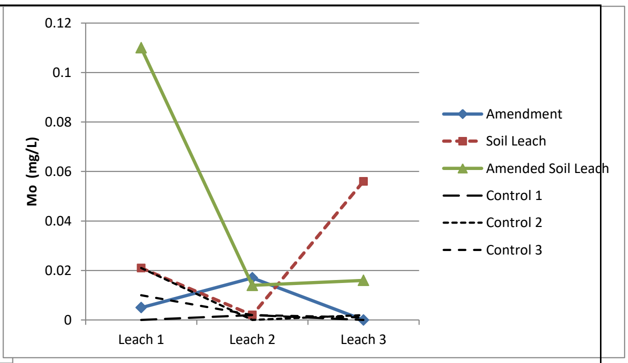

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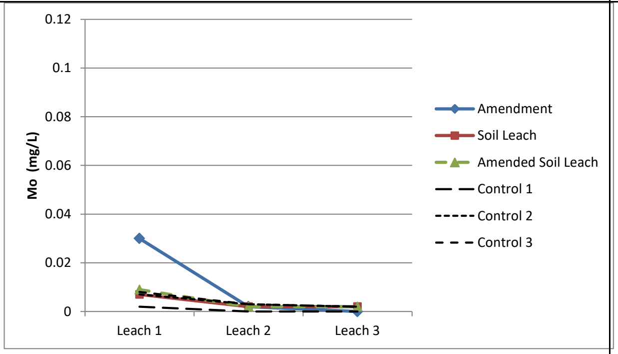

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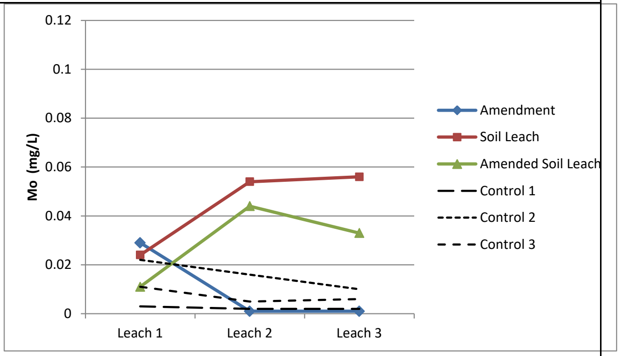

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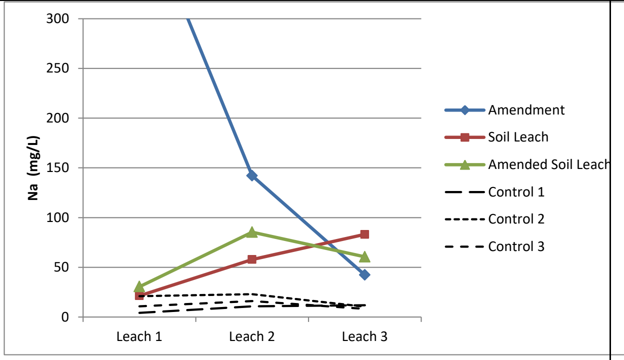

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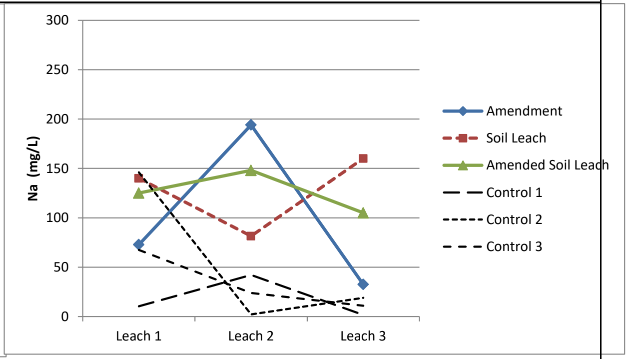

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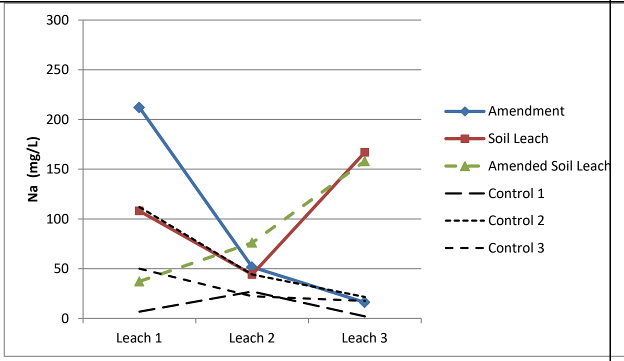

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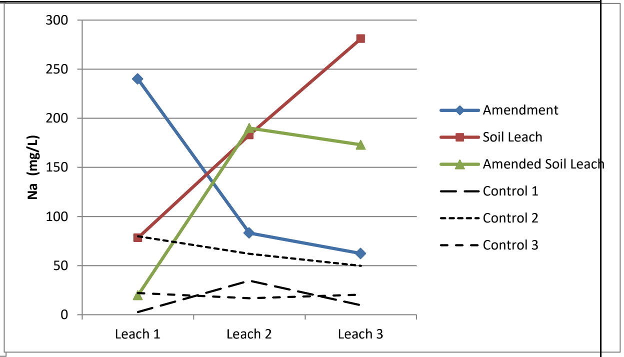

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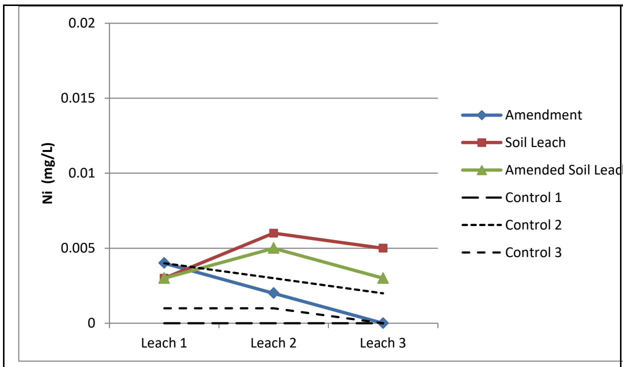
A12-1. Alkaloam



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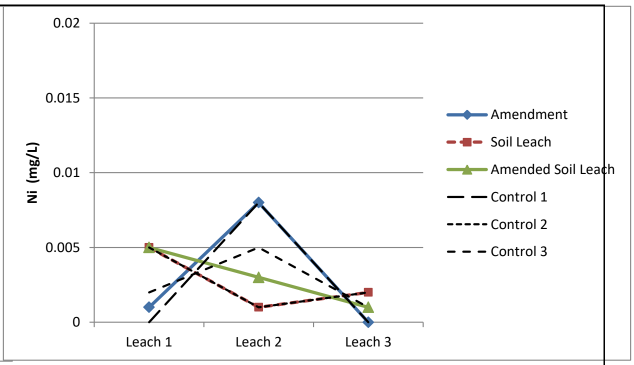

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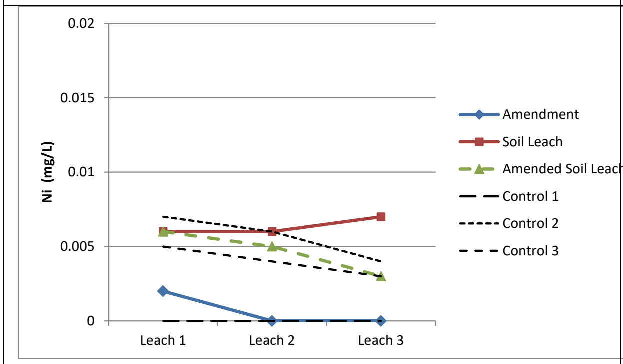

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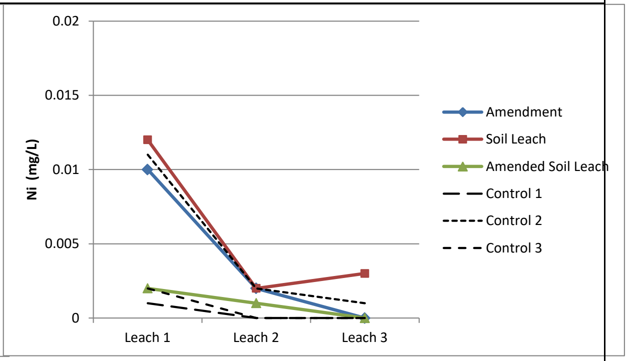

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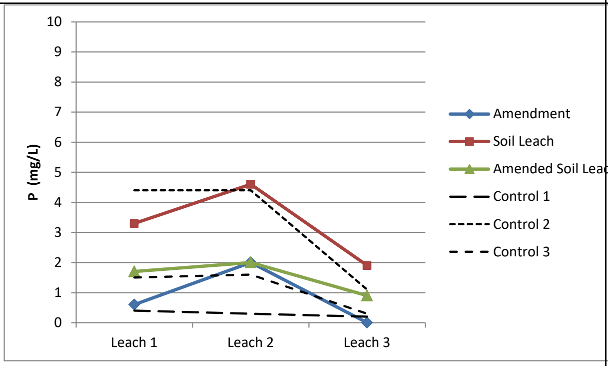

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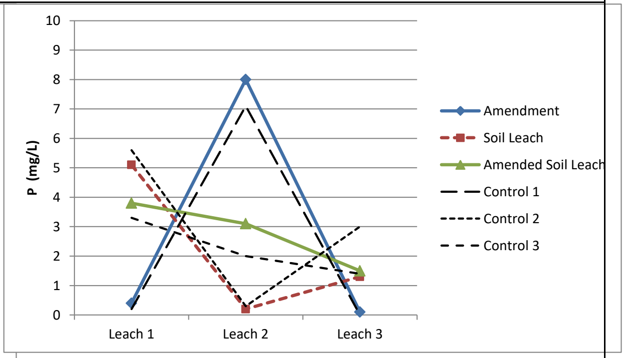

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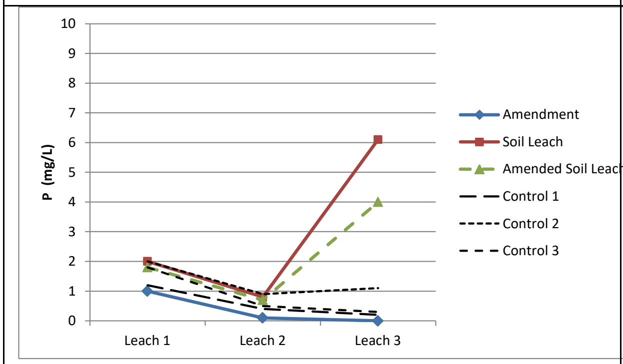

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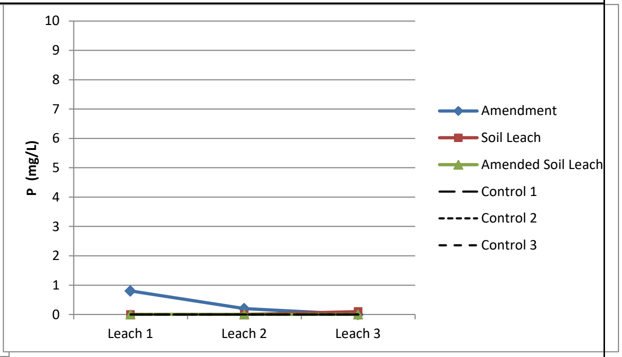
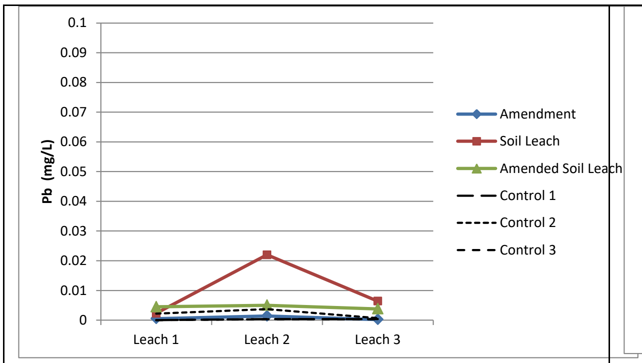
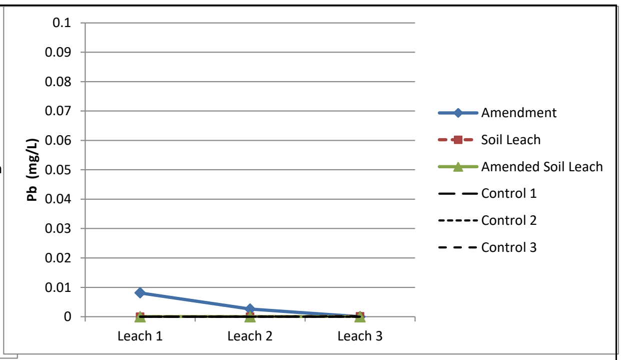


Spearwood

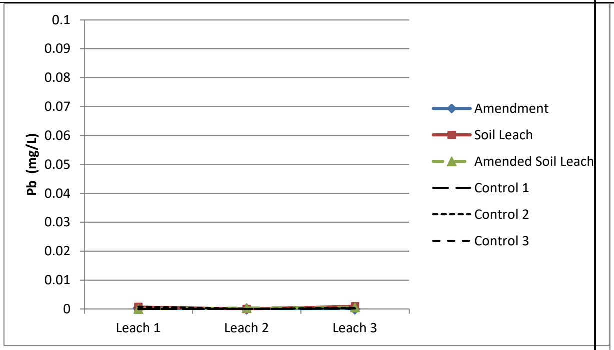
A12-1. Alkaloam

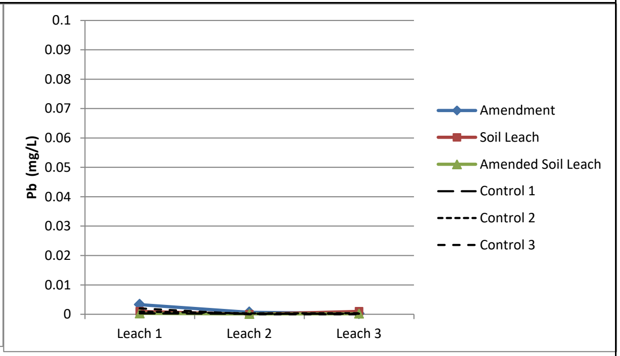




Bassendean Ellenbrook

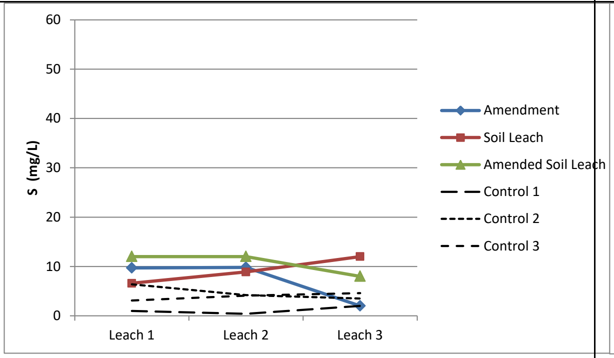
Bassendean Joel

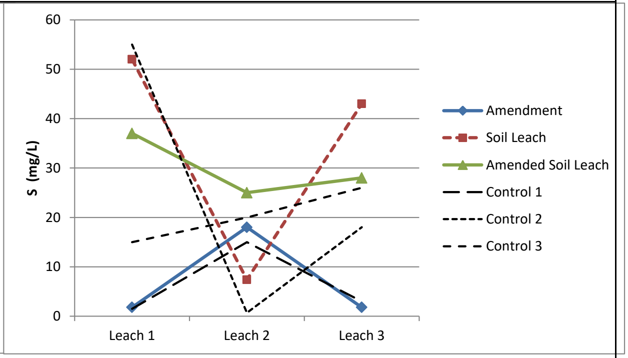




Fairbridge Duplex

Spearwood





Bassendean Ellenbrook

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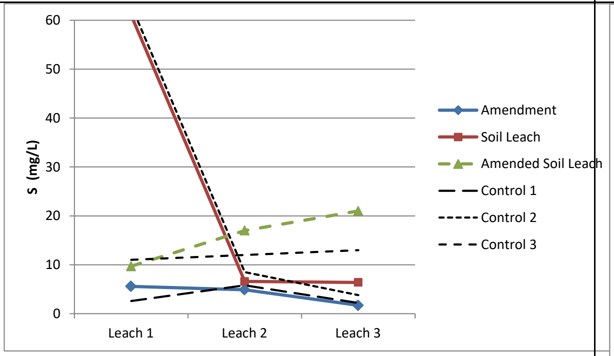
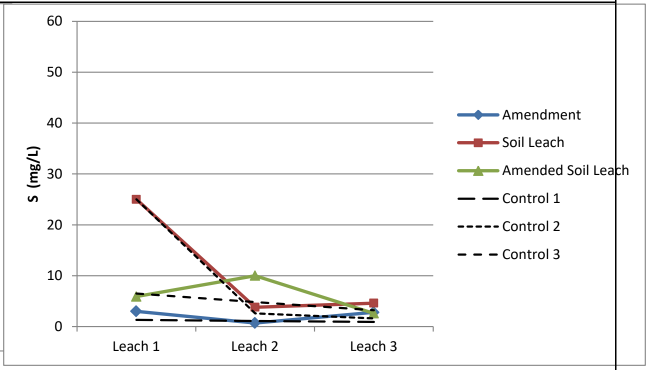
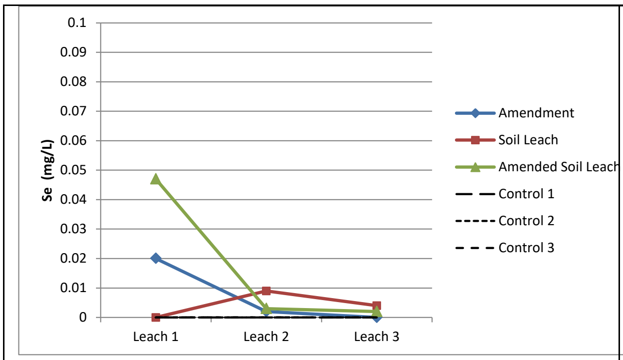




Fairbridge Duplex

Spearwood

A12-1. Alkaloam



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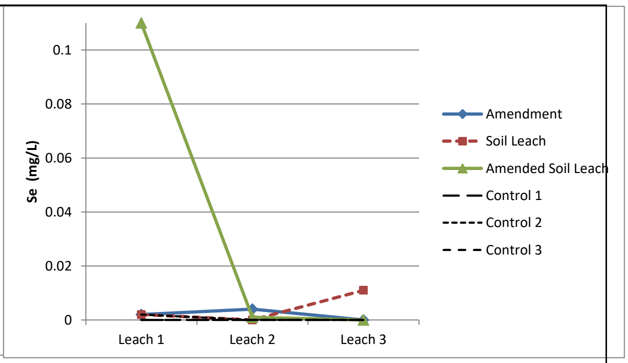

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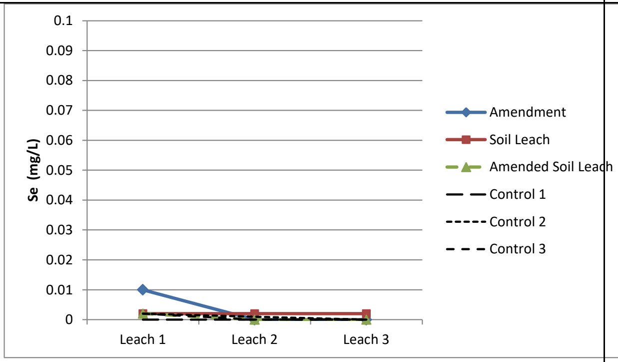

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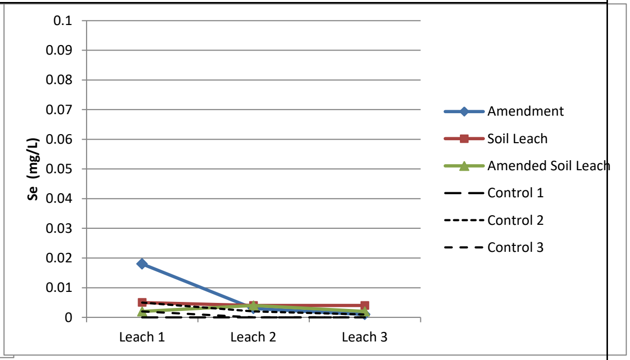

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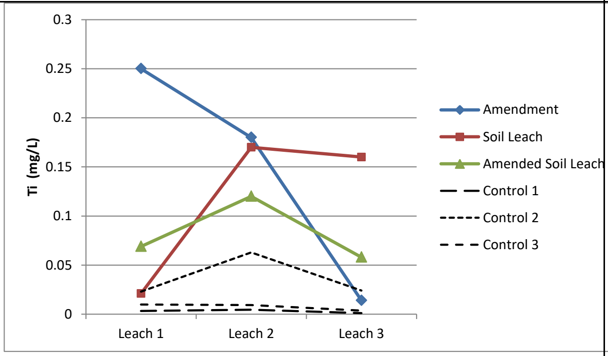

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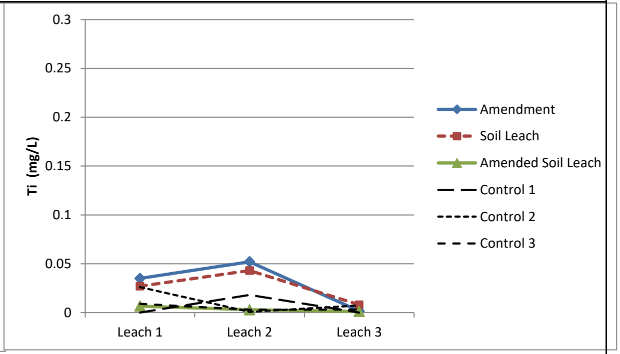

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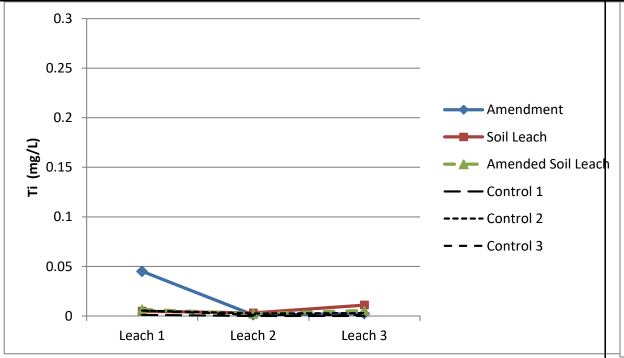

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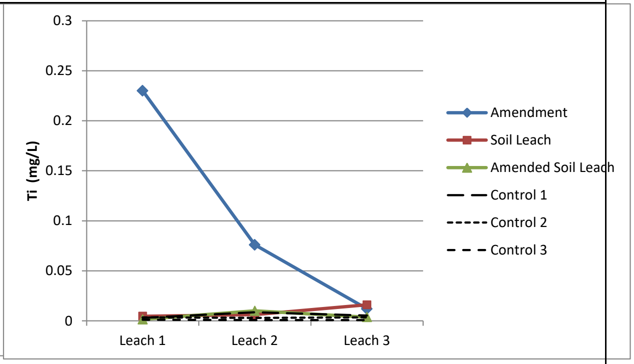

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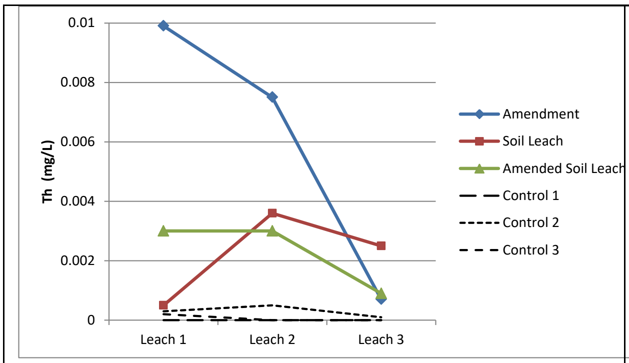
A12-1. Alkaloam



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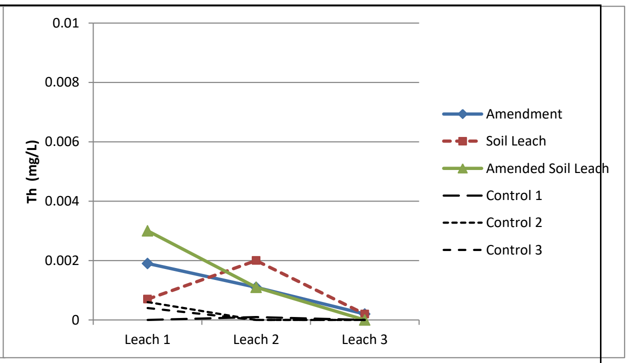

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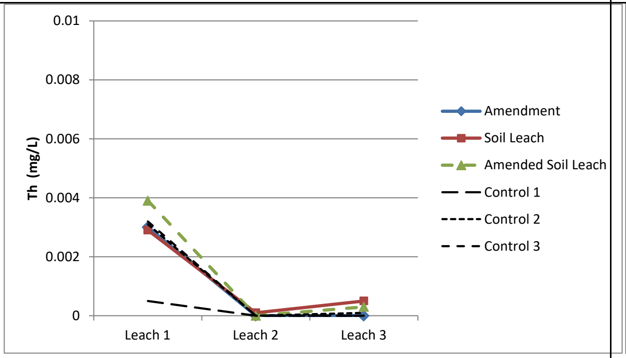

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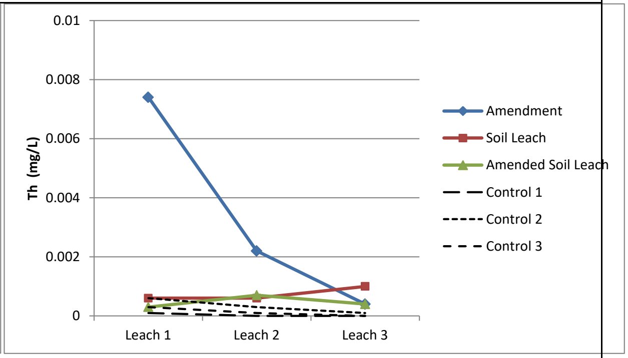

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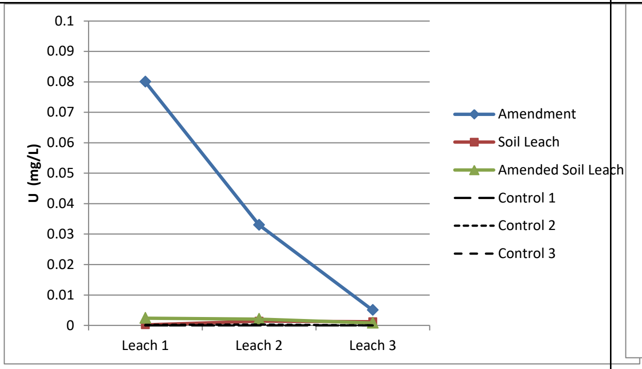

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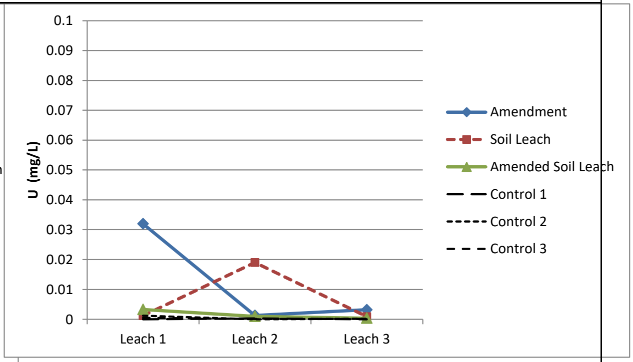

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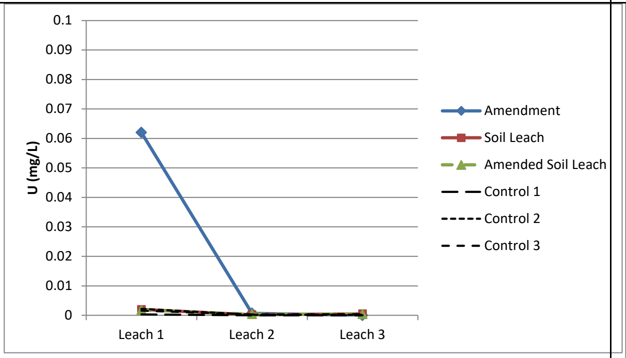

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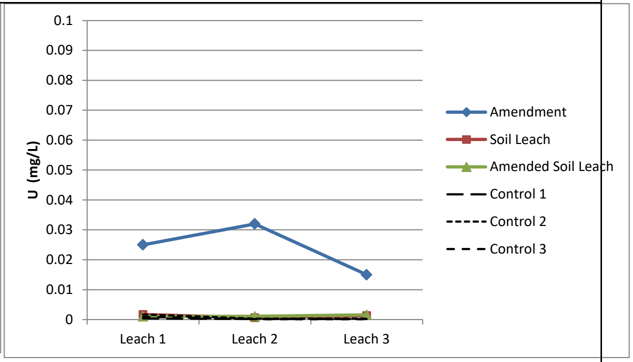

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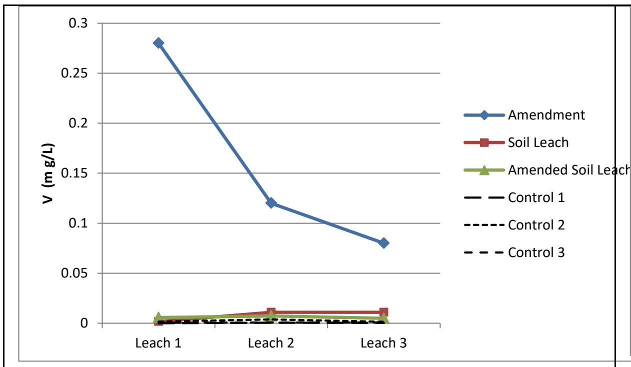
A12-1. Alkaloam



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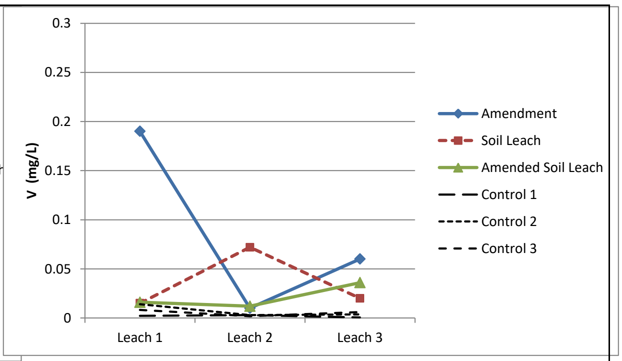

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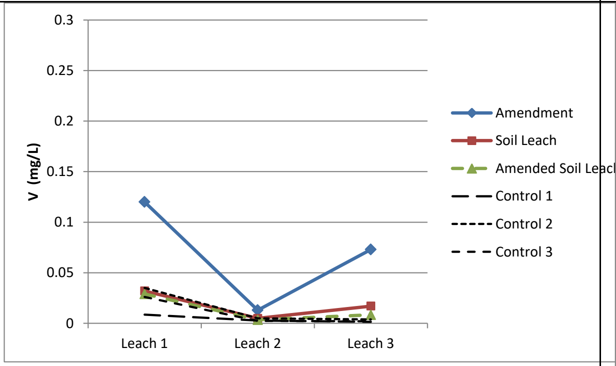

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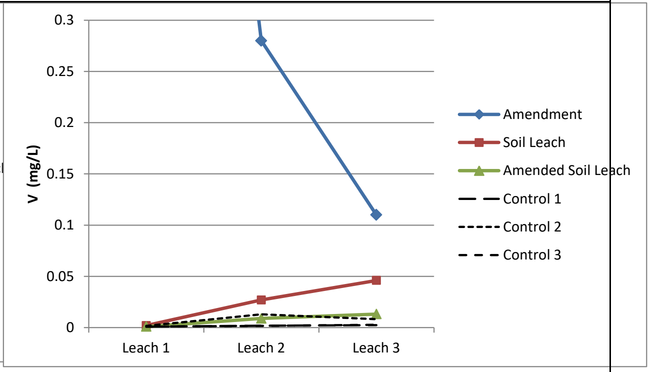

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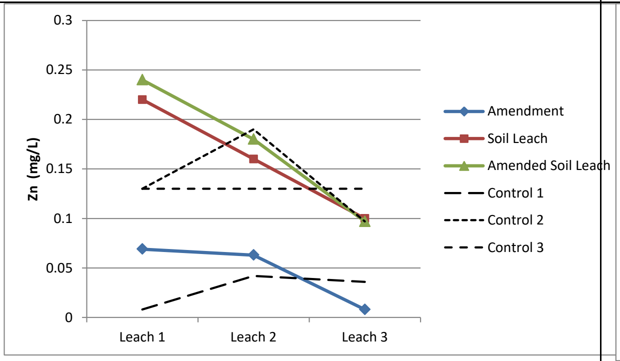

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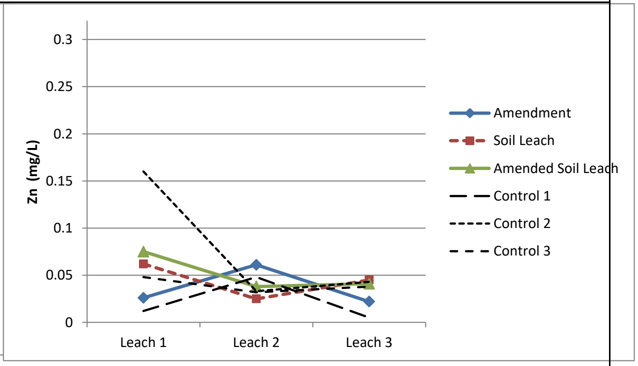

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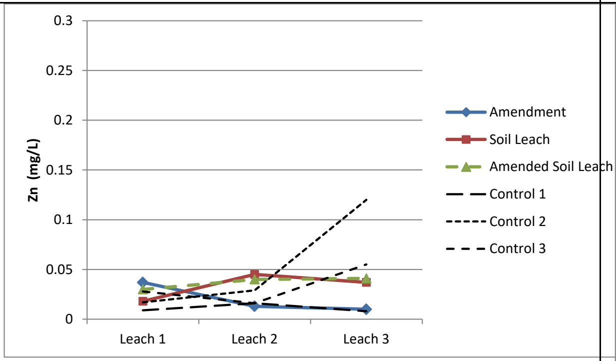

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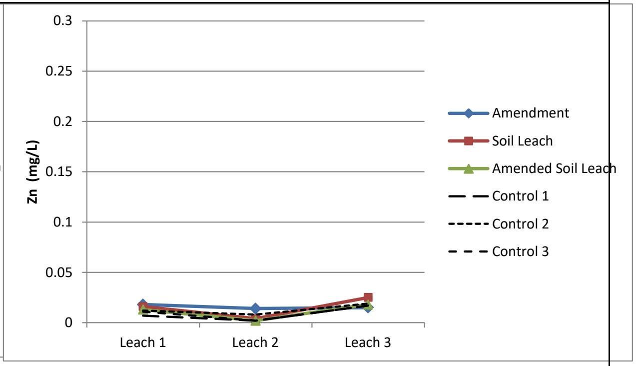
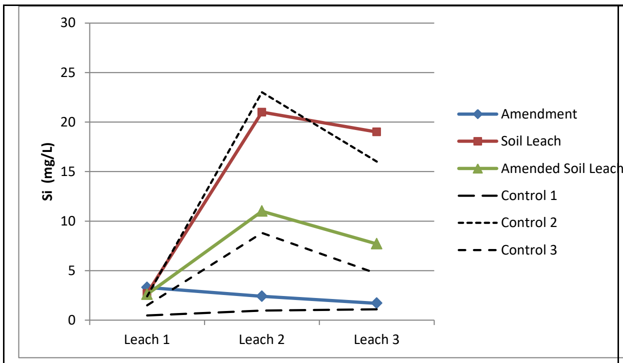


Spearwood

A12-1. Alkaloam



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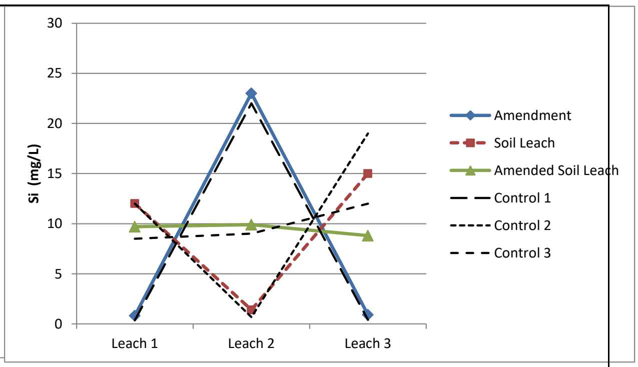

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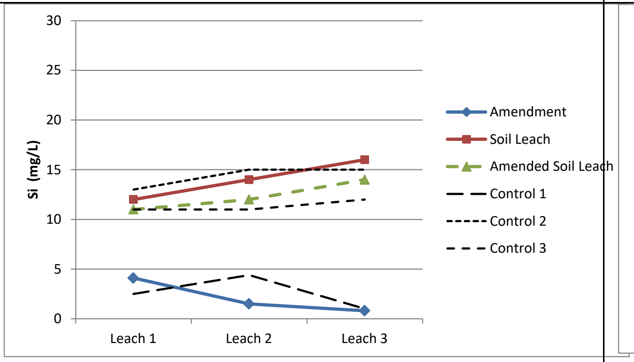

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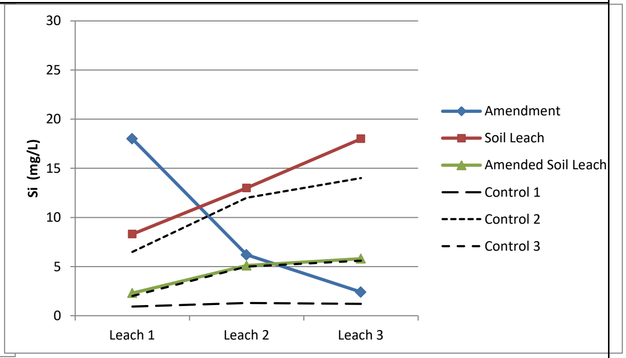
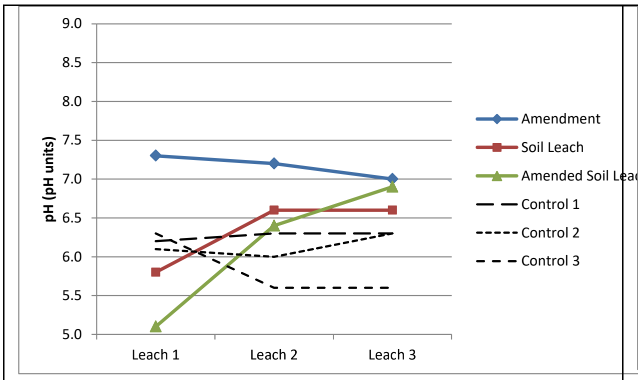


Spearwood

A12-2. Ironman Gypsum (IMG)



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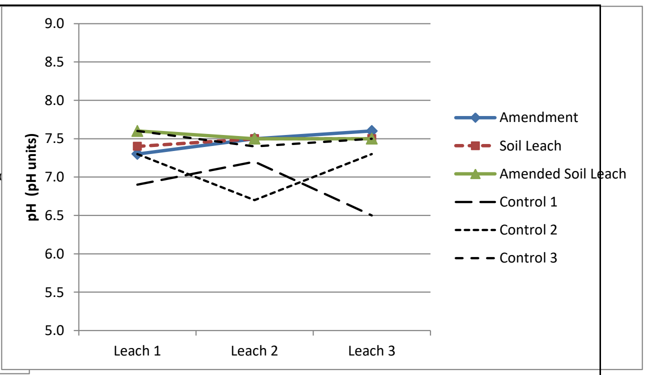

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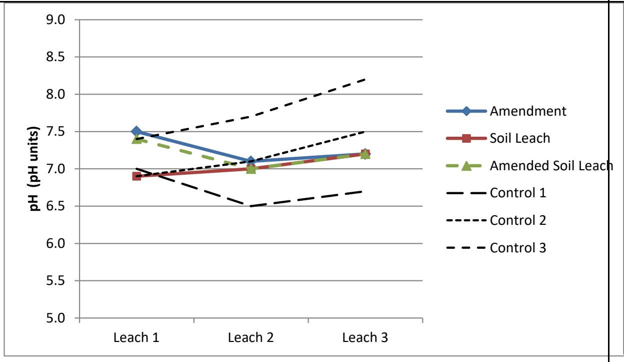

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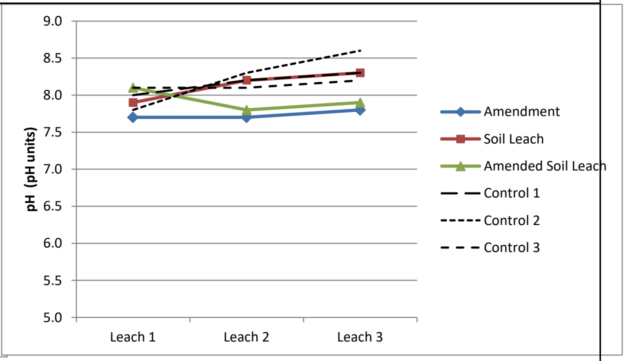

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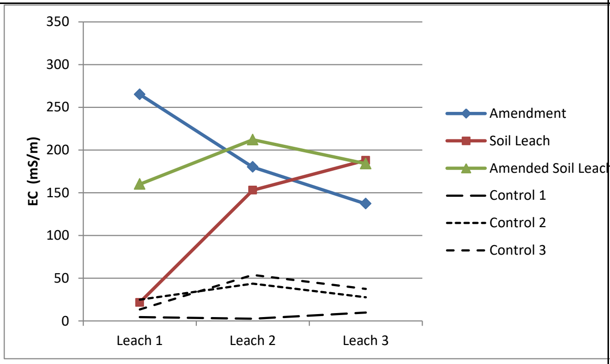
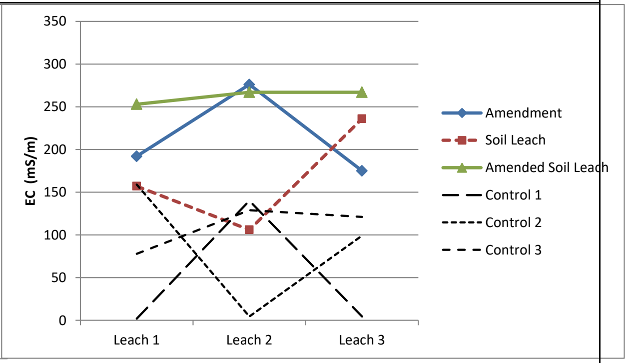


Bassendean Ellenbrook



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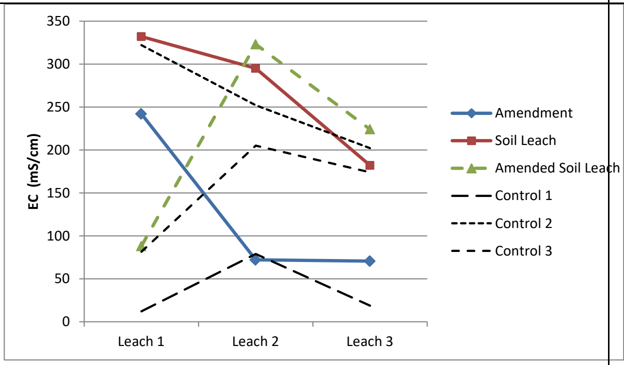
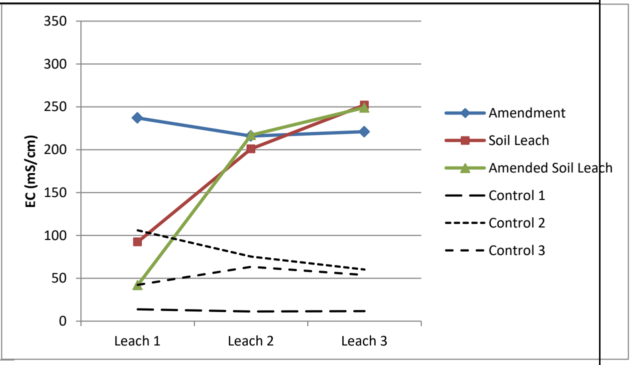
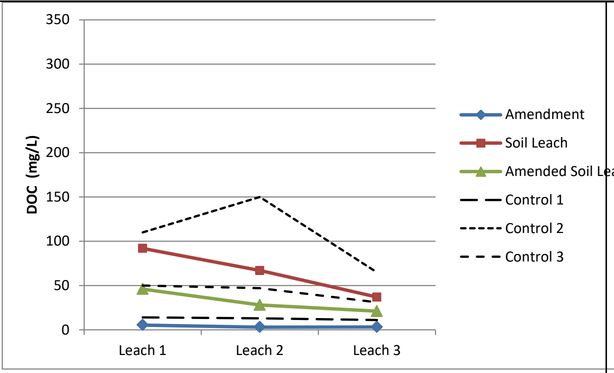


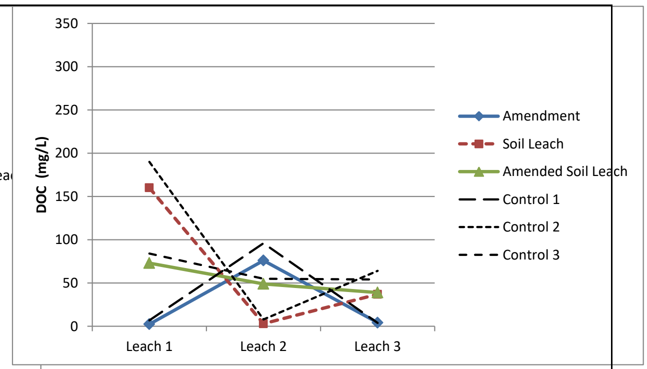
Fairbridge Duplex



Spearwood

A12-2. Ironman Gypsum (IMG)





Bassendean Ellenbrook

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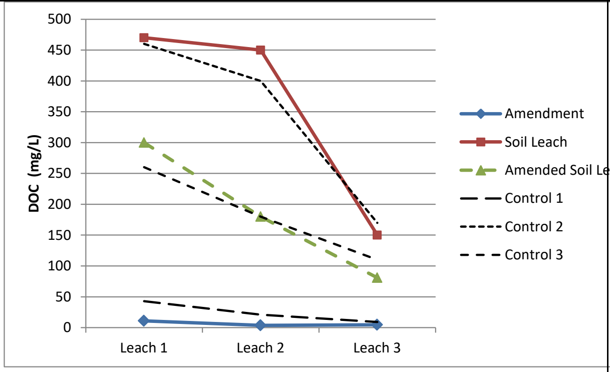
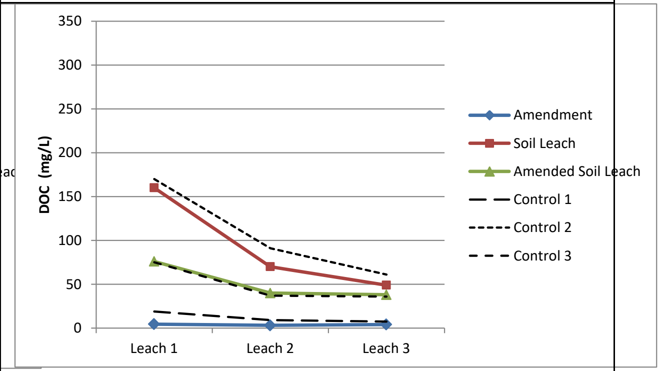
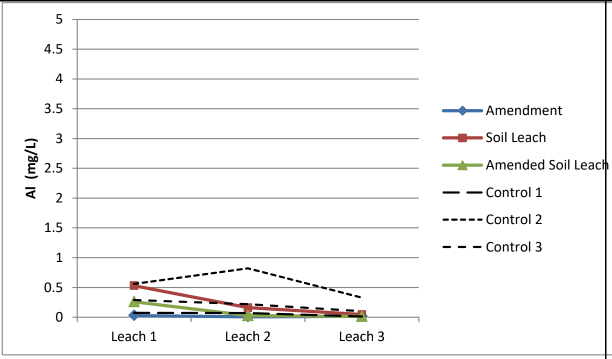
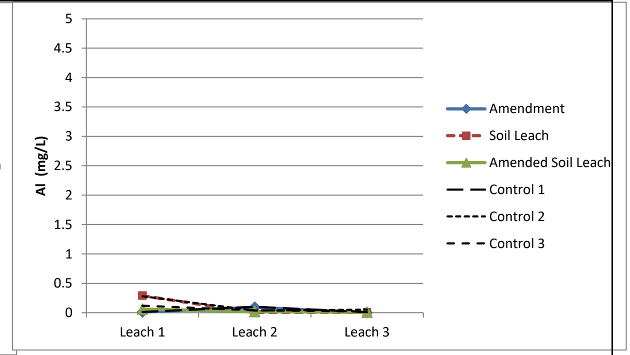




Fairbridge Duplex

Spearwood





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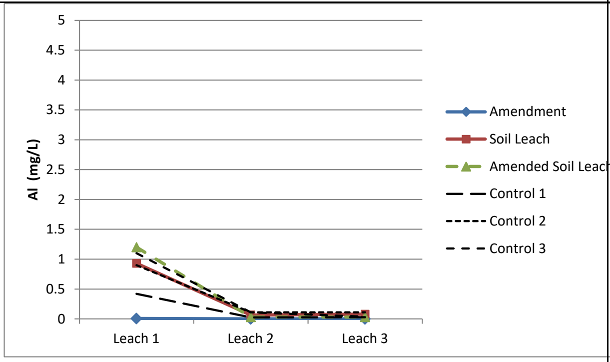
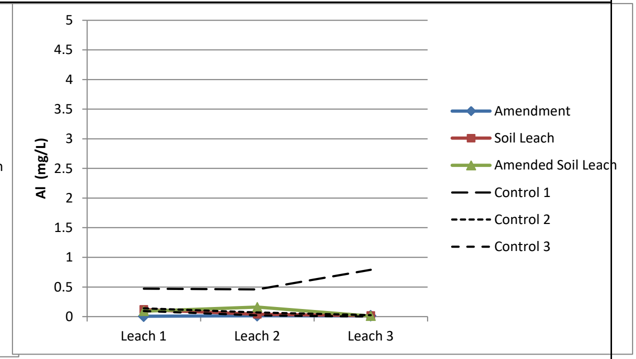
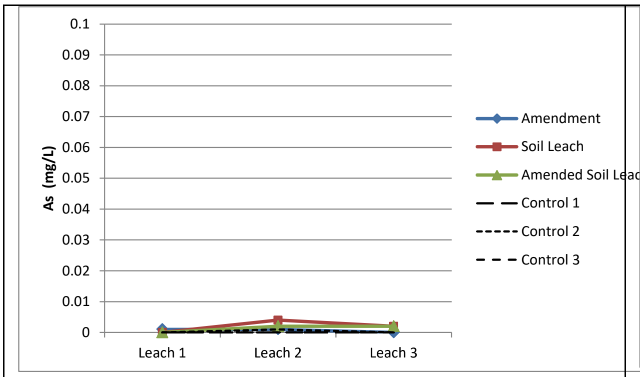


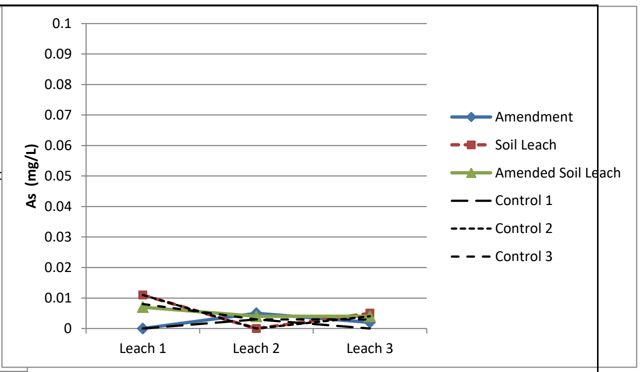


Fairbridge Duplex

Spearwood

A12-2. Ironman Gypsum (IMG)





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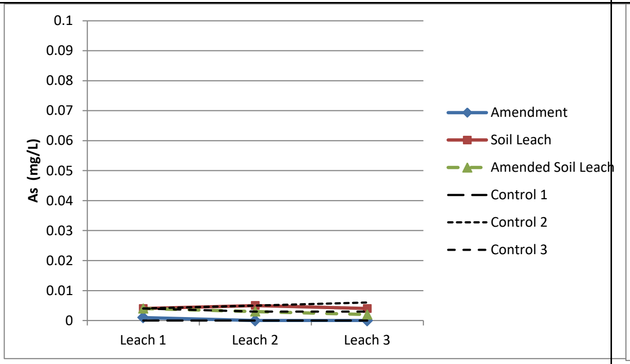

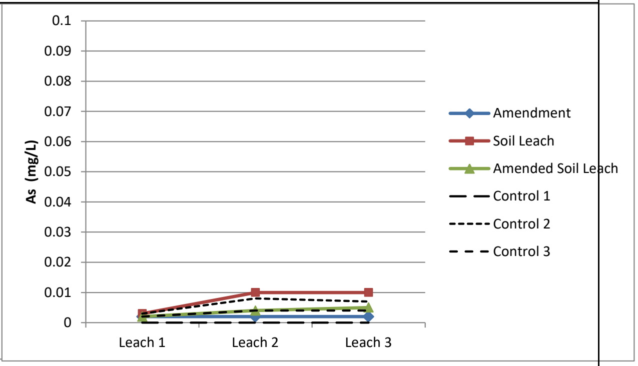

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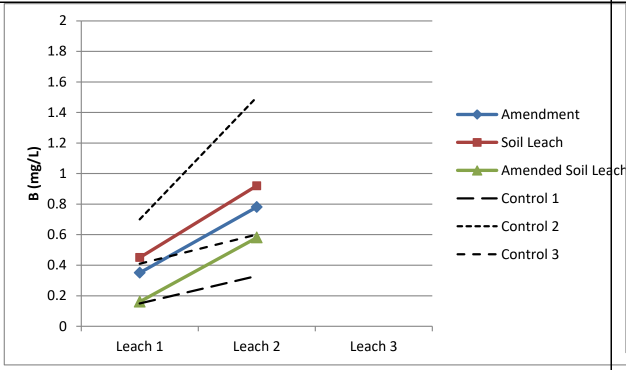
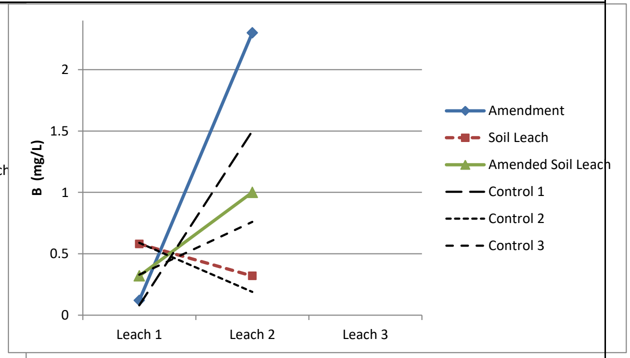
Spearwood





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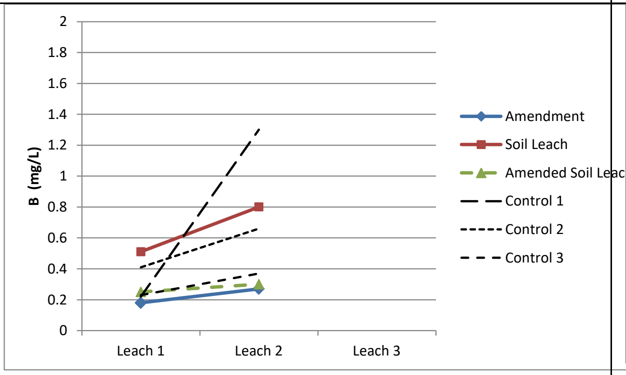
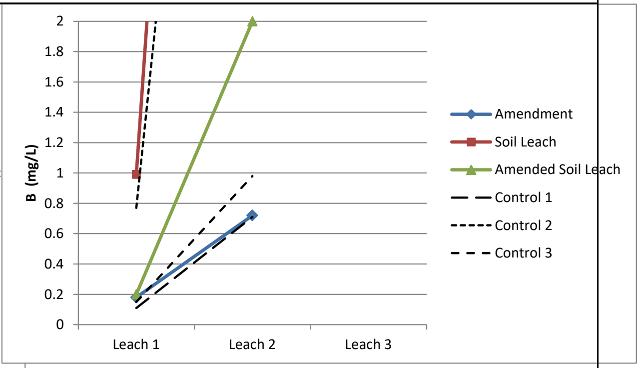
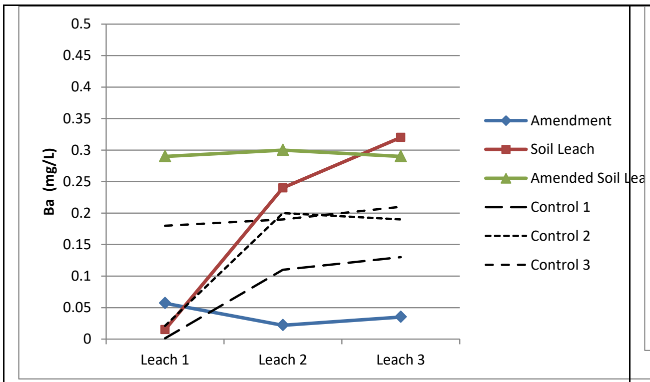




Fairbridge Duplex

Spearwood

A12-2. Ironman Gypsum (IMG)



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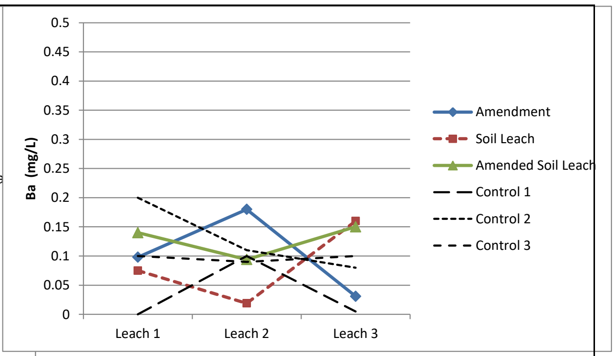

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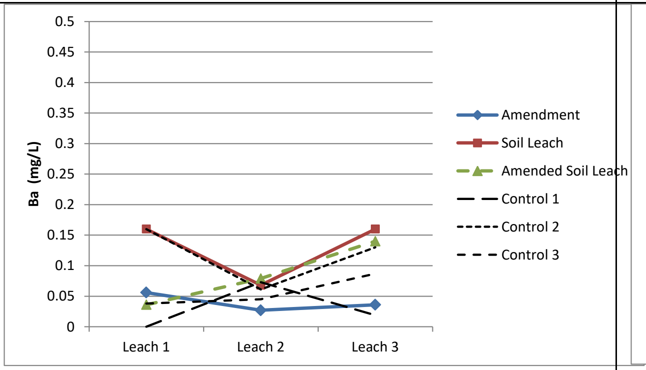

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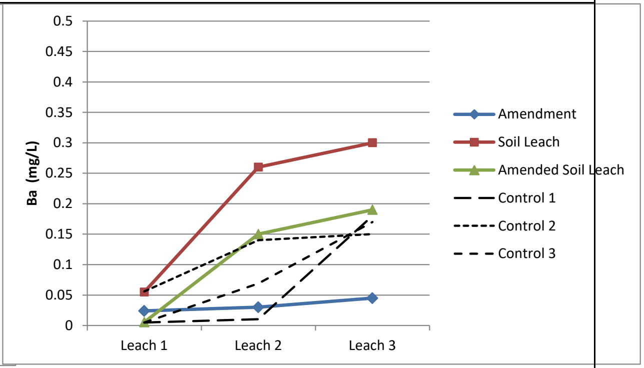

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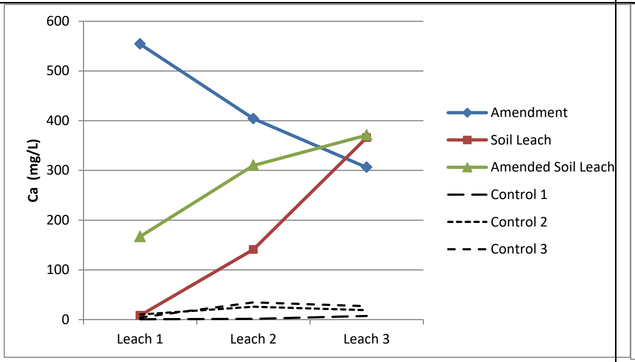

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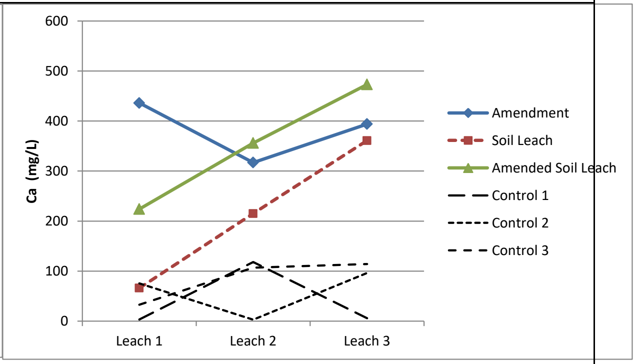

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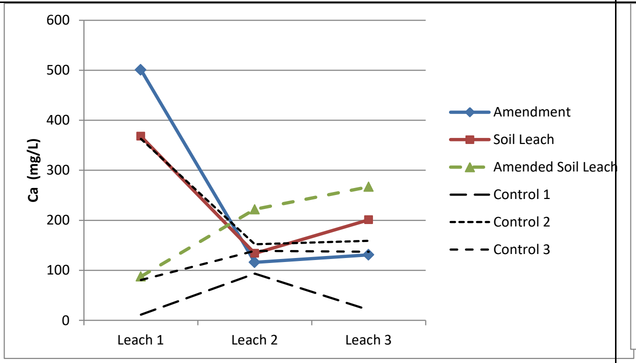

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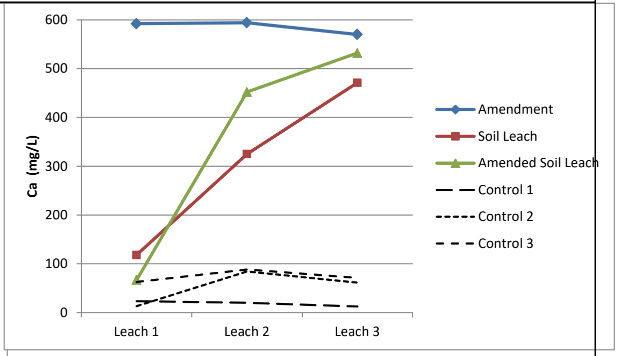
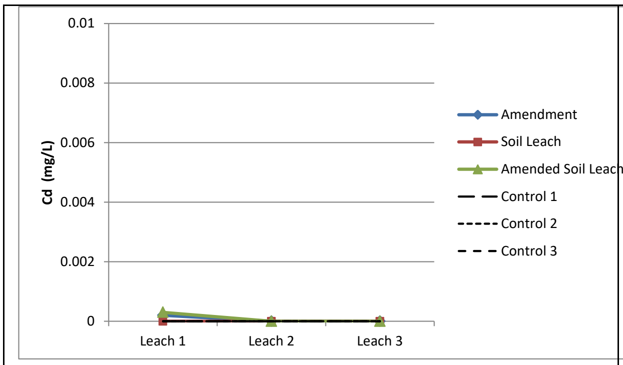


Spearwood

A12-2. Ironman Gypsum (IMG)



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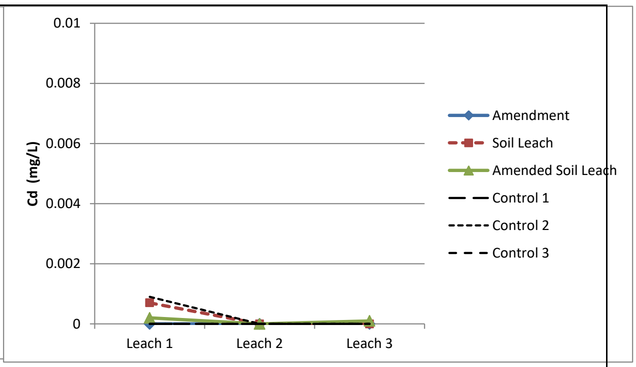

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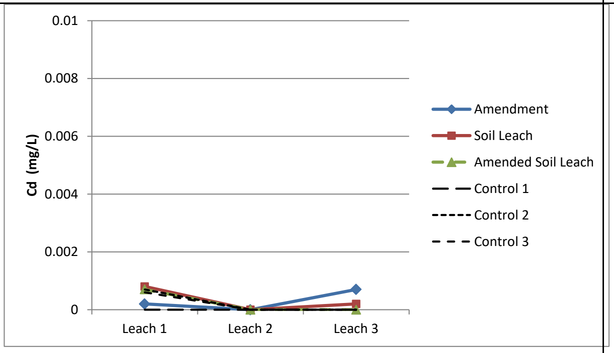

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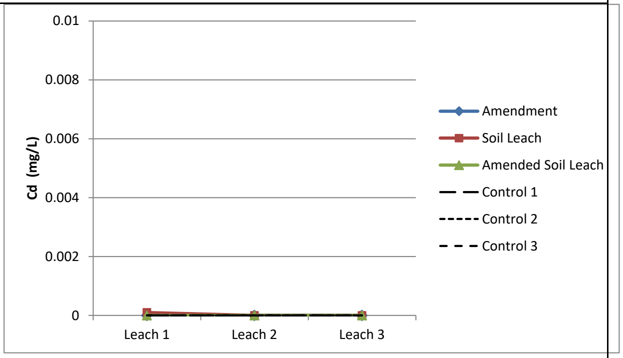

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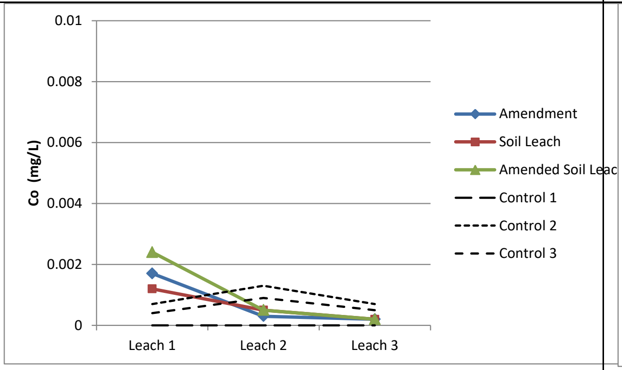

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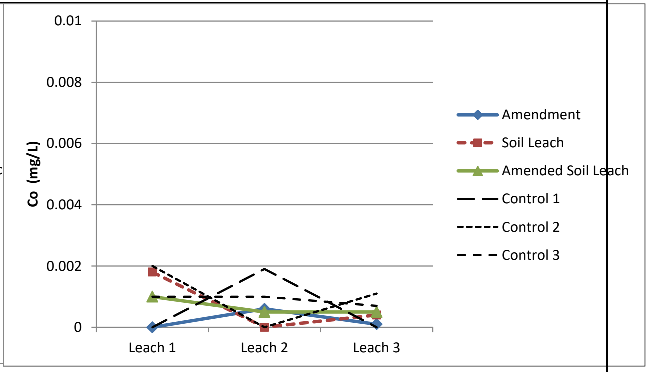

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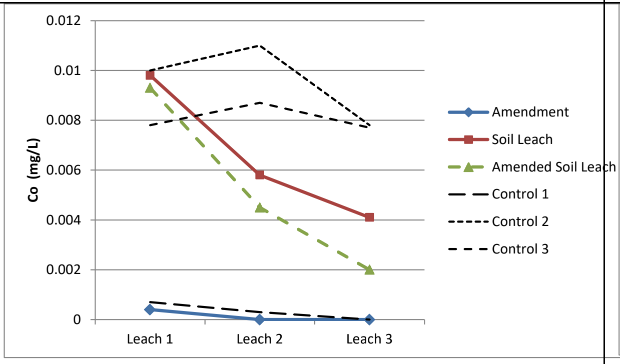

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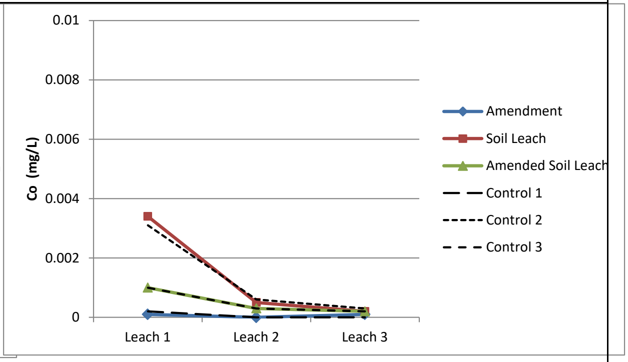
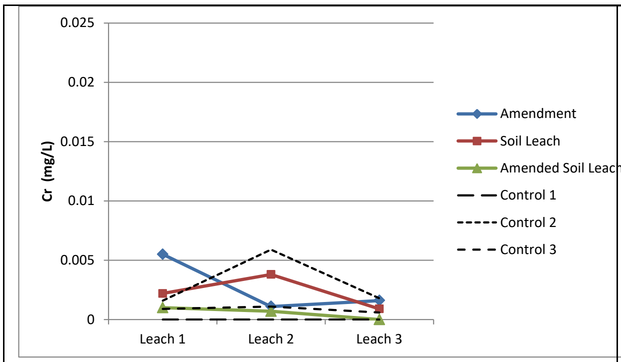


Spearwood

A12-2. Ironman Gypsum (IMG)



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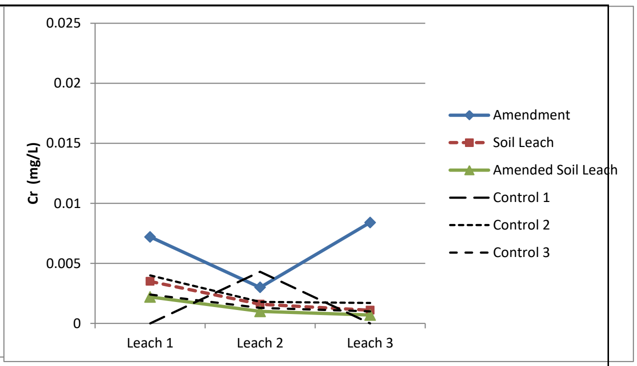

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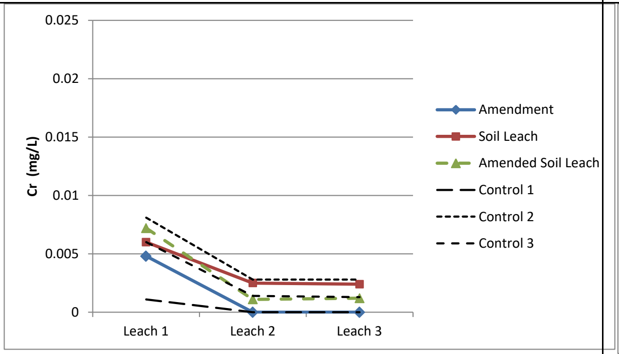

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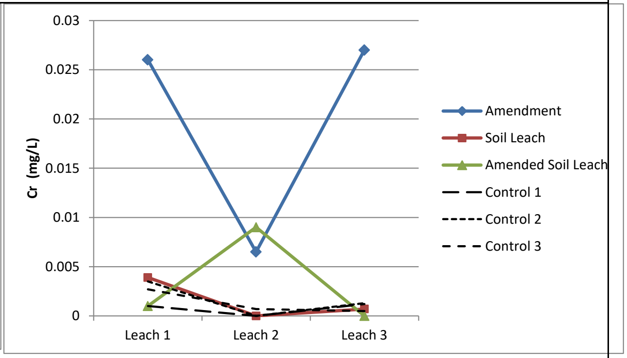

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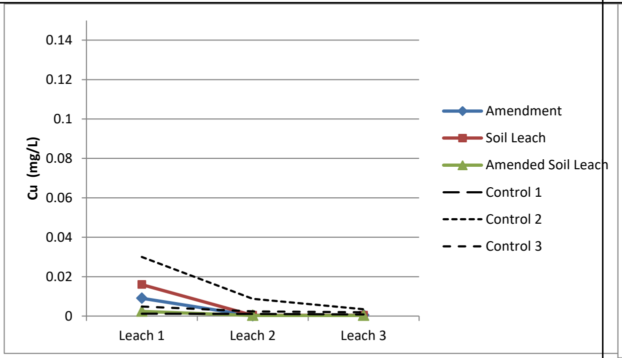

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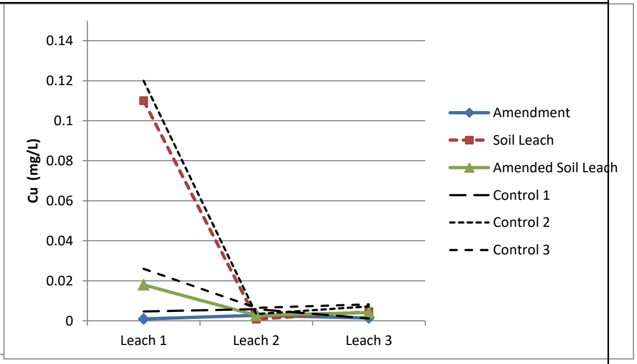

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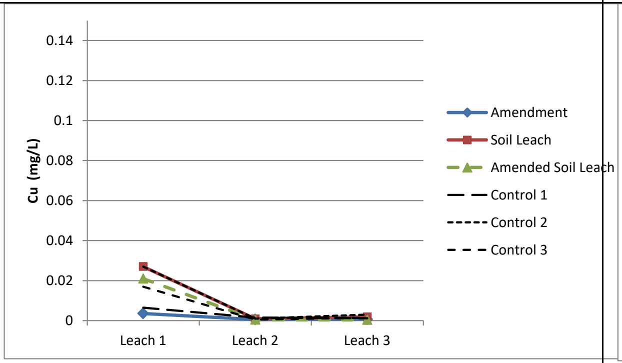

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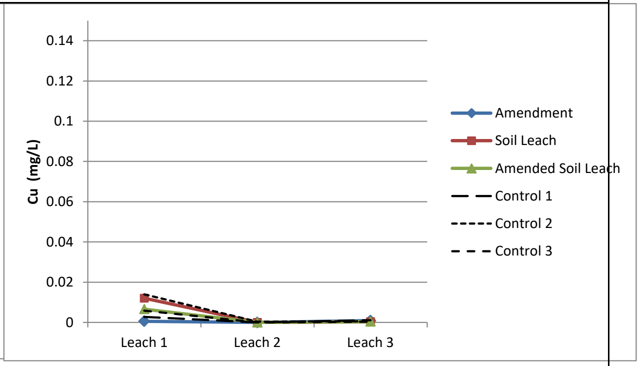
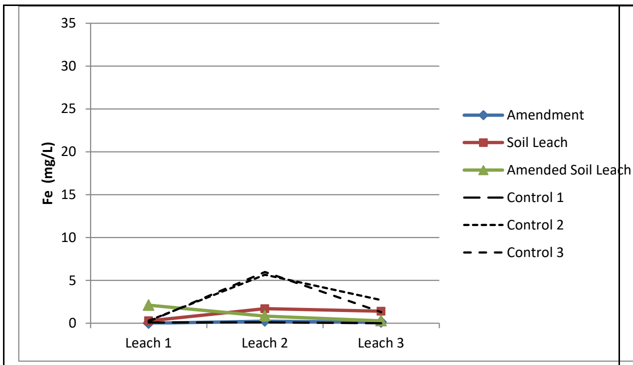
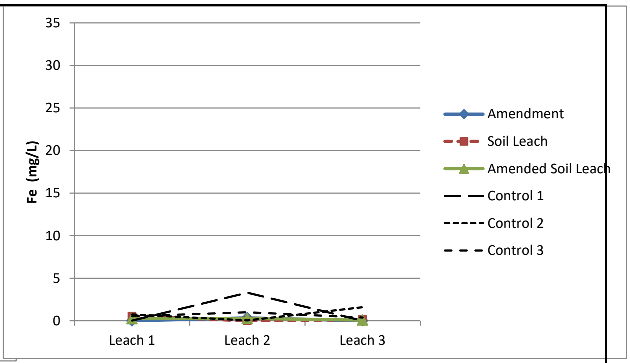


Spearwood

A12-2. Ironman Gypsum (IMG)





Bassendean Ellenbrook

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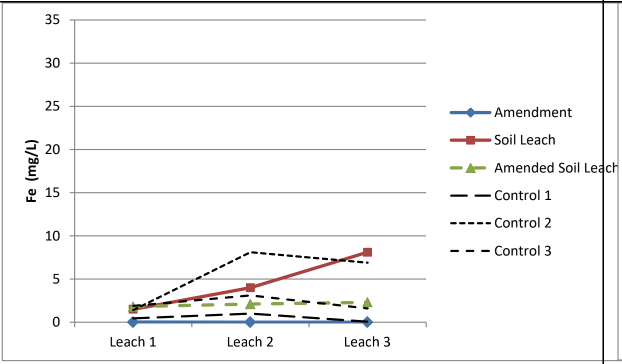

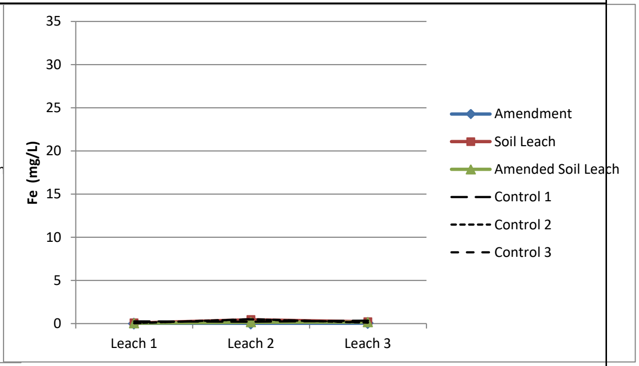

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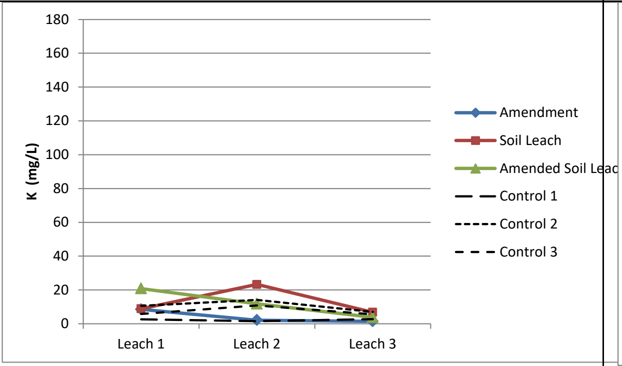

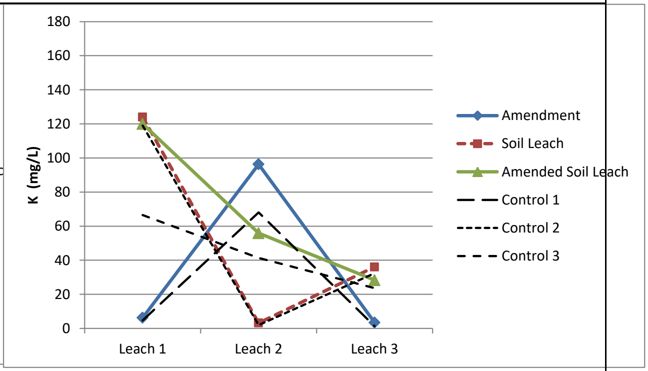

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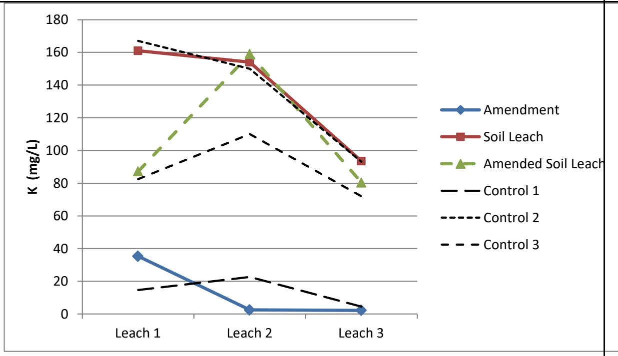
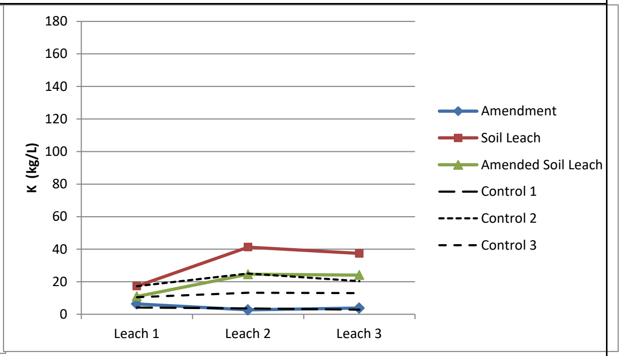
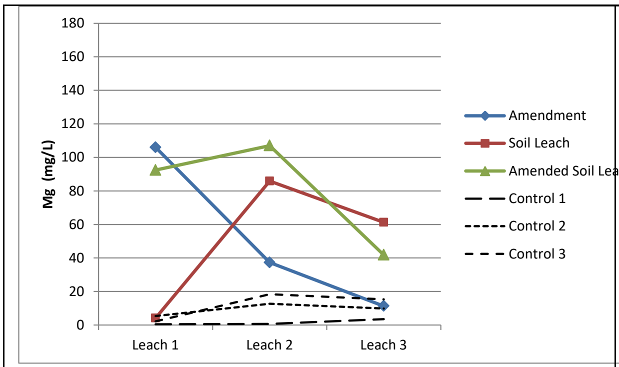


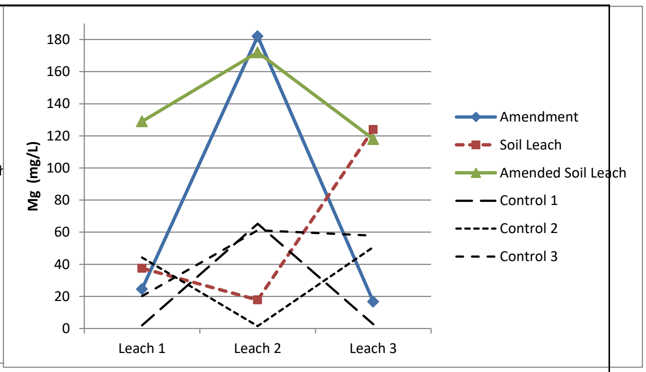


Fairbridge Duplex

Spearwood

A12-2. Ironman Gypsum (IMG)





Bassendean Ellenbrook

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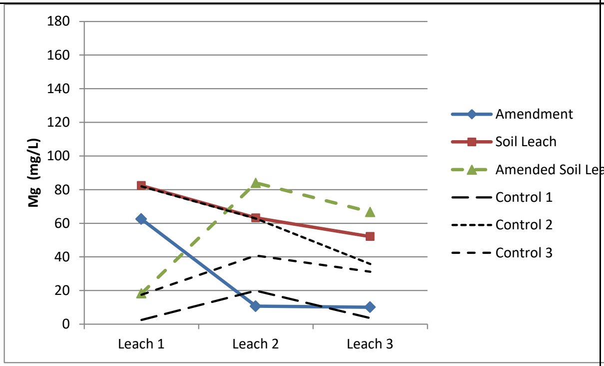

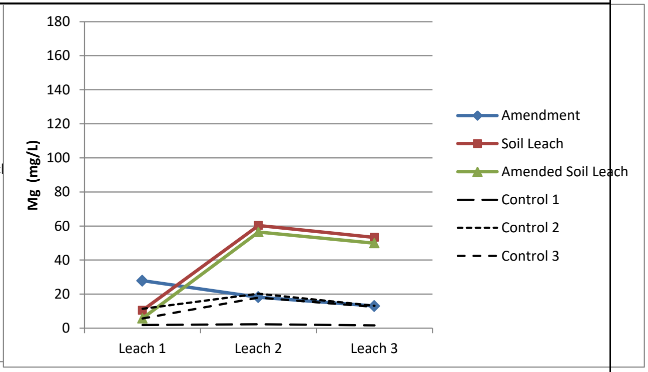

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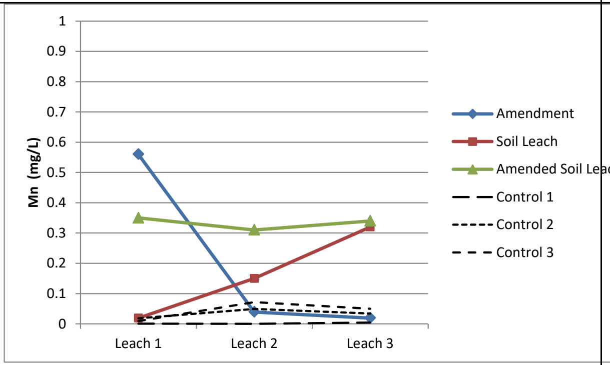

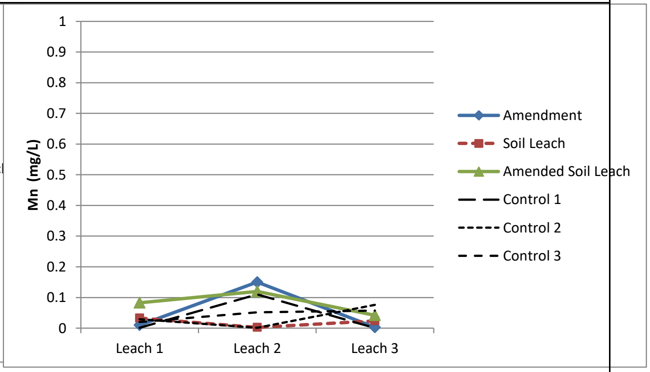

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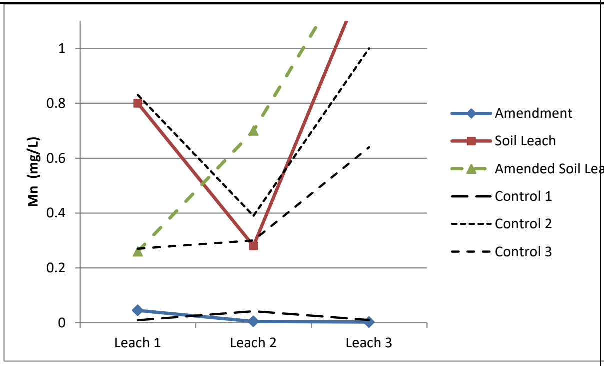
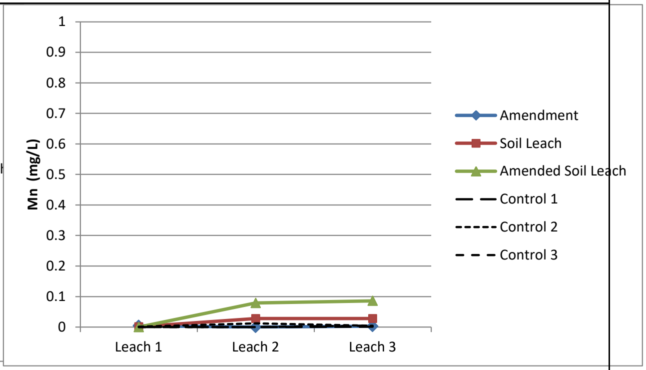
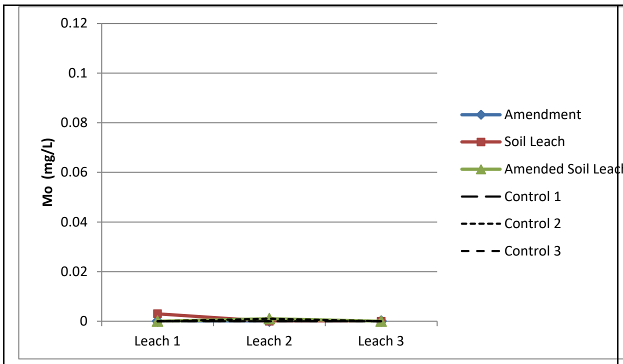




Fairbridge Duplex

Spearwood

A12-2. Ironman Gypsum (IMG)



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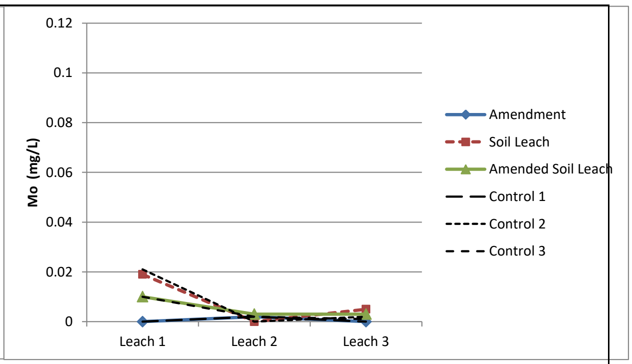

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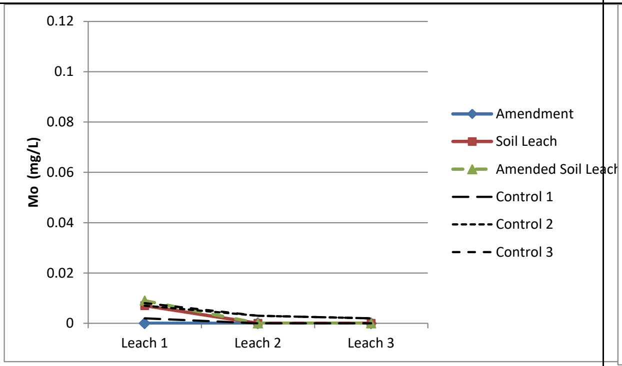

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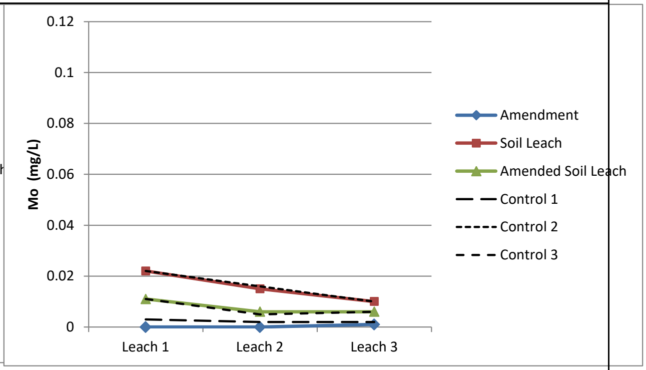

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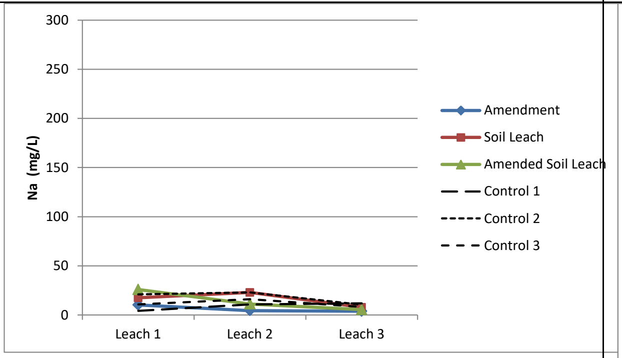

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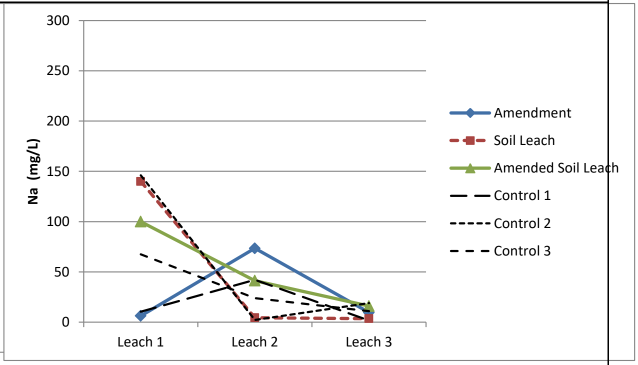

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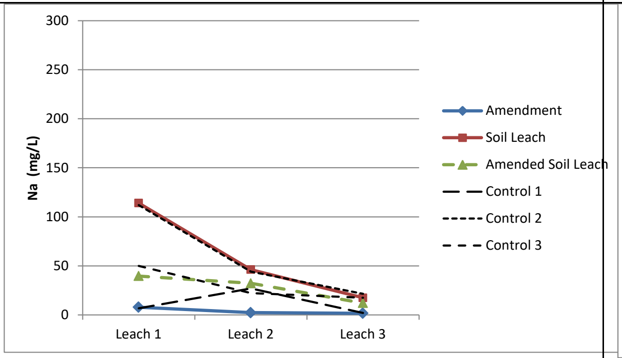

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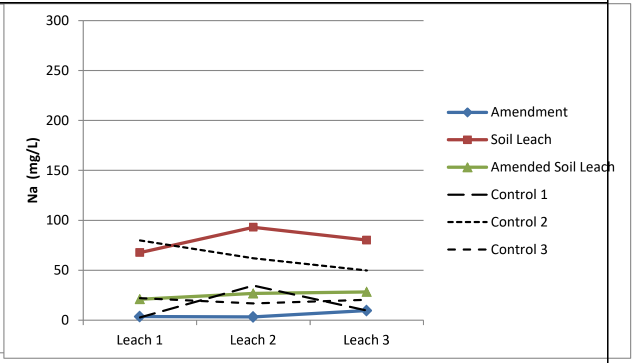
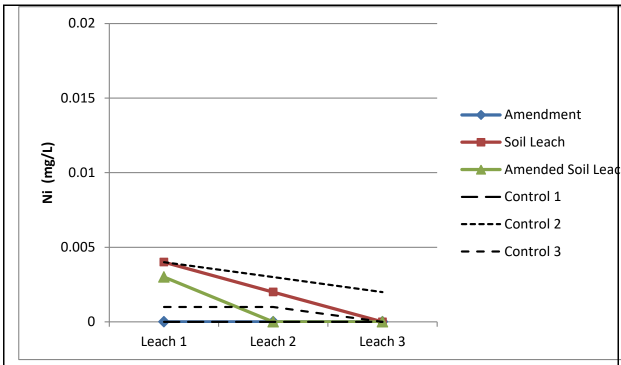


Spearwood

A12-2. Ironman Gypsum (IMG)



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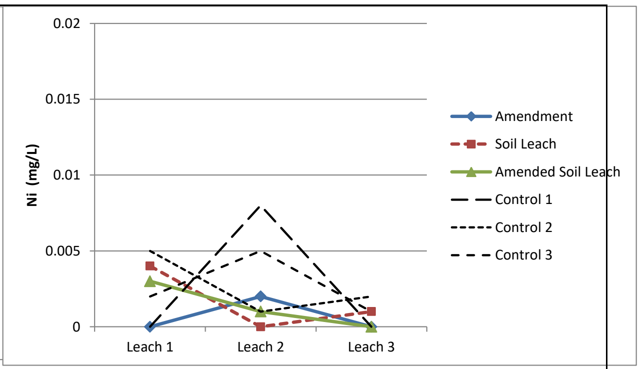

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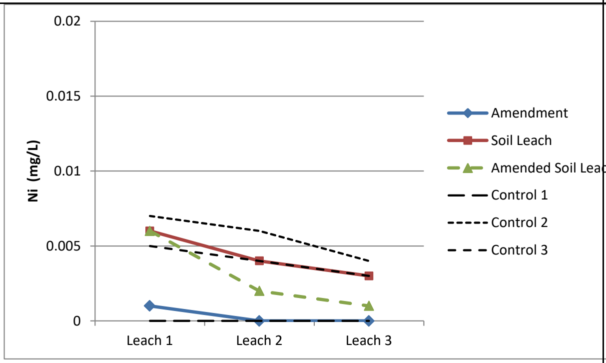

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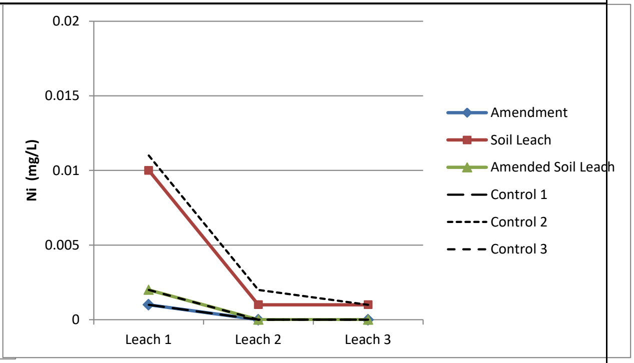
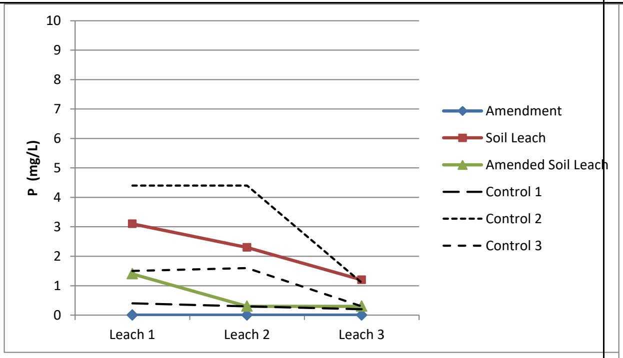


Spearwood



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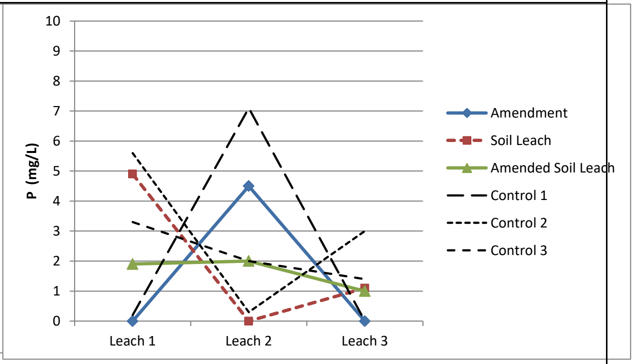

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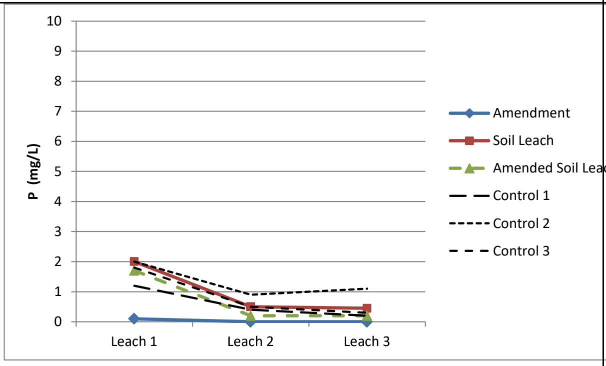

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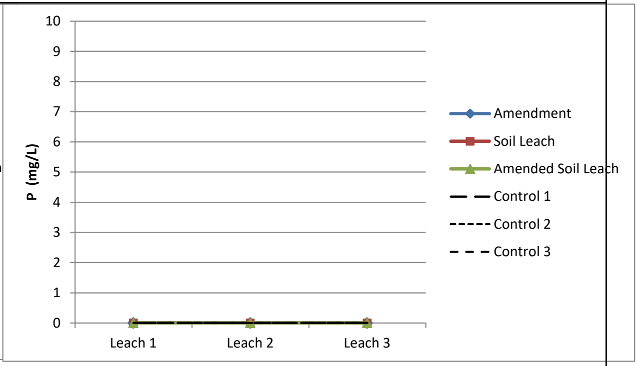

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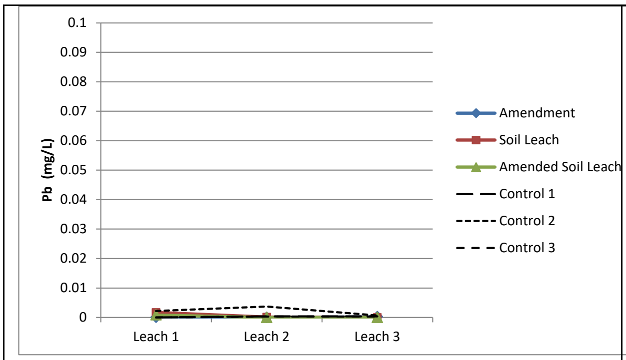
A12-2. Ironman Gypsum (IMG)



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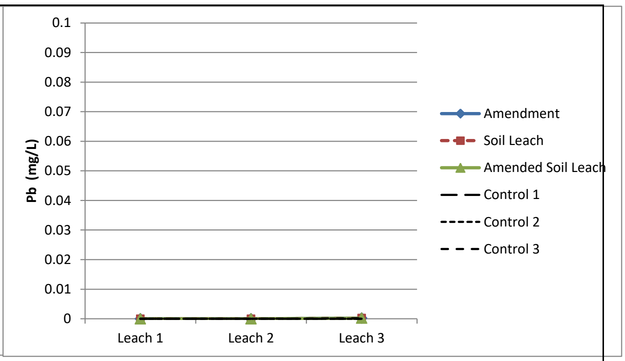

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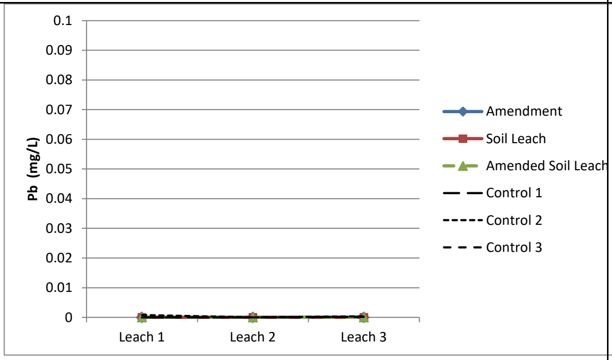

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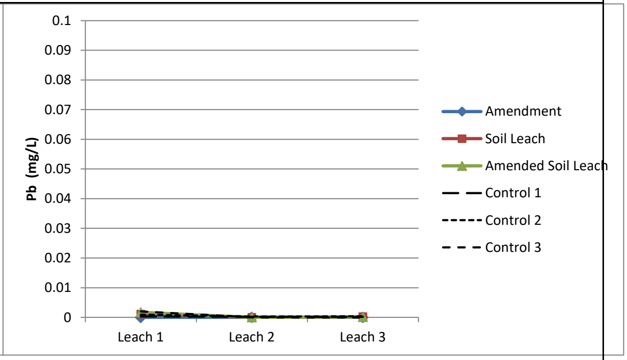

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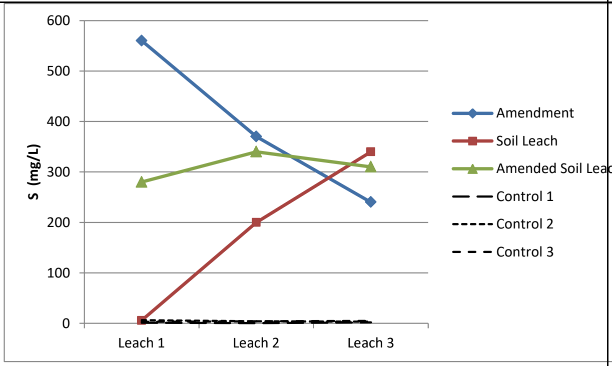

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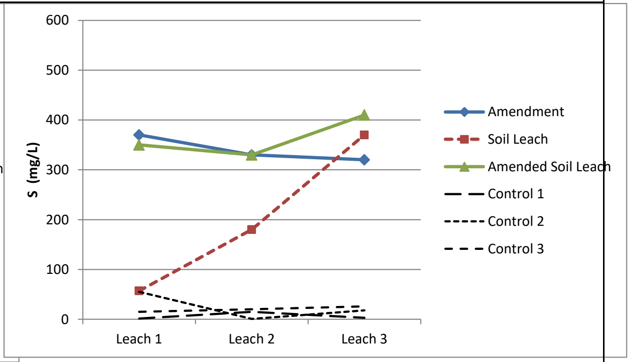

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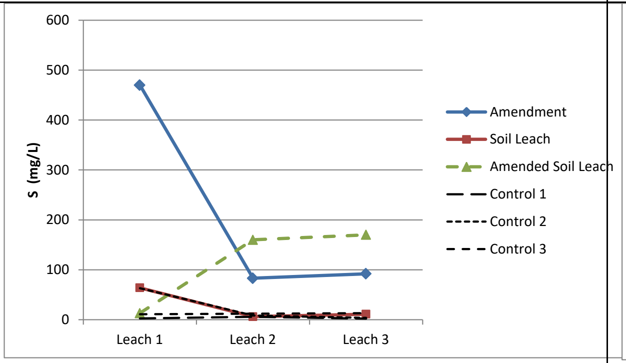

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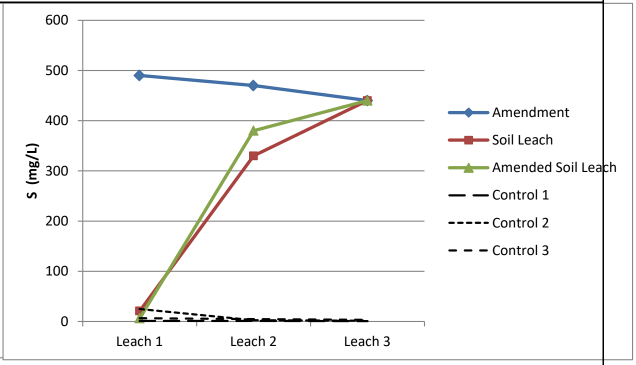

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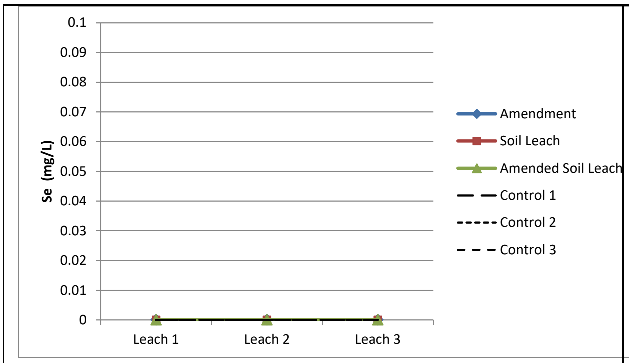
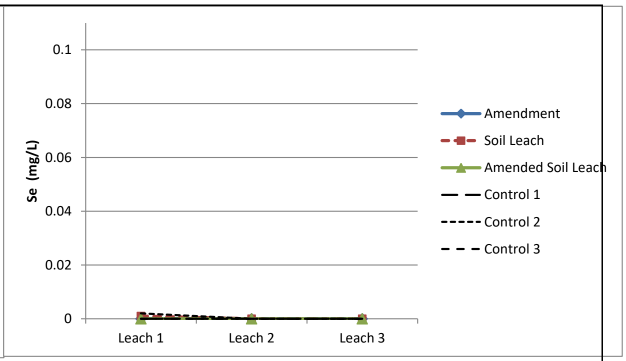
A12-2. Ironman Gypsum (IMG)





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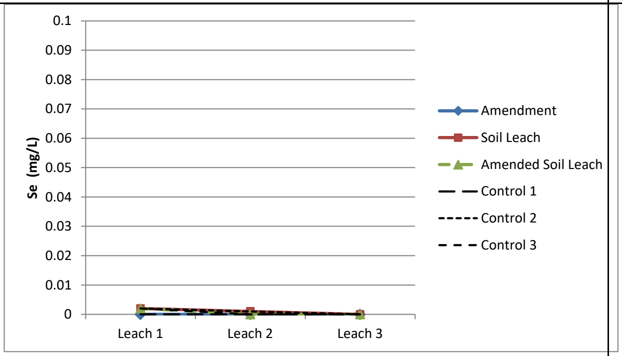

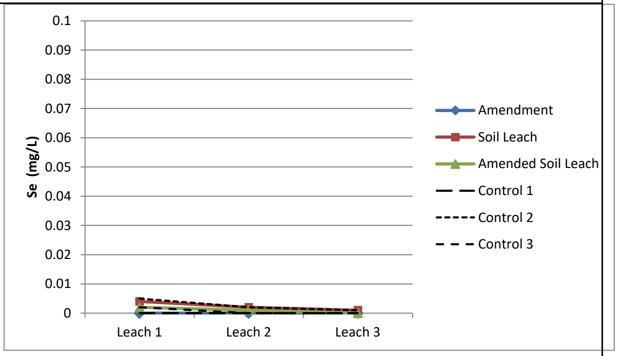

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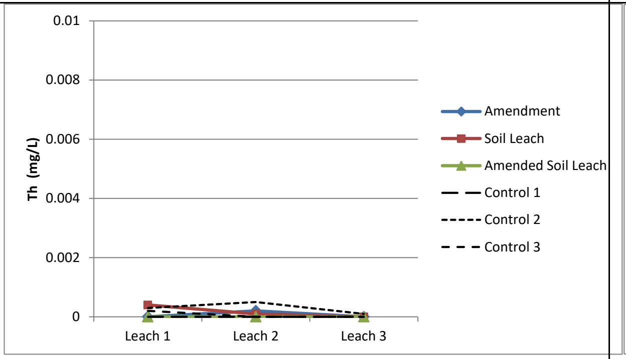

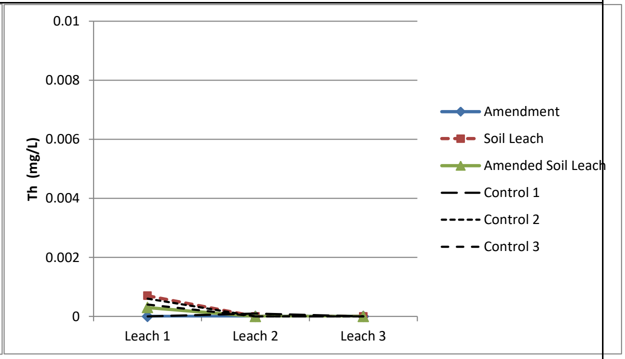

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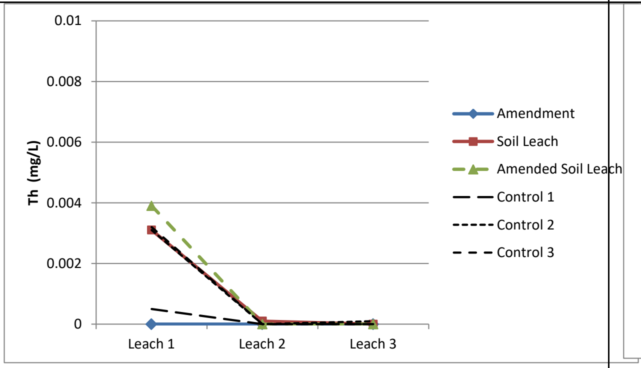
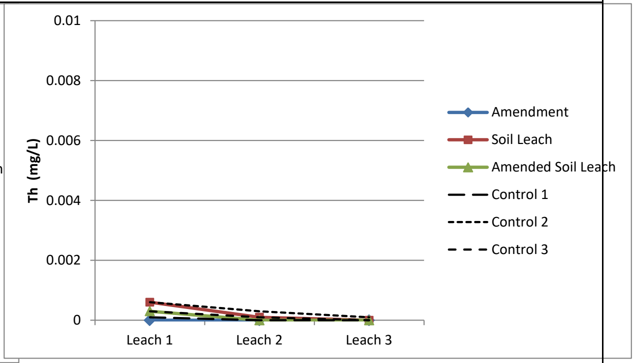
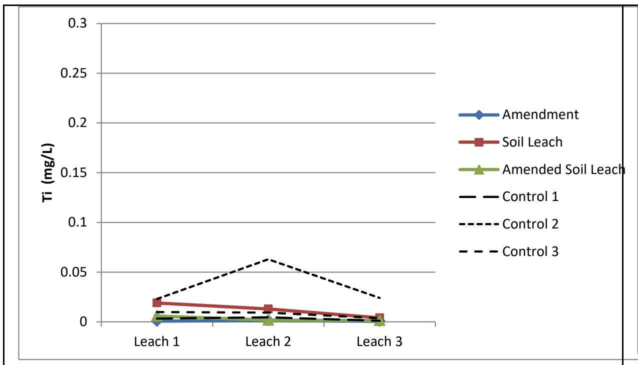




Fairbridge Duplex

Spearwood

A12-2. Ironman Gypsum (IMG)



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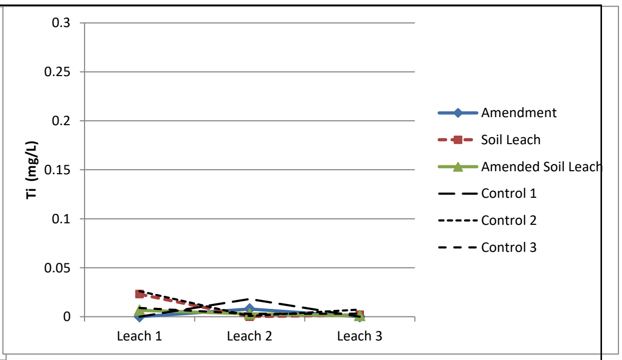

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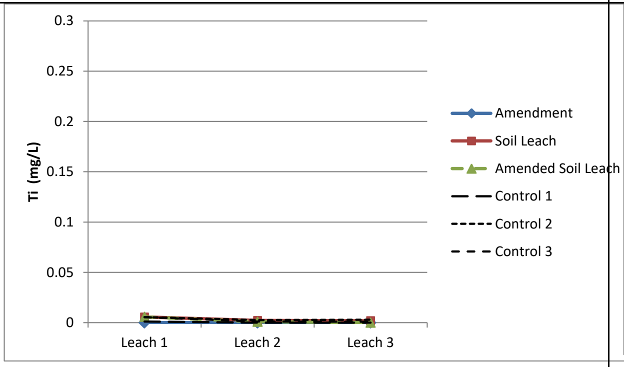

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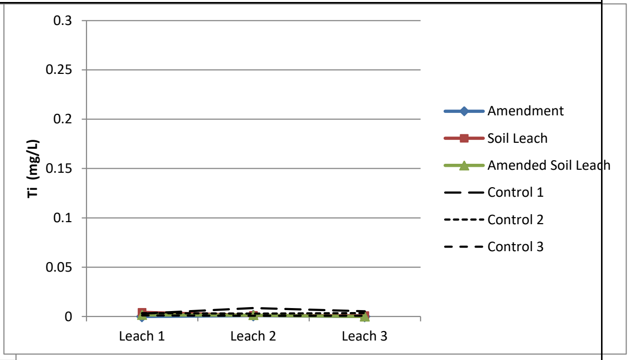

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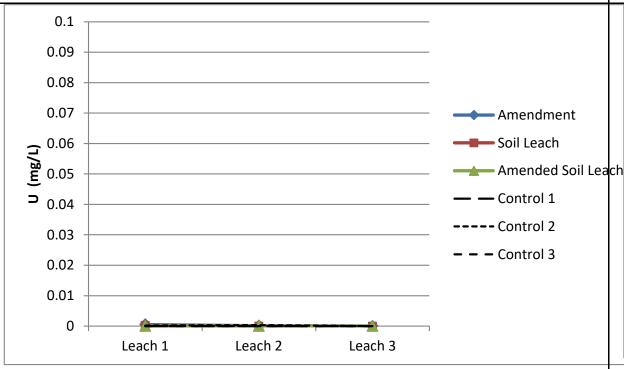

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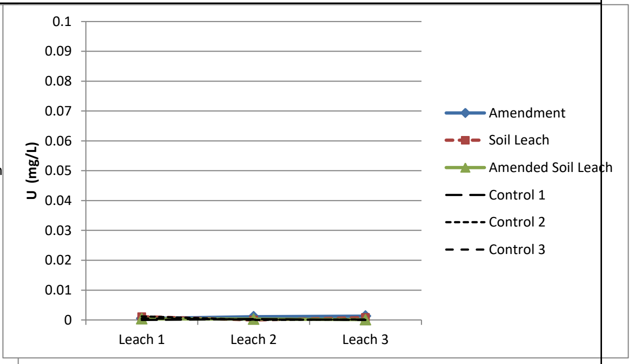

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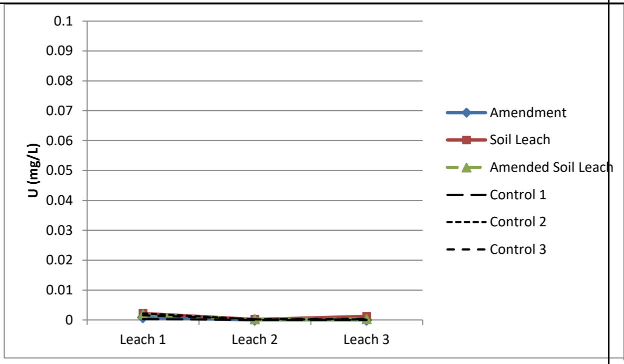

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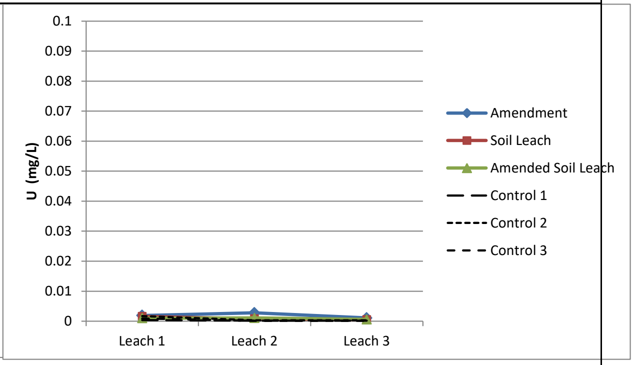
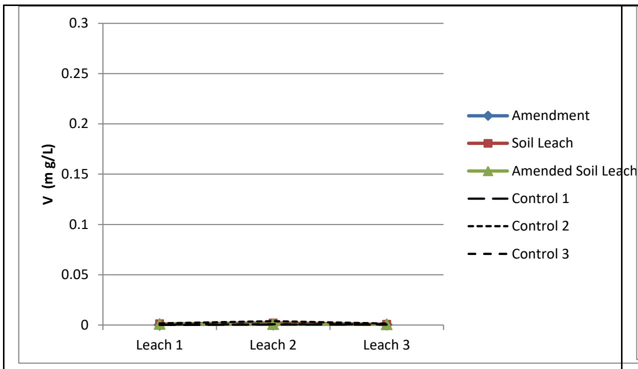
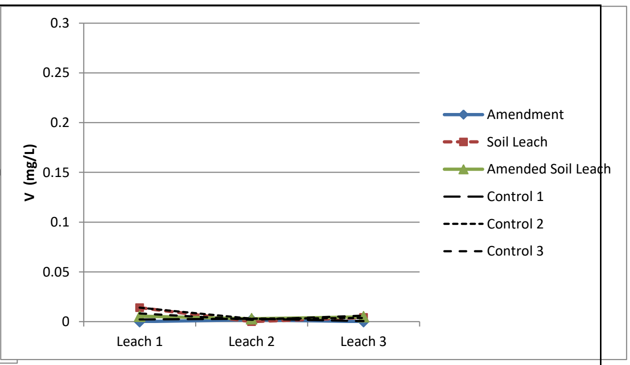


Spearwood

A12-2. Ironman Gypsum (IMG)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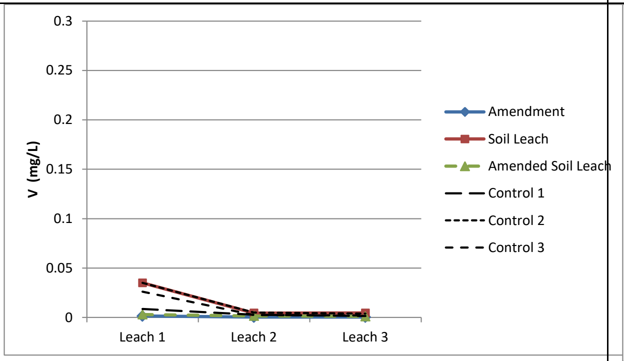
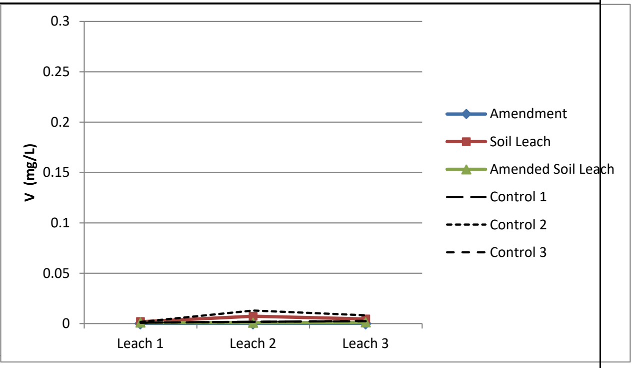
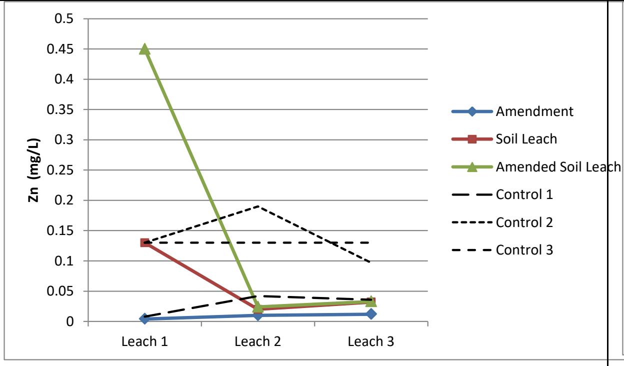
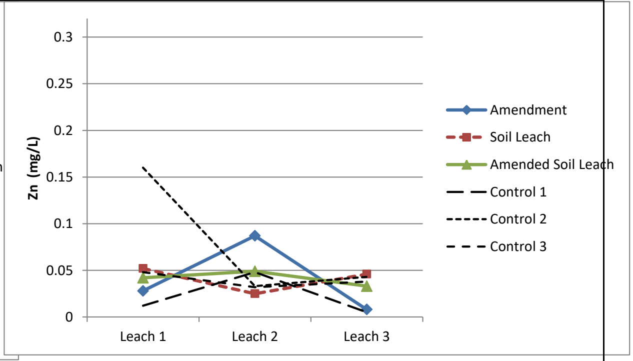
	
Fairbridge Duplex	Spearwood
	
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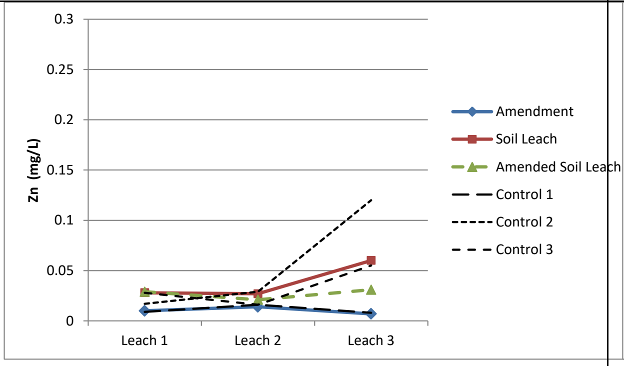	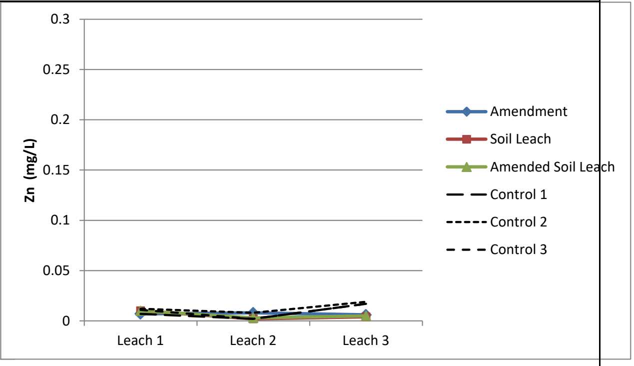
Fairbridge Duplex	Spearwood

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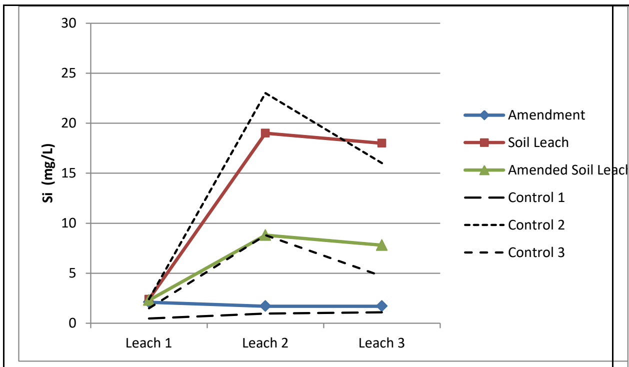

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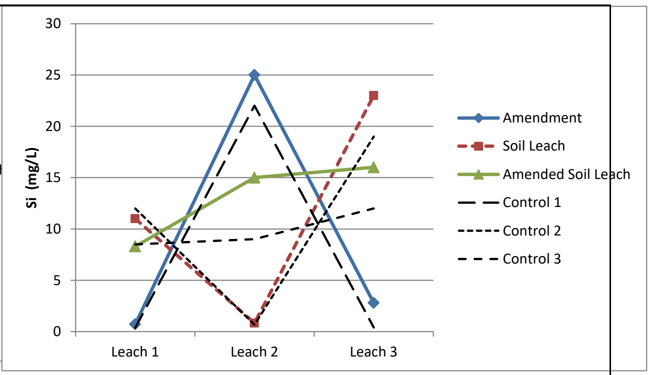

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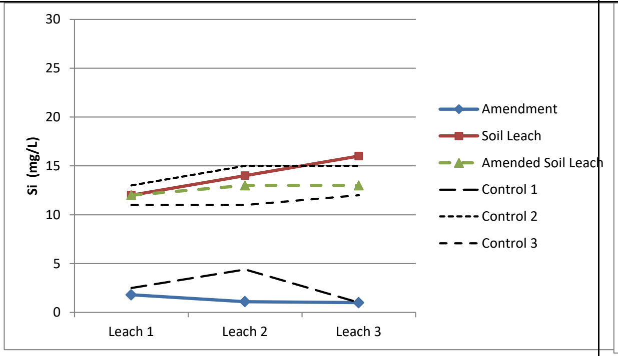

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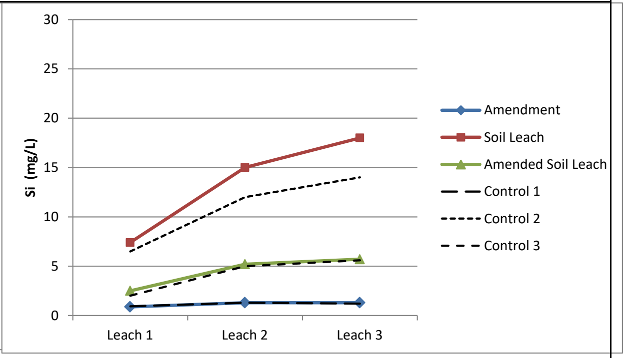
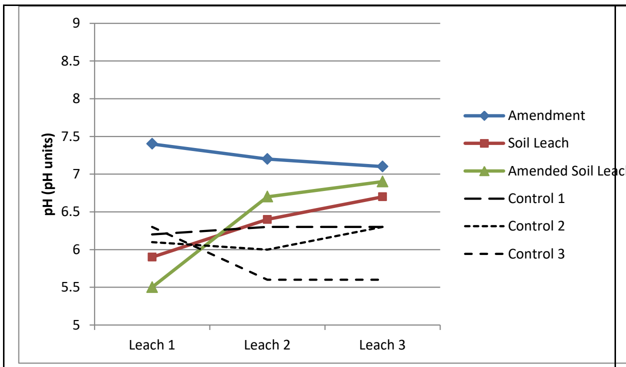


Spearwood

A12-3. NRP



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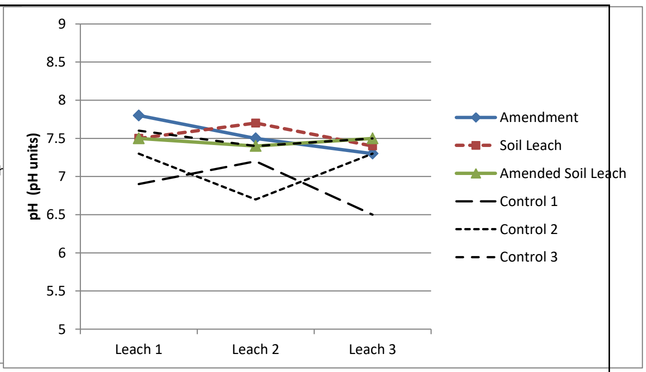

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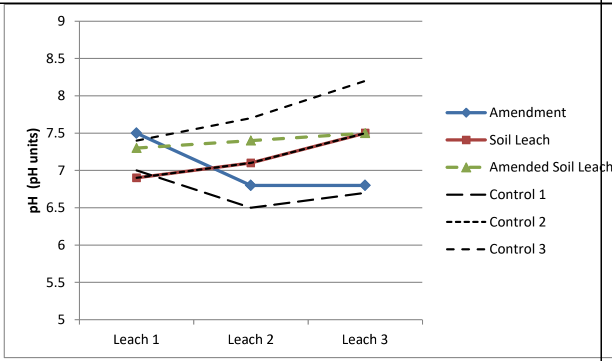

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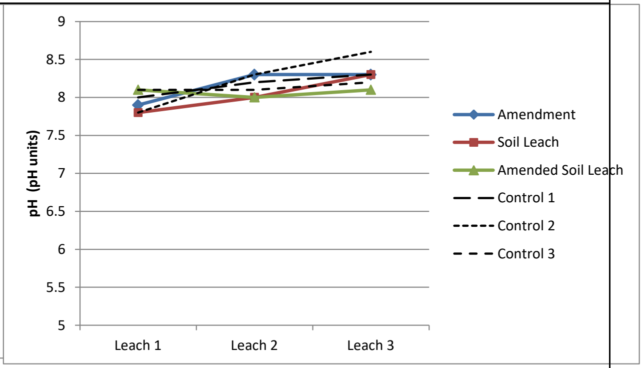

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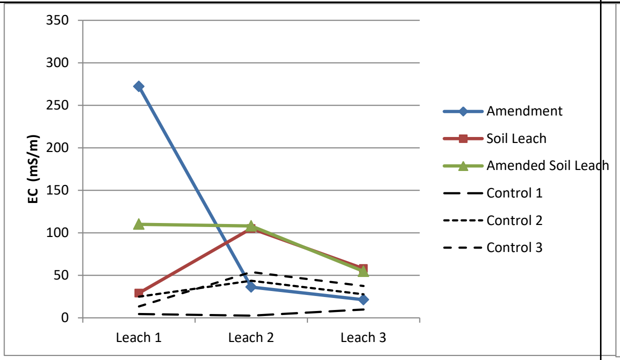

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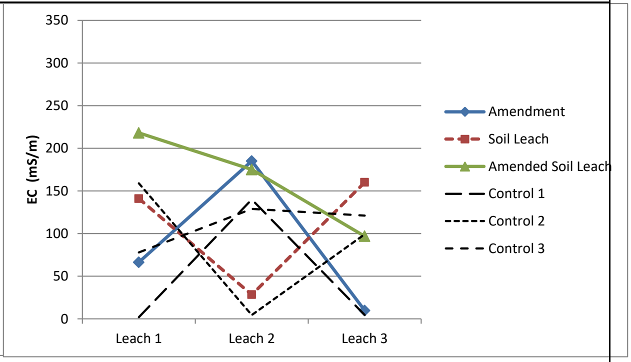

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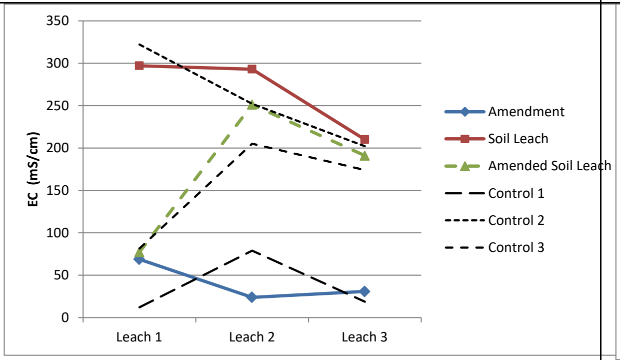

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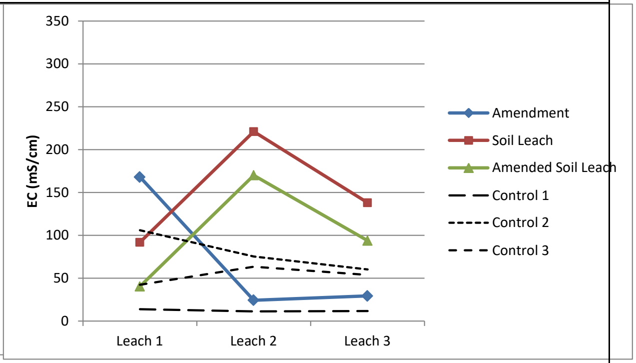

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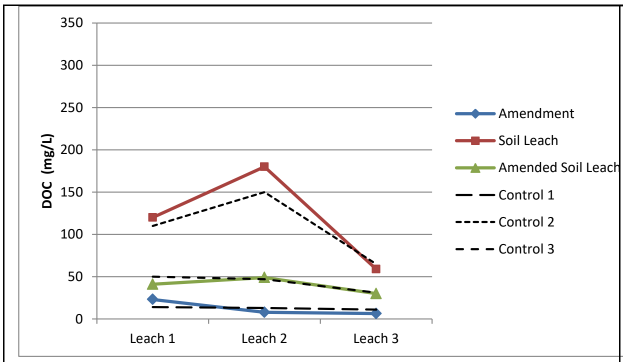

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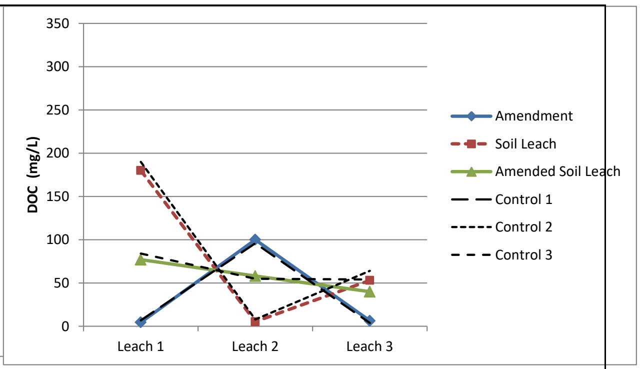

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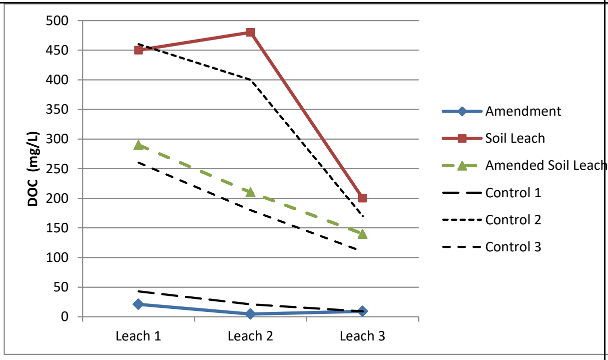

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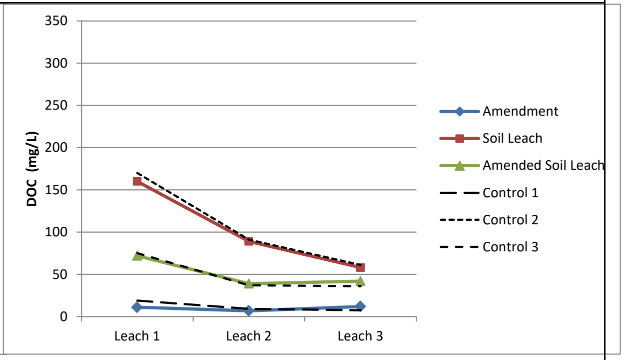

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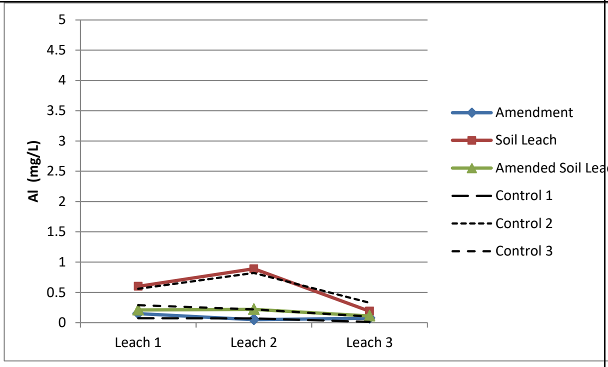

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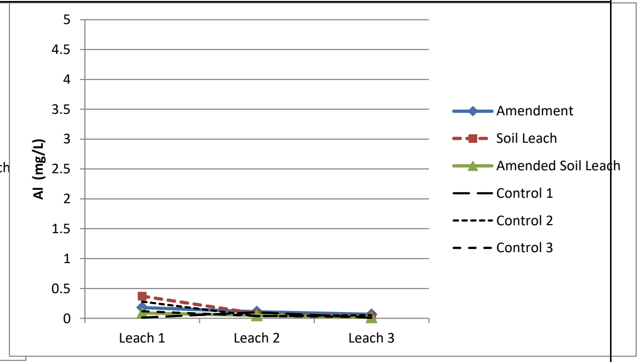

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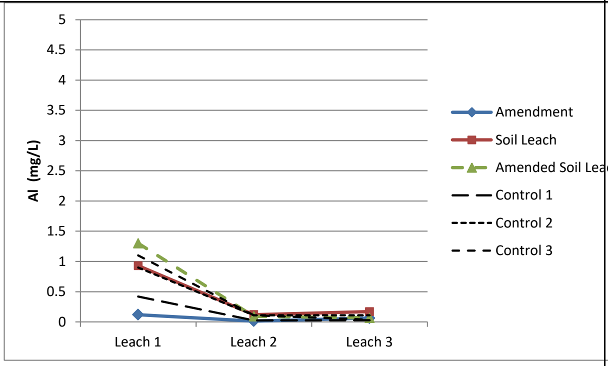

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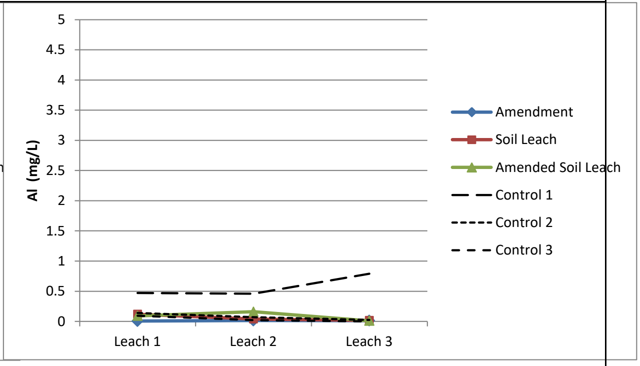

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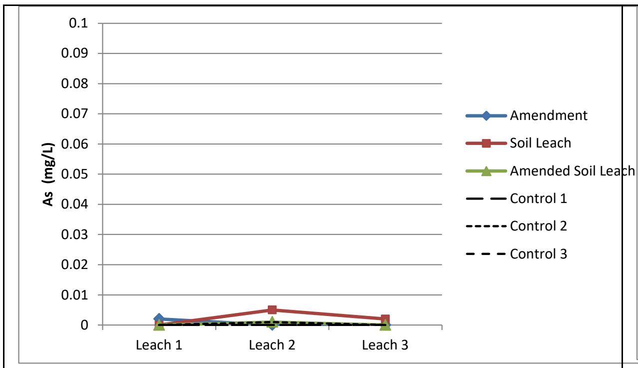
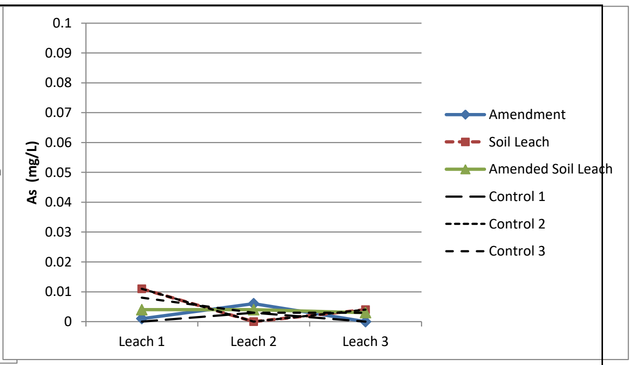
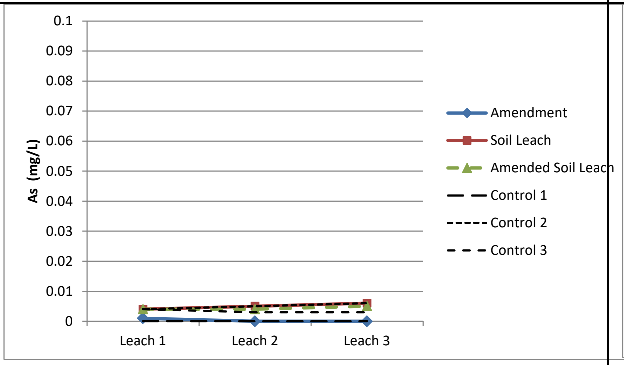
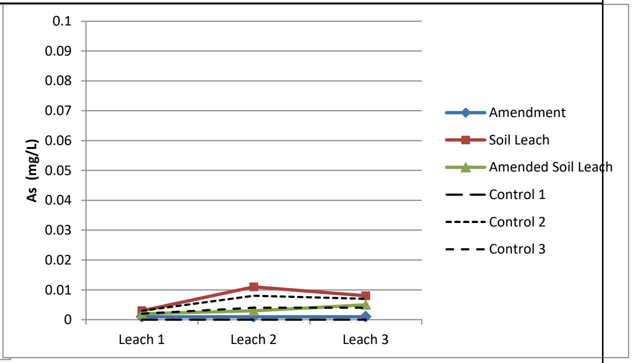




Bassendean Ellenbrook

Bassendean Joel





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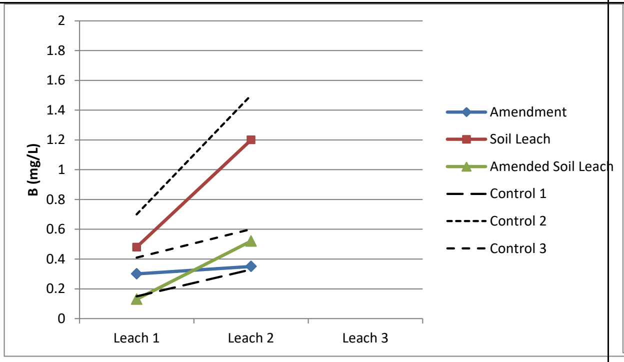

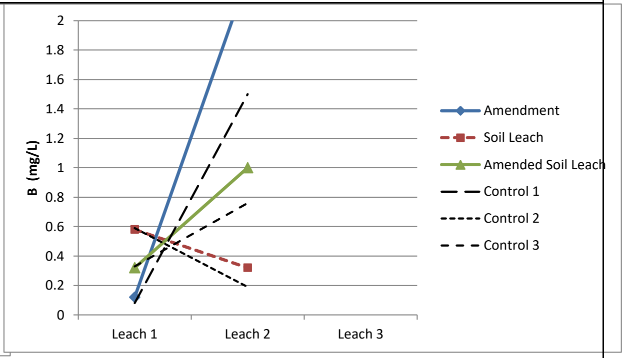

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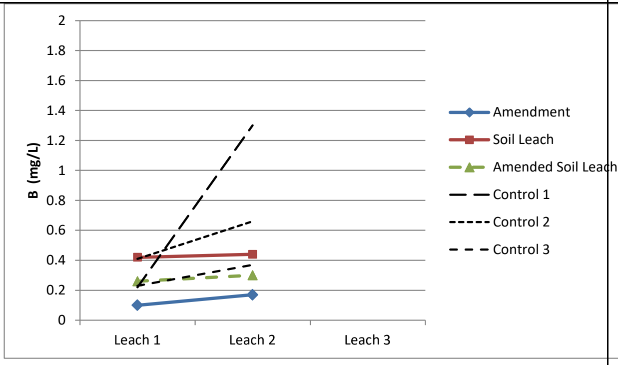

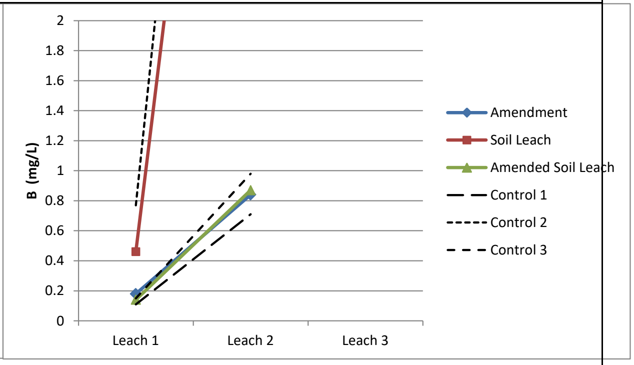

Fairbridge Duplex

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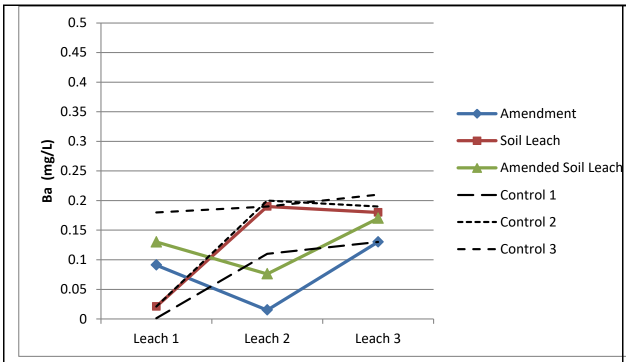
A12-3. NRP



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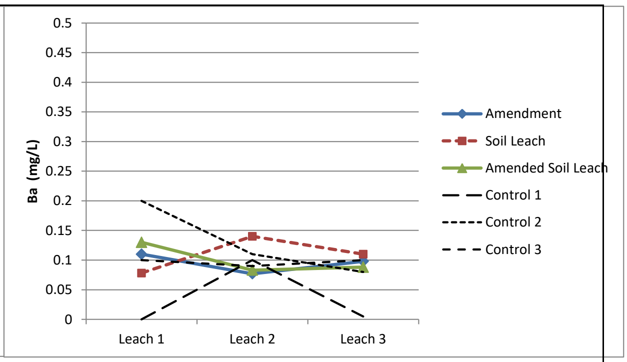

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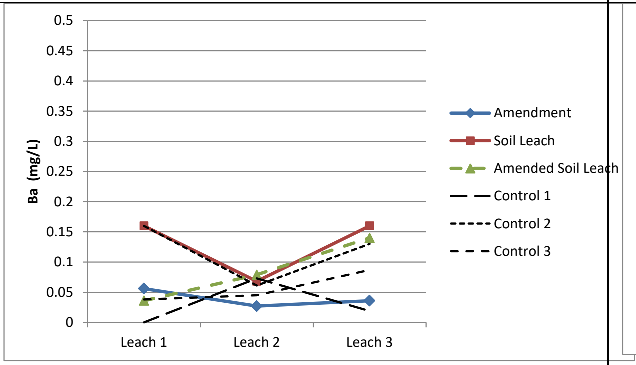

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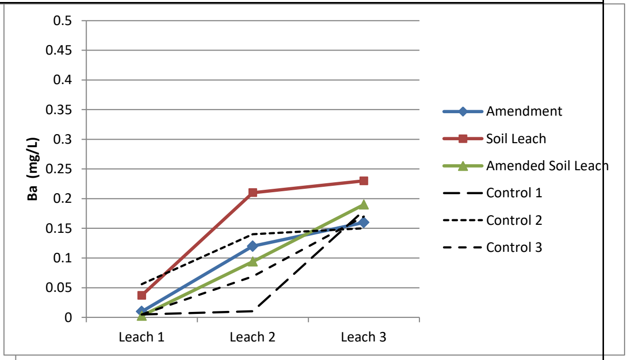

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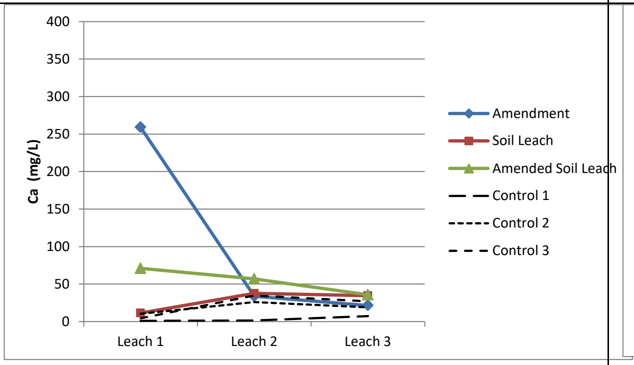

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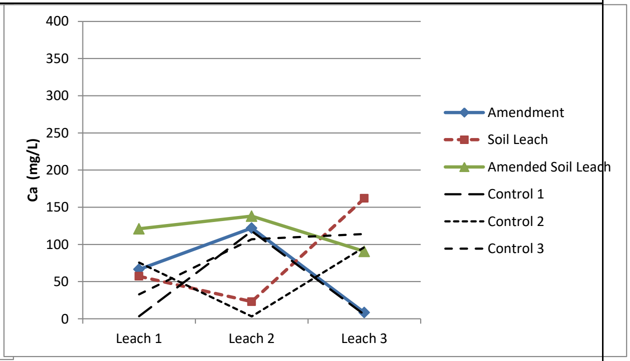

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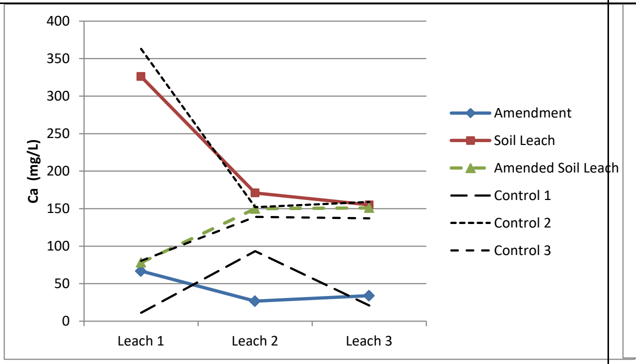

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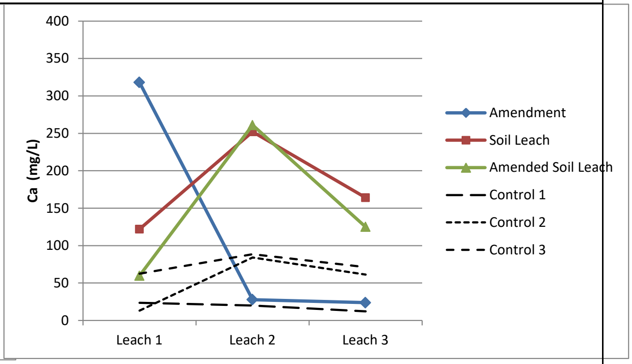

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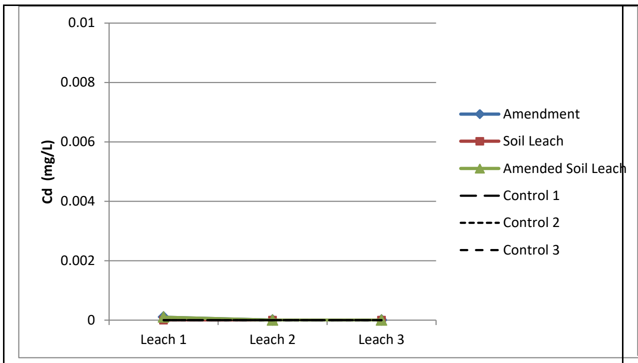
A12-3. NRP



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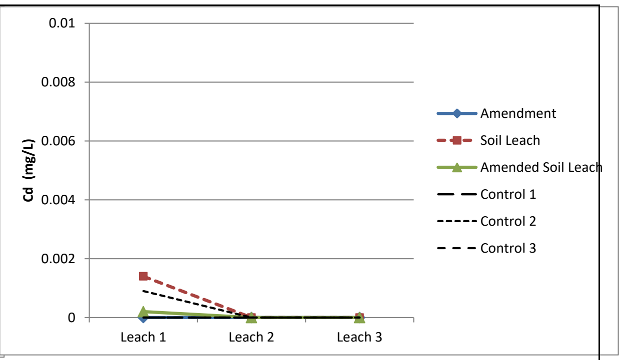

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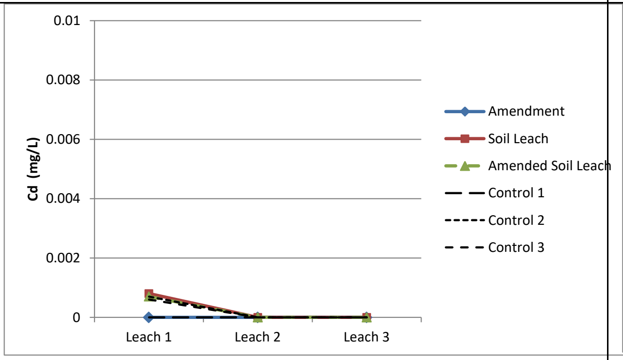

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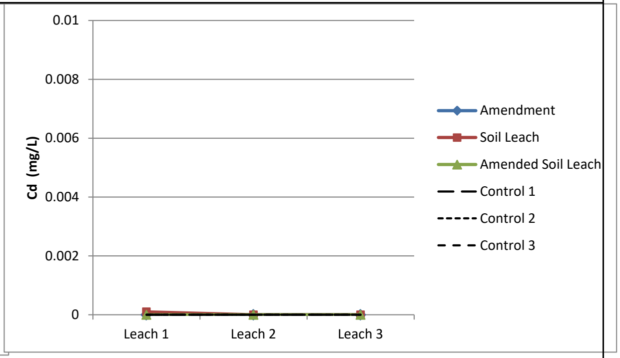

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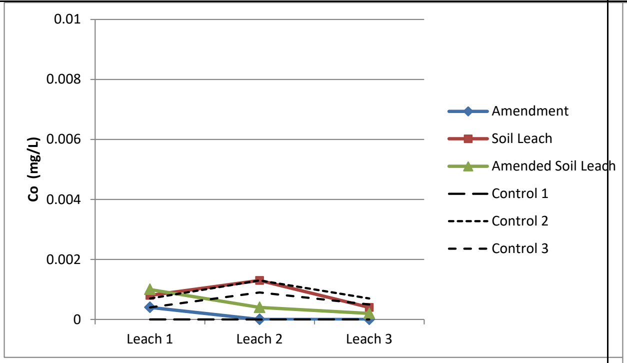

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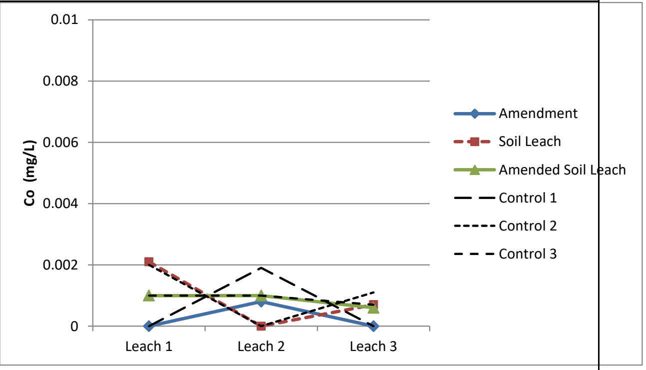

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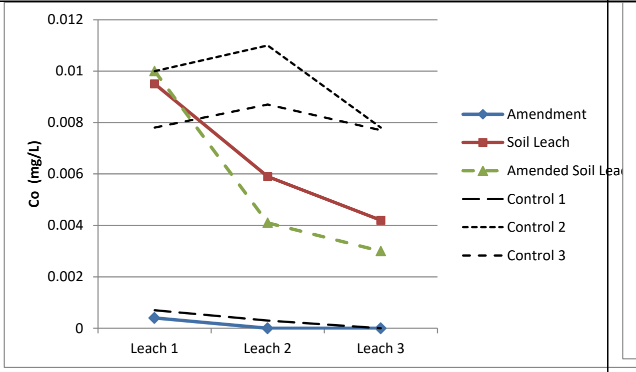

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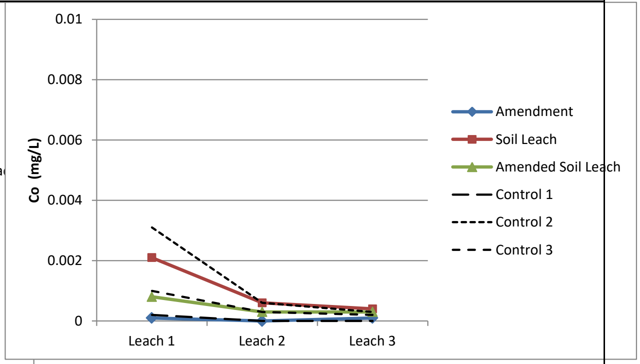

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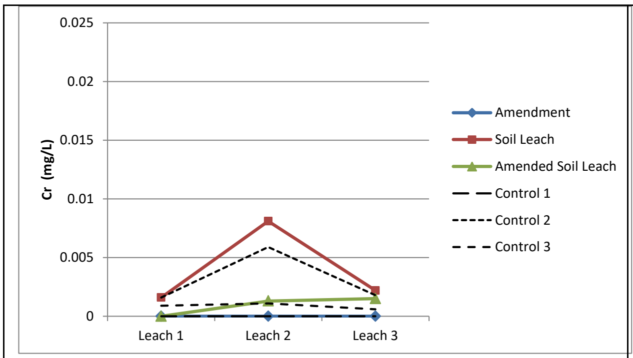

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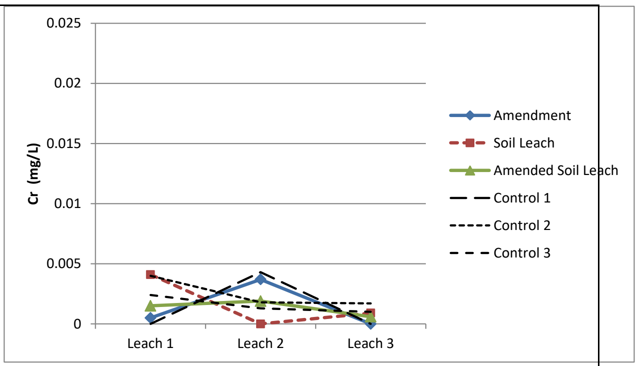

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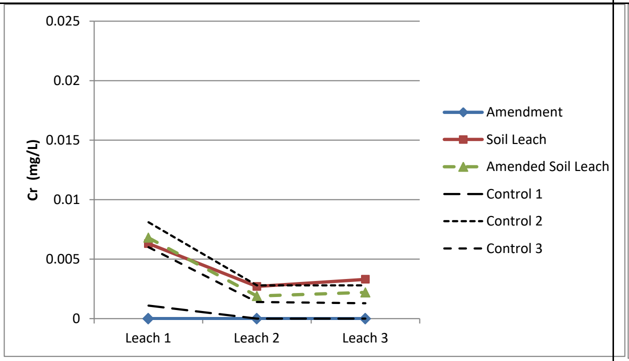

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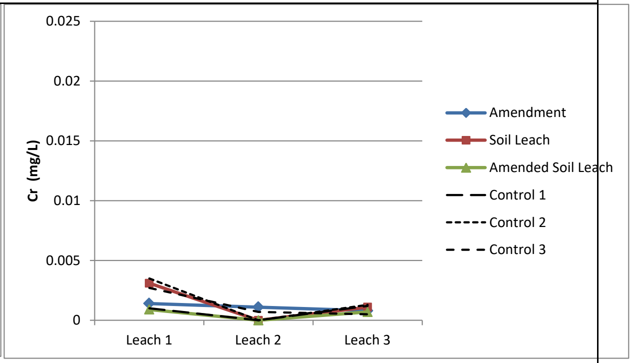

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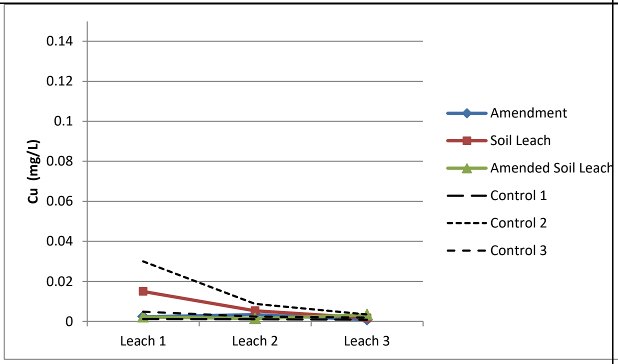

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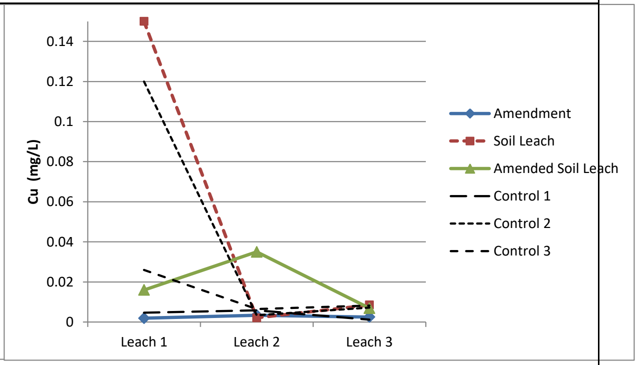

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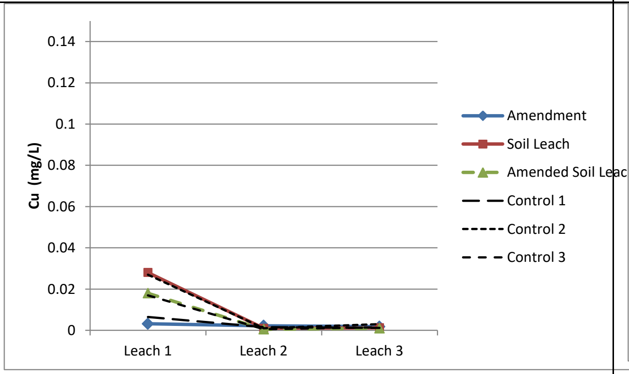

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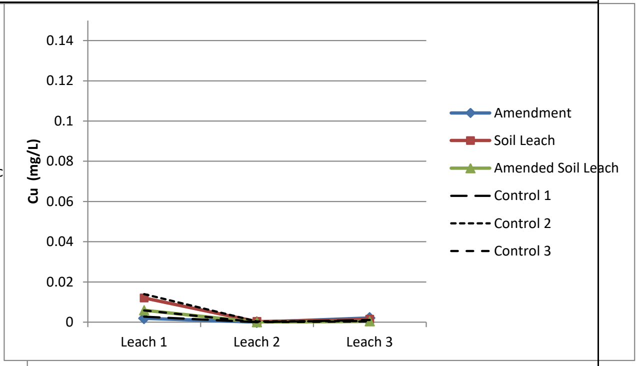

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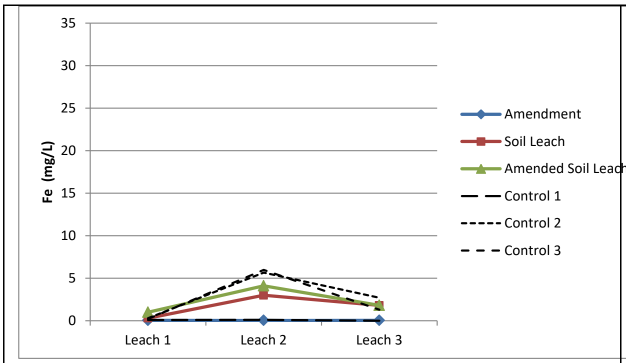

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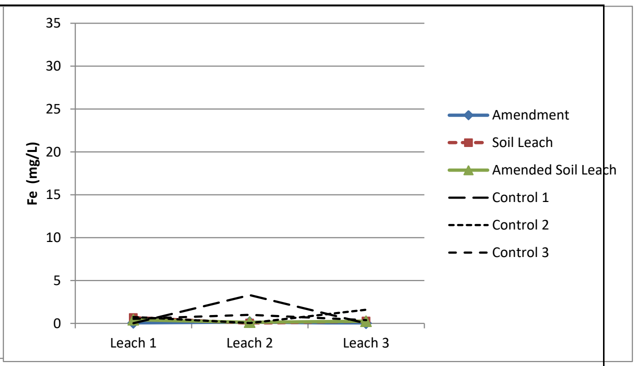

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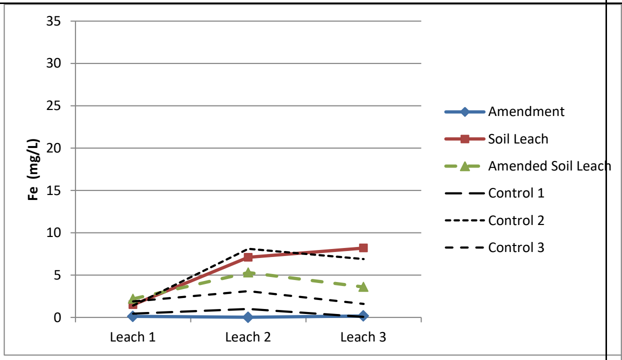

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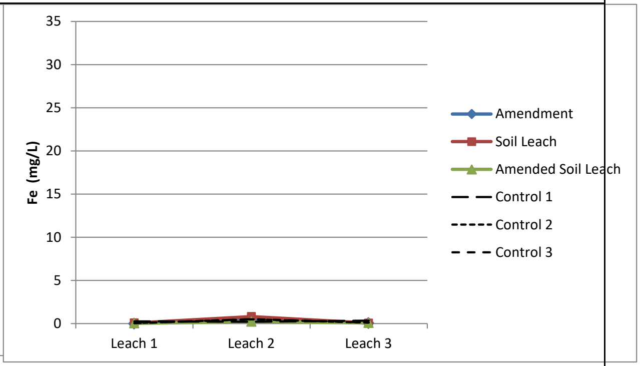

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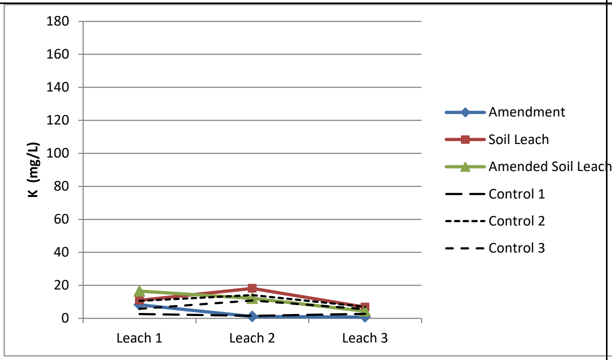

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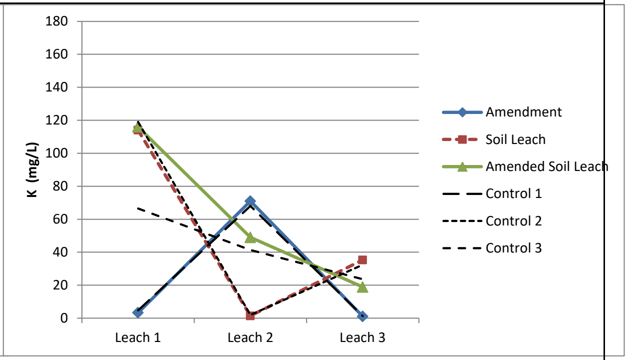

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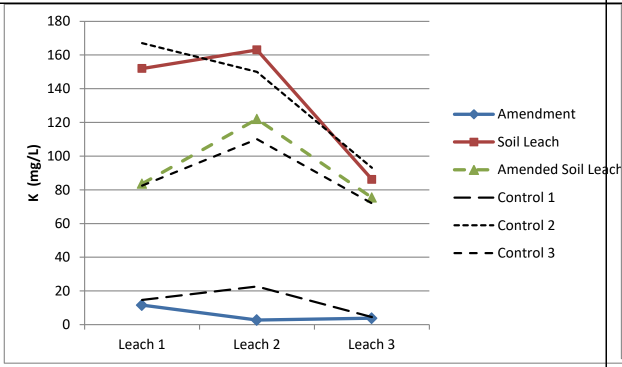

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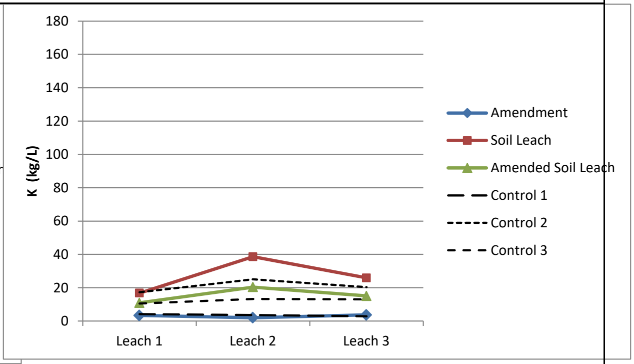

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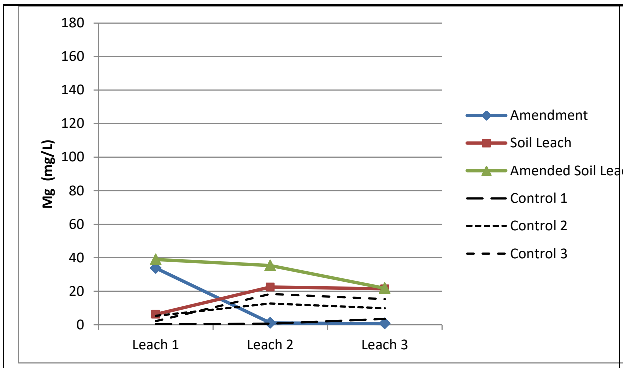

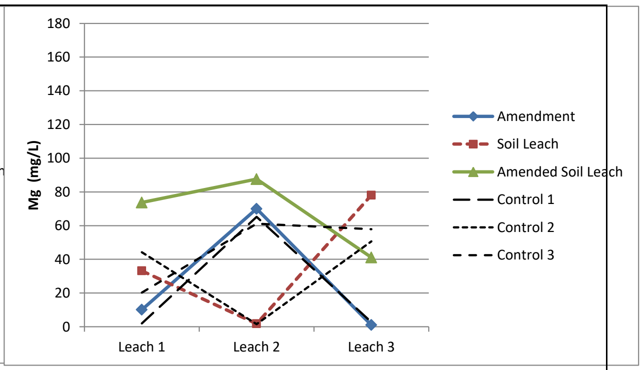

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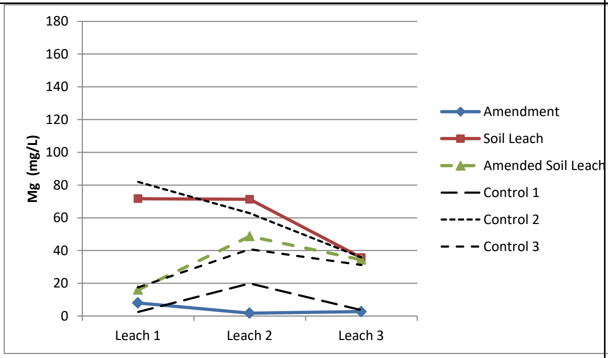

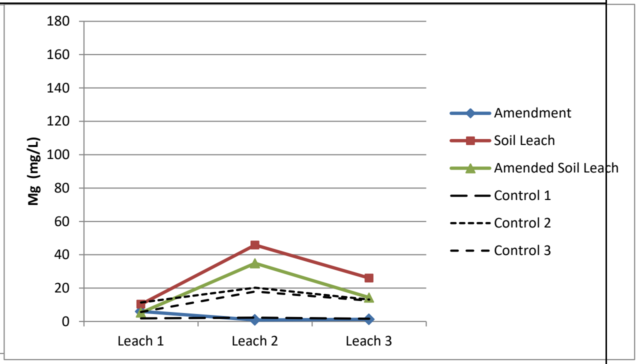

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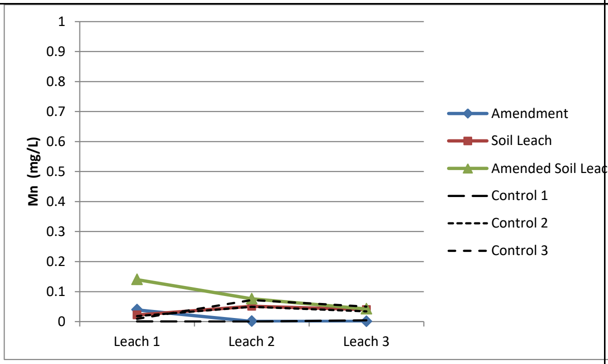

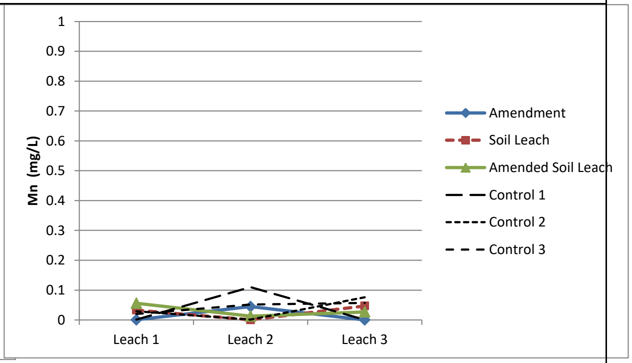

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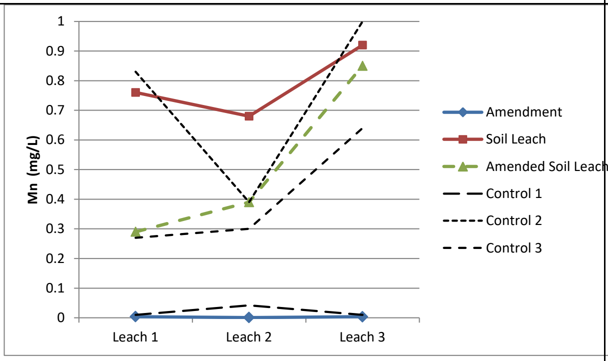

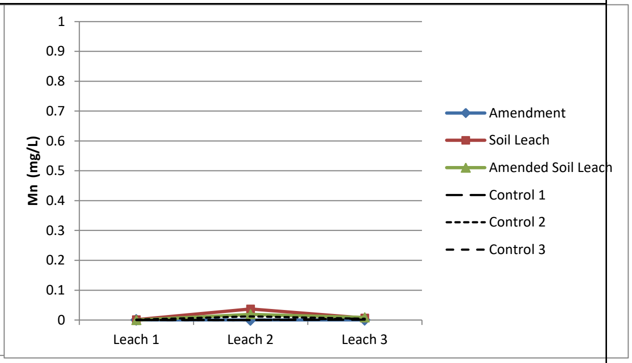

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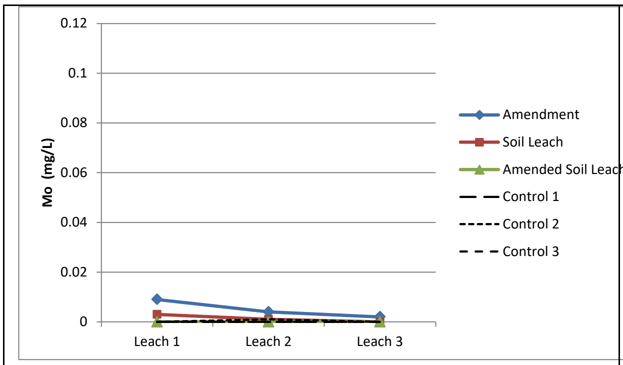

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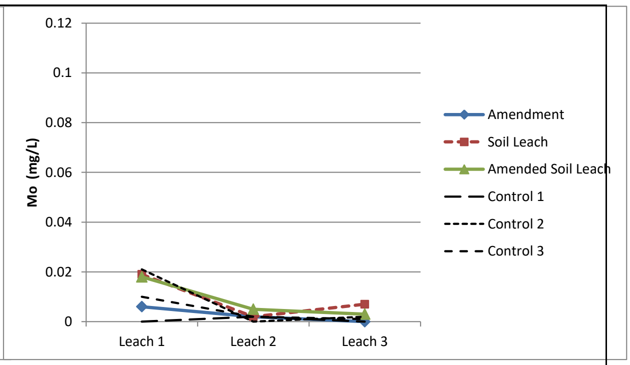

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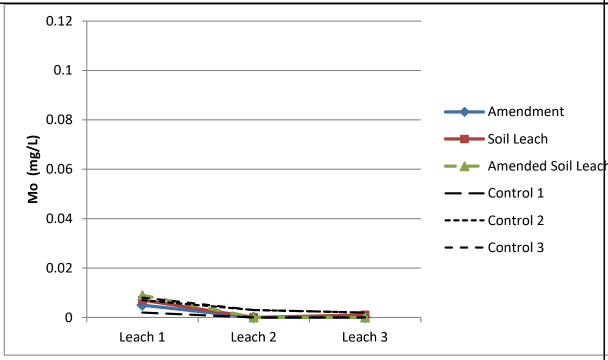

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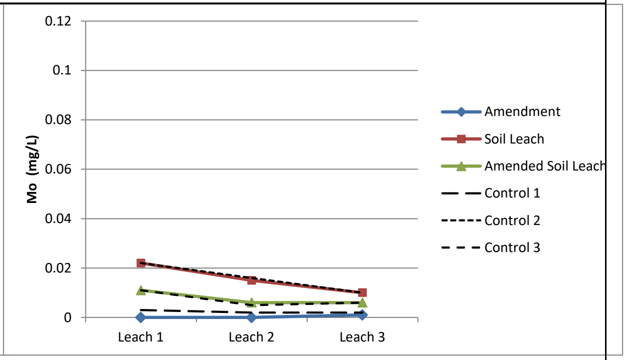

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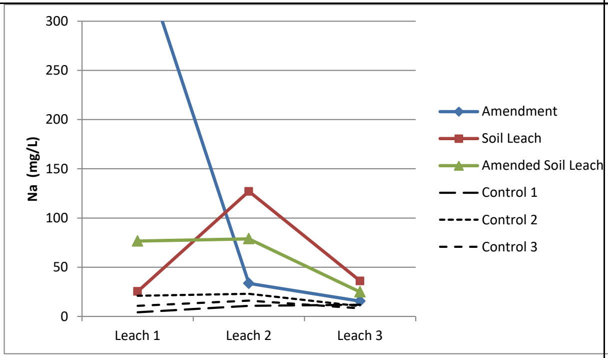

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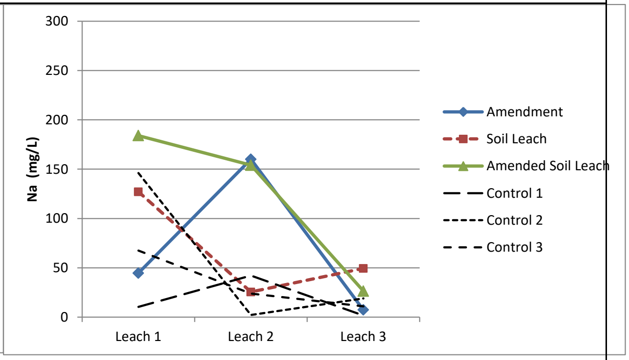

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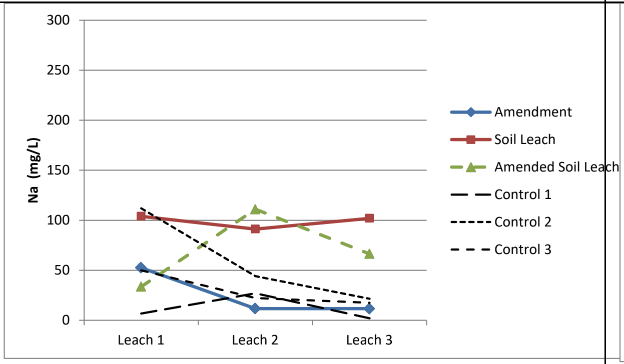

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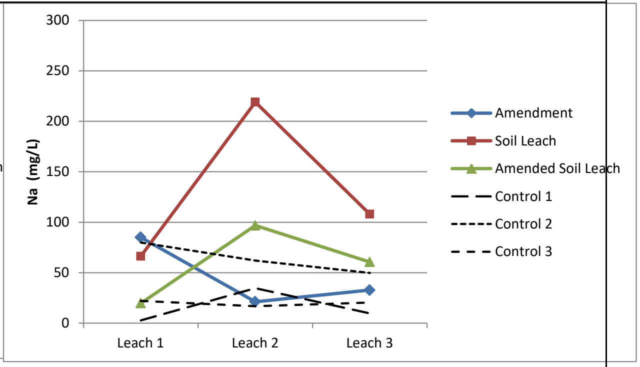

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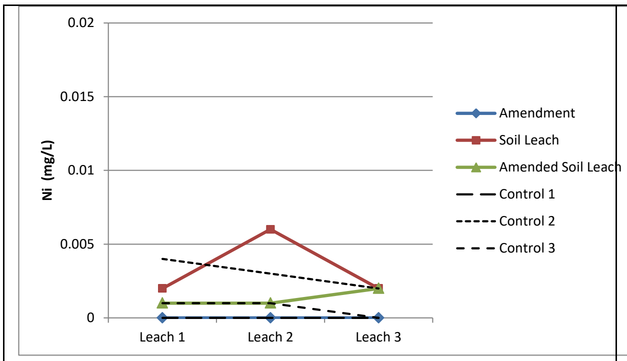

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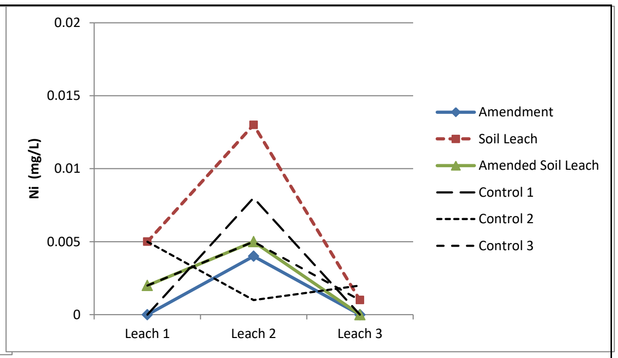

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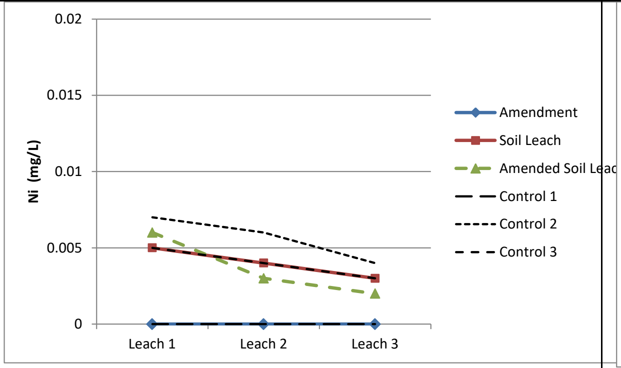

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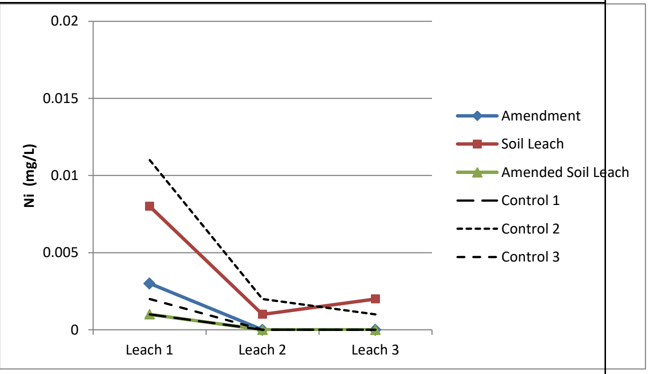

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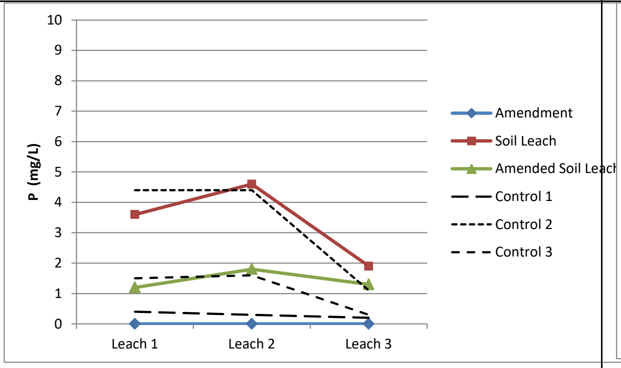

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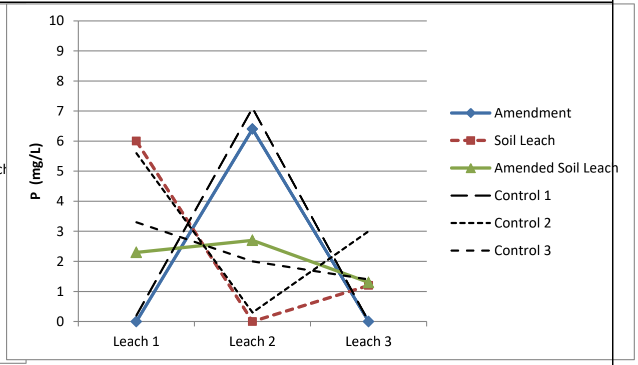

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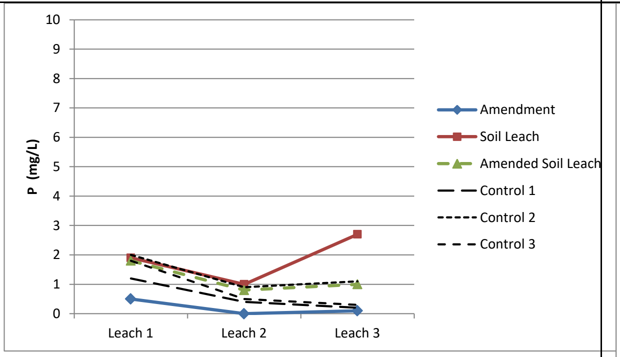

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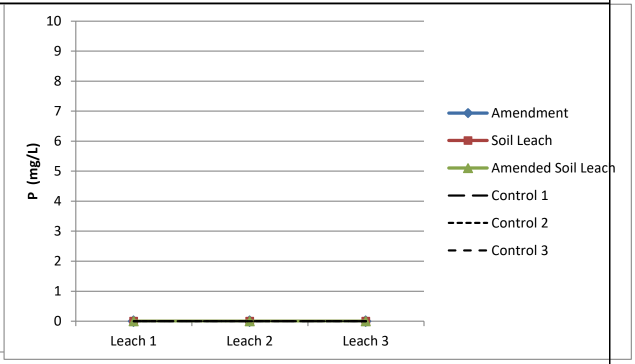

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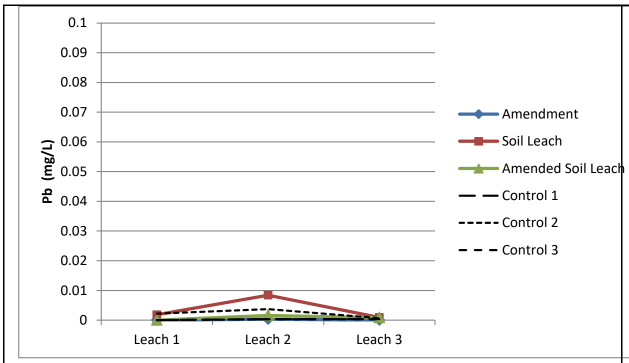

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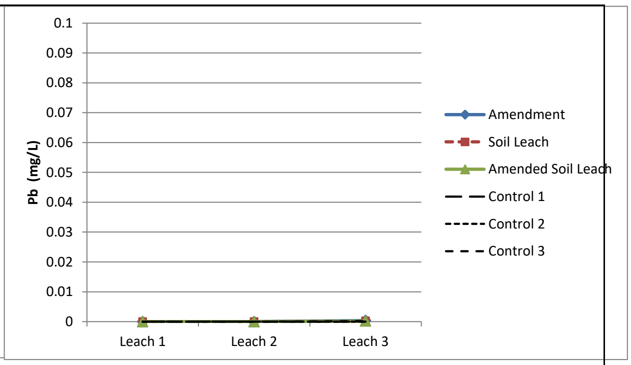

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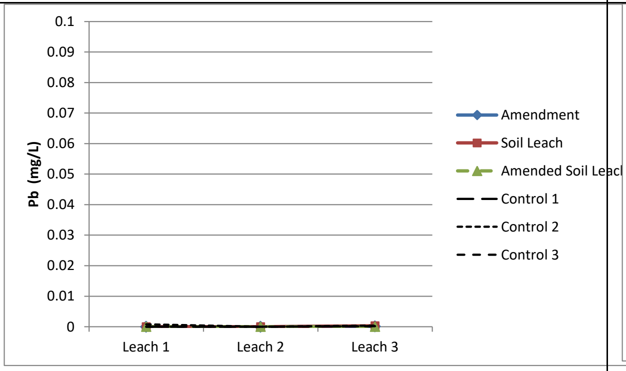

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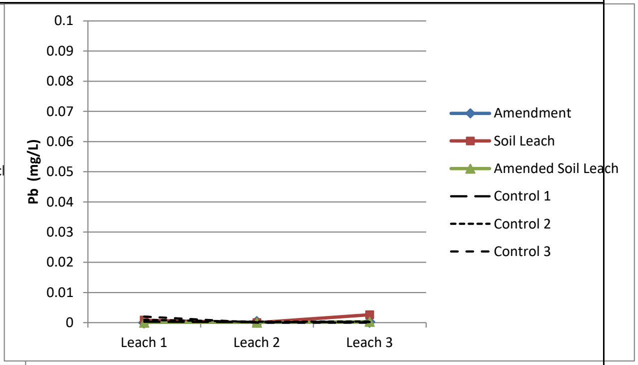

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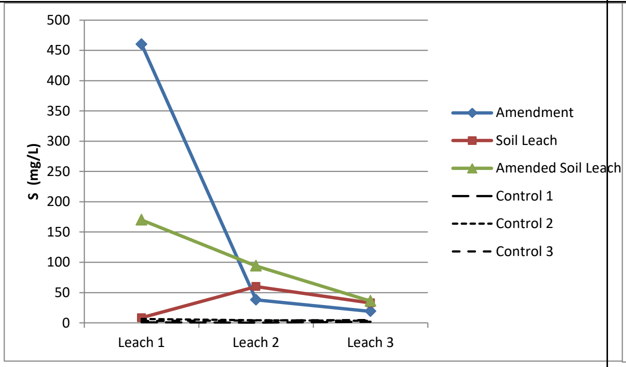

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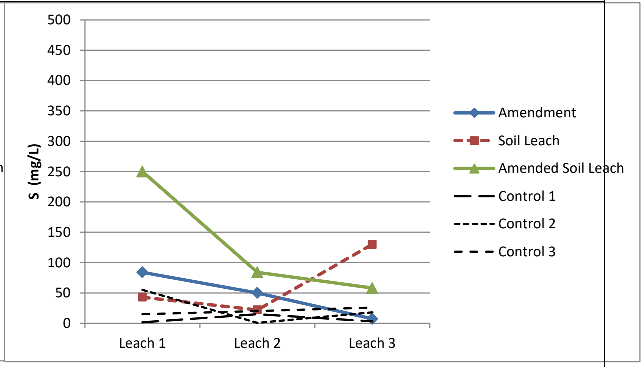

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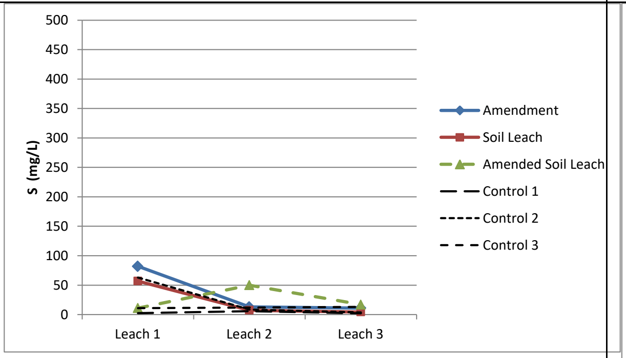

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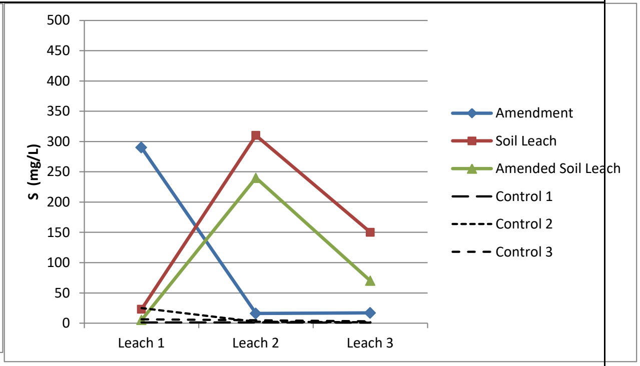

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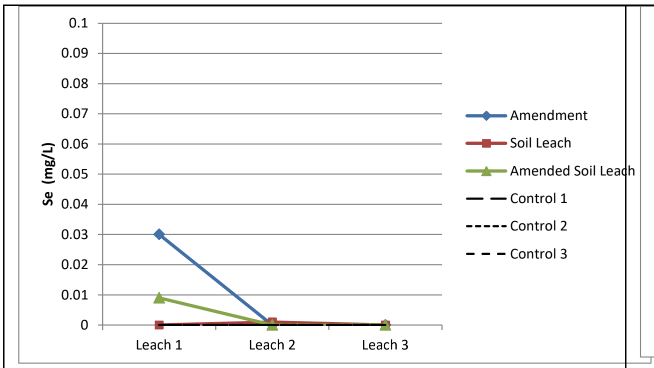

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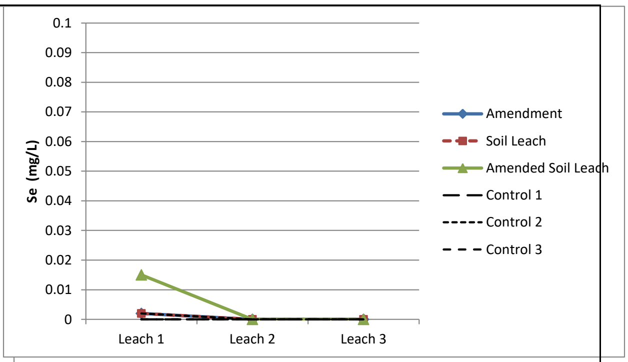

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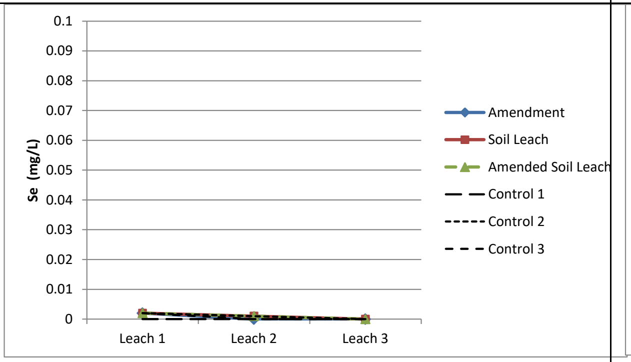

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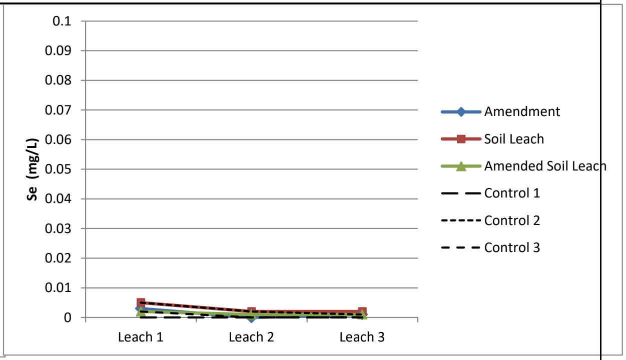

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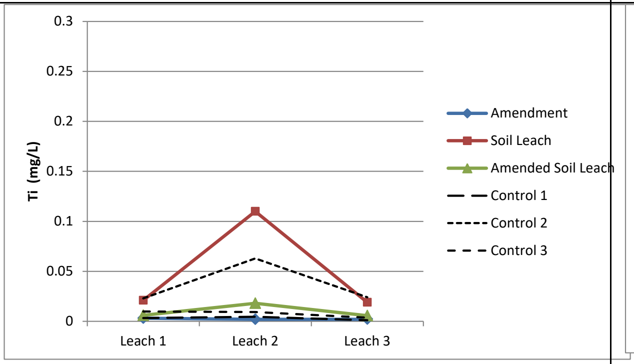

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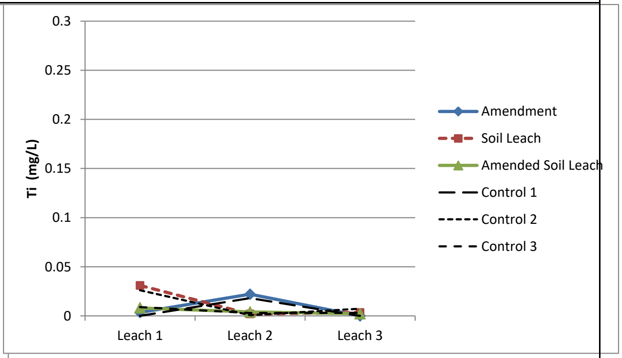

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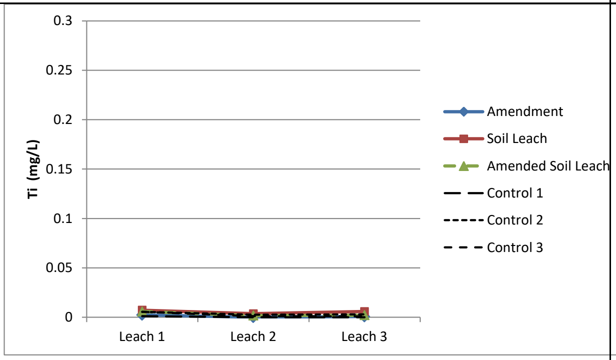

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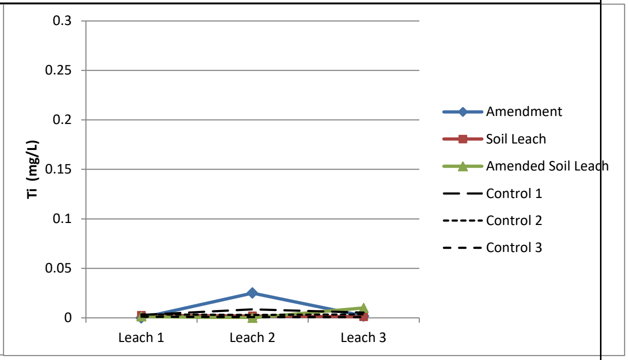

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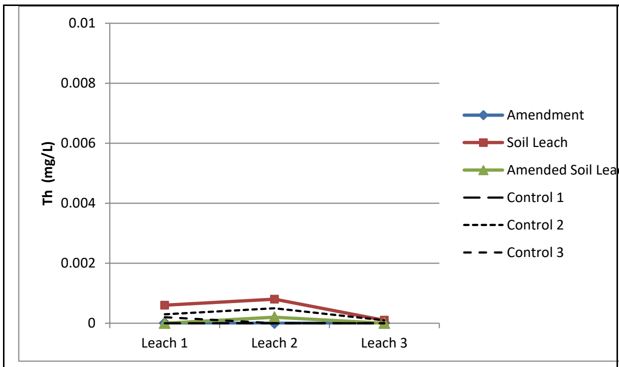

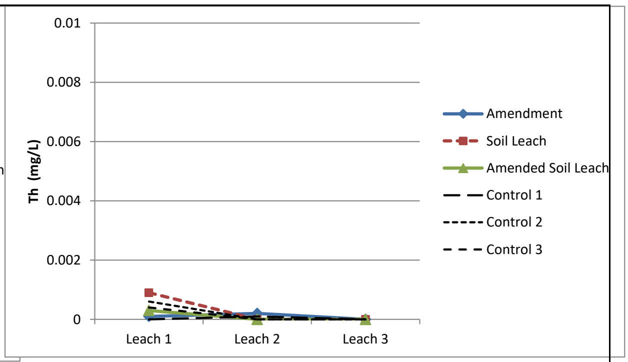

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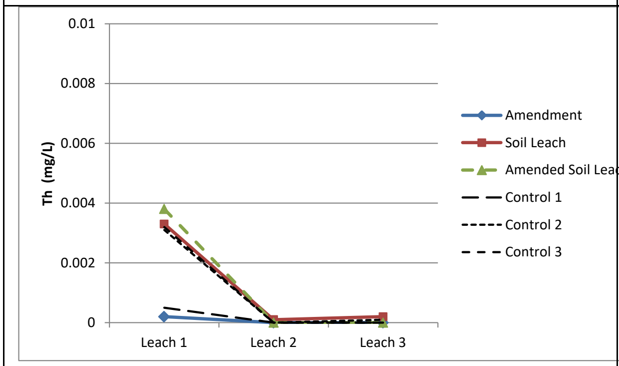
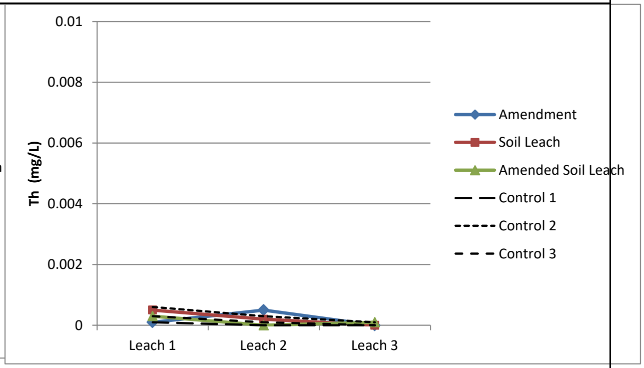
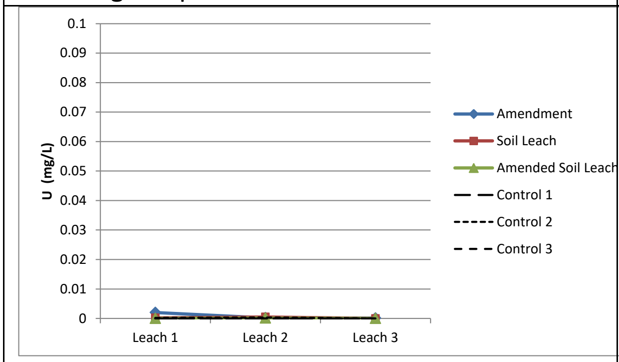
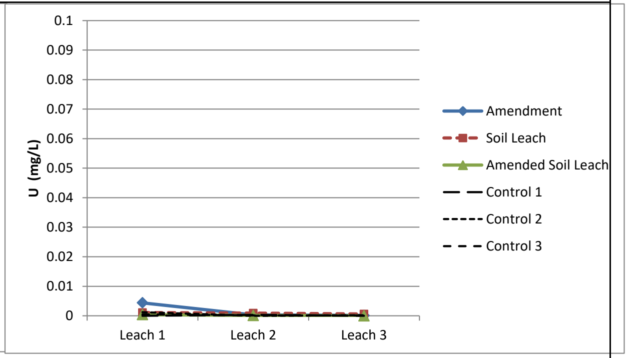




Fairbridge Duplex

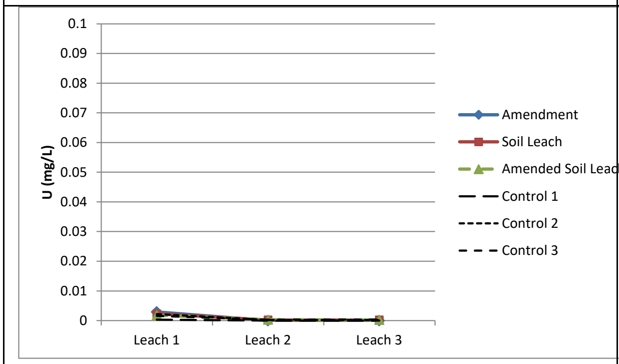
Spearwood

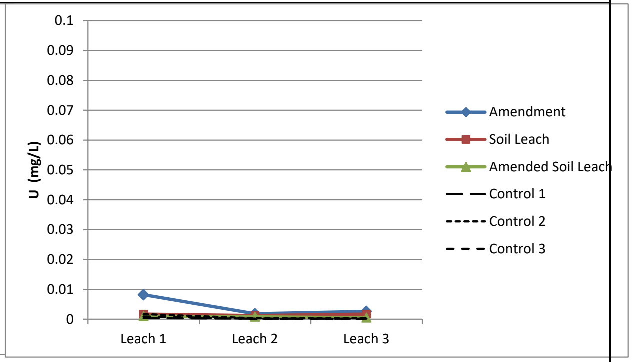




Bassendean Ellenbrook

Bassendean Joel

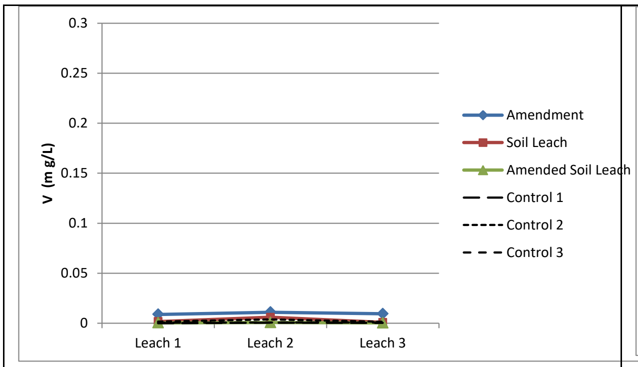




Fairbridge Duplex

Spearwood

A12-3. NRP



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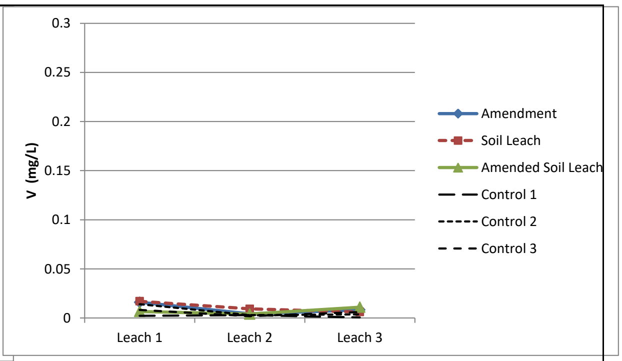

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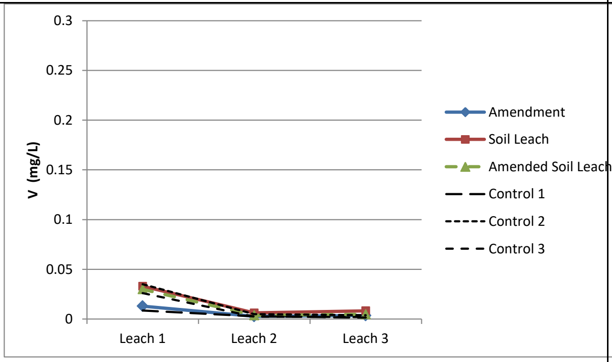

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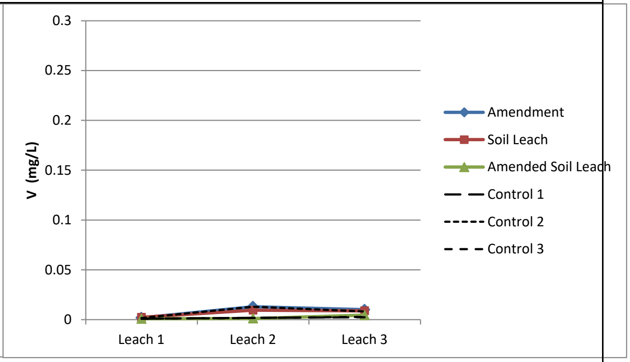

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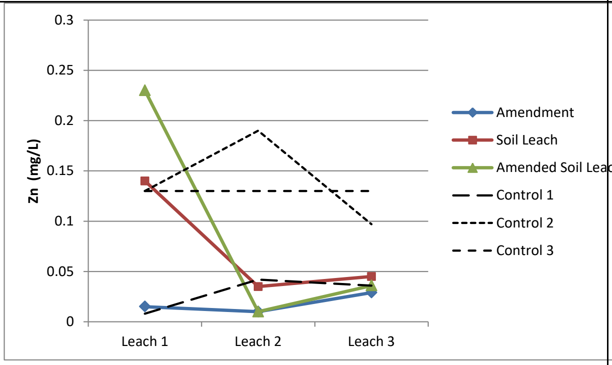

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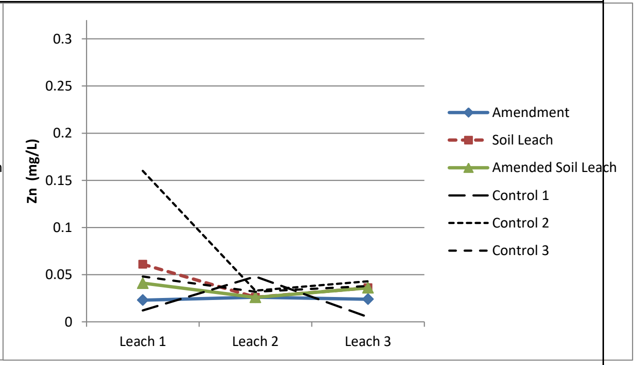

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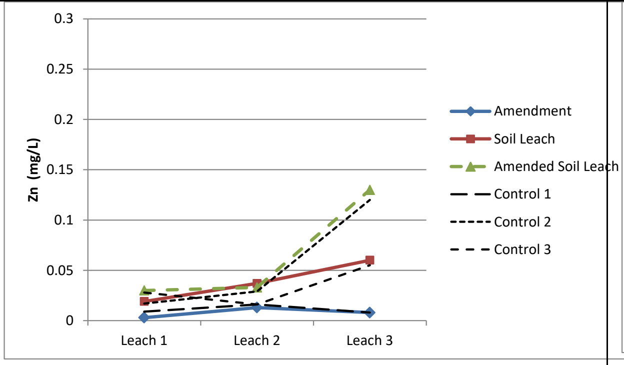

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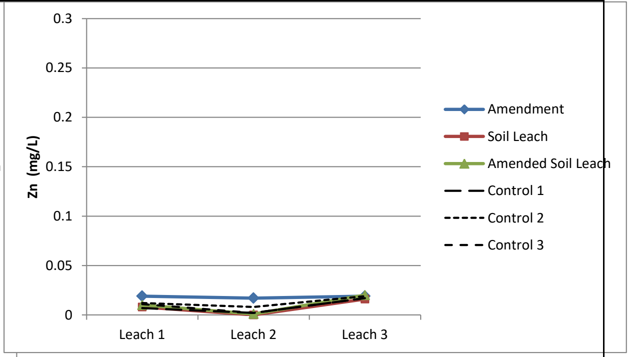

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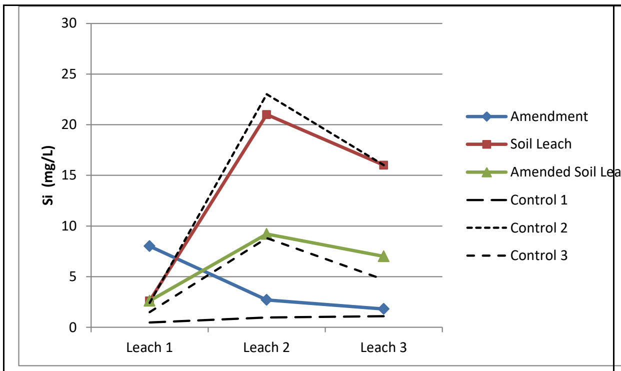
A12-3. NRP



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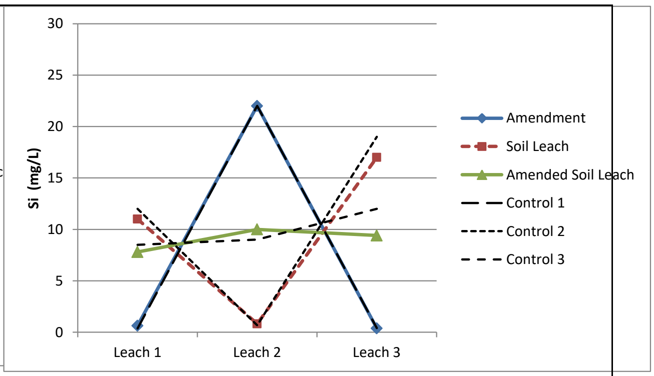

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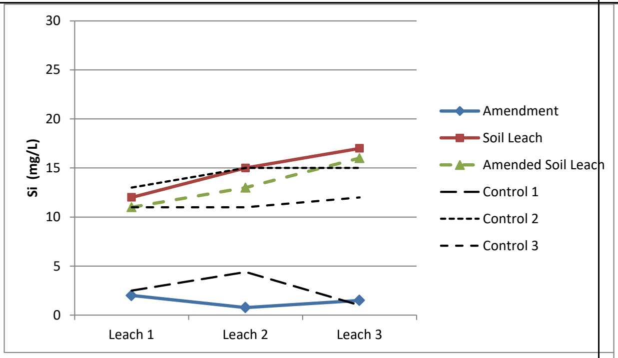

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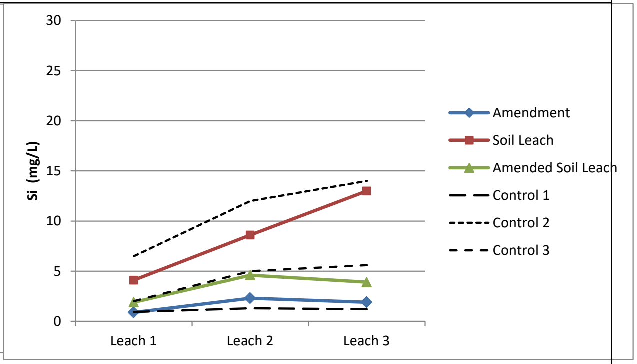
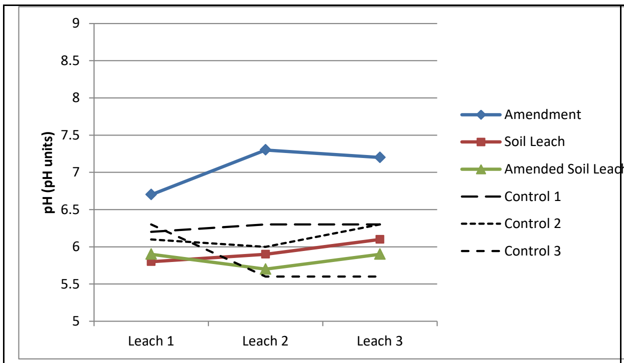


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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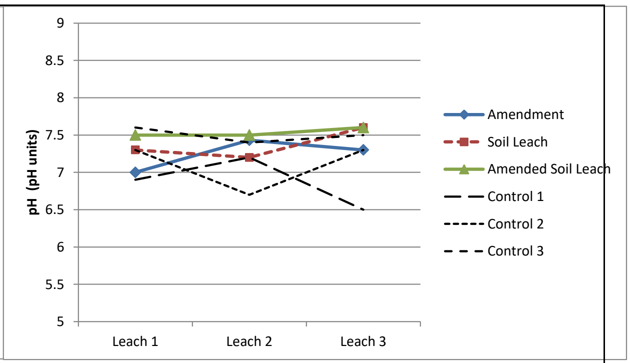

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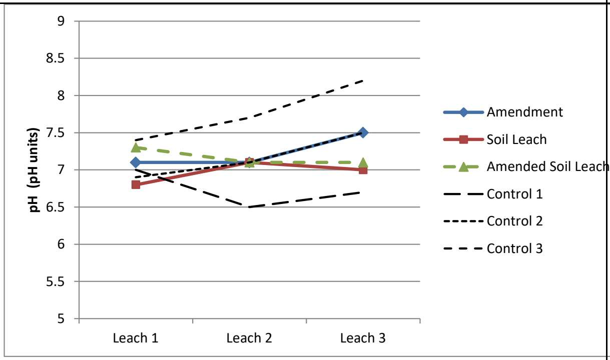

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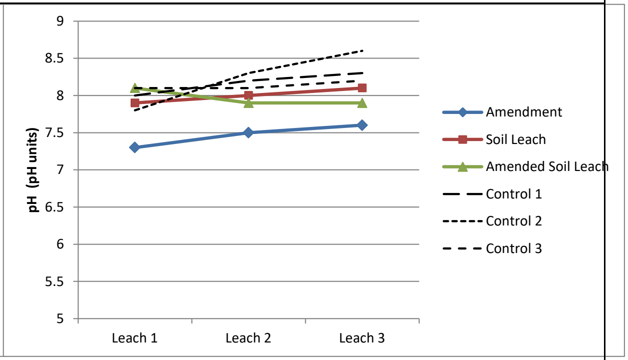

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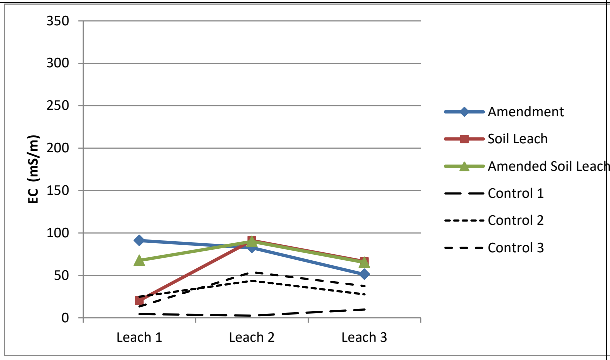

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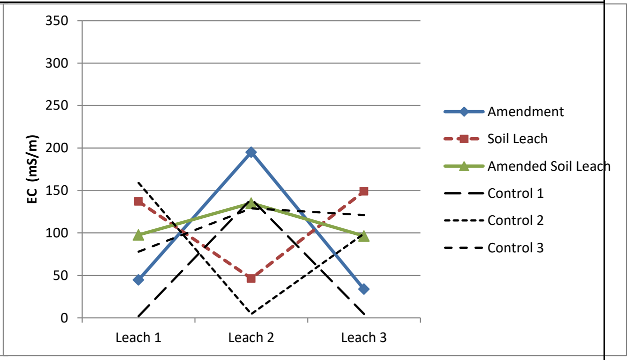

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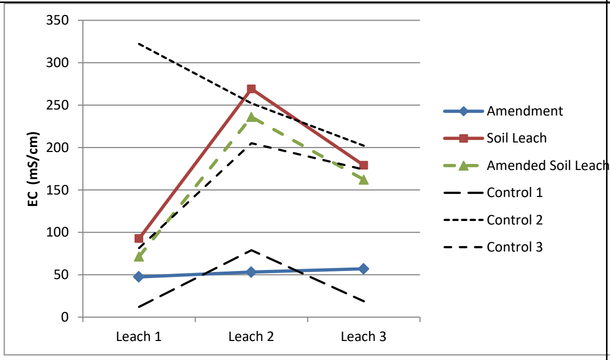

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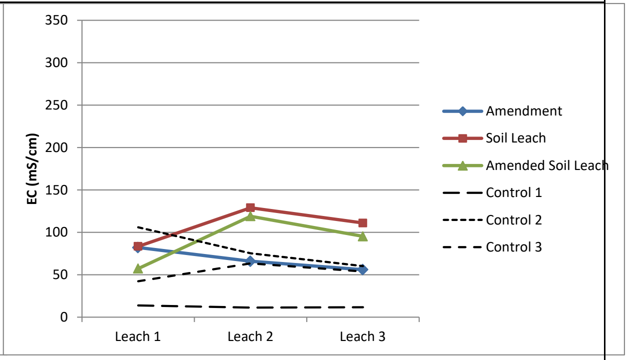
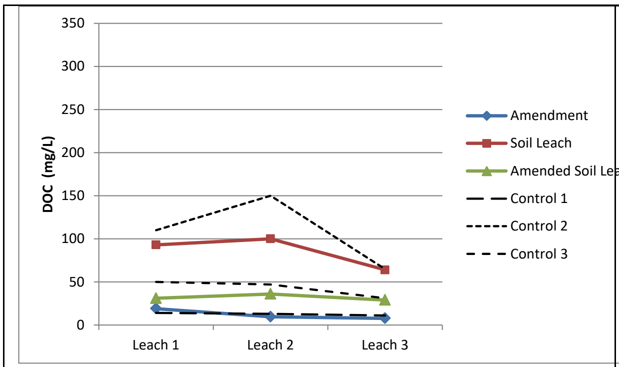


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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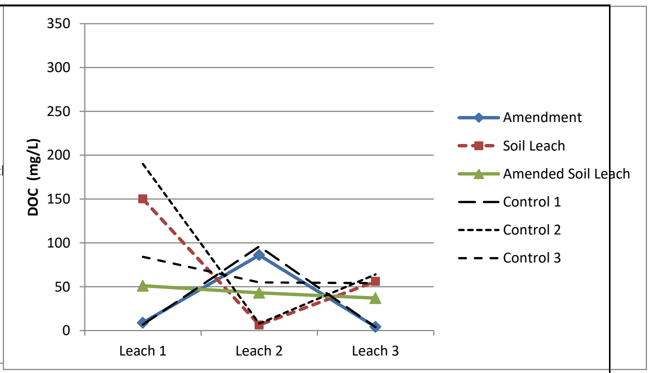

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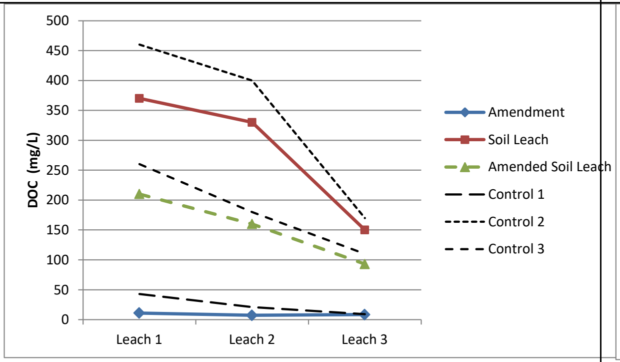

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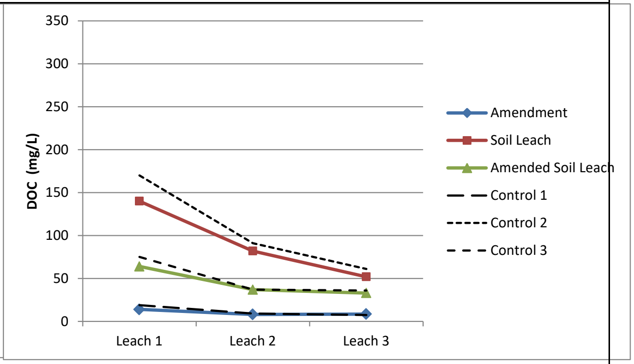

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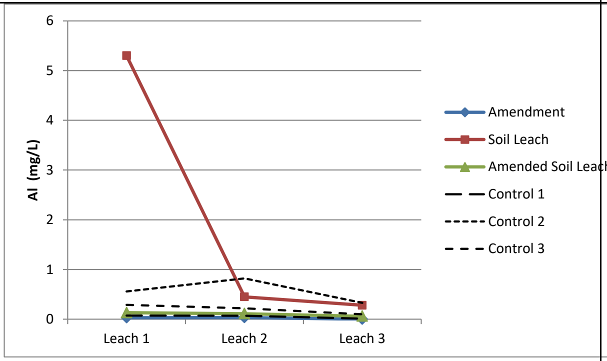

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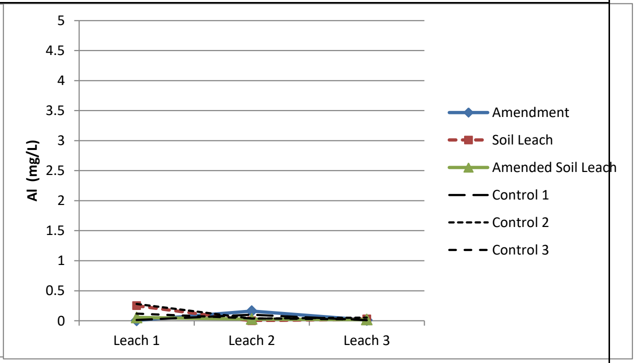

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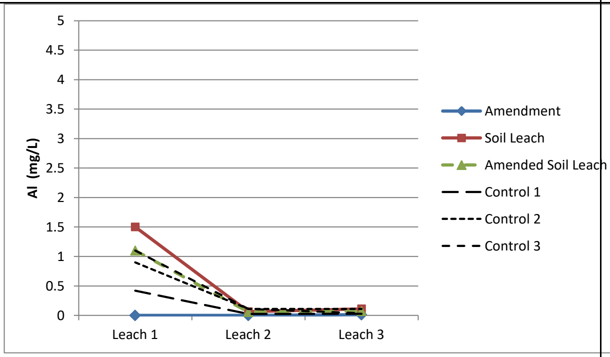

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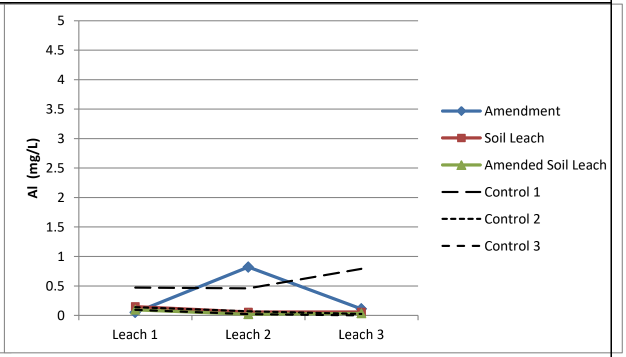
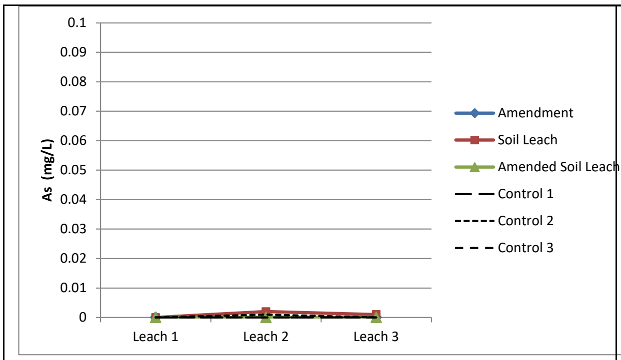
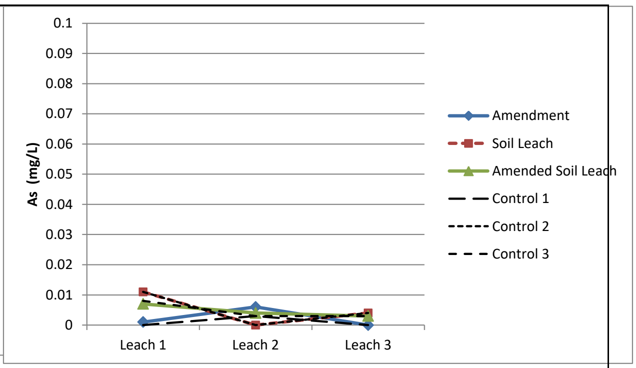


Spearwood

A12-4. Wanneroo Groundwater Residue Charts





Bassendean Ellenbrook

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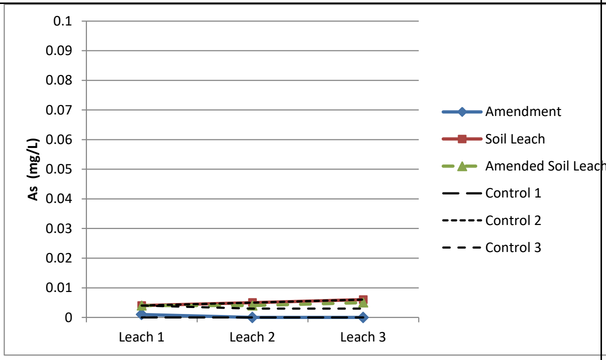
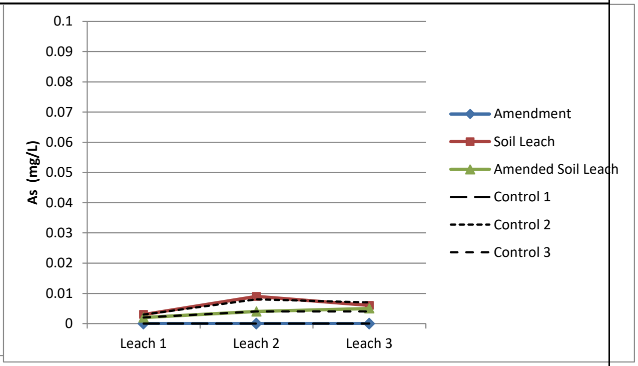
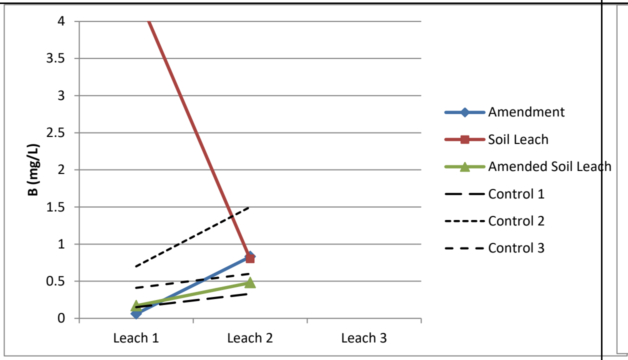
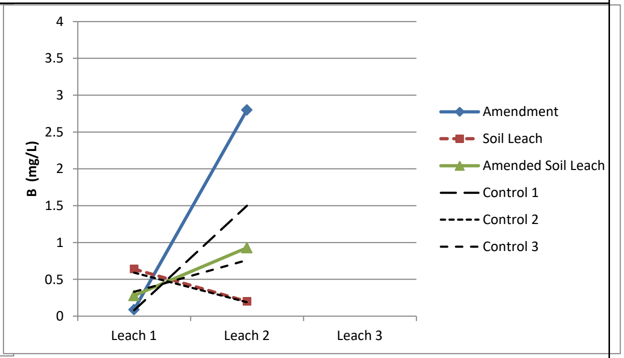




Fairbridge Duplex

Spearwood





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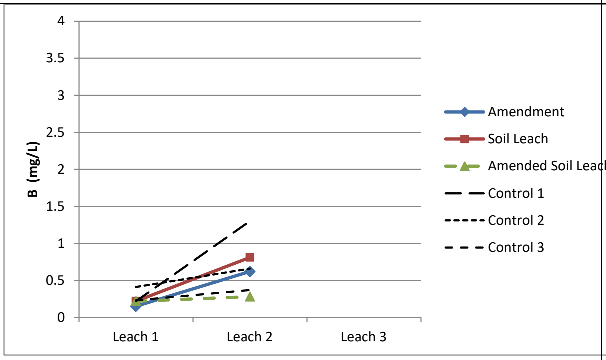
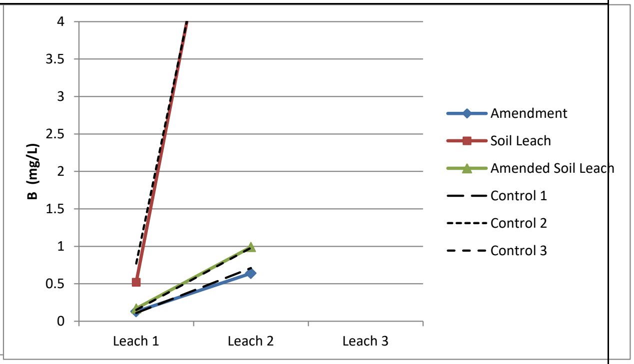
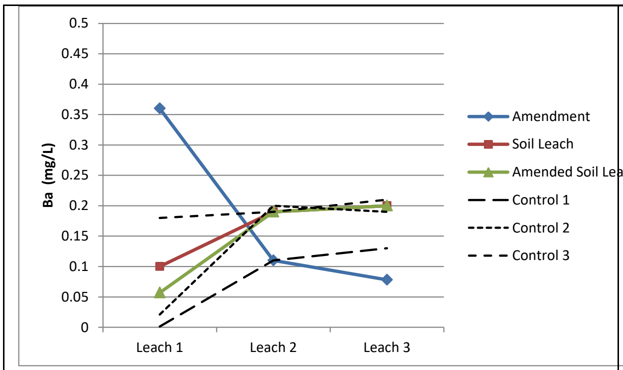




Fairbridge Duplex

Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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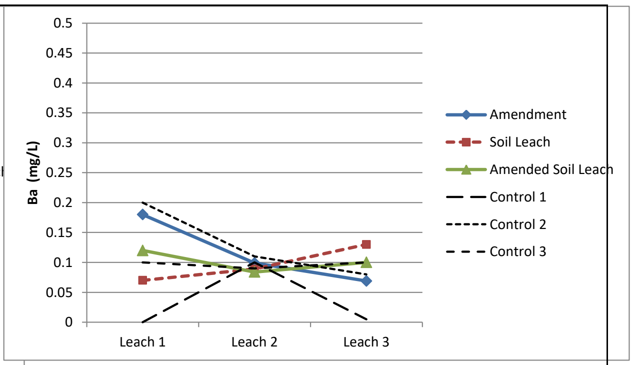

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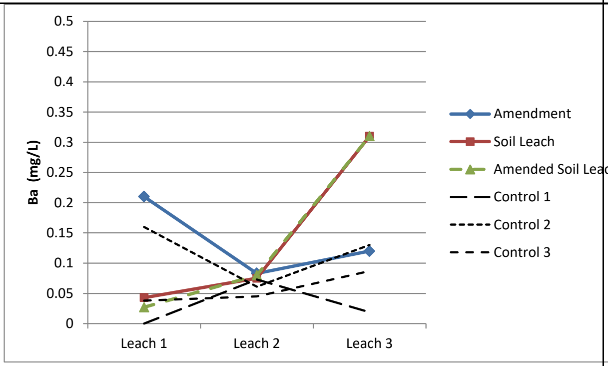

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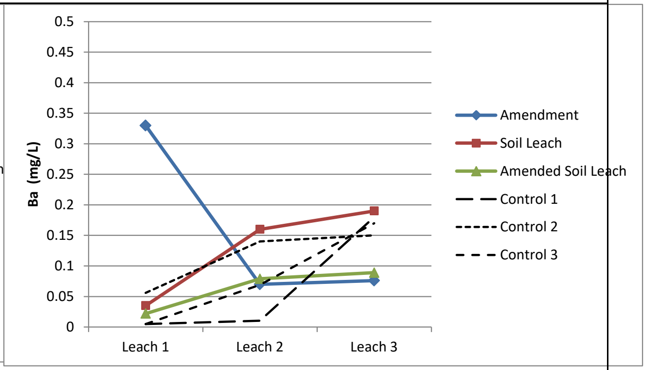

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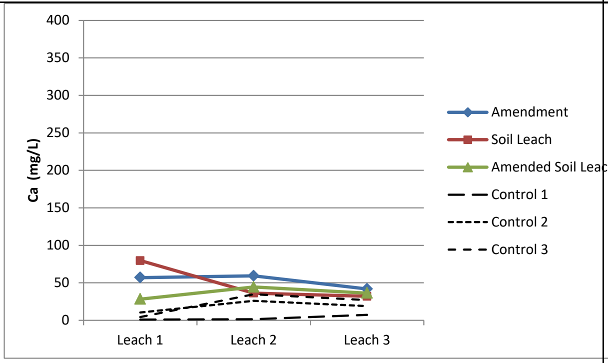

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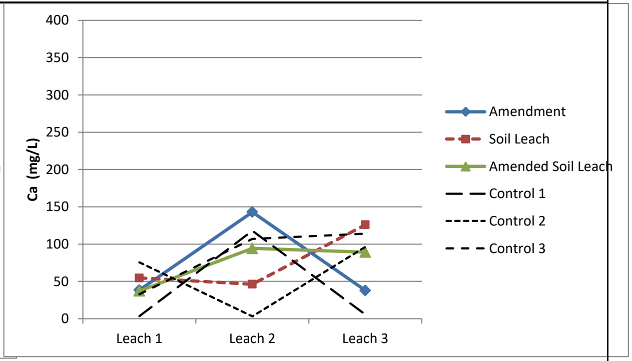

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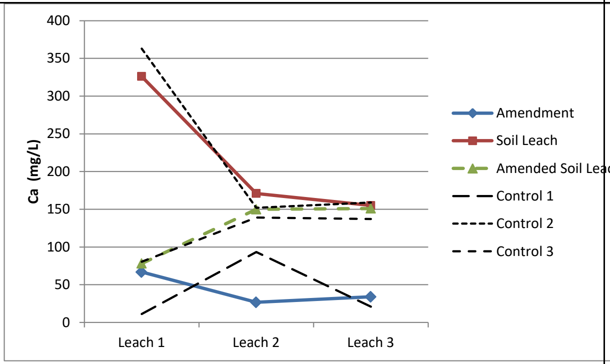

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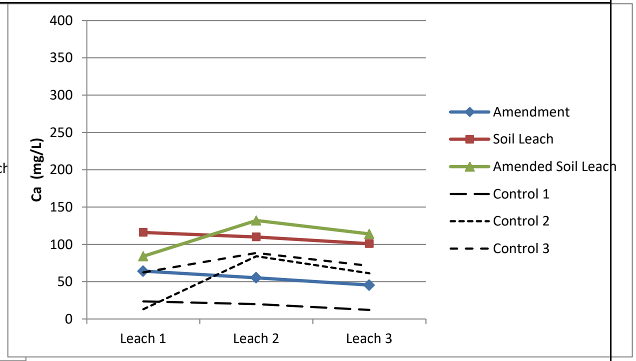
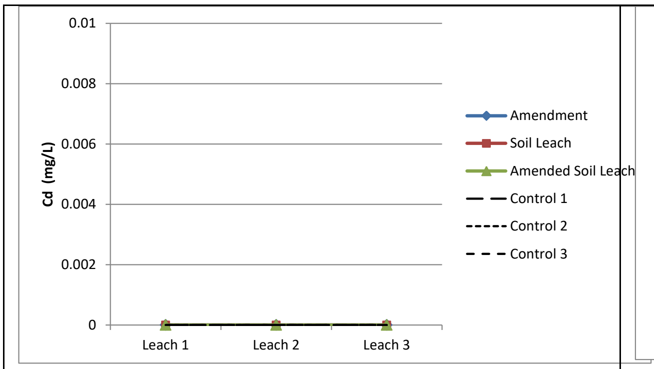


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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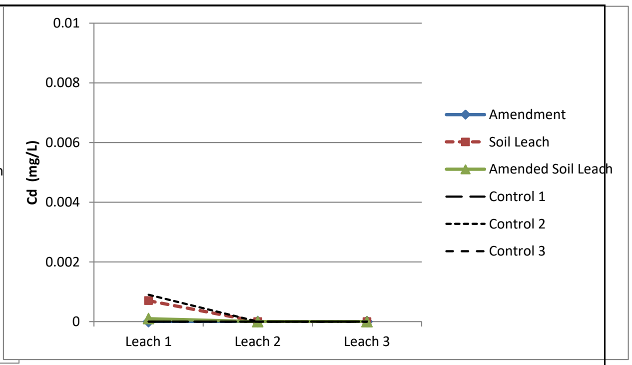

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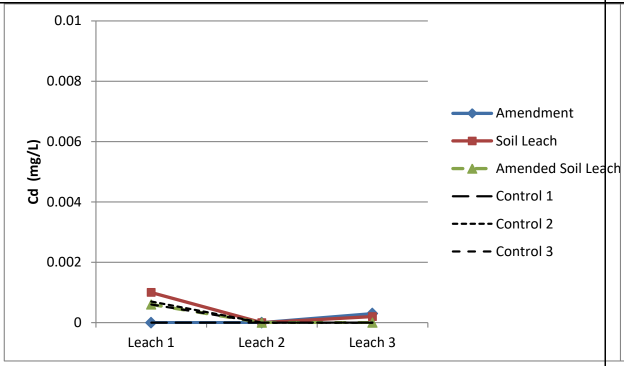

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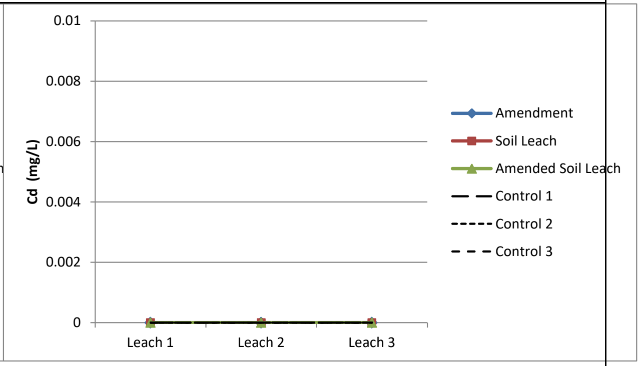

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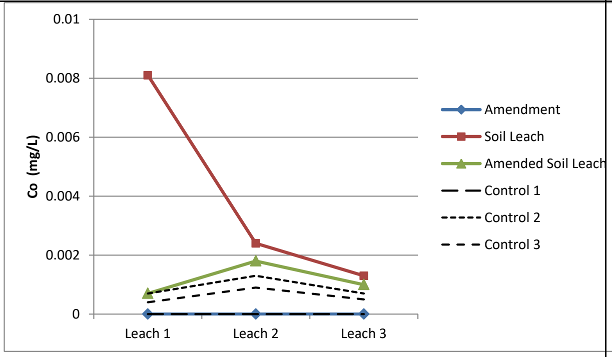

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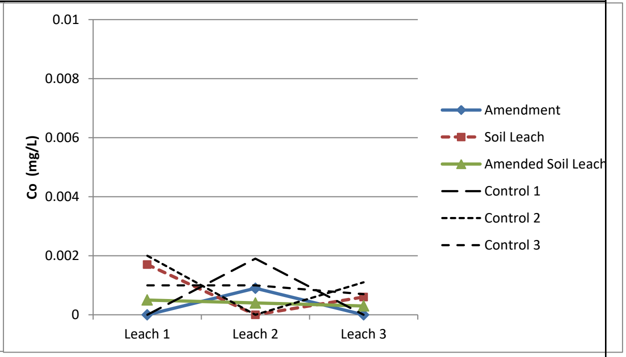

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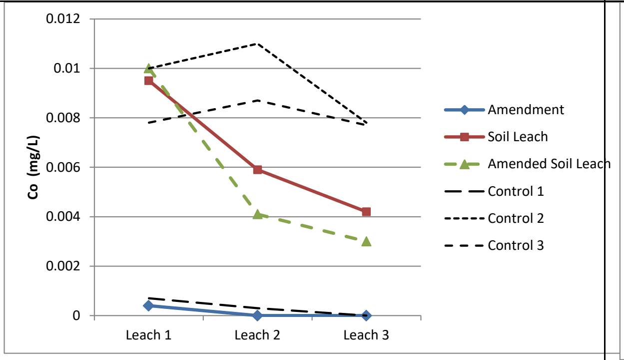

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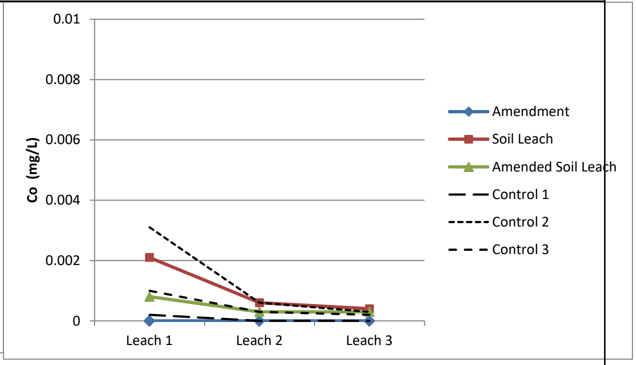
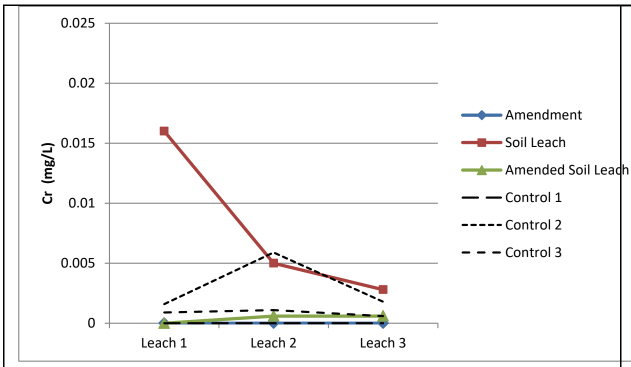


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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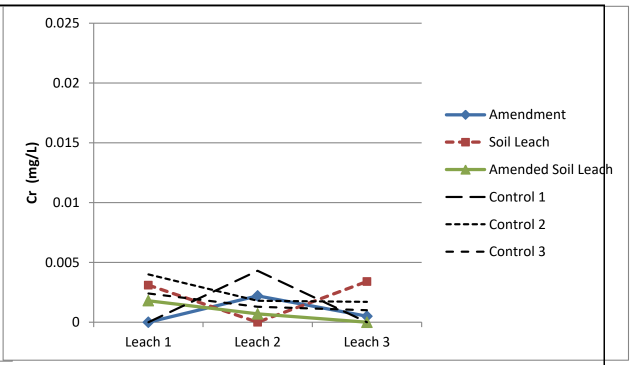

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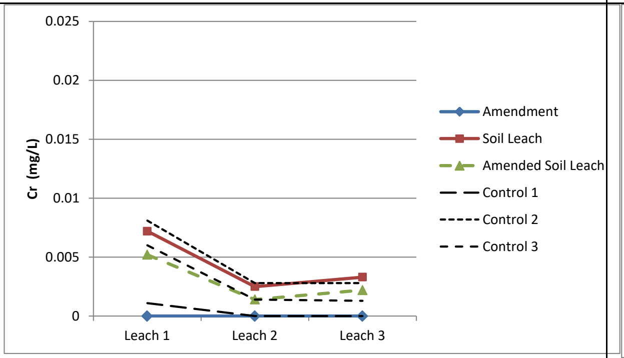

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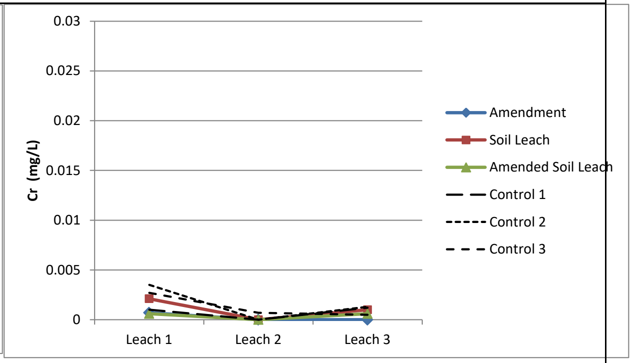

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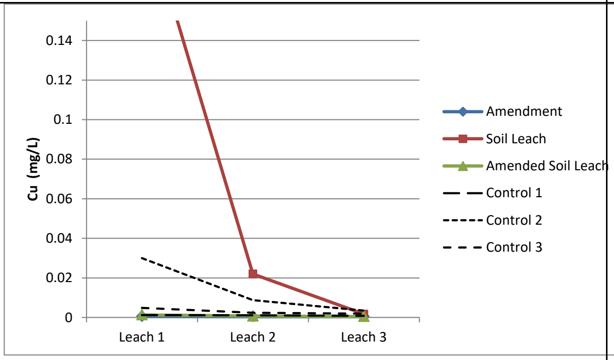

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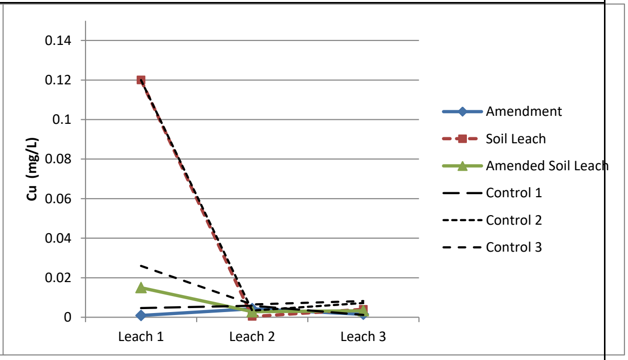
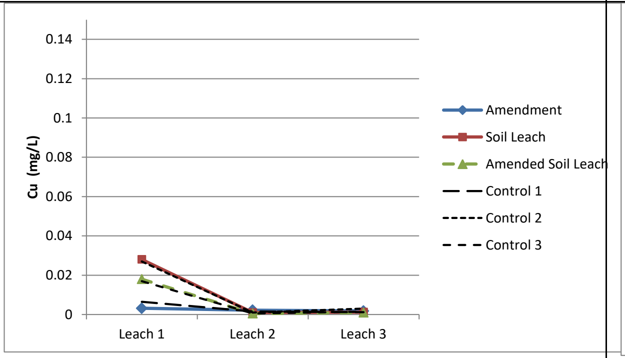


Bassendean Joel



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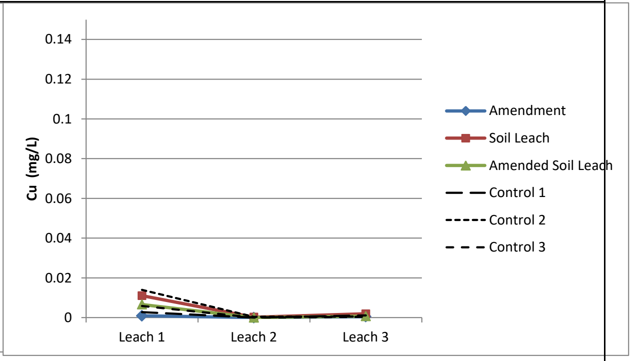
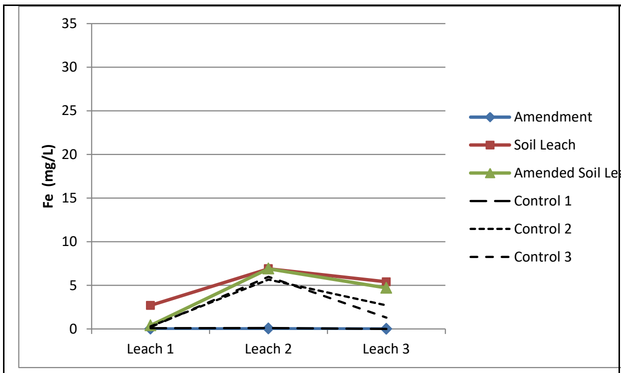
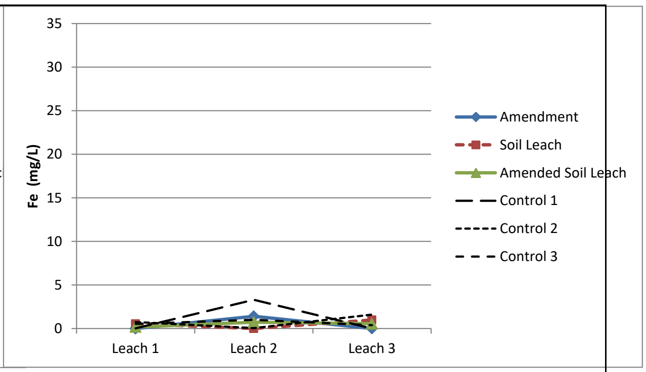


Spearwood

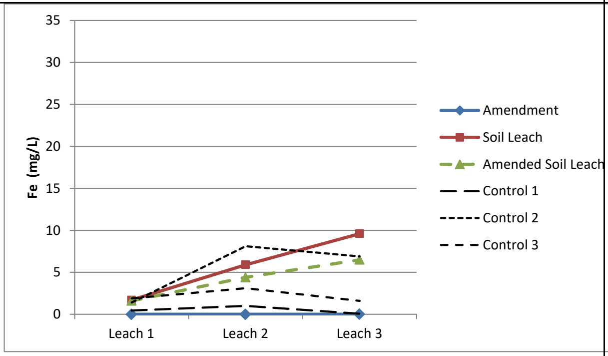
A12-4. Wanneroo Groundwater Residue Charts

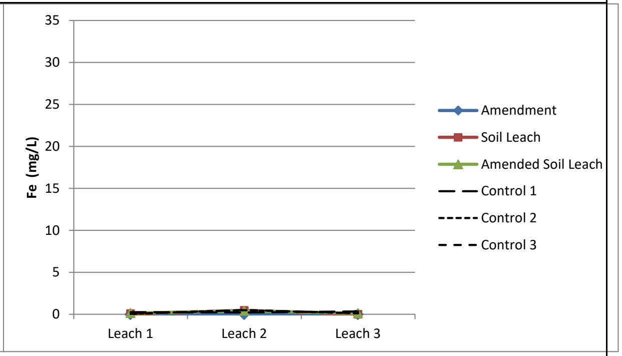




Bassendean Ellenbrook

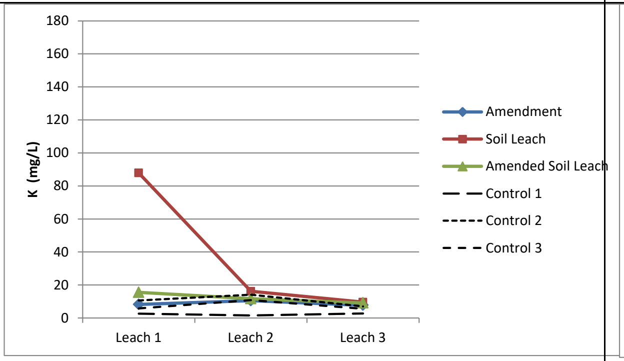
Bassendean Joel

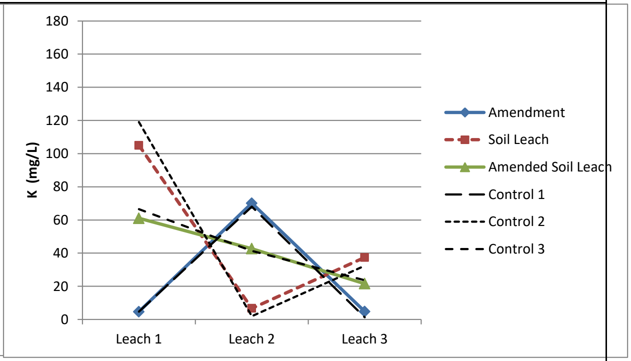




Fairbridge Duplex

Spearwood





Bassendean Ellenbrook

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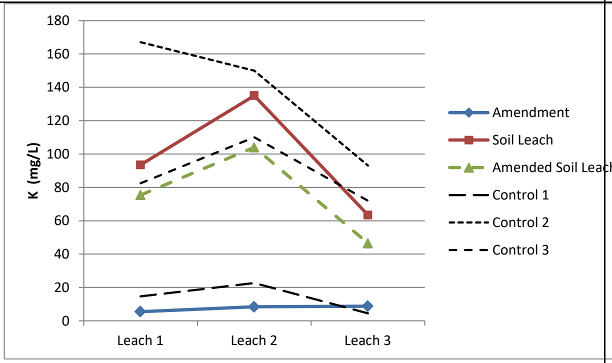
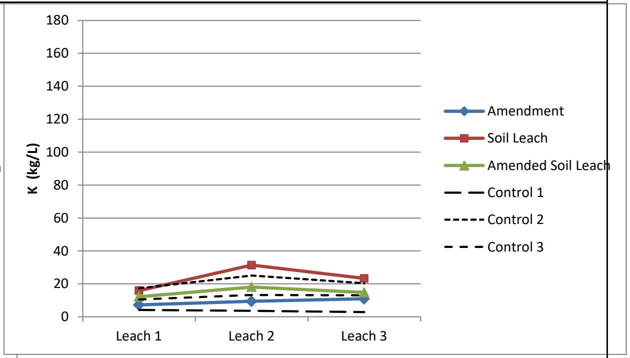
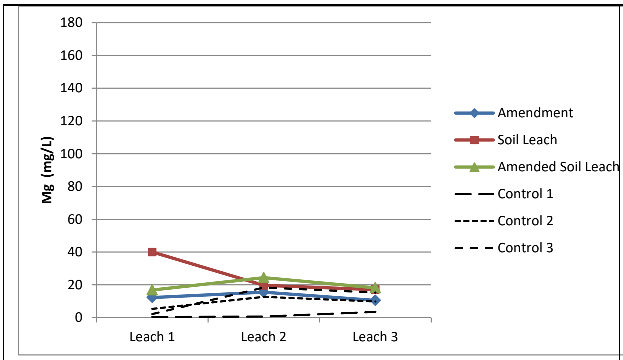




Fairbridge Duplex

Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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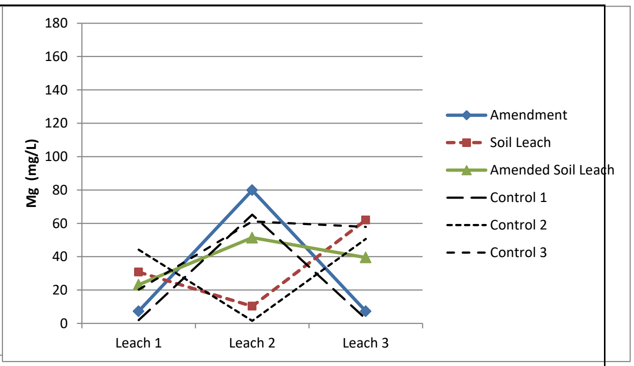

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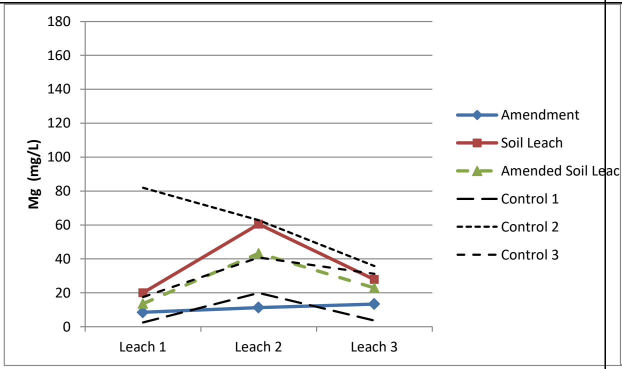

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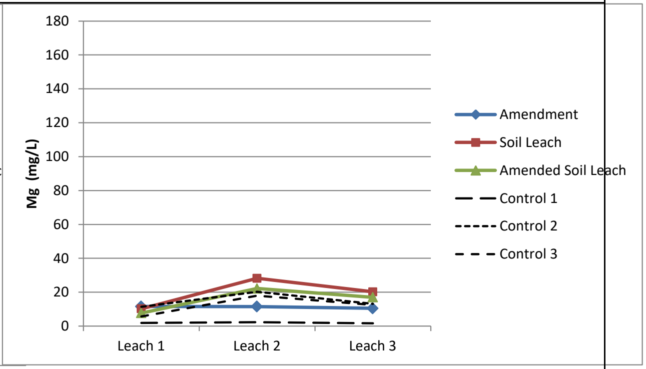

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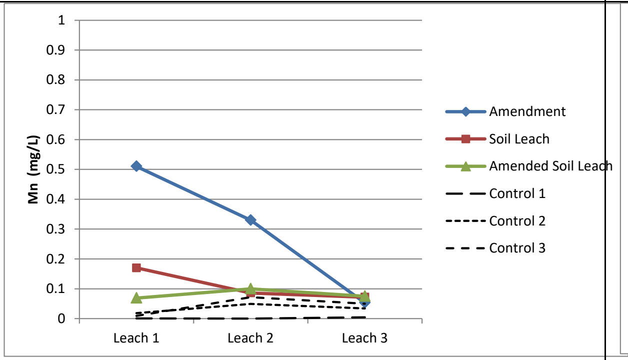

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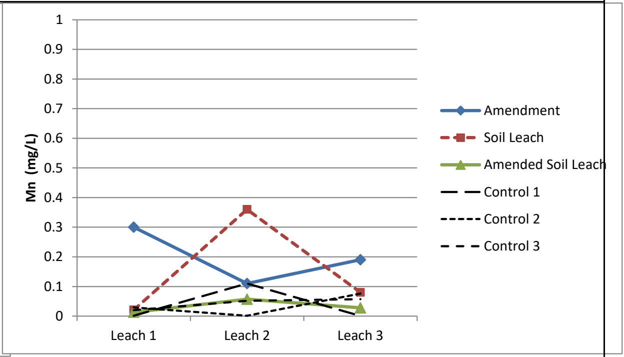

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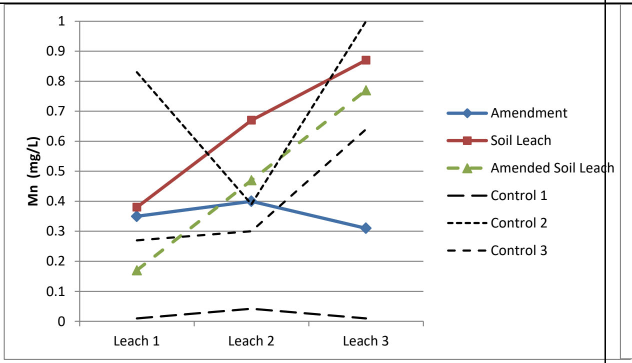

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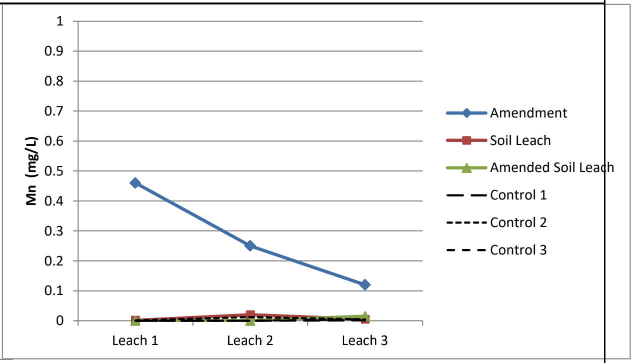
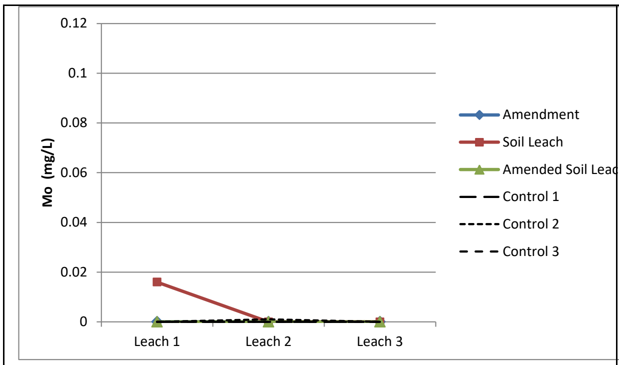


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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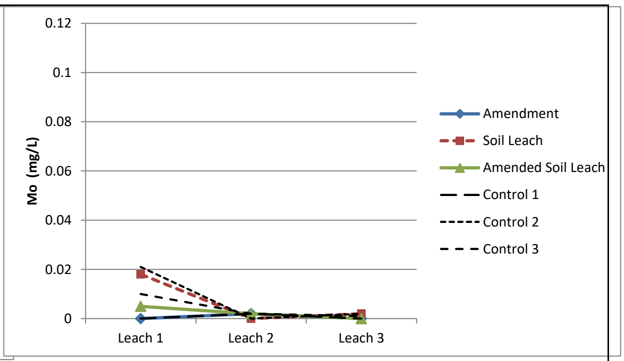

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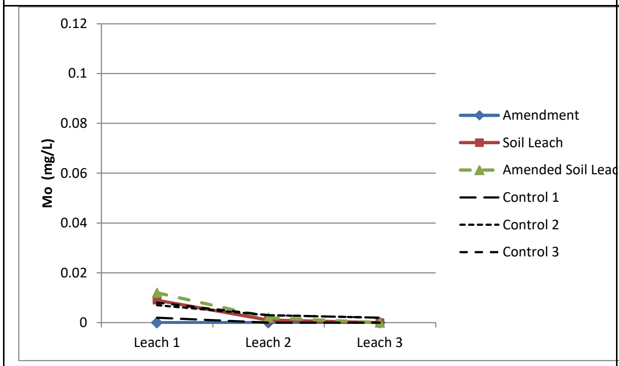

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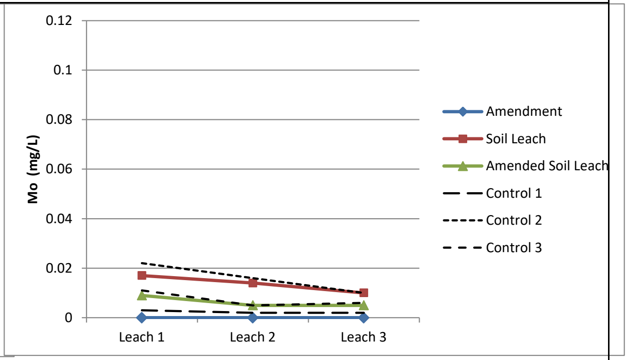

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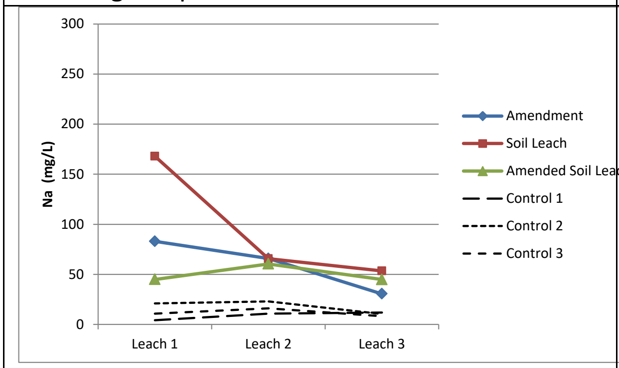

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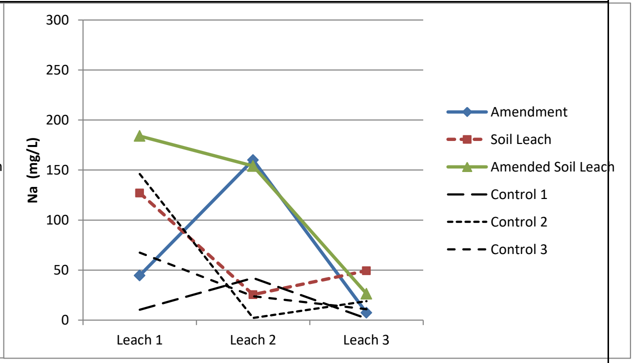

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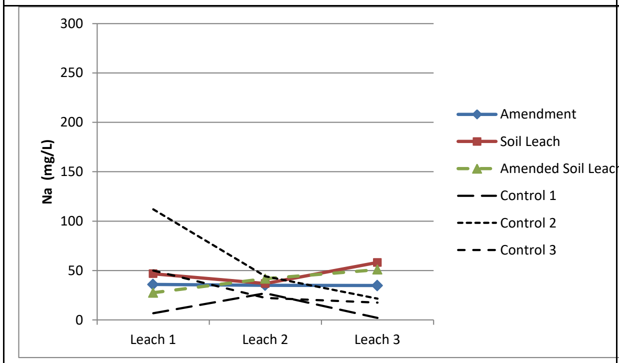

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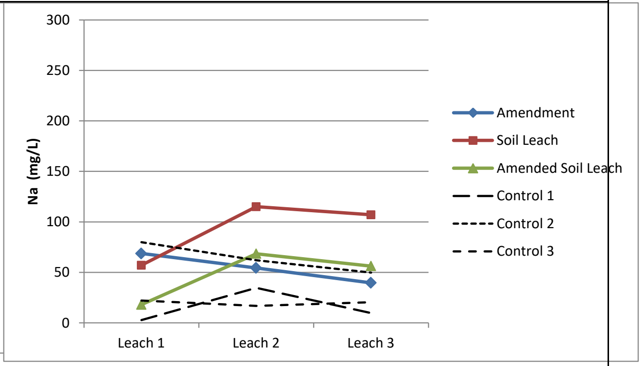
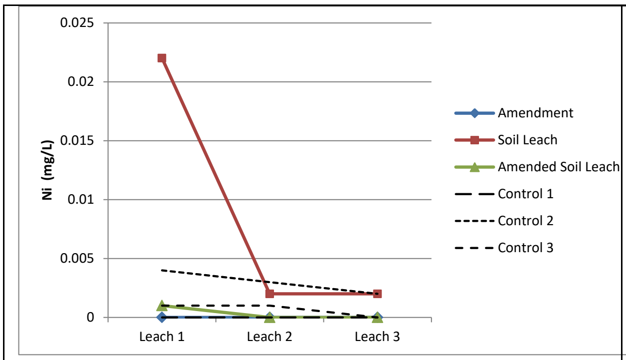


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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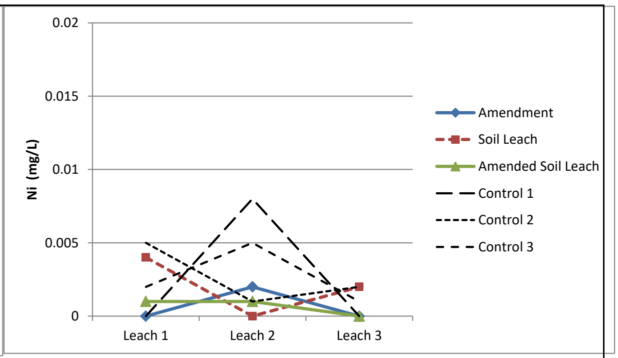

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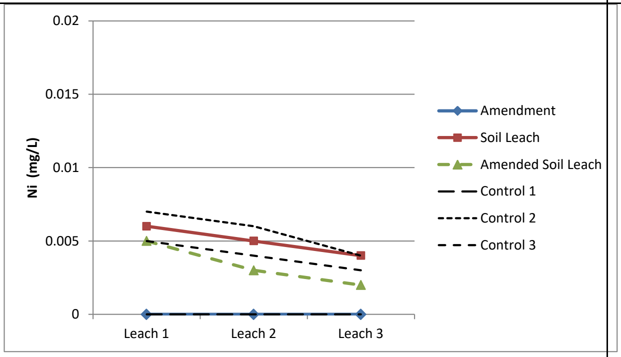

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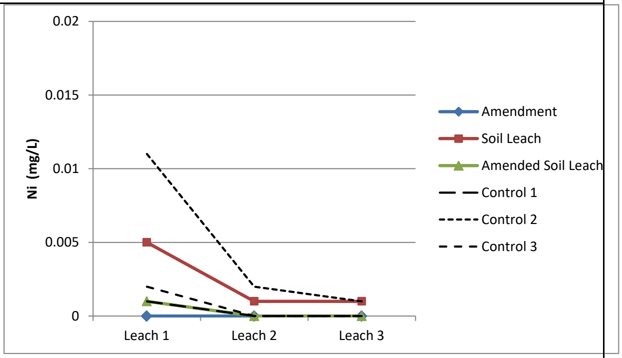

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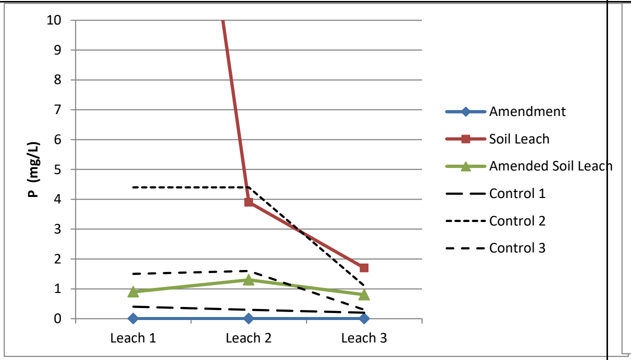

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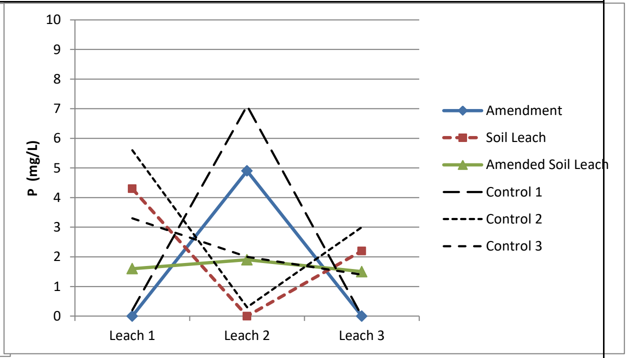

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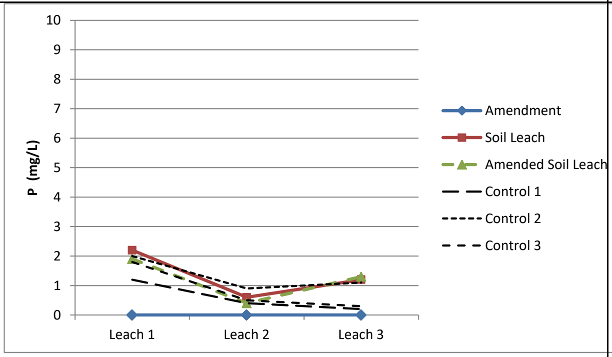

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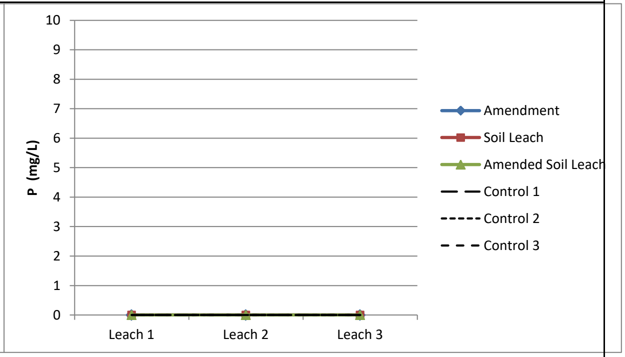
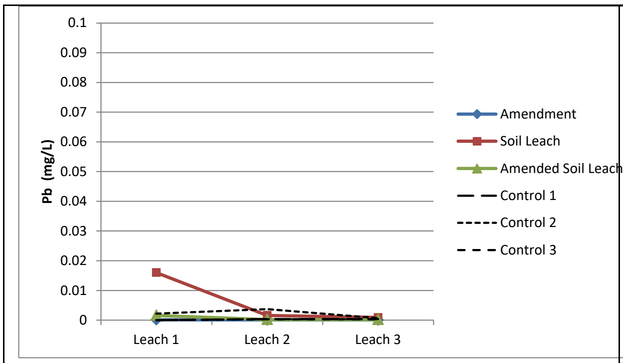


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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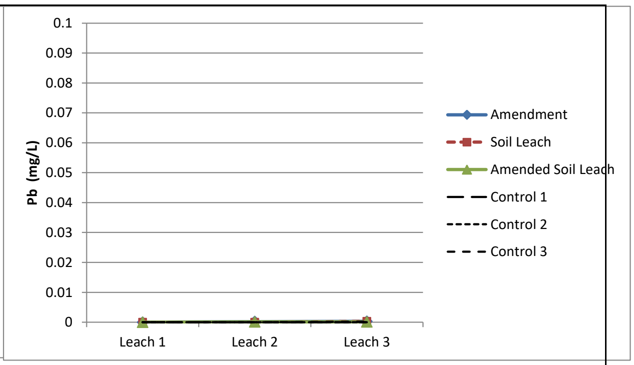

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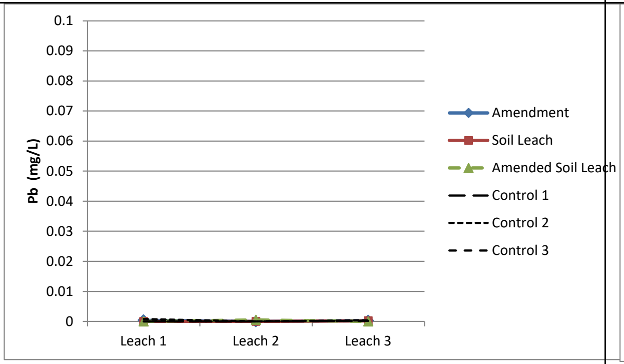

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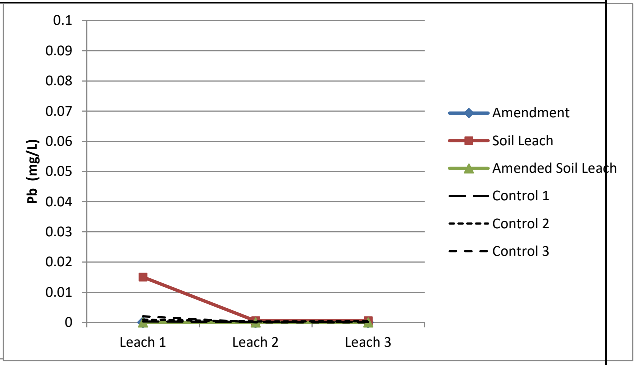

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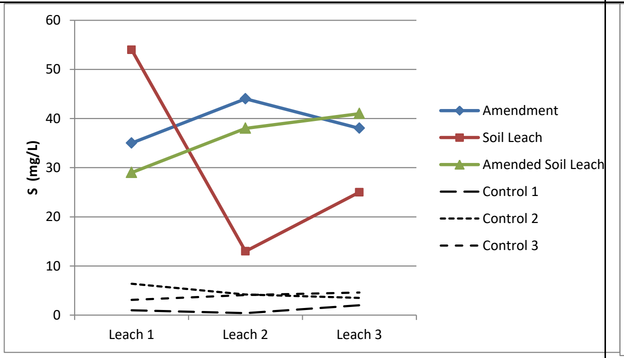

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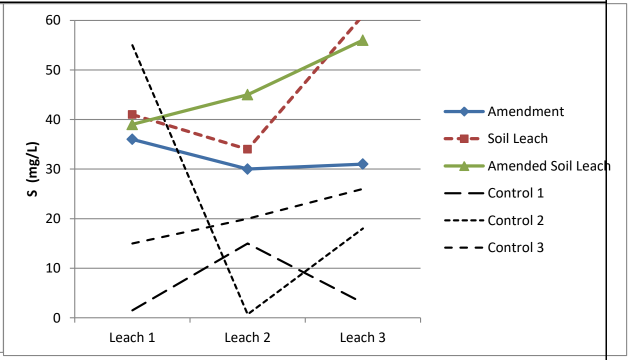

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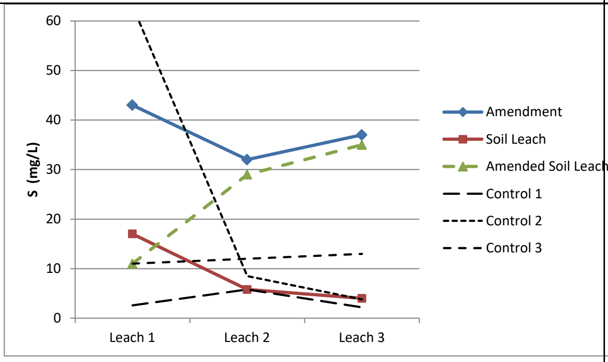

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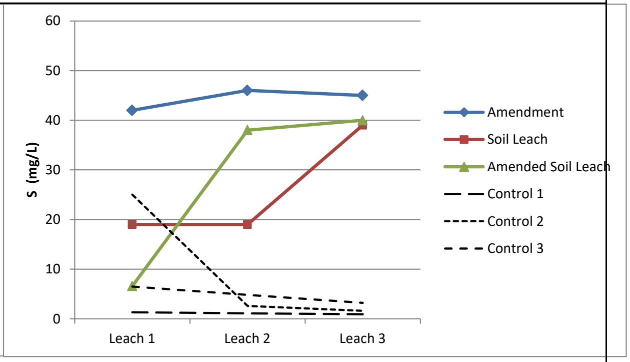
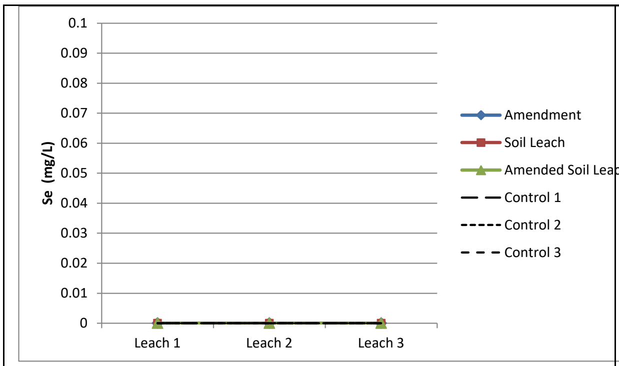


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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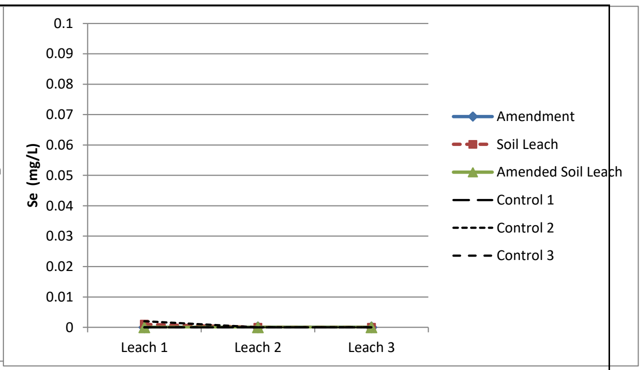

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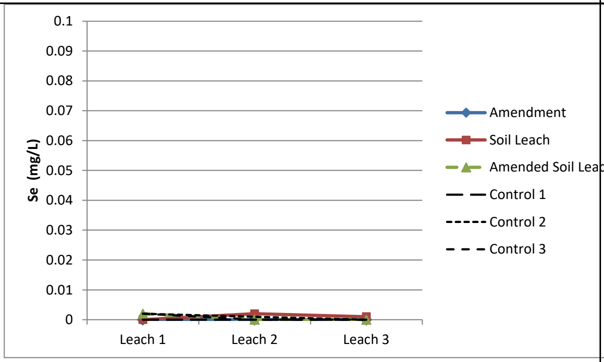

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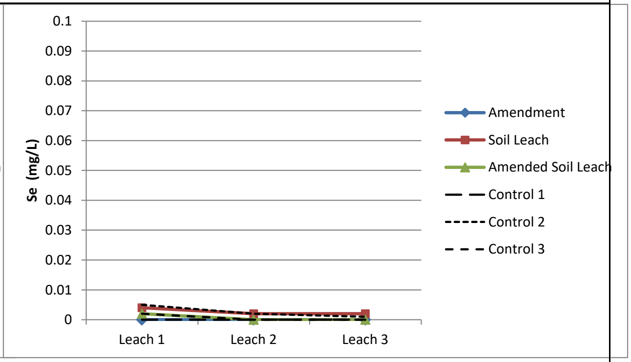

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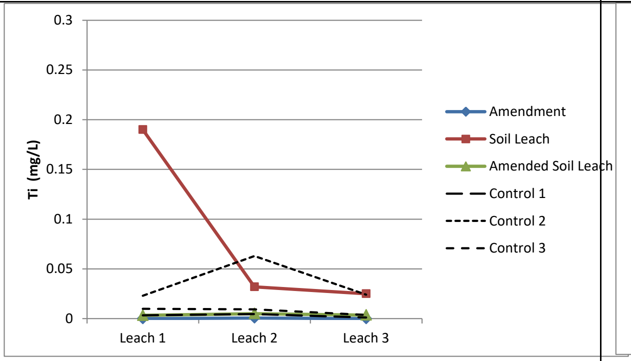

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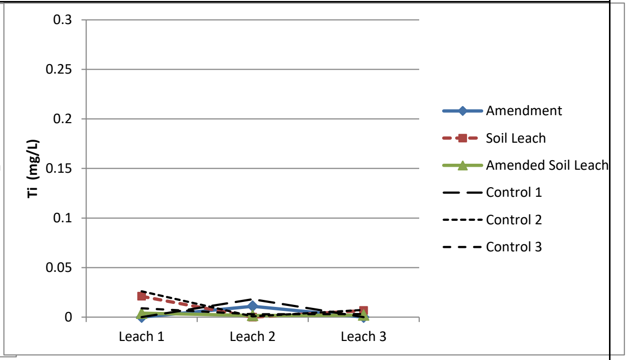

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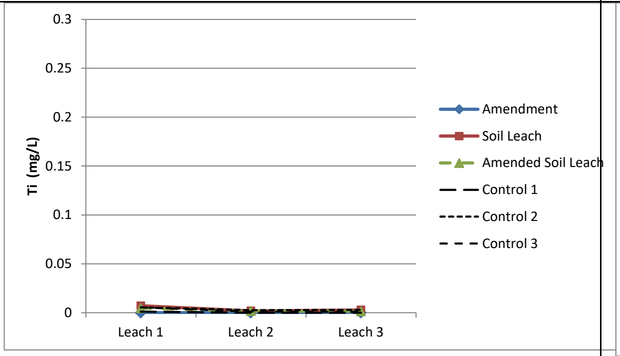

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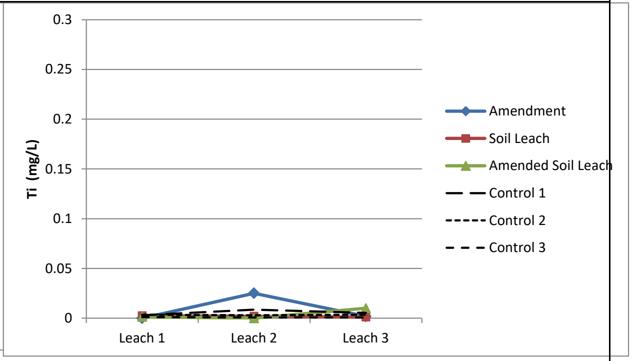
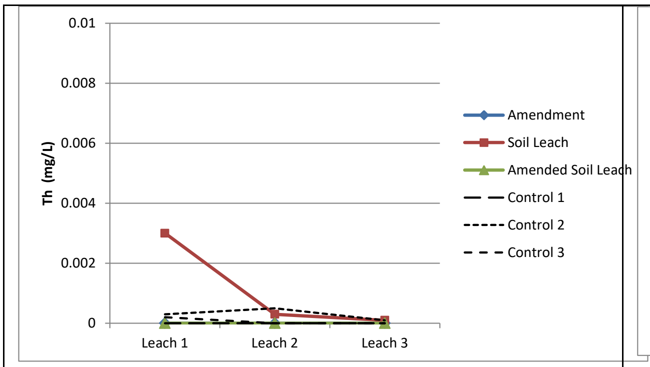


Spearwood

A12-4. Wanneroo Groundwater Residue Charts



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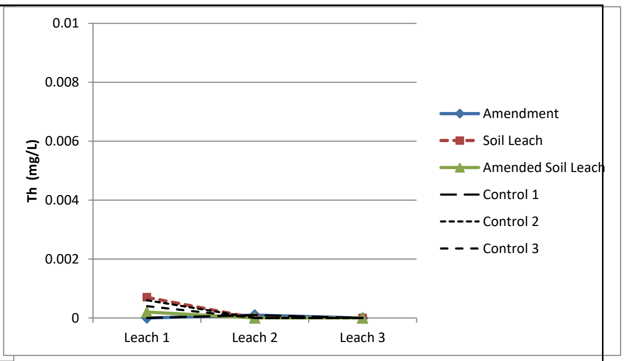

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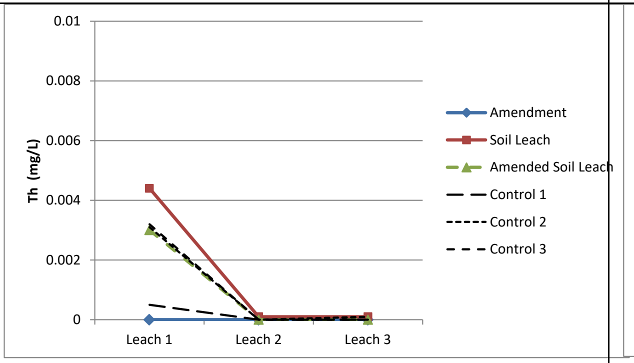

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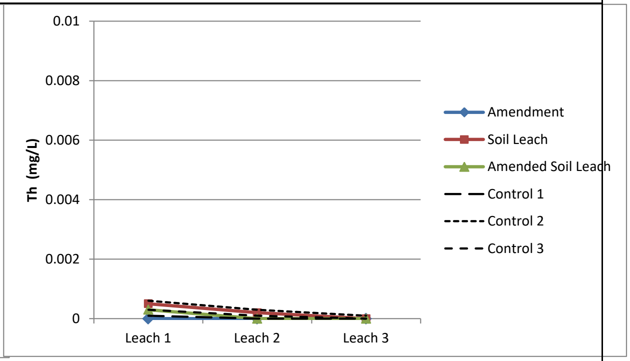

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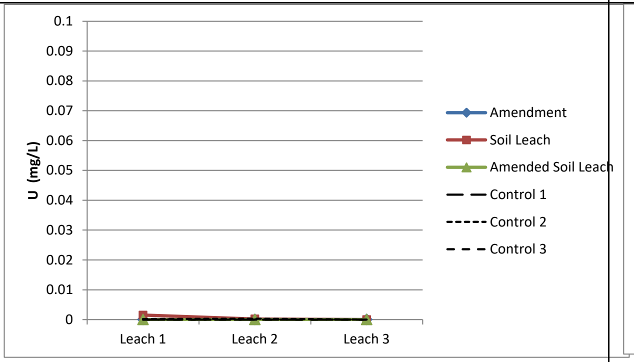

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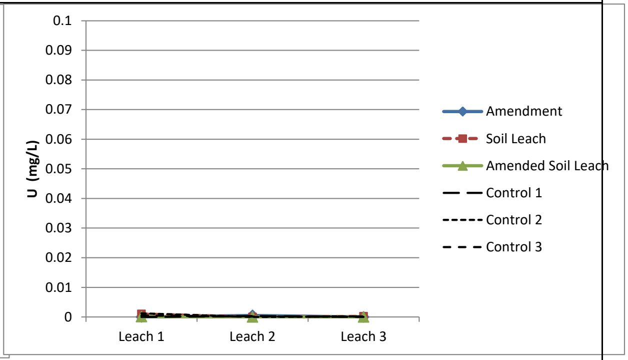

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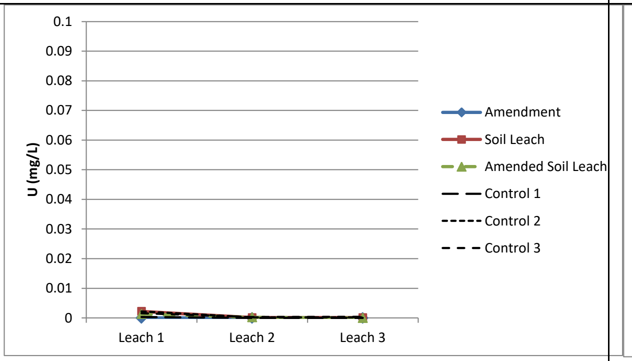

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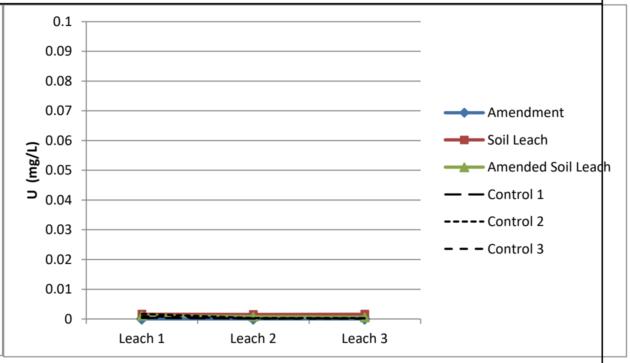
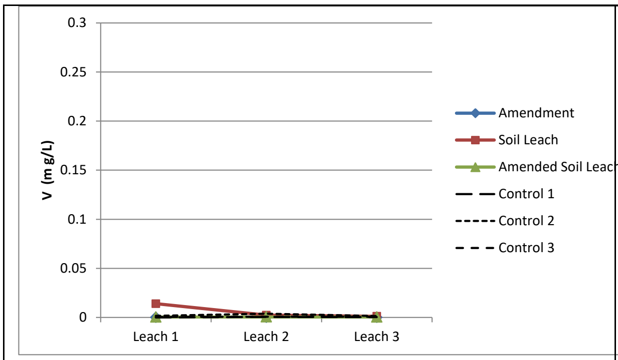
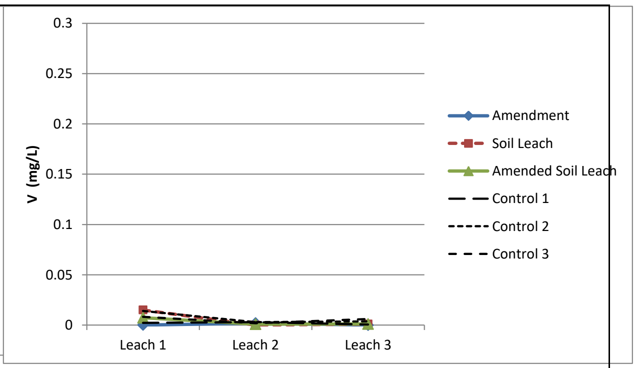


Spearwood

A12-4. Wanneroo Groundwater Residue Charts





Bassendean Ellenbrook

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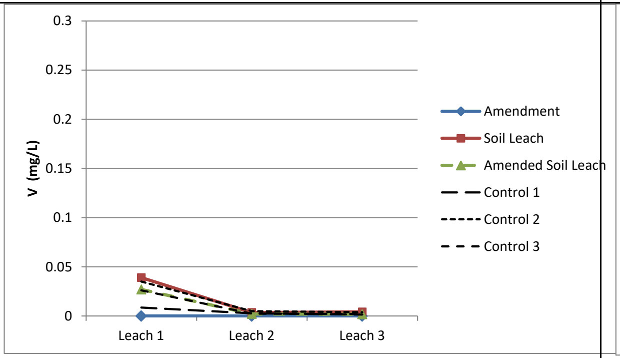

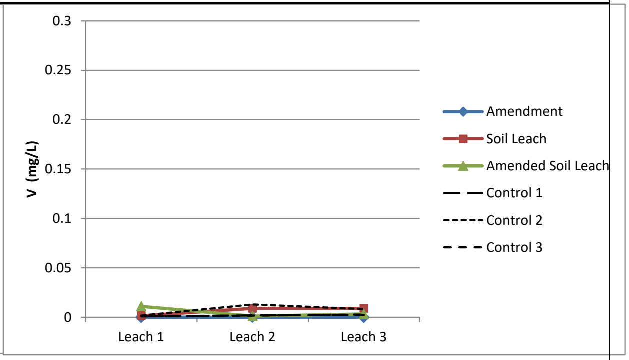

Fairbridge Duplex

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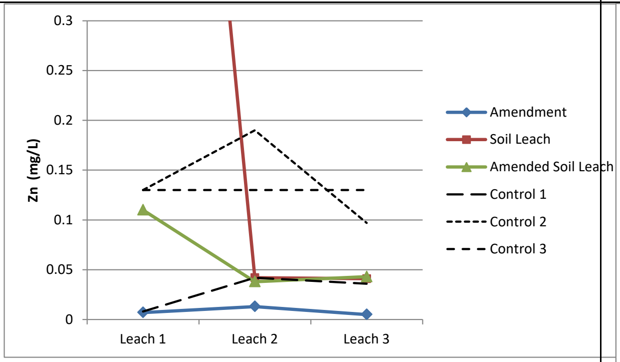
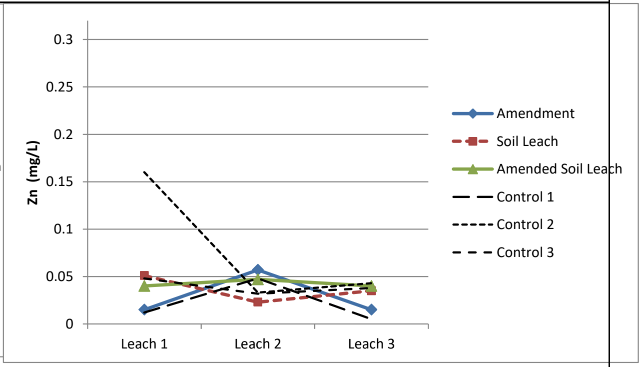
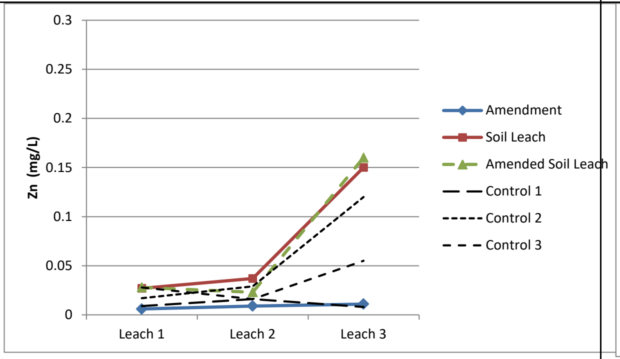
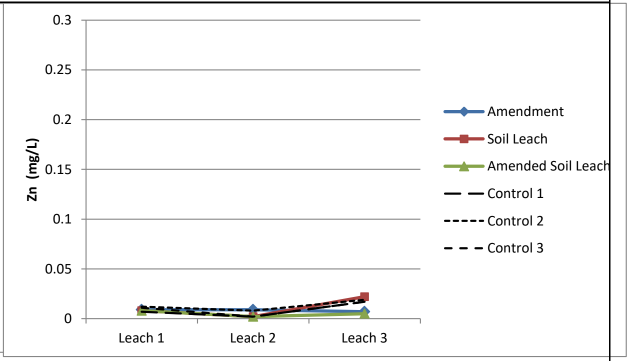




Bassendean Ellenbrook

Bassendean Joel

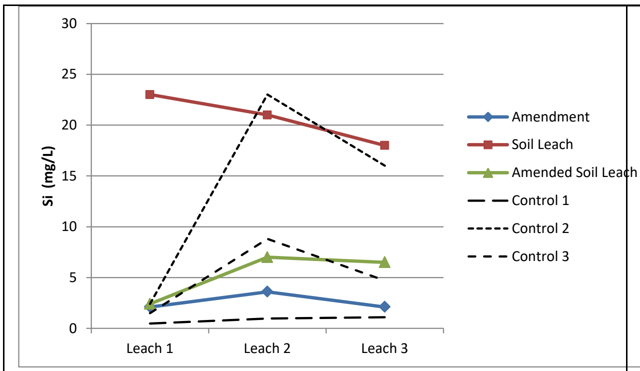


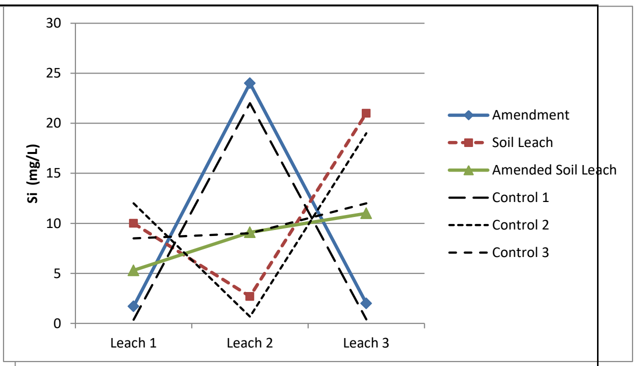


Fairbridge Duplex

Spearwood

A12-4. Wanneroo Groundwater Residue Charts





Bassendean Ellenbrook

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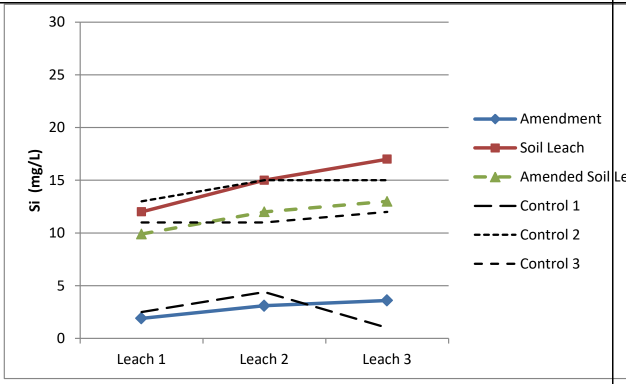
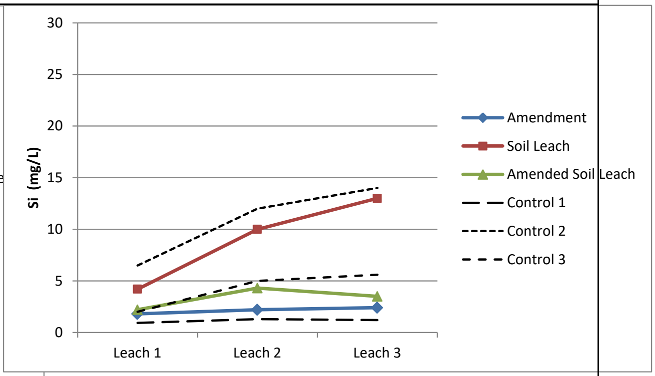
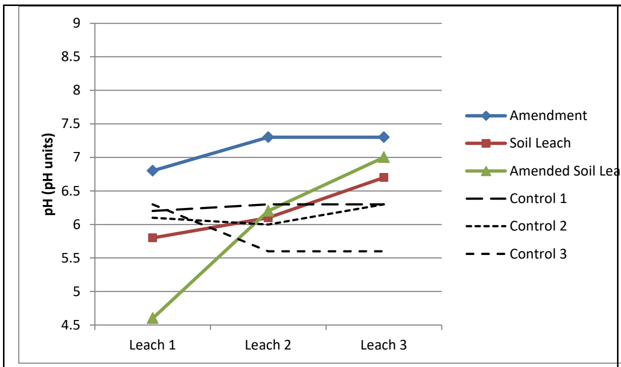




Fairbridge Duplex

Spearwood

A12-5 Jandakot Groundwater Residue



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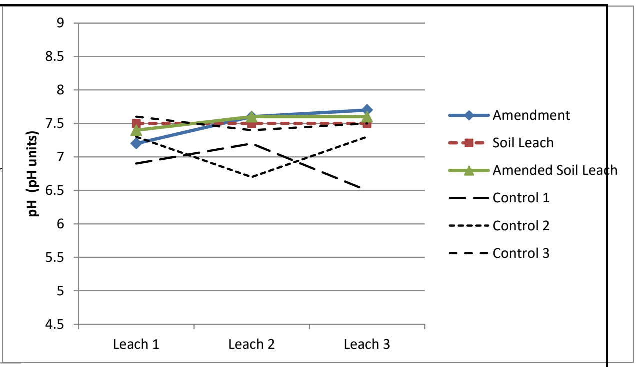
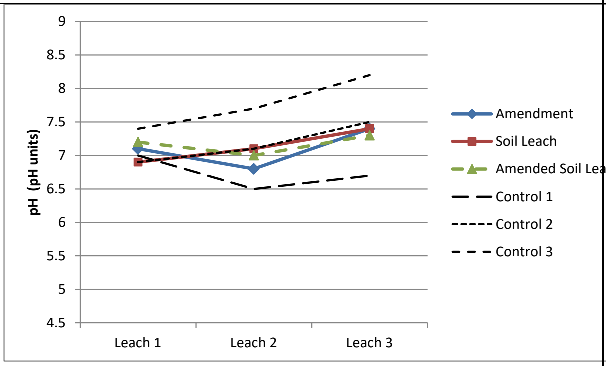


Bassendean Joel



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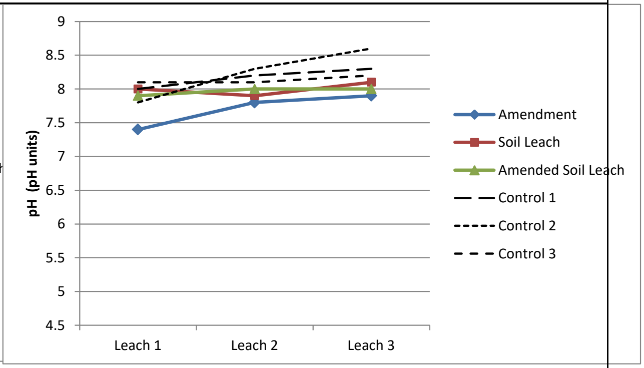

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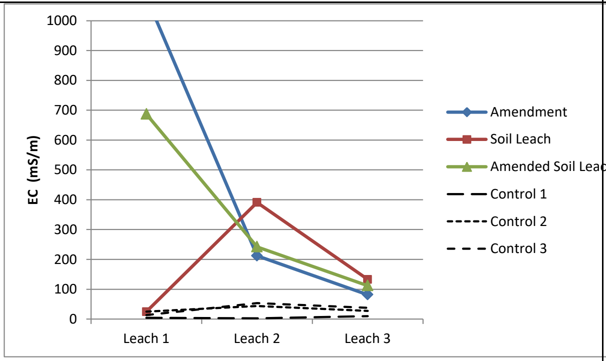
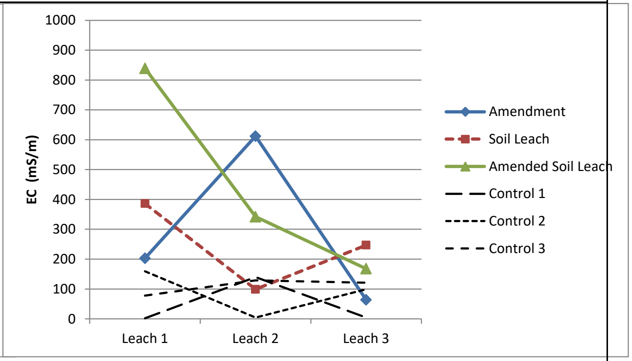
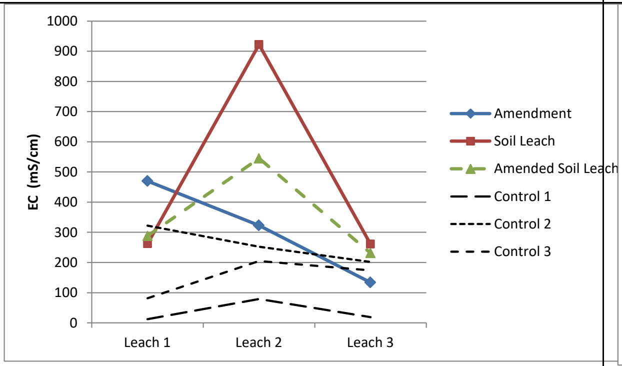


Bassendean Ellenbrook



Bassendean Joel



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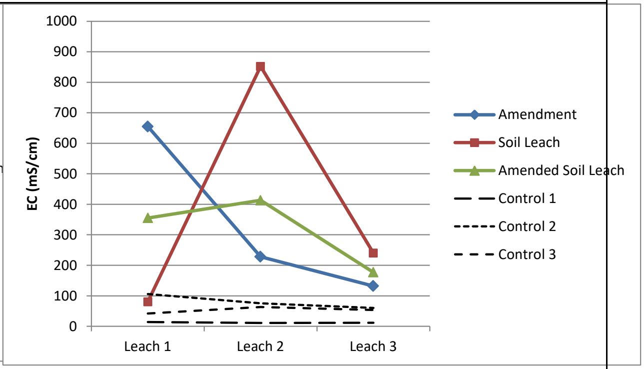
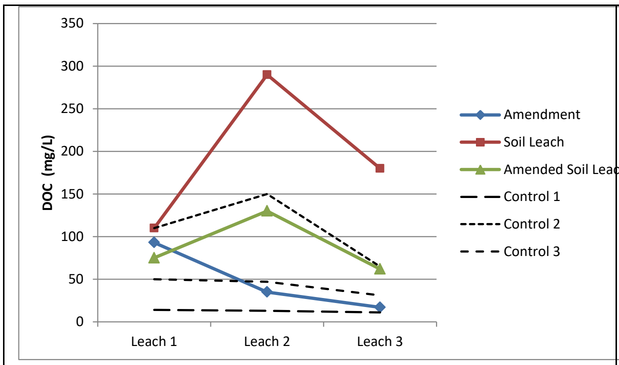


Spearwood

A12-5 Jandakot Groundwater Residue



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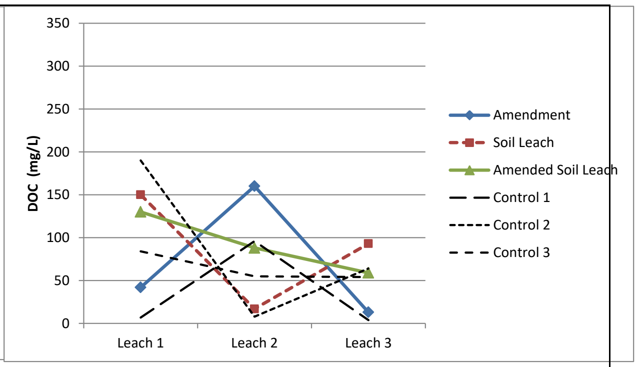

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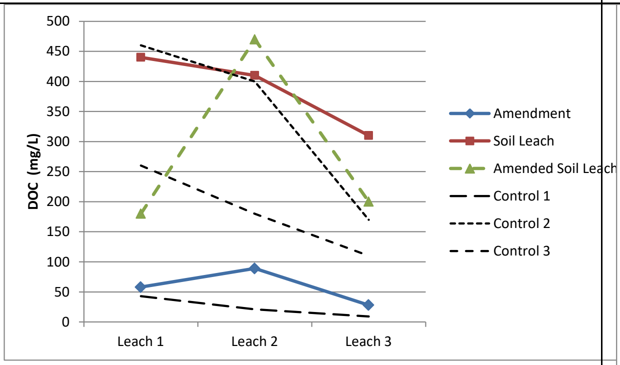

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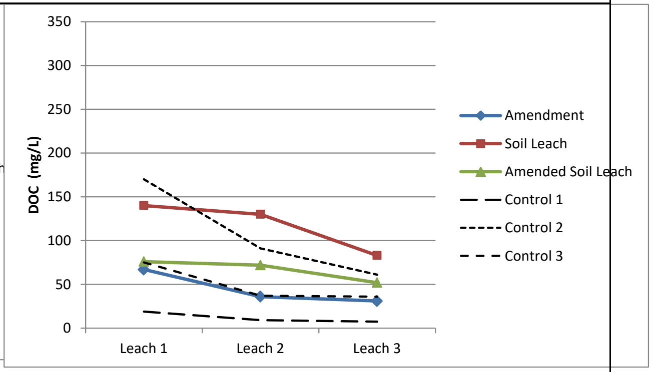

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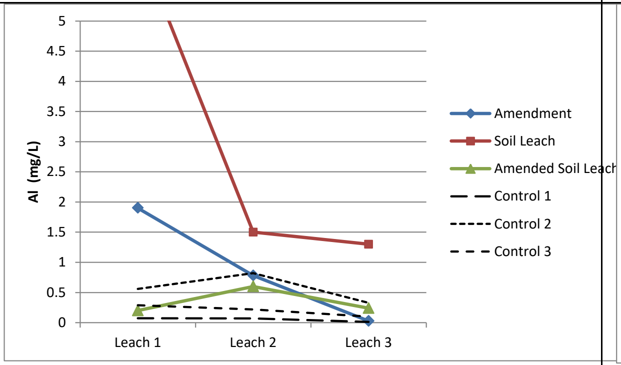

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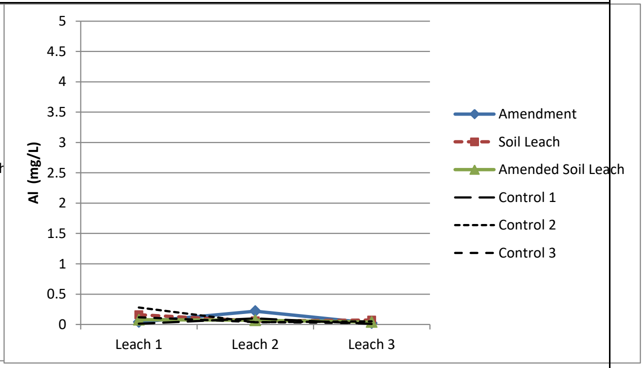

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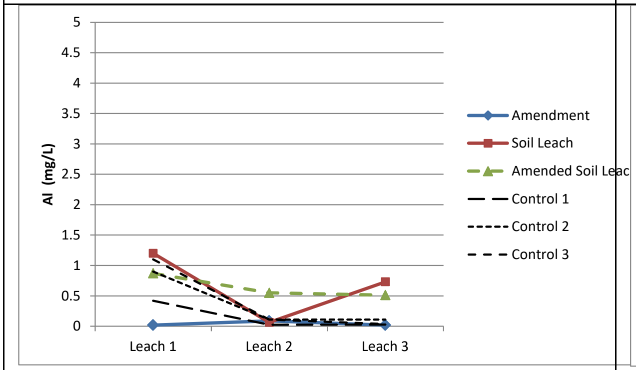

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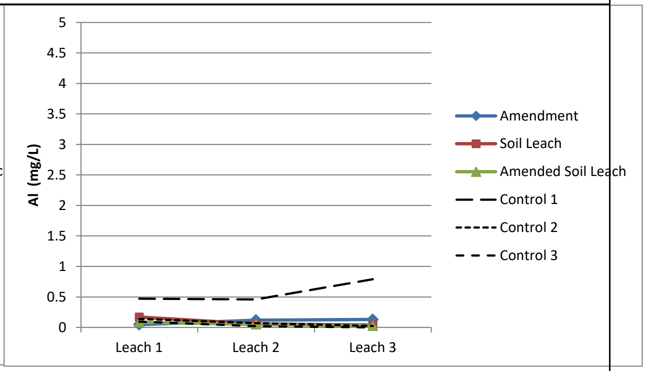

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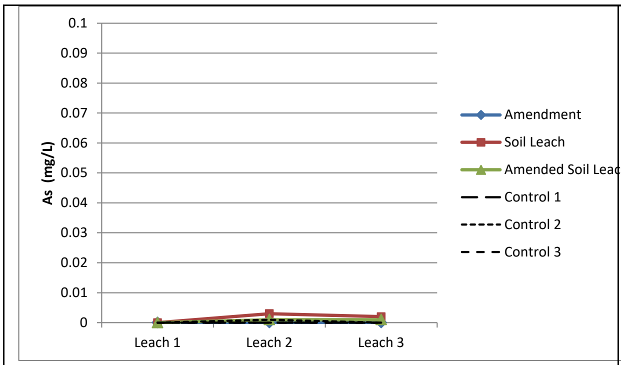
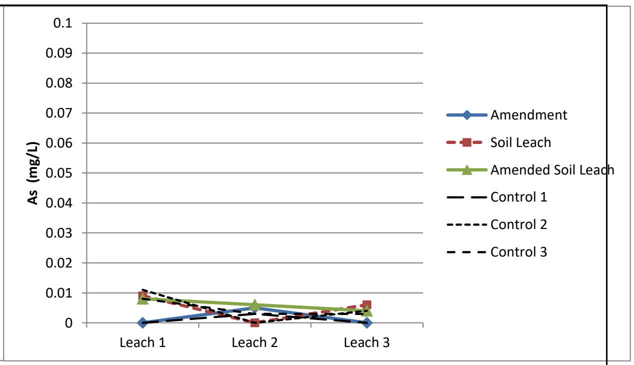
A12-5 Jandakot Groundwater Residue





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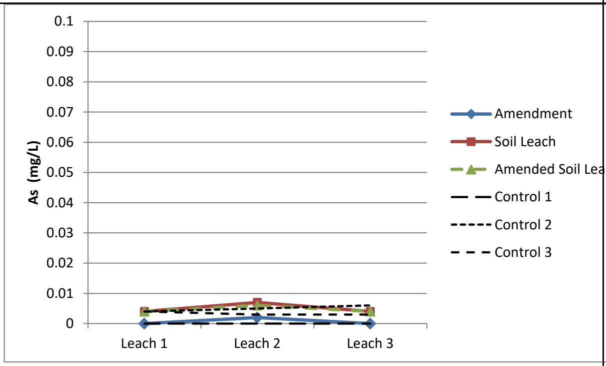

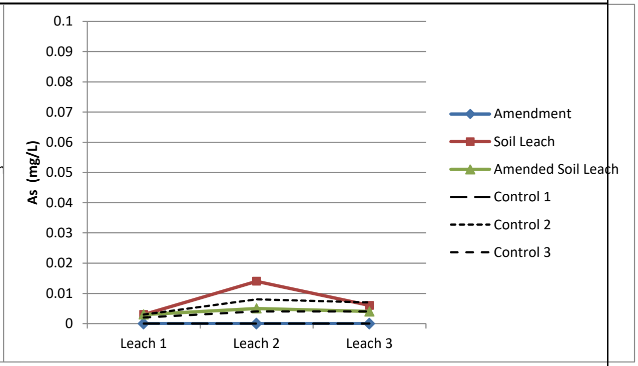

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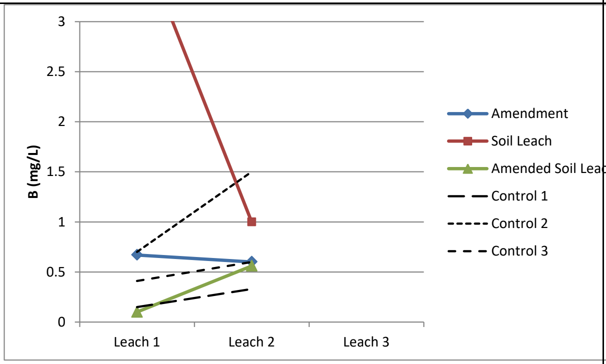

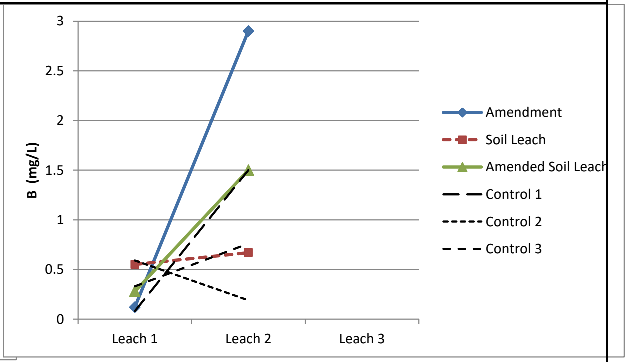

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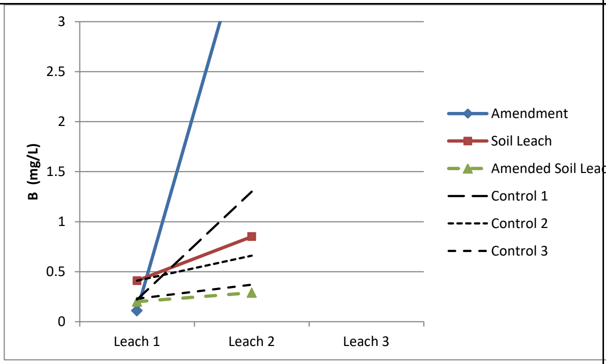

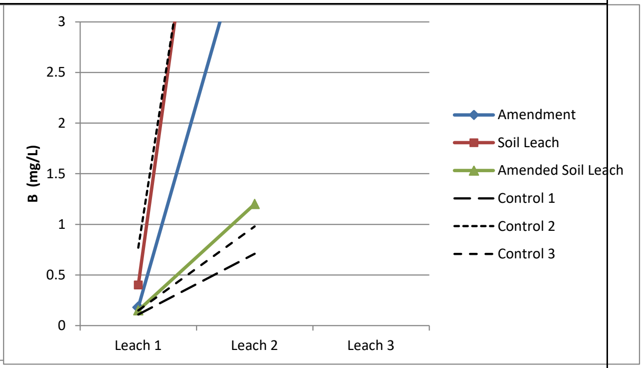

Fairbridge Duplex

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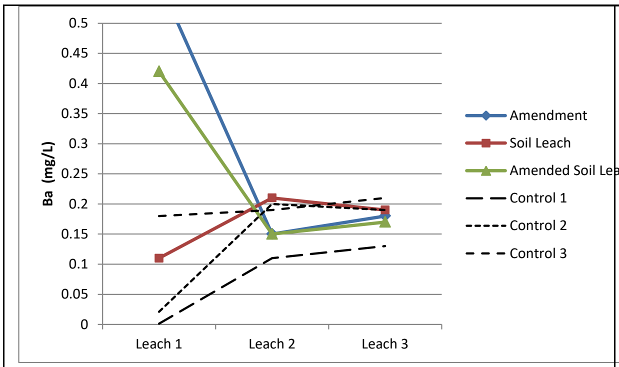
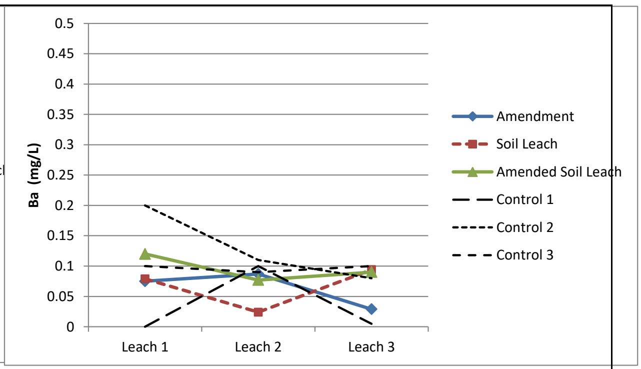
A12-5 Jandakot Groundwater Residue





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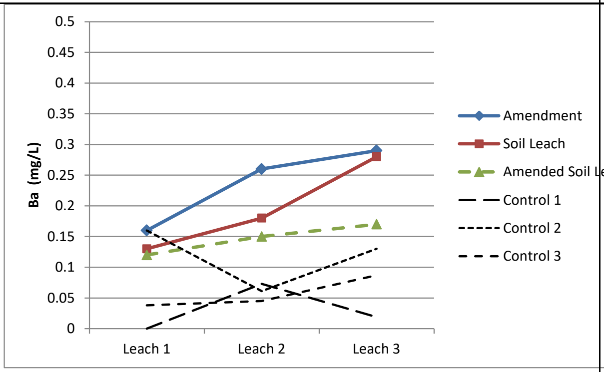

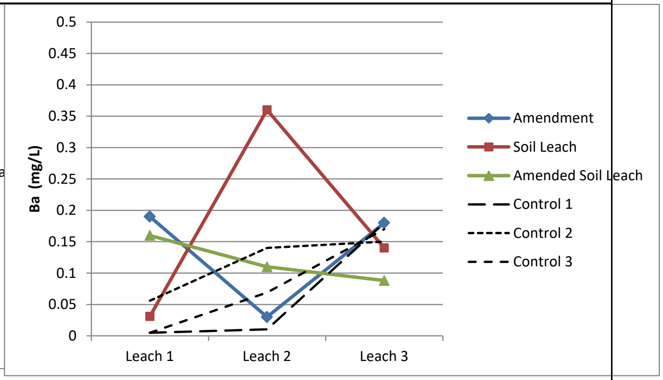

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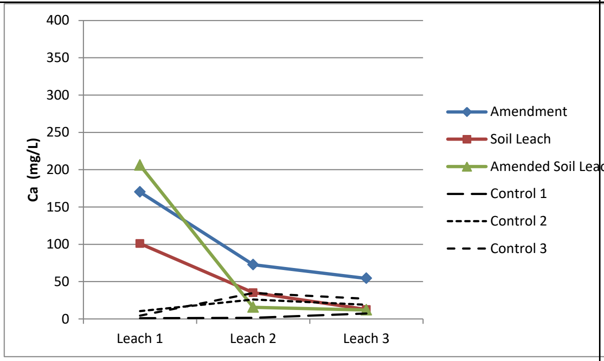

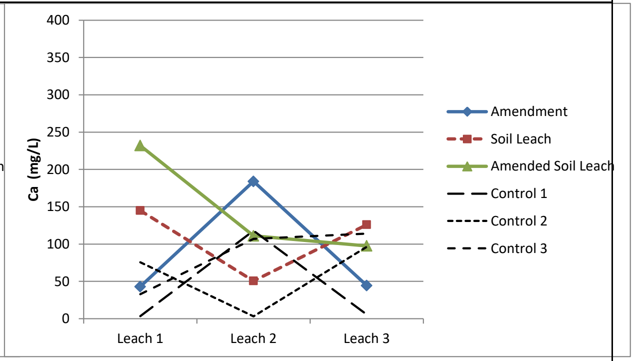

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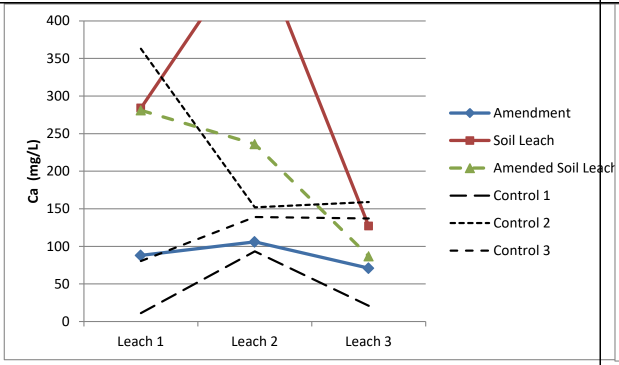
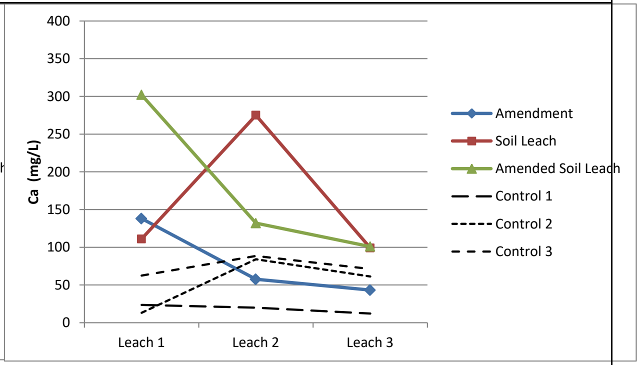
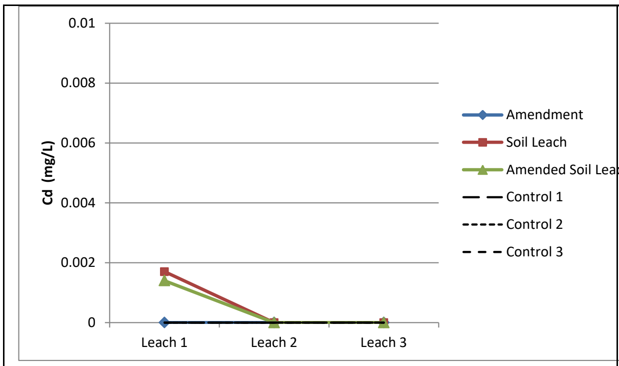




Fairbridge Duplex

Spearwood

A12-5 Jandakot Groundwater Residue



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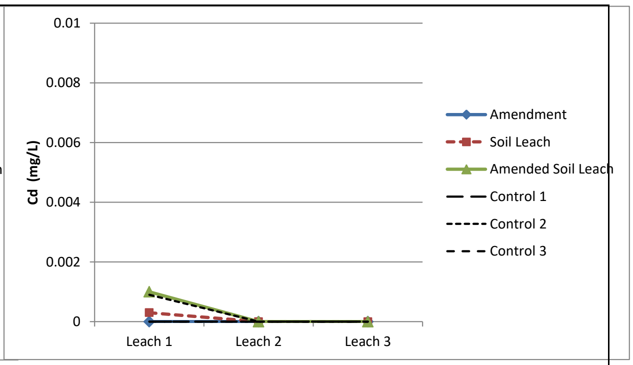

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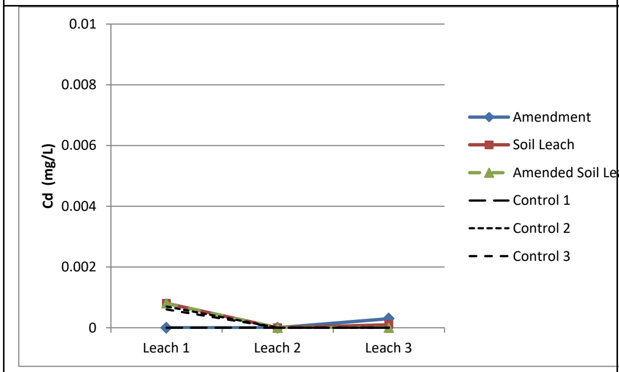

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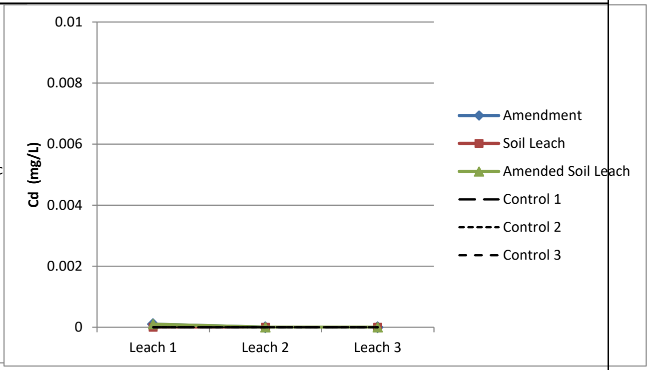

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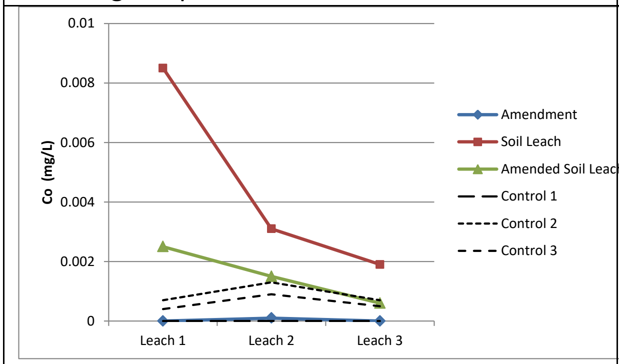

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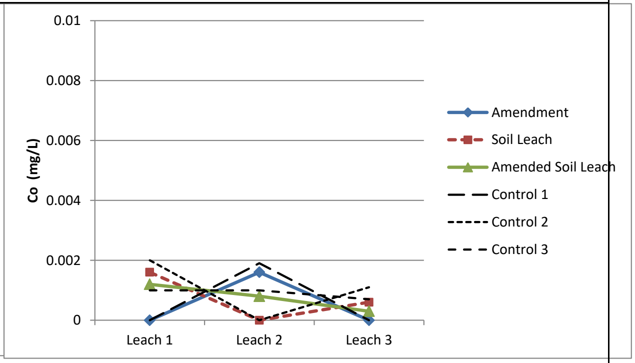

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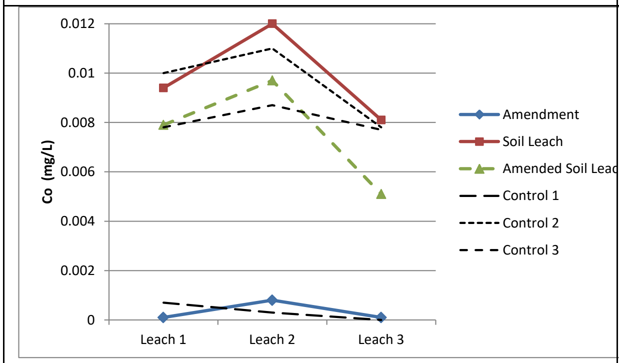

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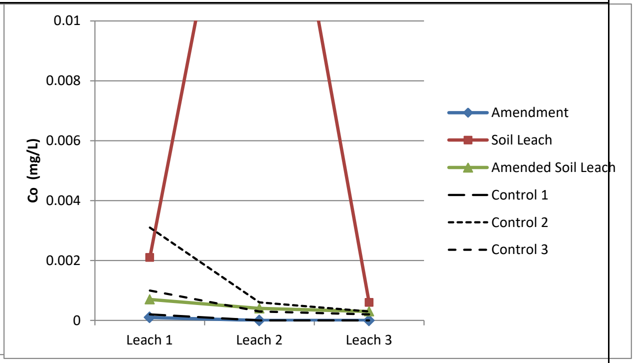

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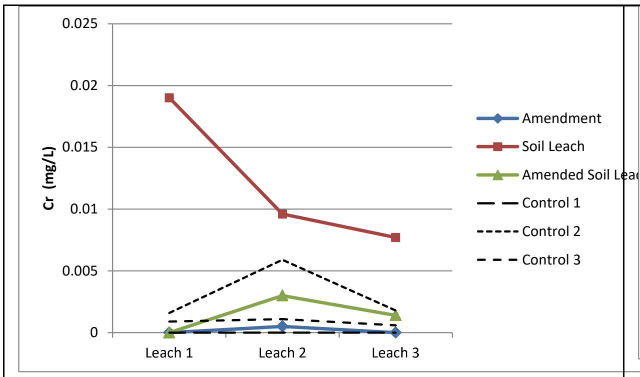
A12-5 Jandakot Groundwater Residue



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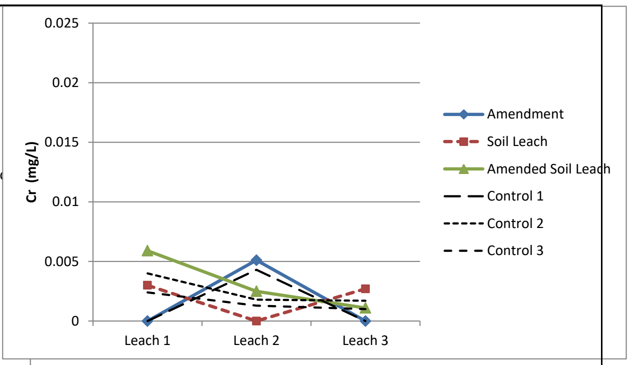

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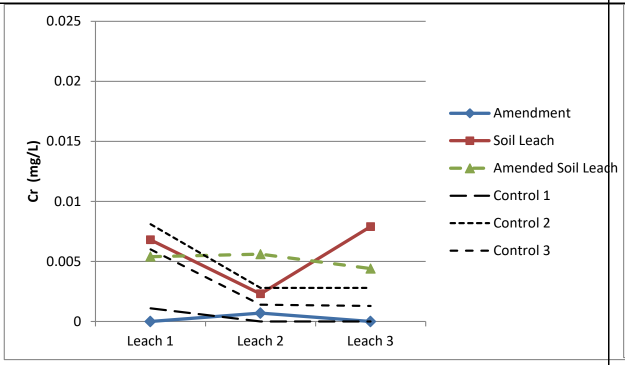

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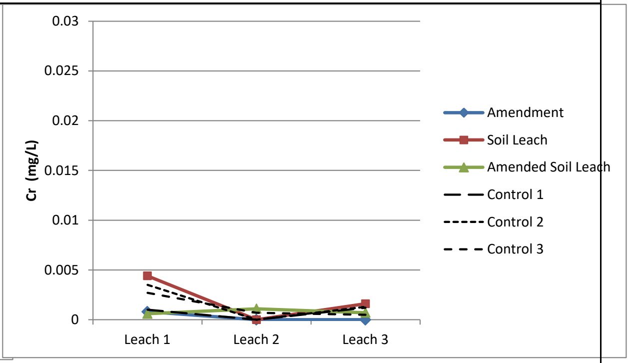

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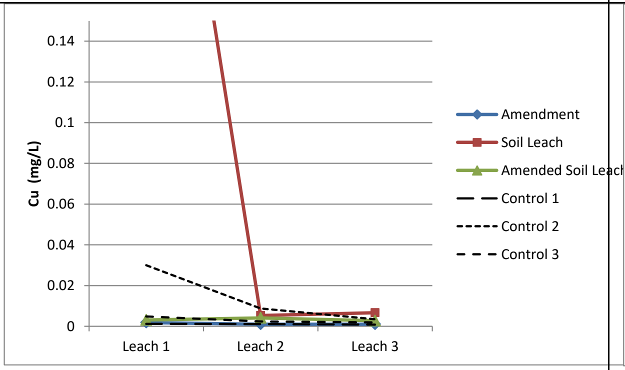

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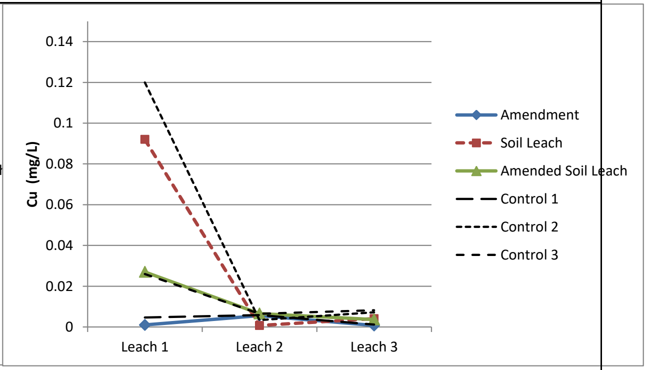

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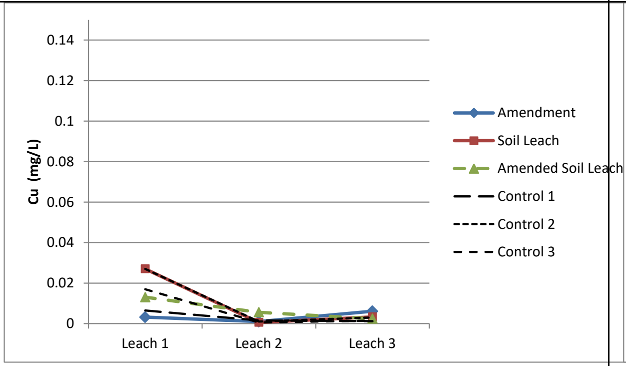

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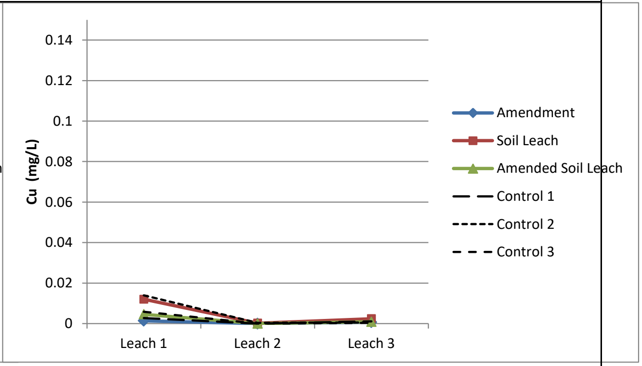

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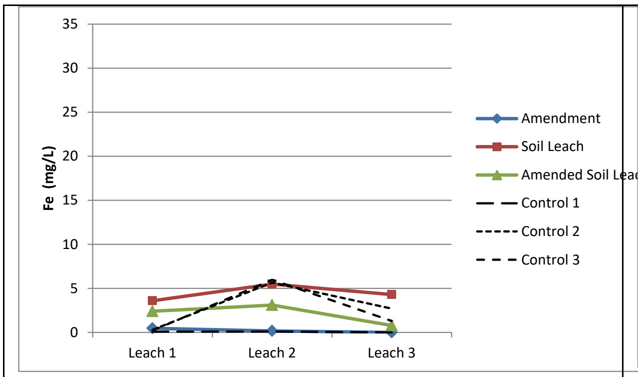
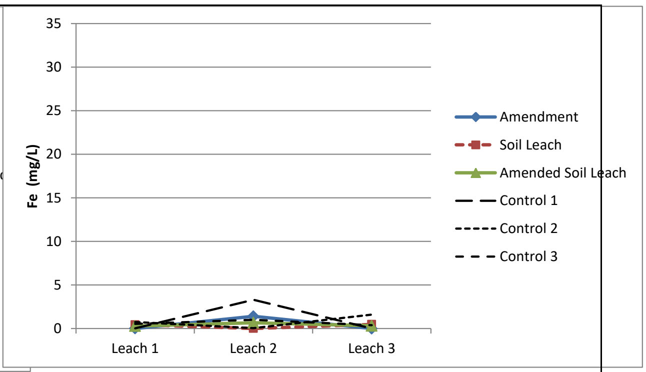
A12-5 Jandakot Groundwater Residue





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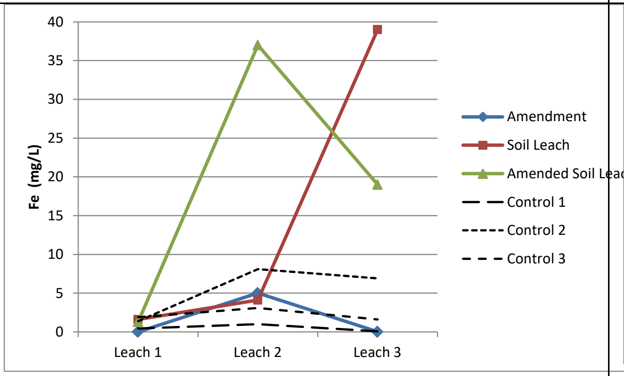

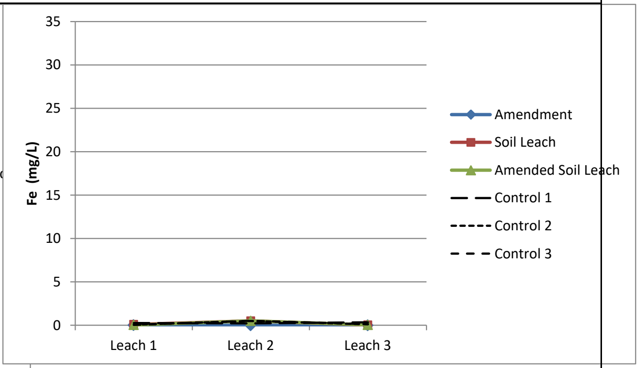

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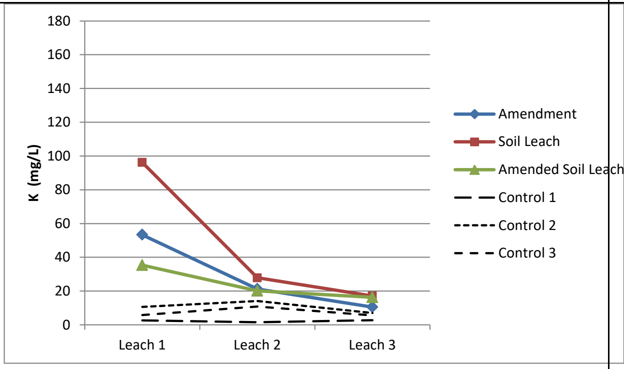

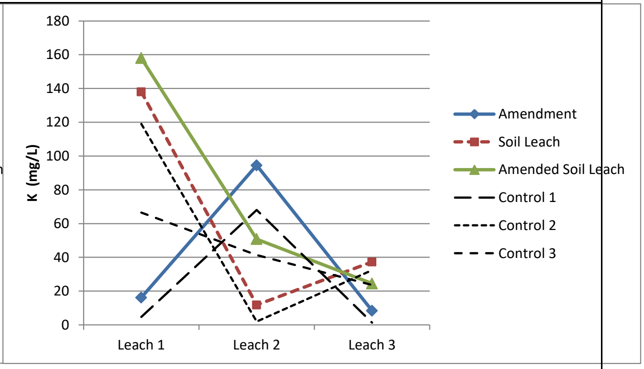

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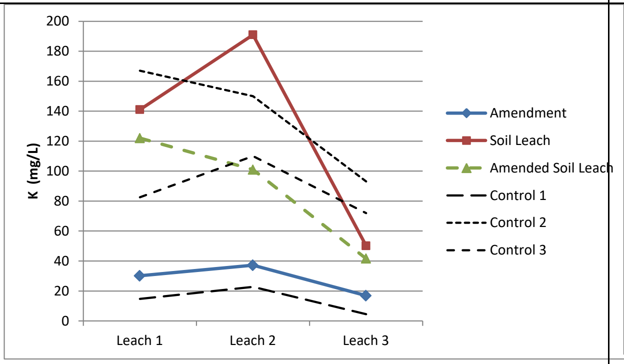

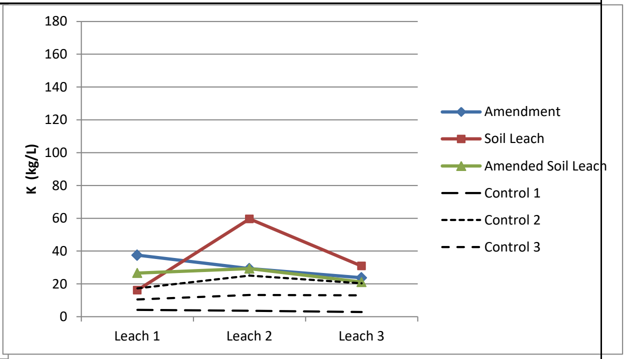

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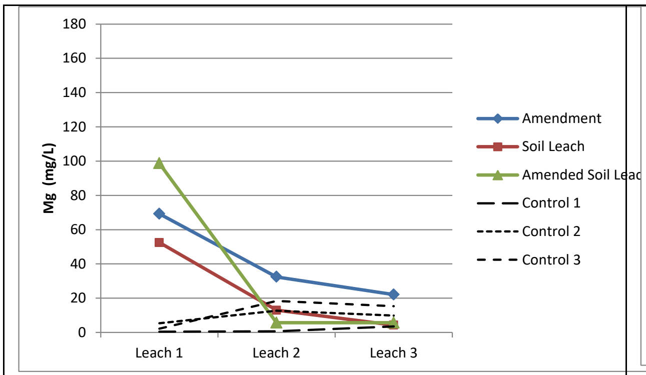
A12-5 Jandakot Groundwater Residue



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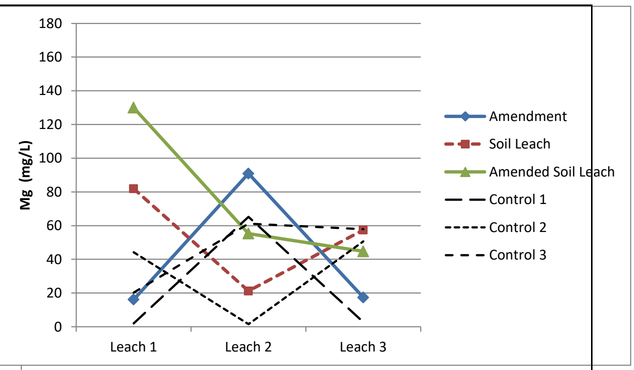

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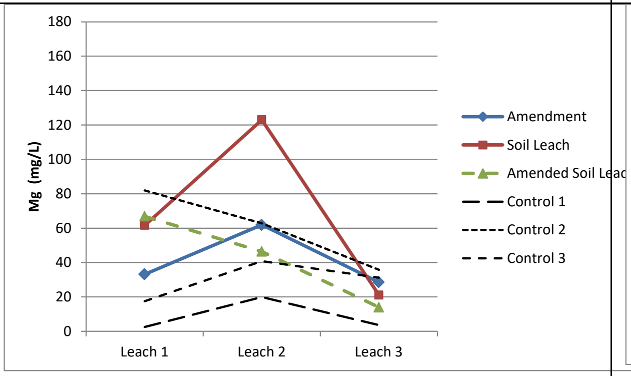

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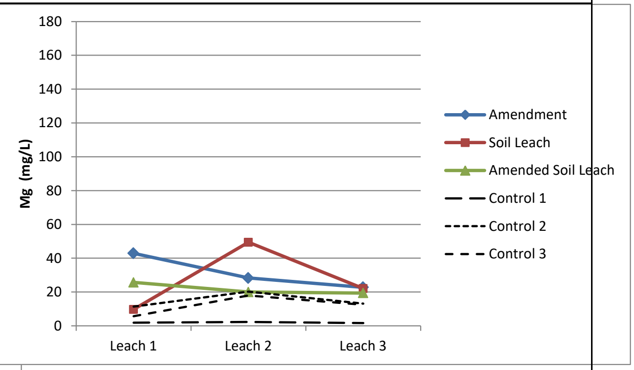

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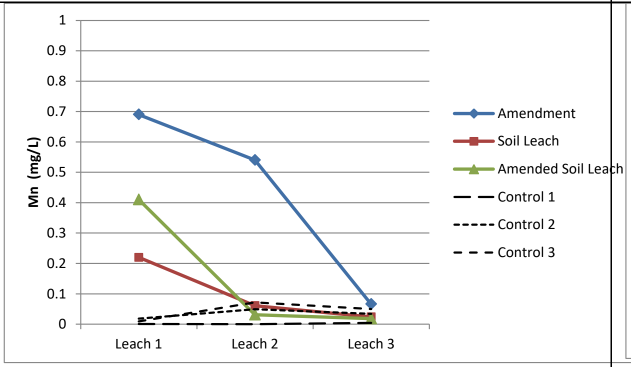

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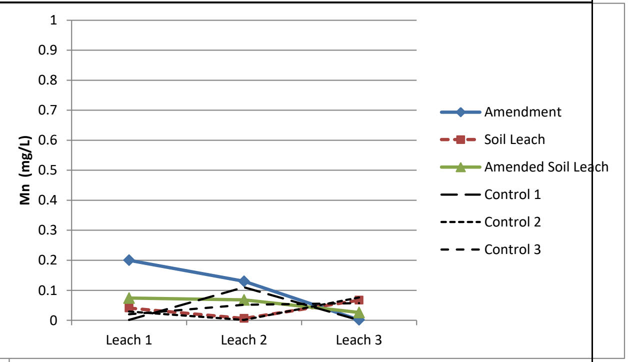

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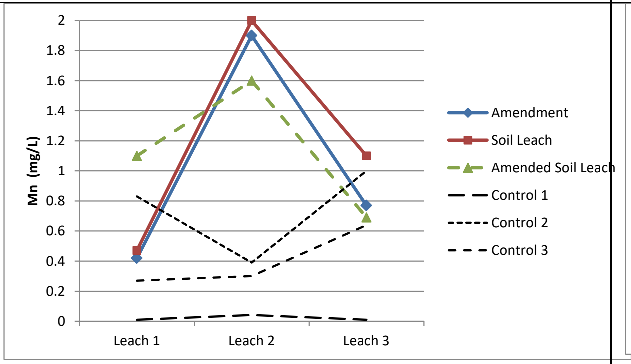

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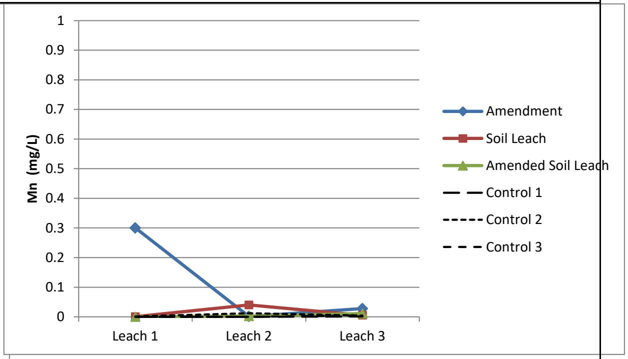

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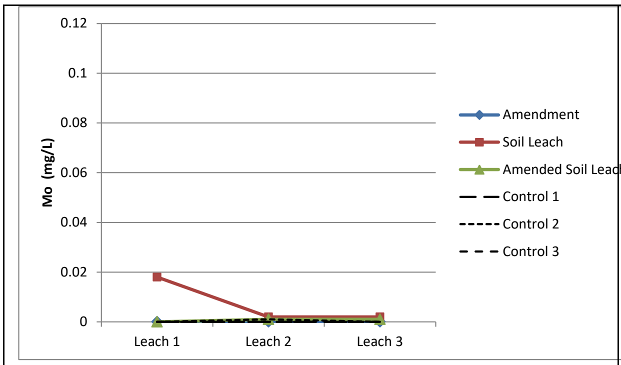
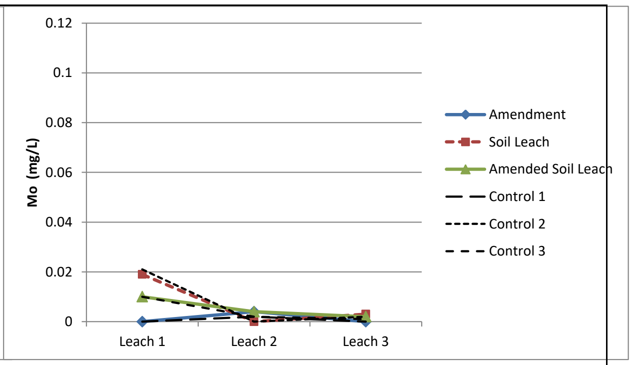
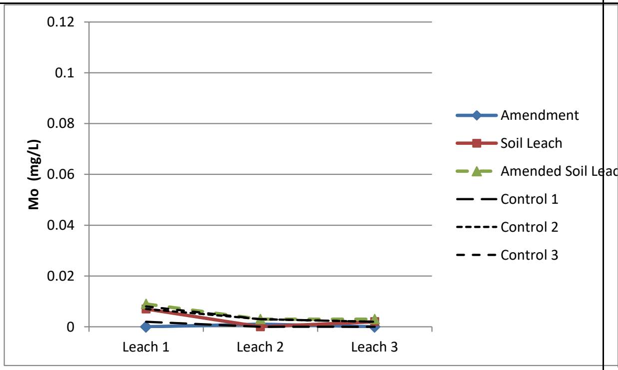
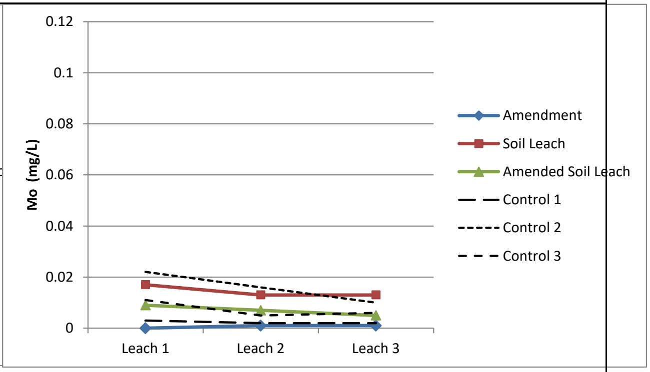
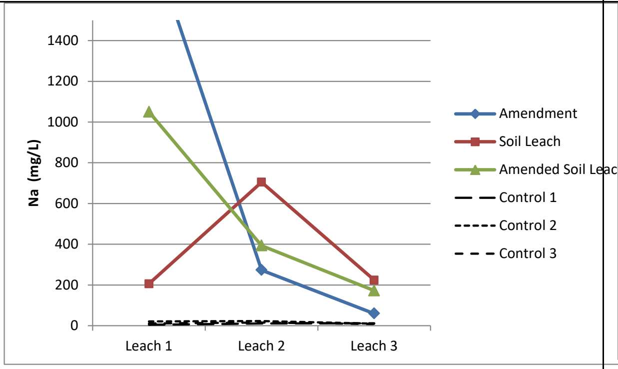
A12-5 Jandakot Groundwater Residue

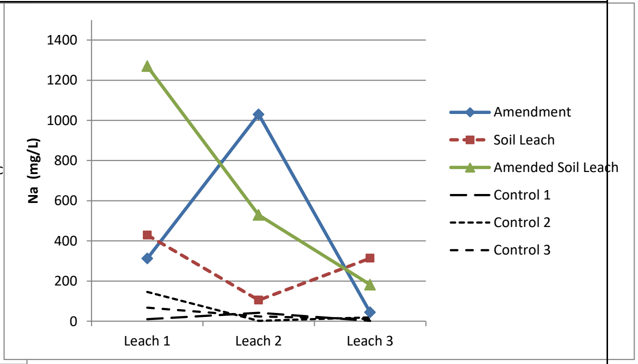


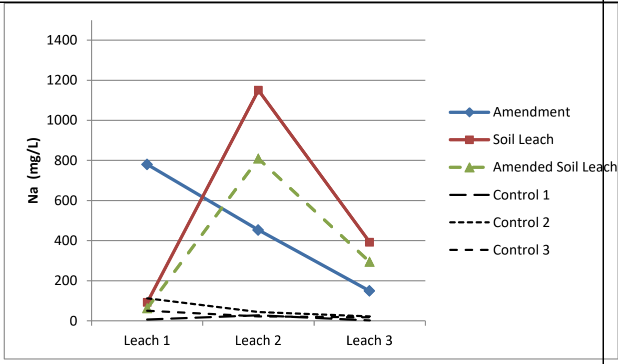


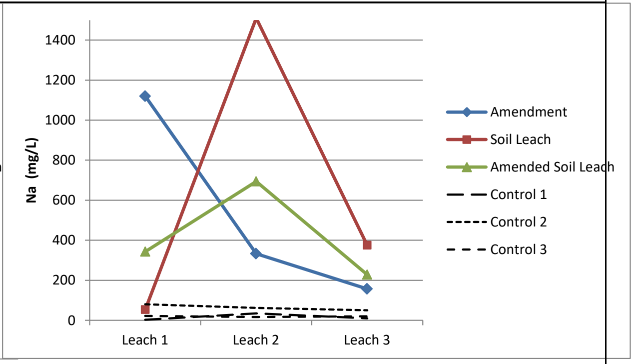




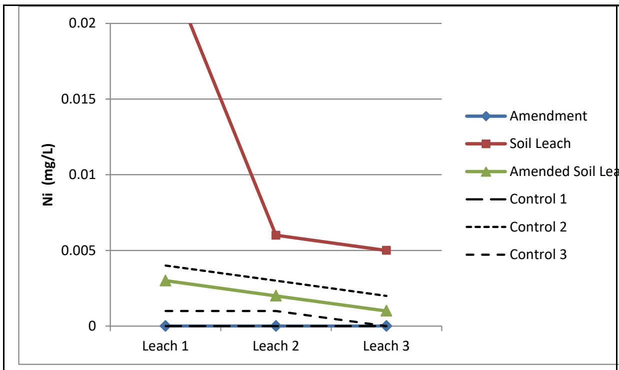








A12-5 Jandakot Groundwater Residue



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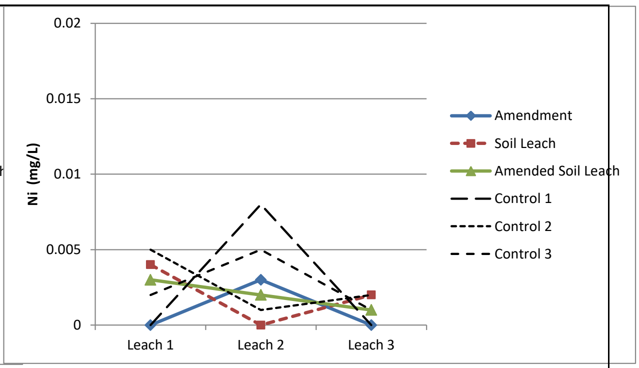

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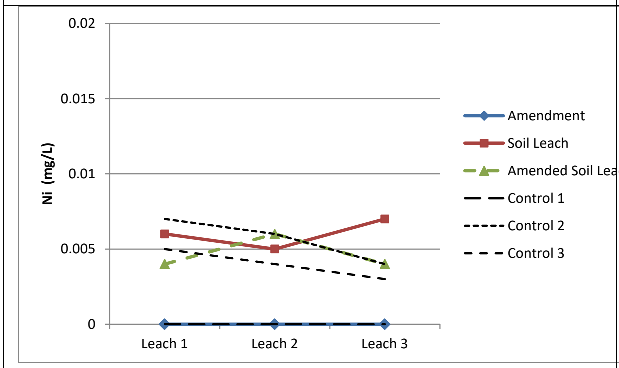

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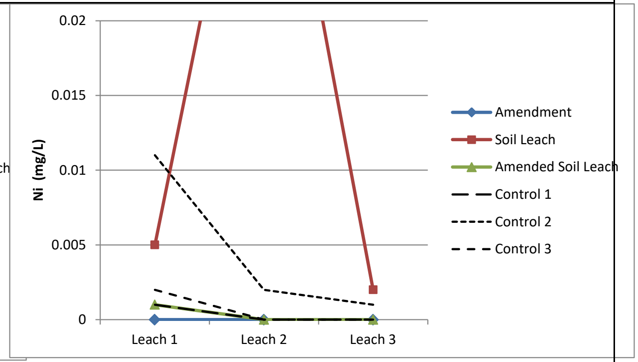

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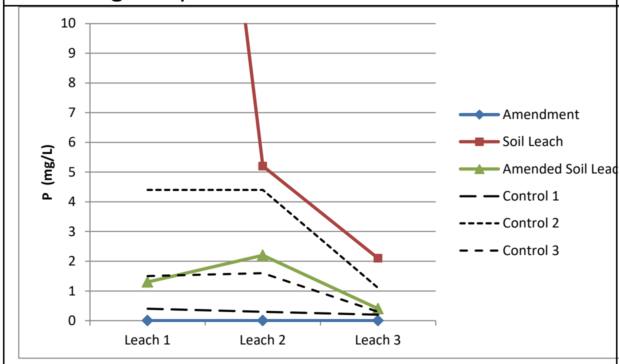

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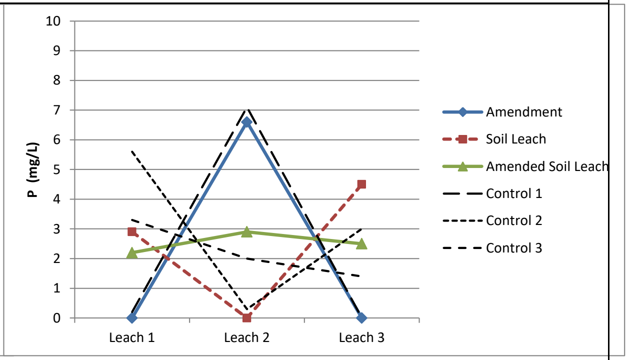

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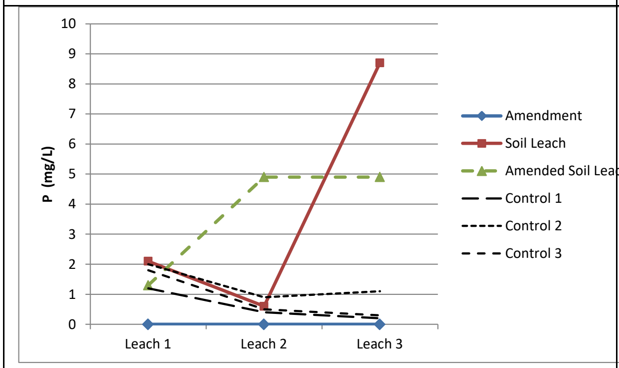

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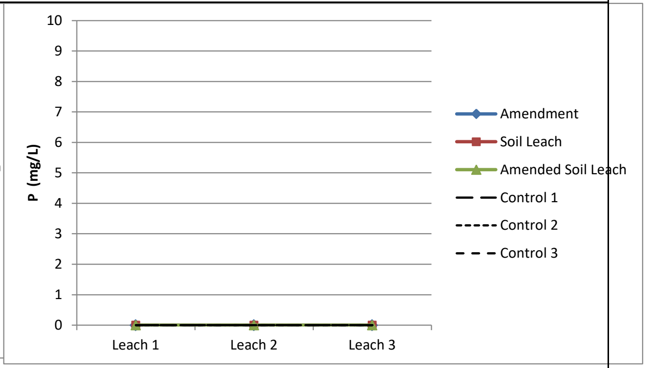
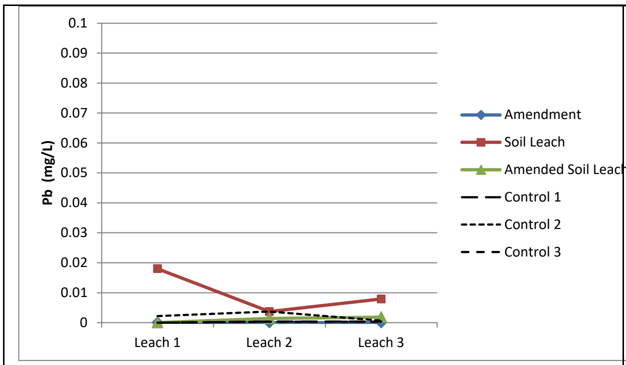


Spearwood

A12-5 Jandakot Groundwater Residue



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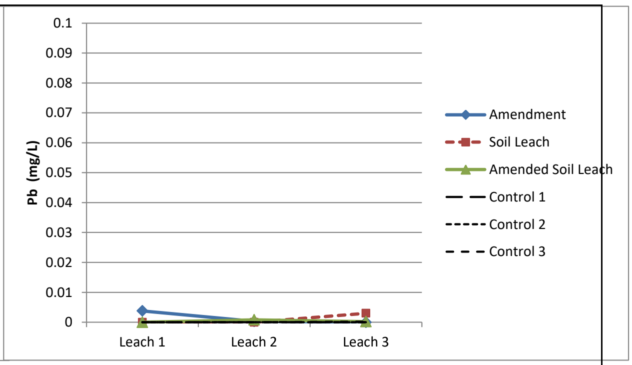

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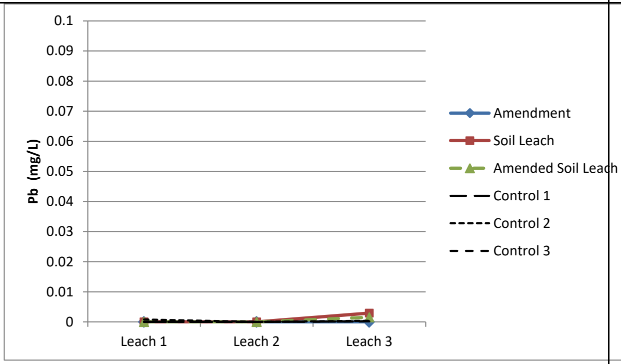

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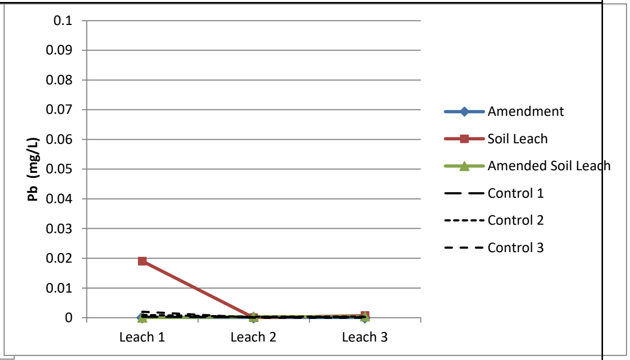

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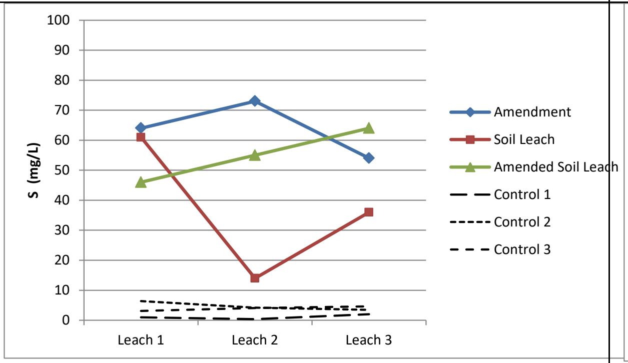

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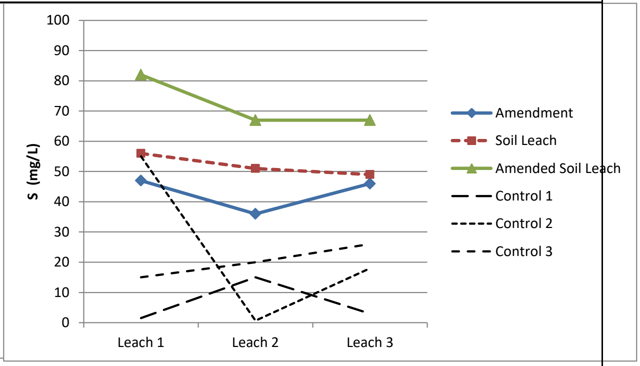

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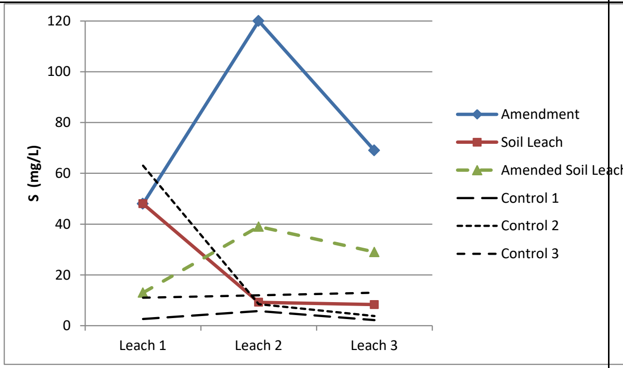

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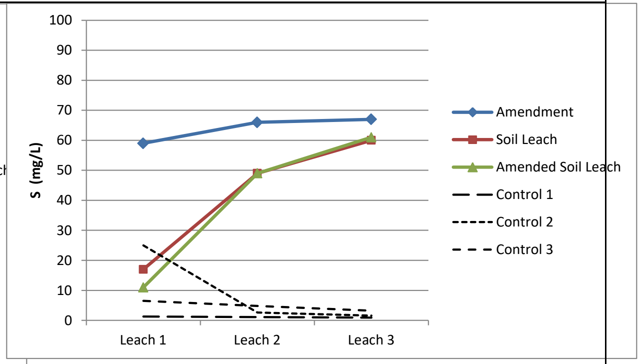

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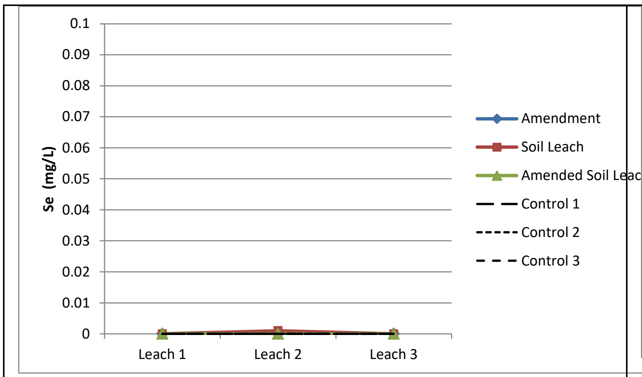
A12-5 Jandakot Groundwater Residue



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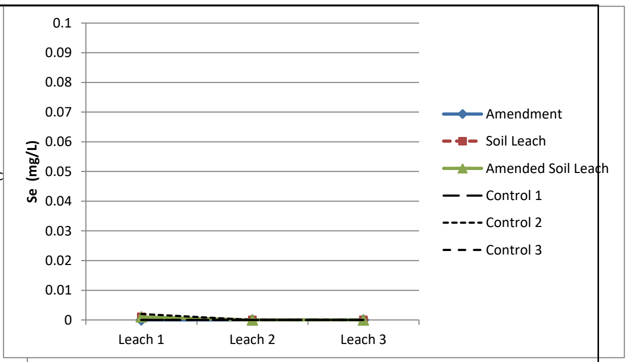

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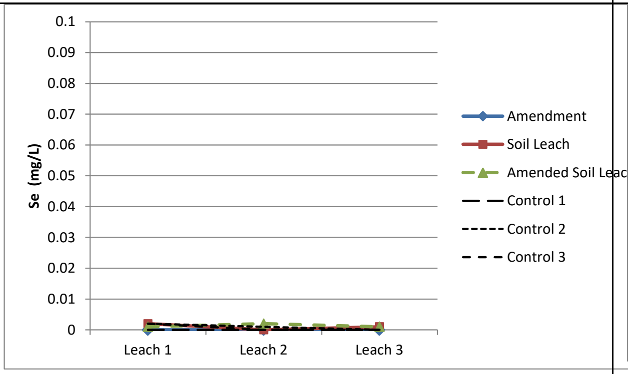

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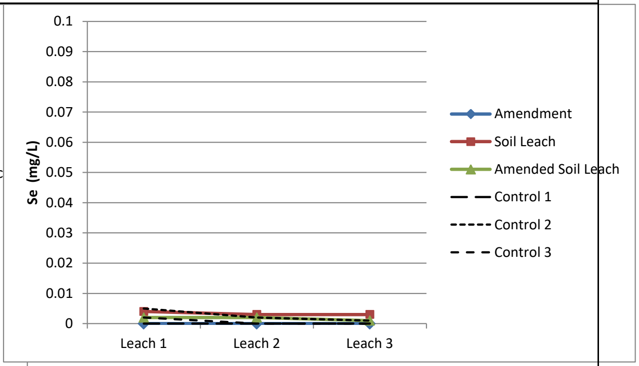

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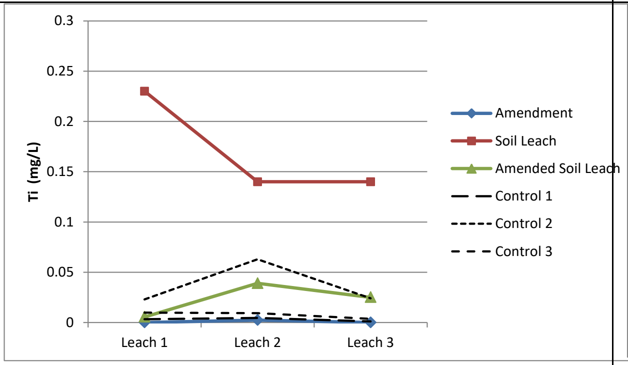

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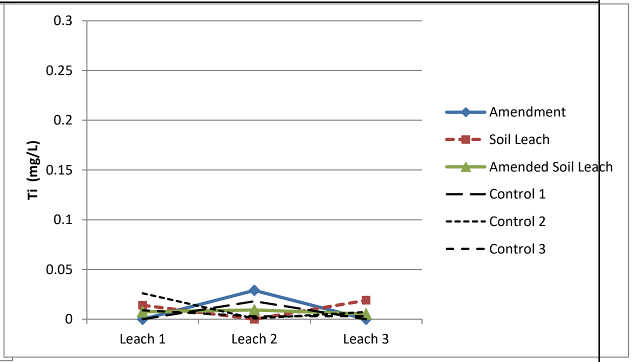

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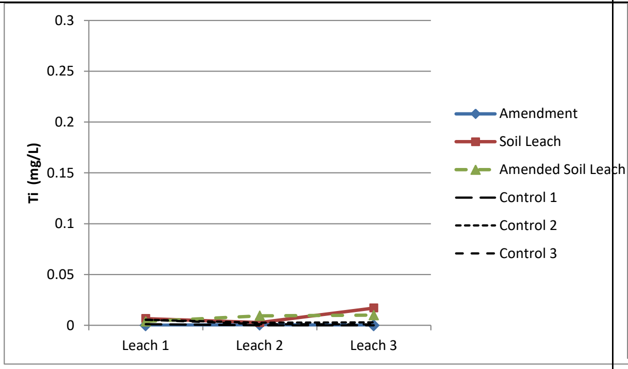

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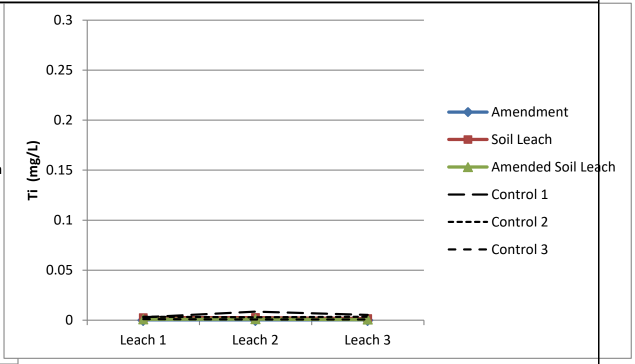

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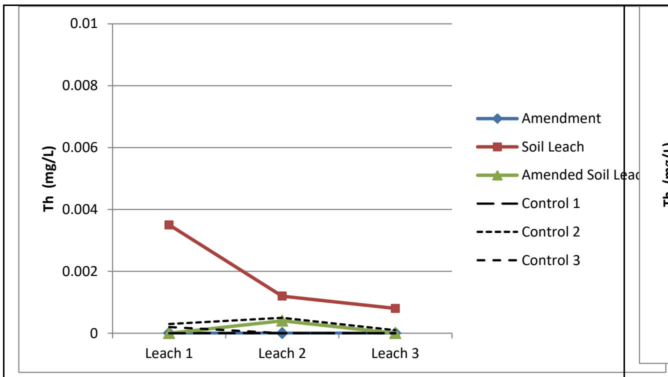
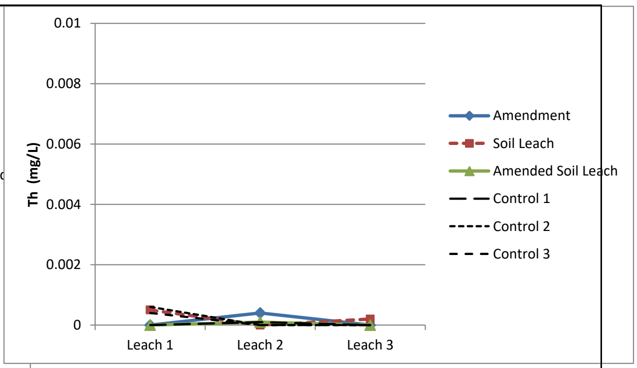
A12-5 Jandakot Groundwater Residue





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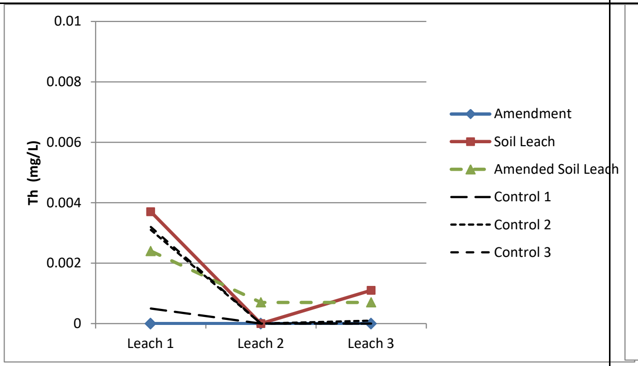

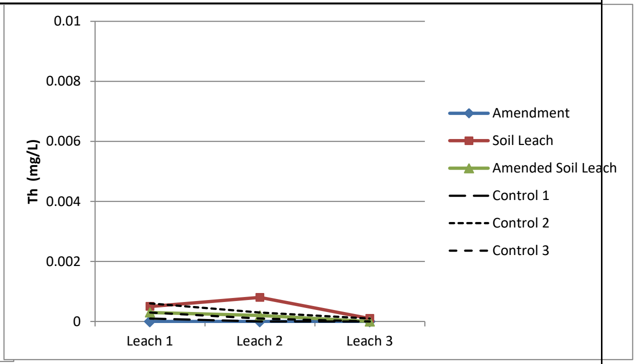

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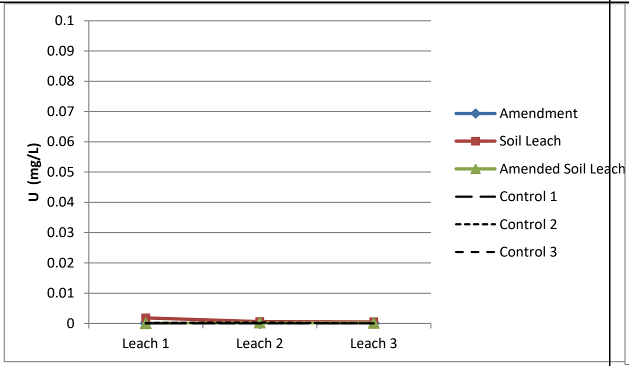

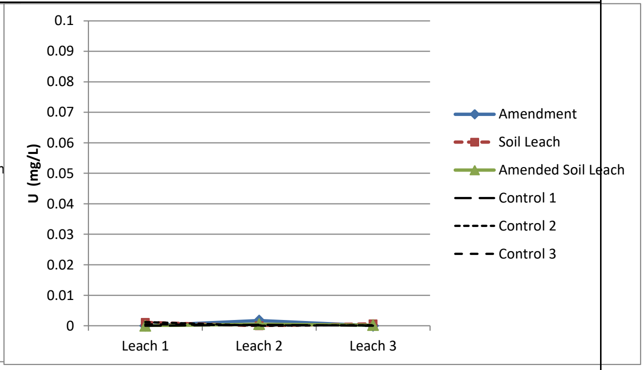

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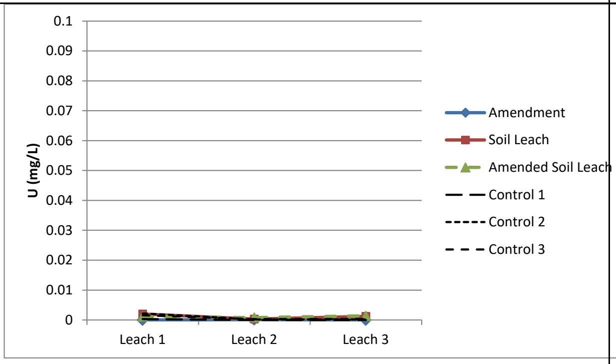
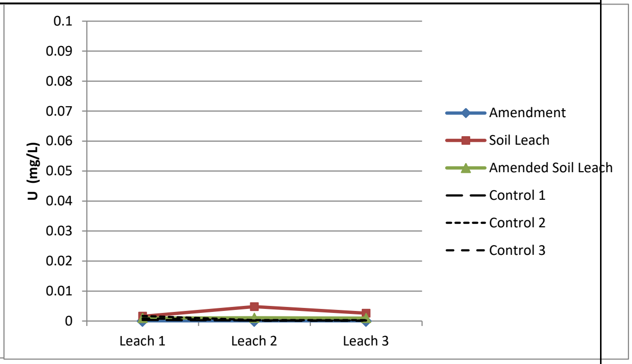
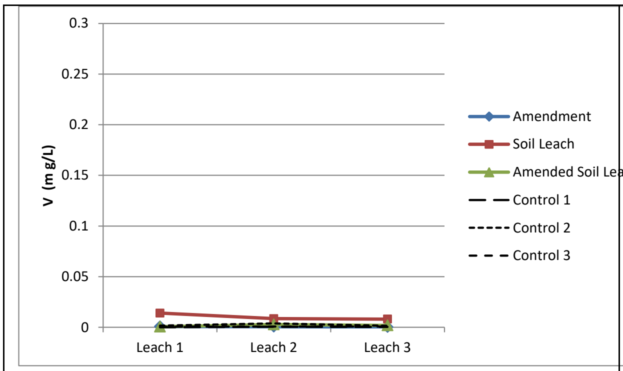




Fairbridge Duplex

Spearwood

A12-5 Jandakot Groundwater Residue



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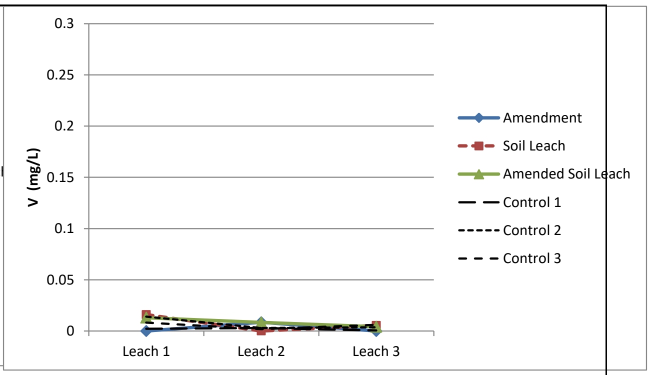

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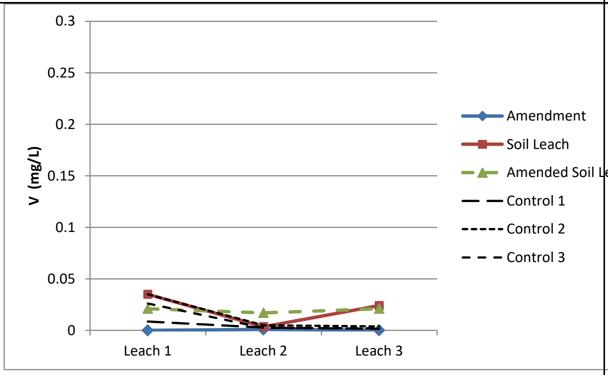

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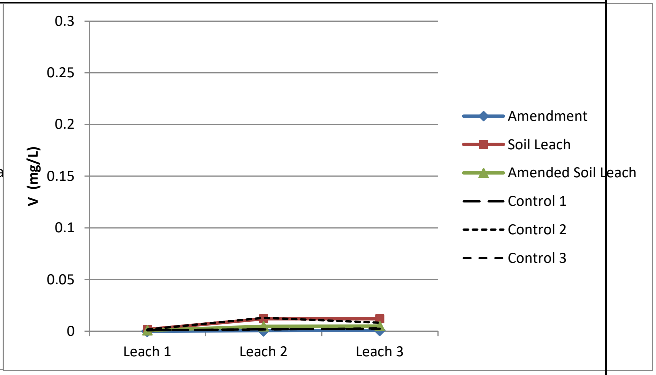

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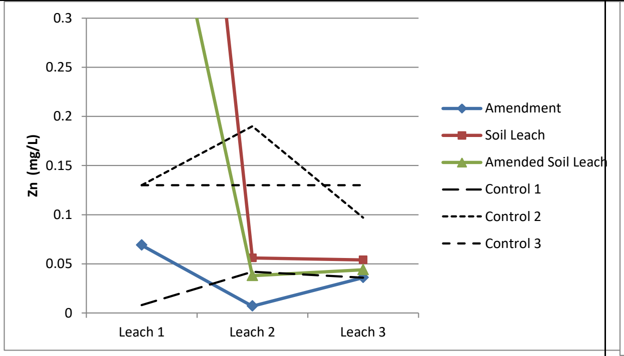

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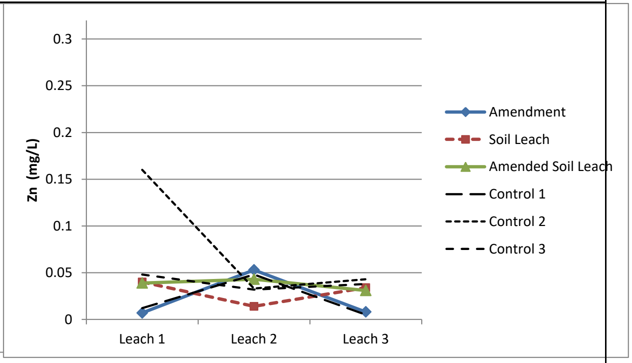

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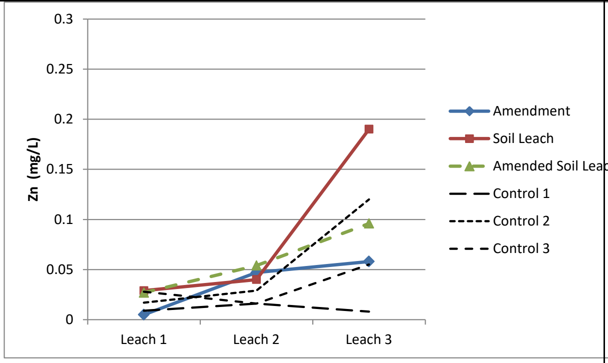

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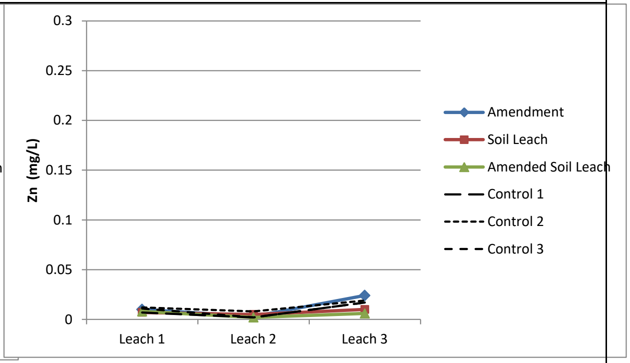

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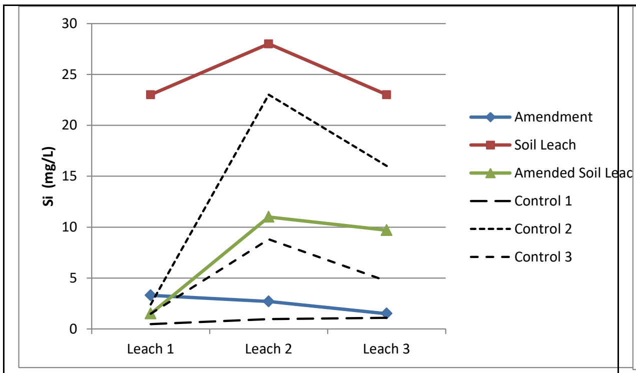
A12-5 Jandakot Groundwater Residue



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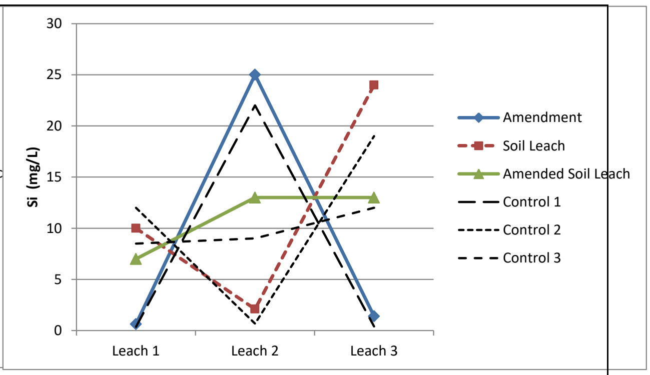

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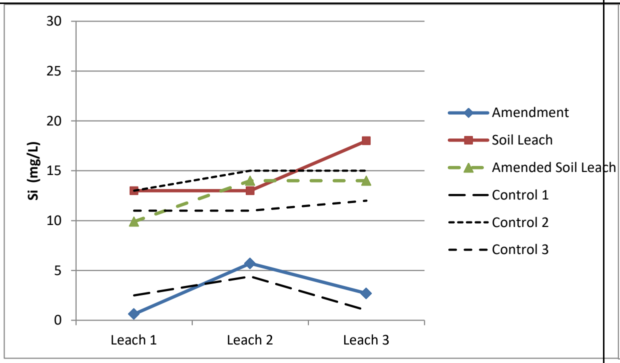

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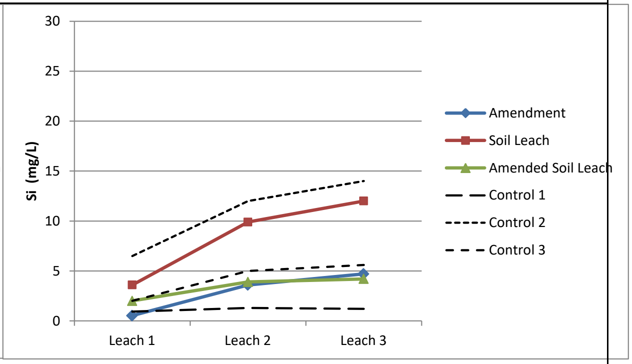
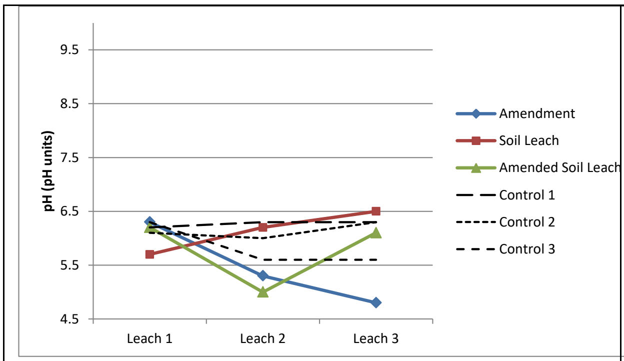


Spearwood

A12-6 Biosolids



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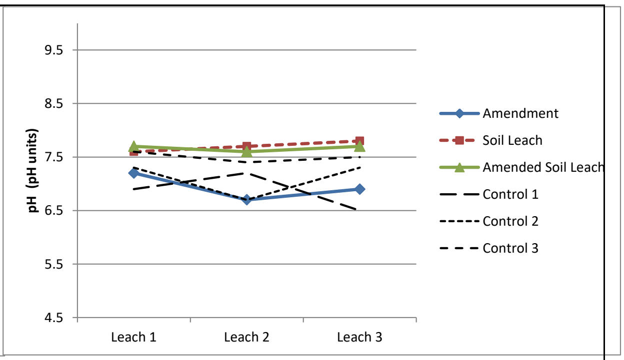

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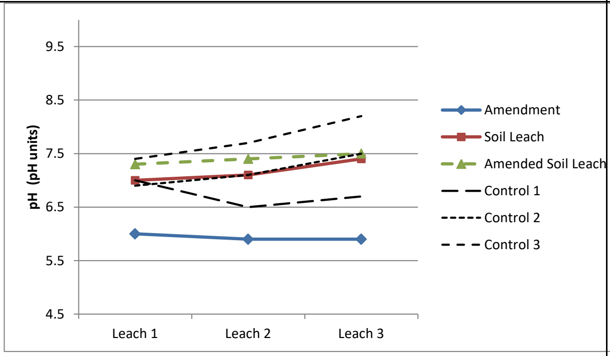

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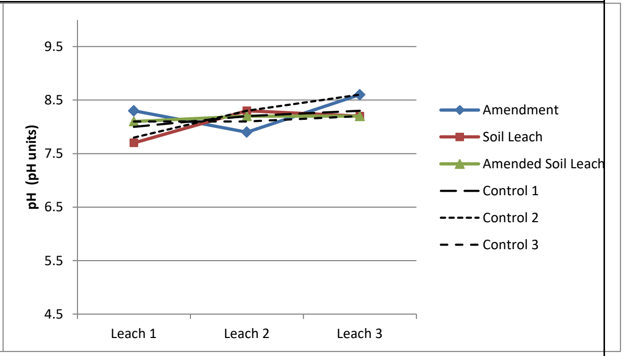

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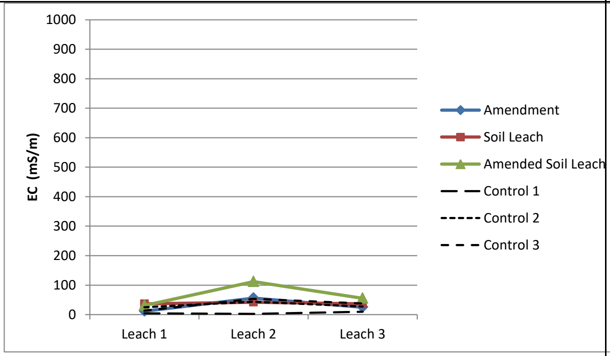

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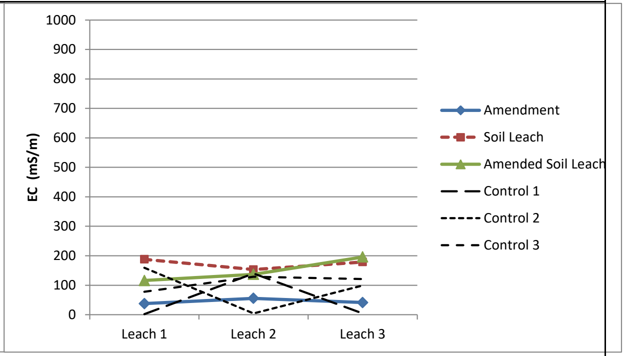

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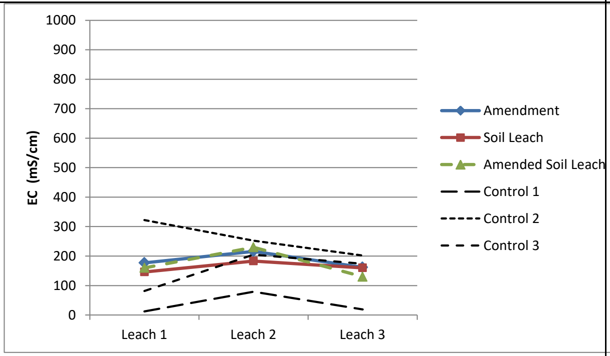

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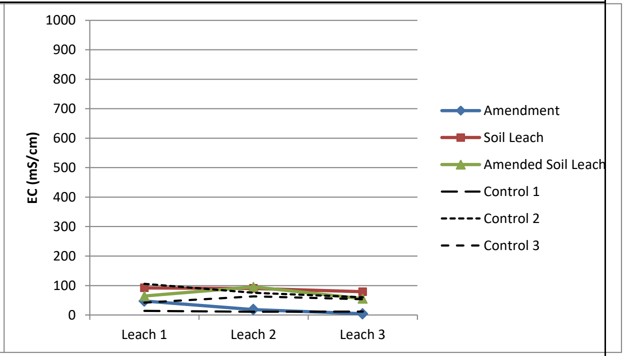
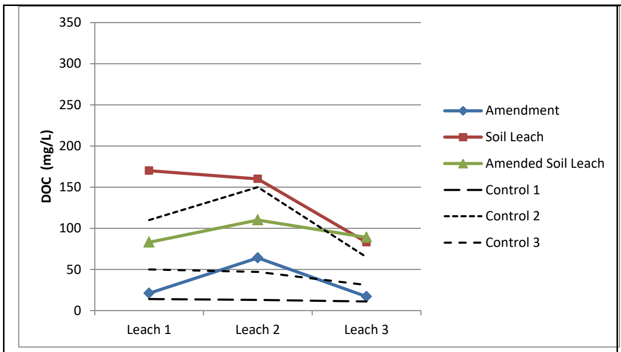


Spearwood

A12-6. Biosolids



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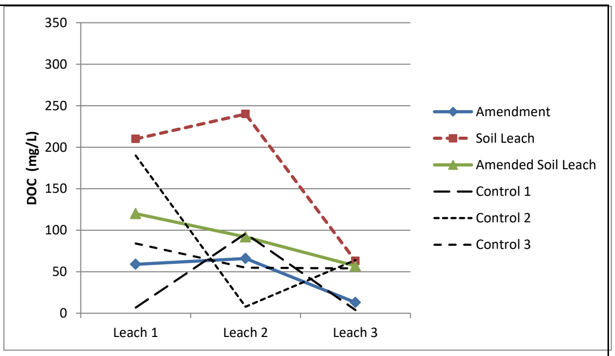

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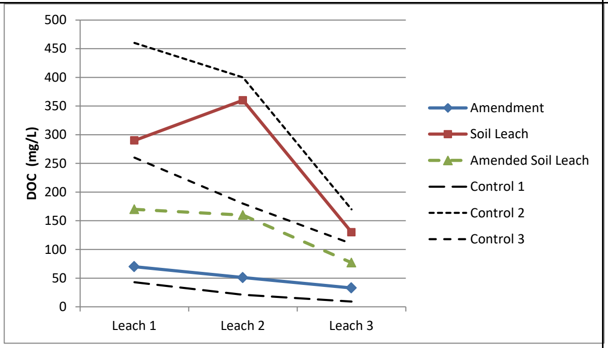

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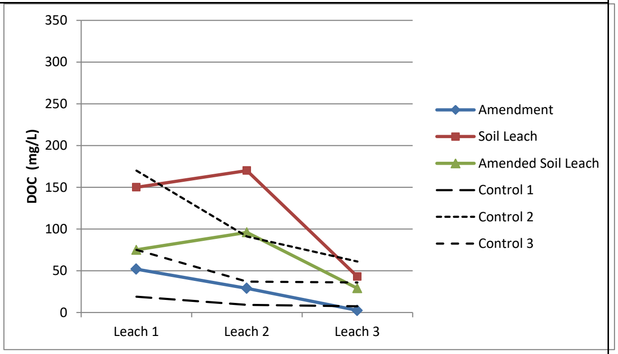

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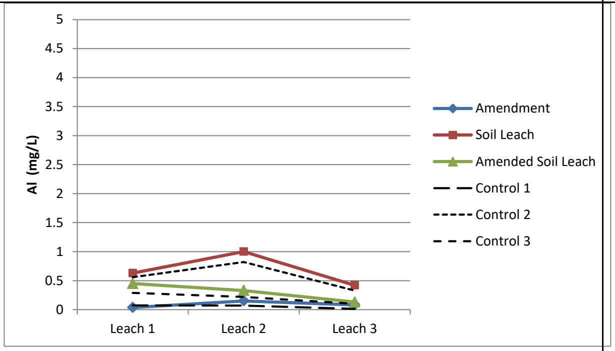

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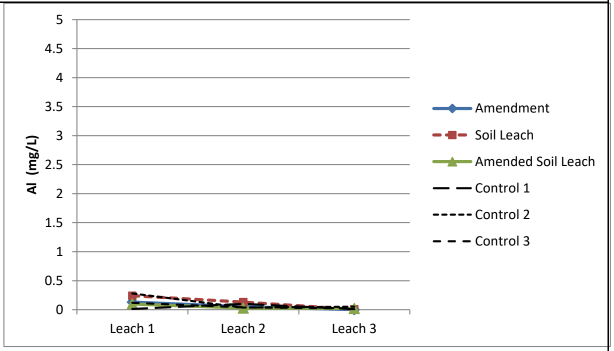

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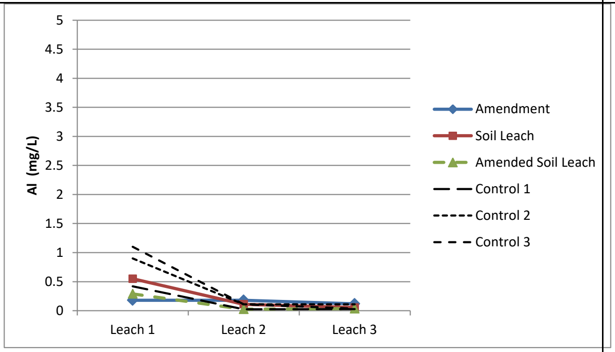

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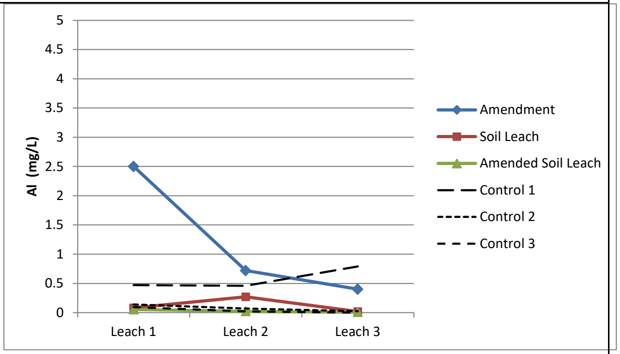

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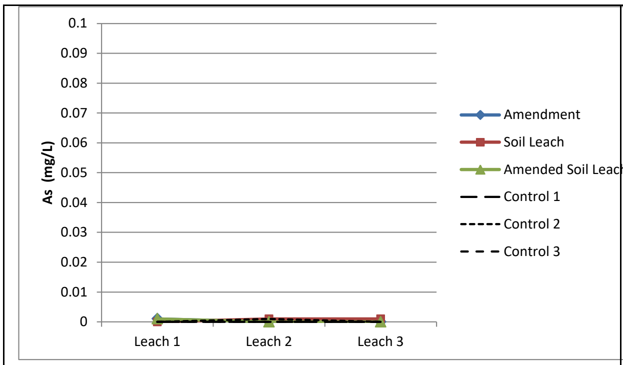
A12-6. Biosolids



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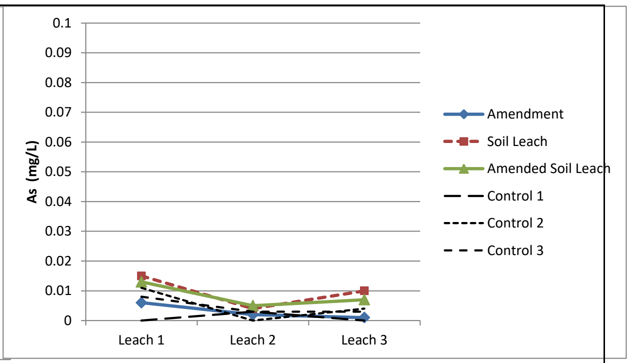

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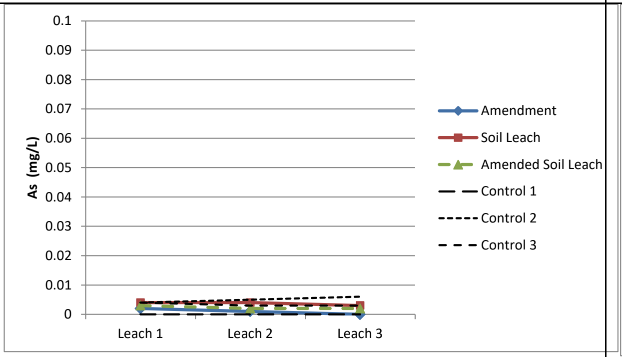

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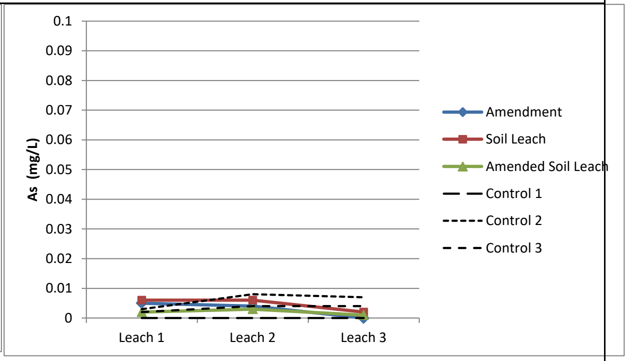

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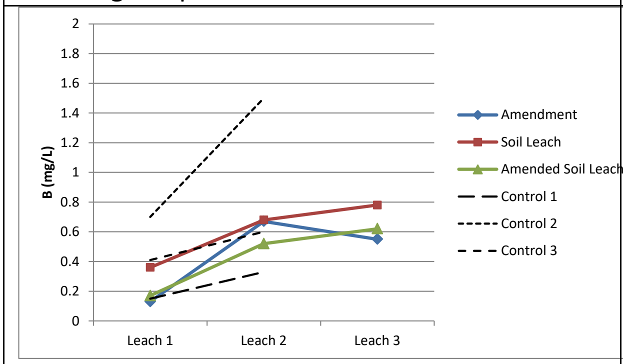

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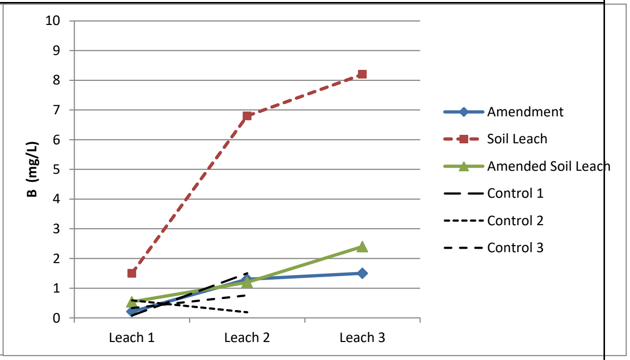

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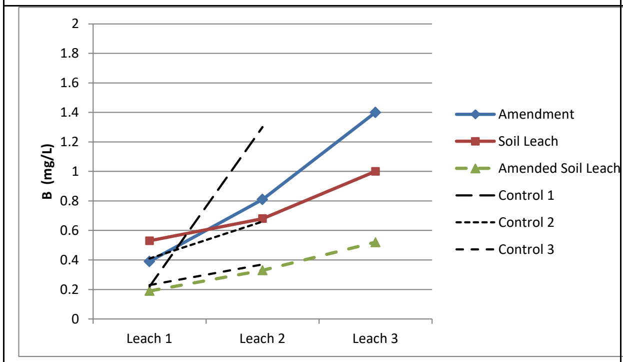

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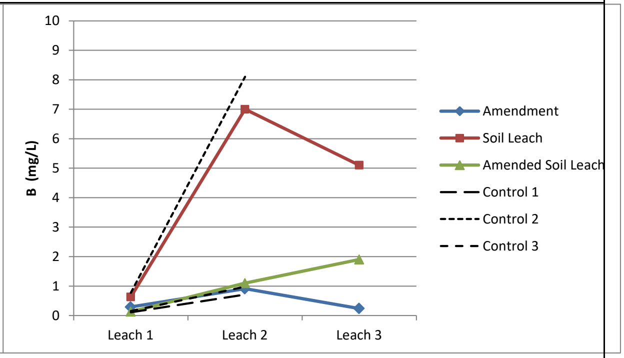

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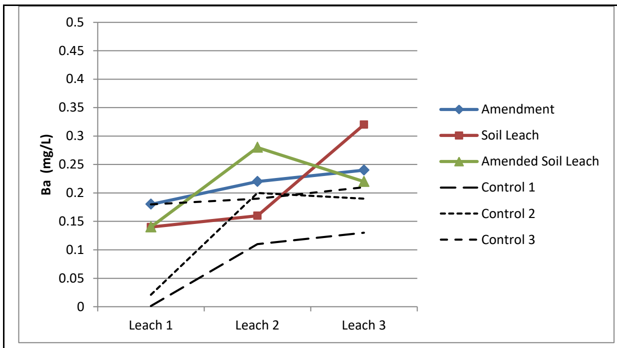
A12-6. Biosolids



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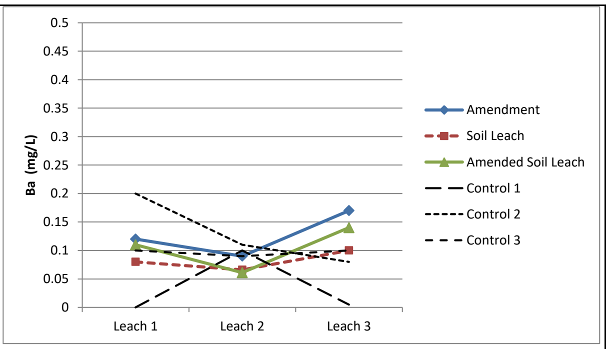

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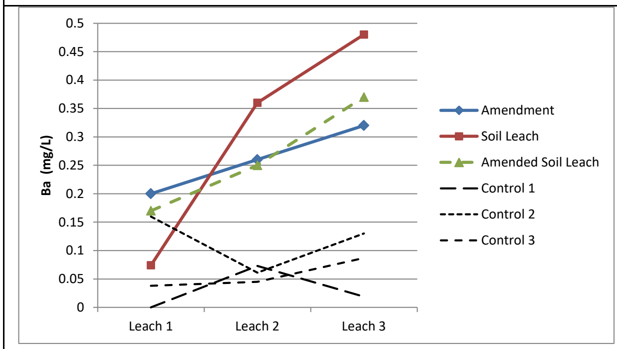

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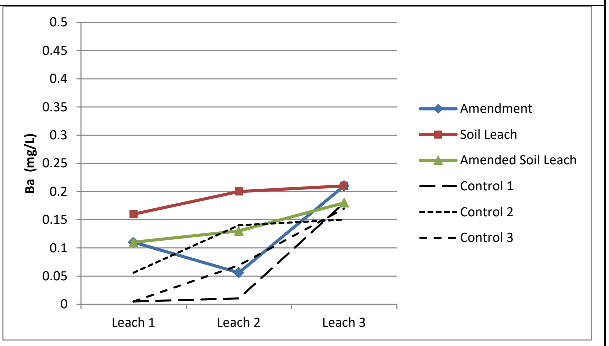

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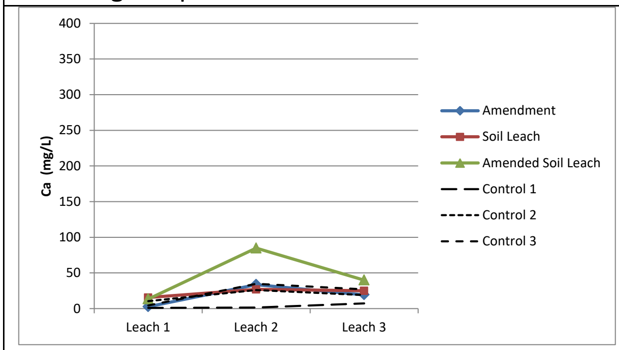

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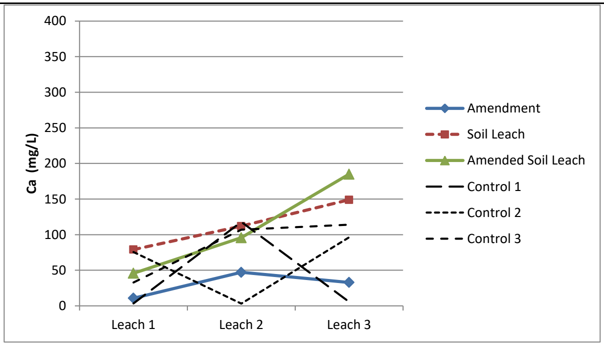

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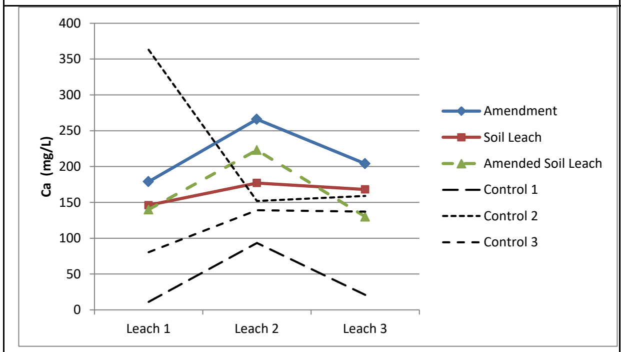

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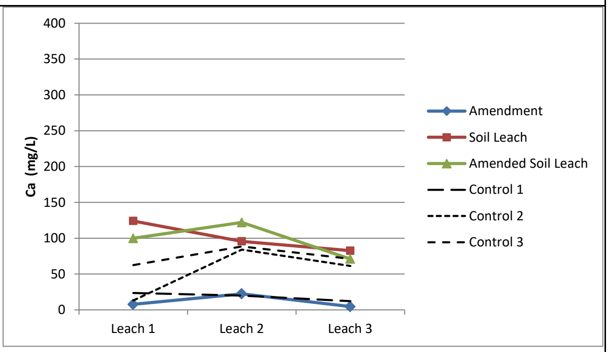

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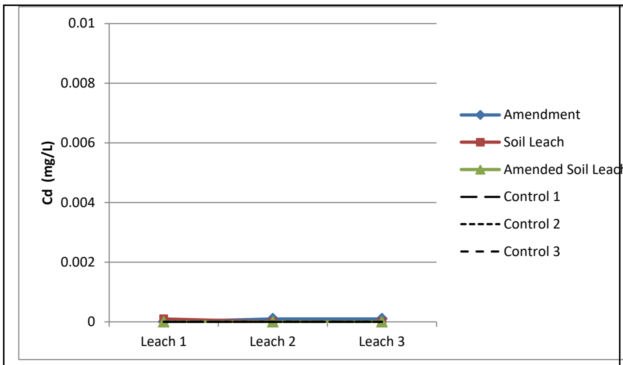
A12-6. Biosolids



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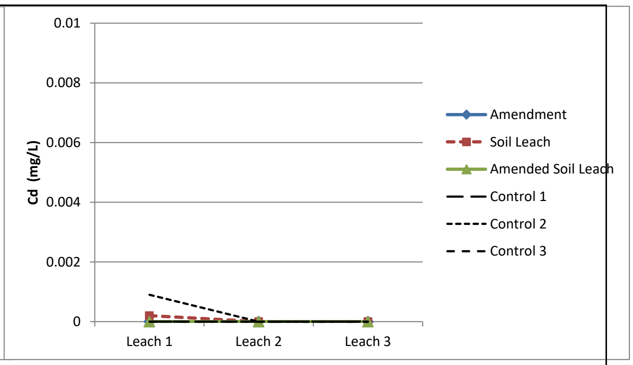

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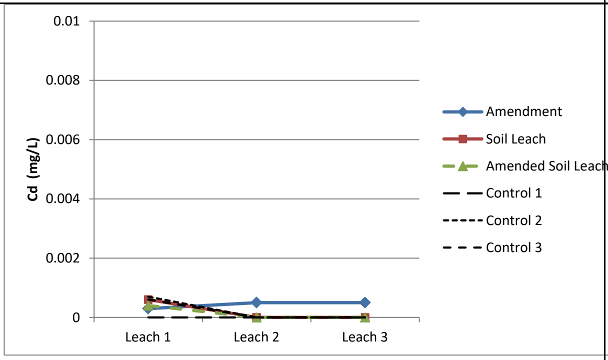

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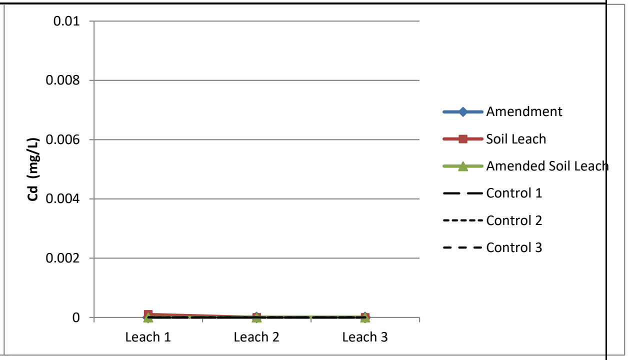

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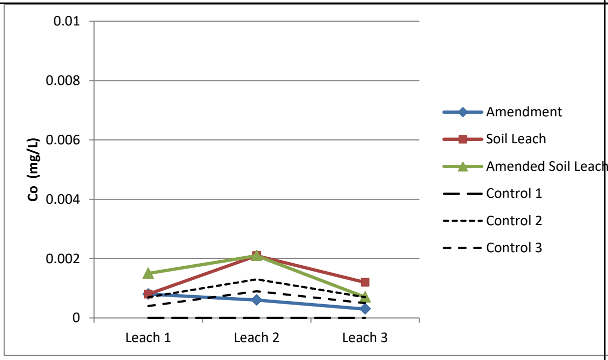

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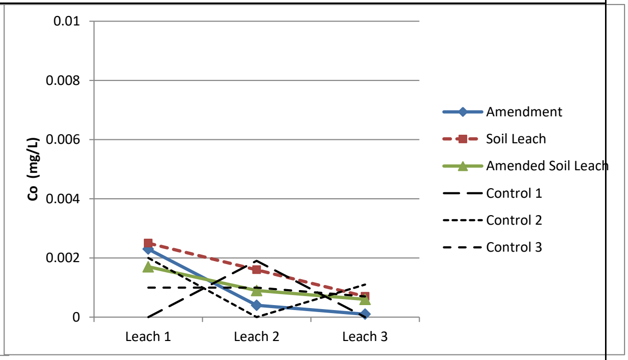

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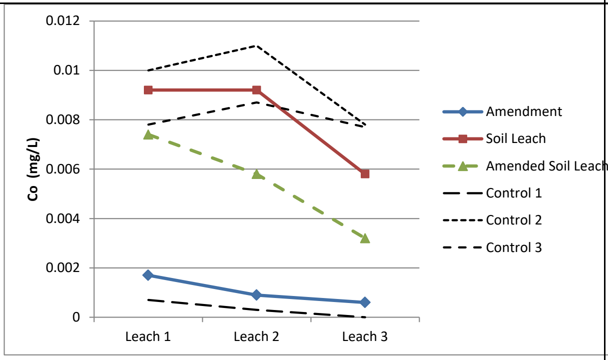

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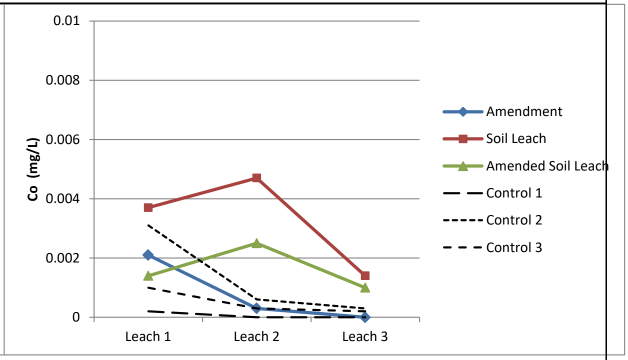

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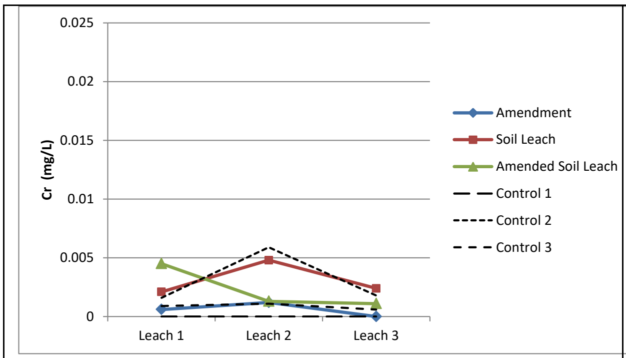
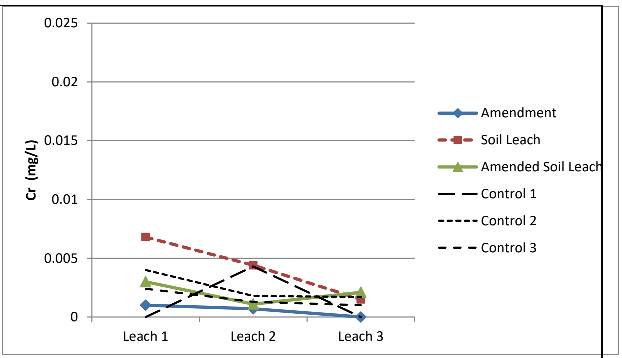
A12-6. Biosolids





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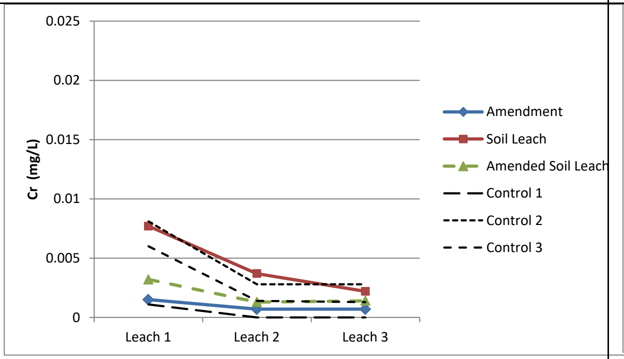

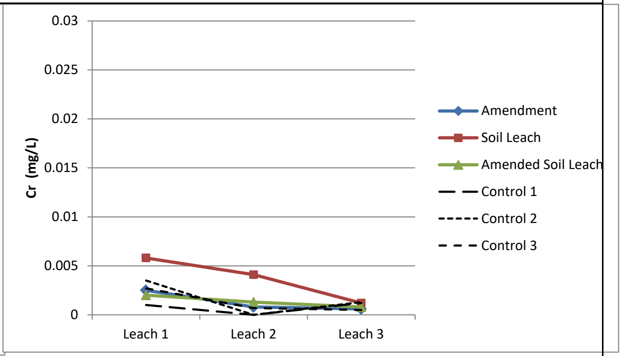

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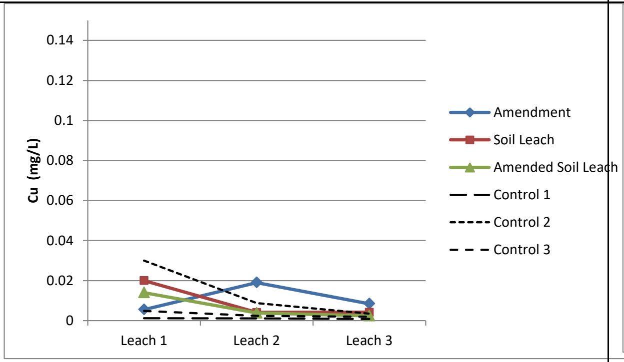

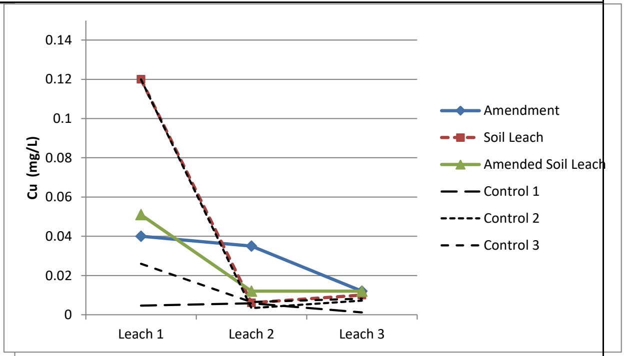

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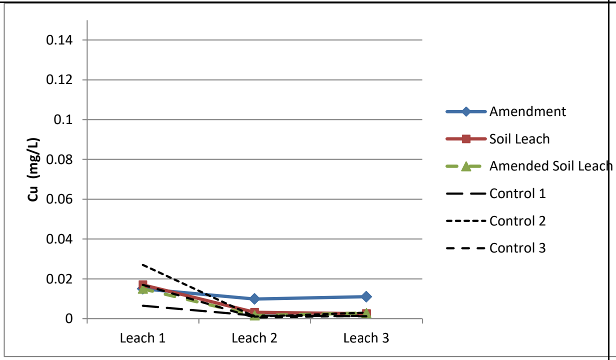

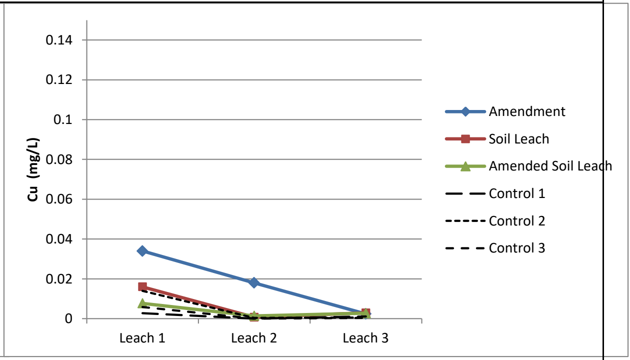

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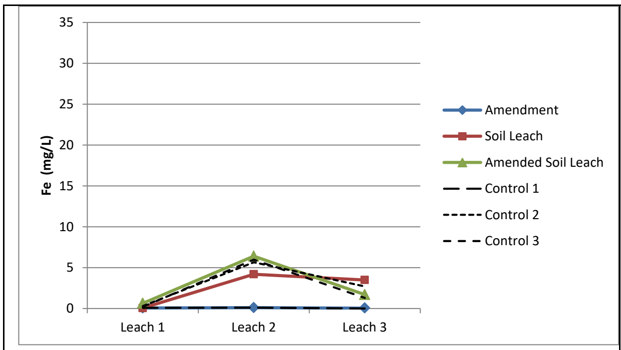
A12-6. Biosolids



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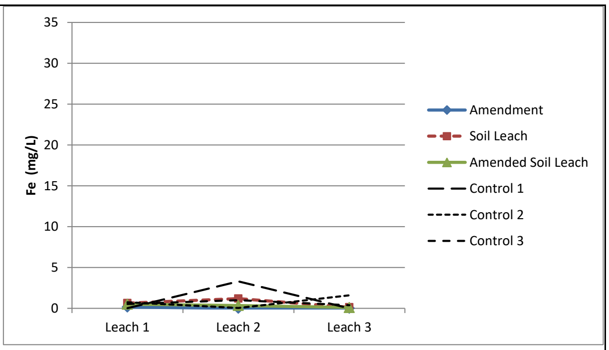

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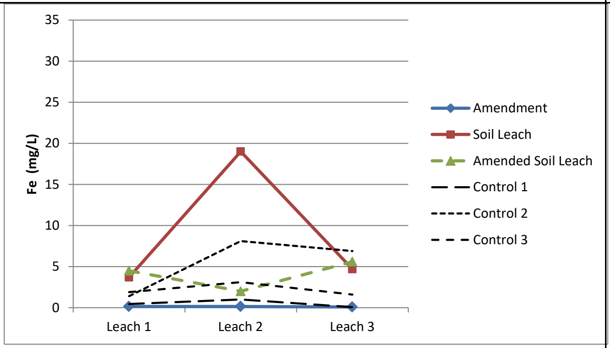

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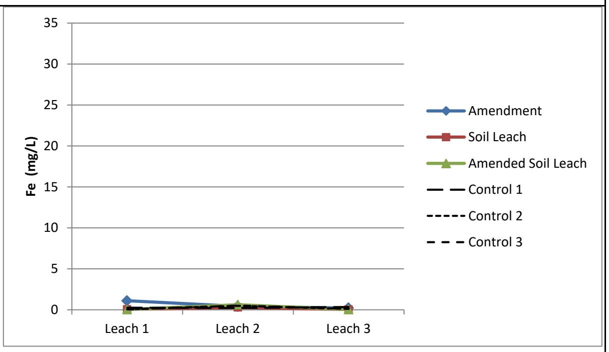

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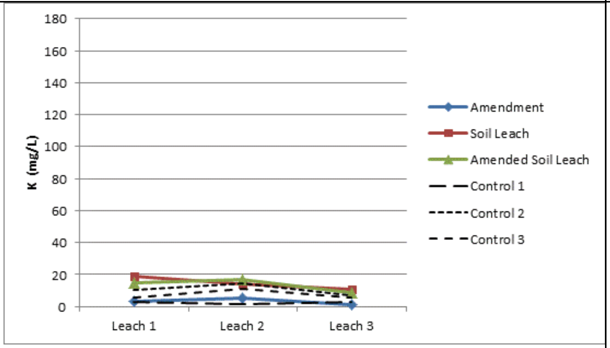

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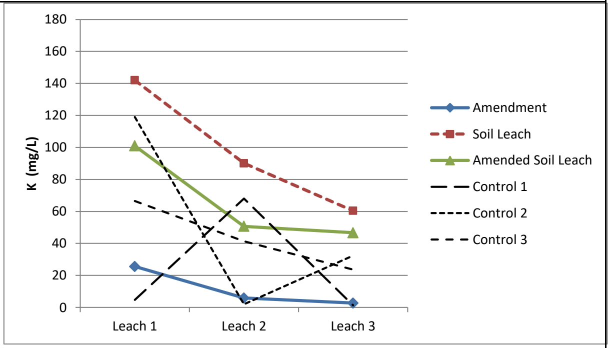

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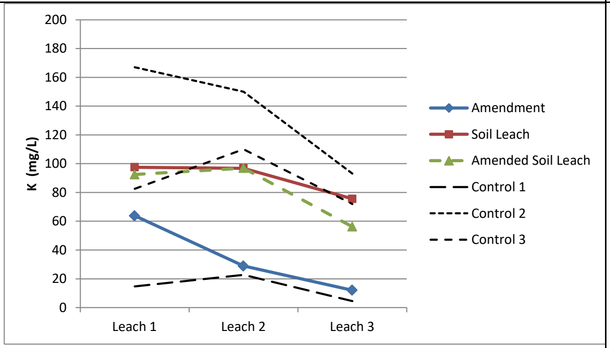

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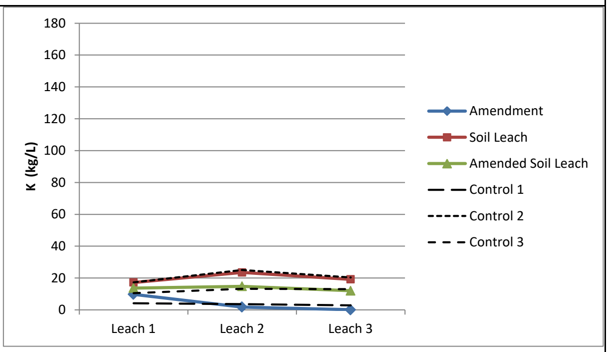

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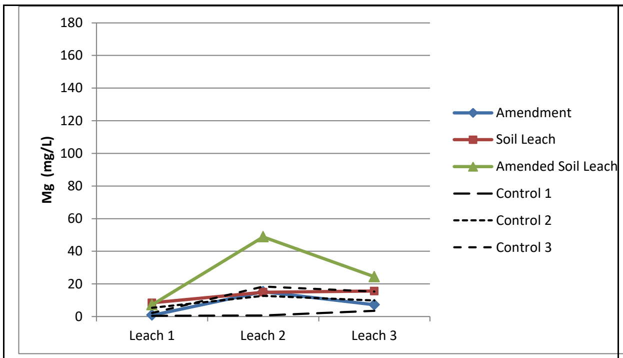
A12-6. Biosolids



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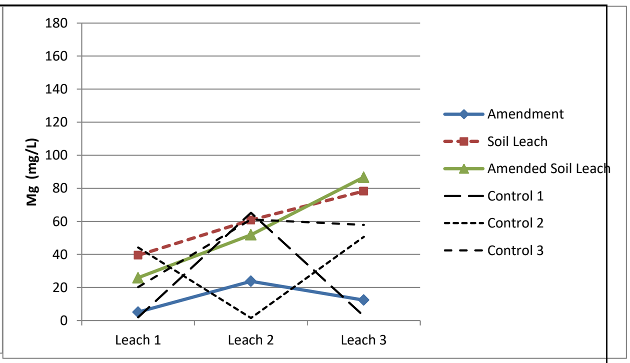

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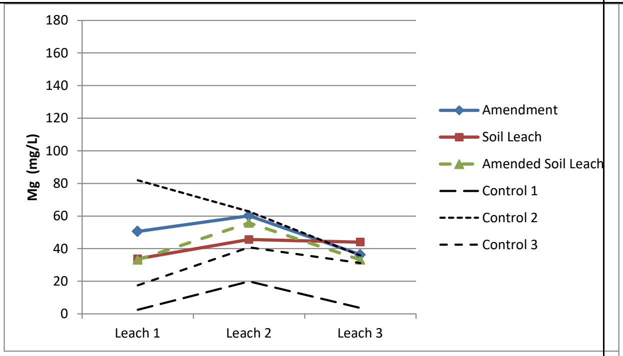

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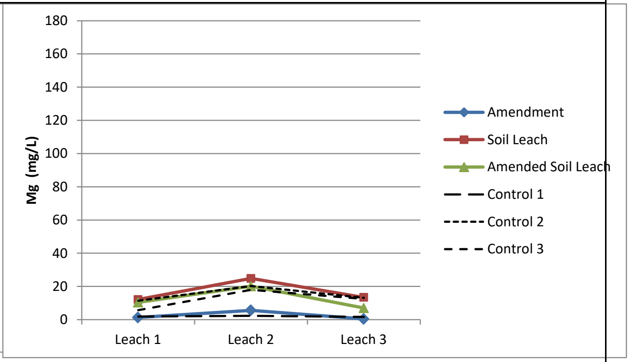

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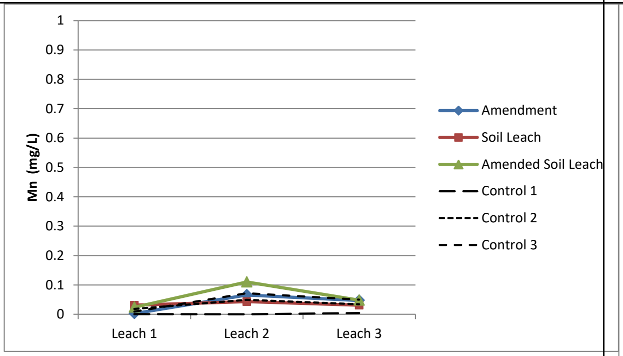

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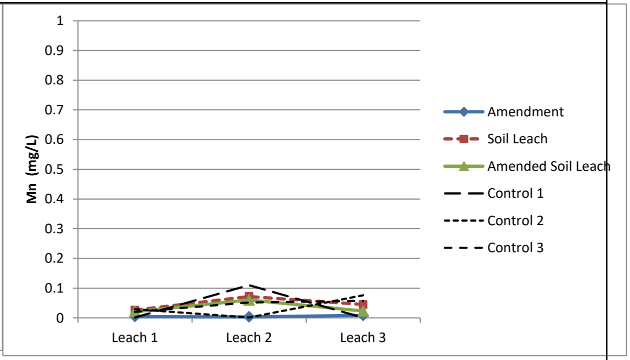

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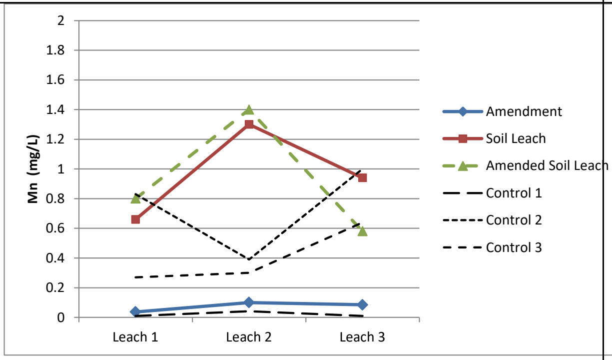

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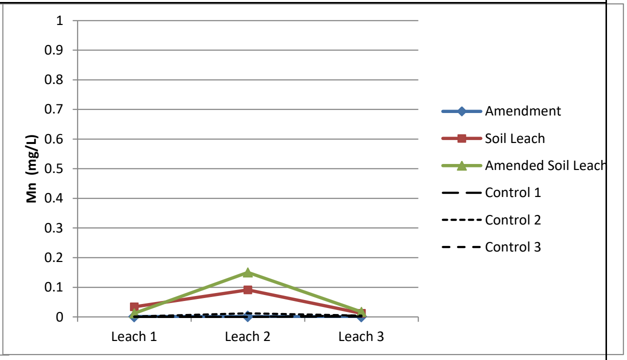

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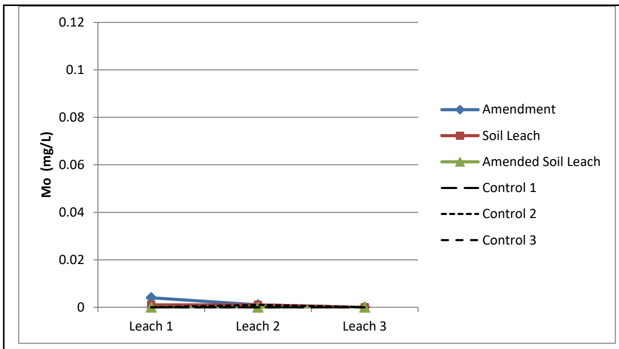

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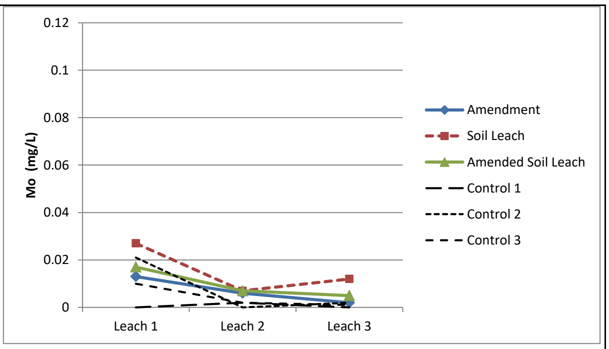

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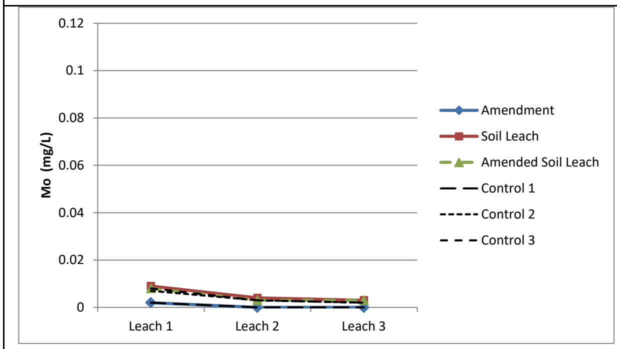

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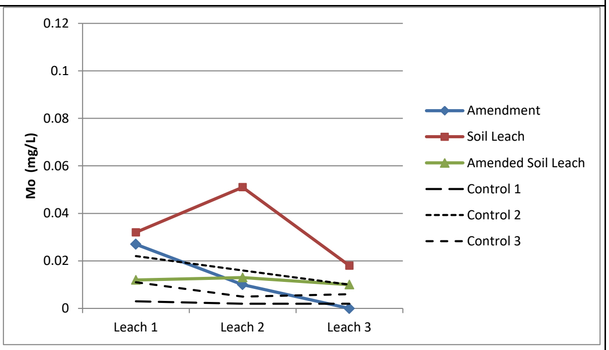

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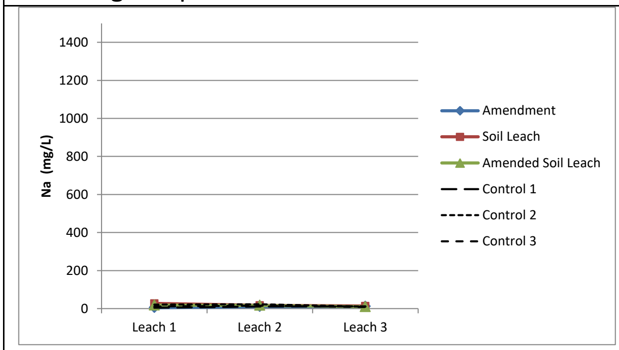

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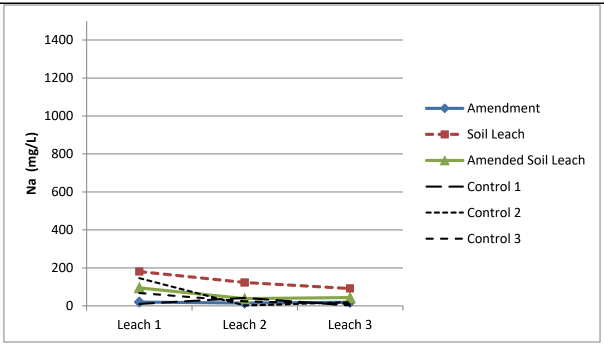

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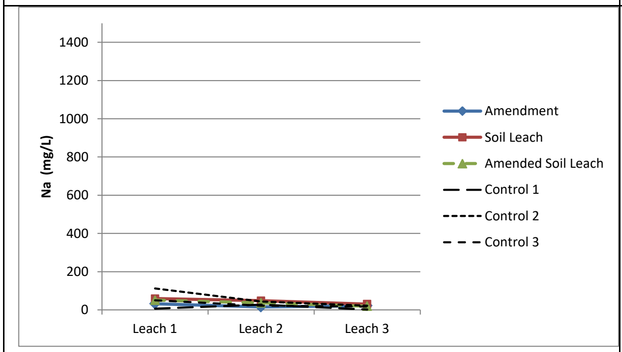

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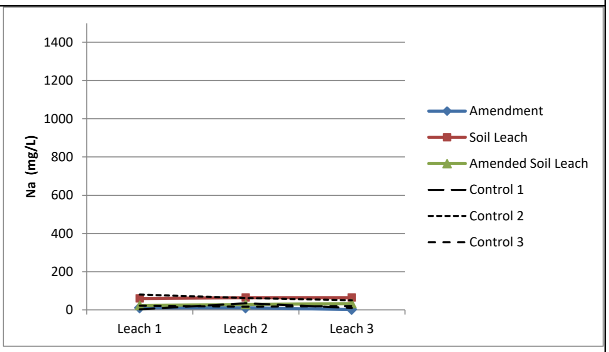

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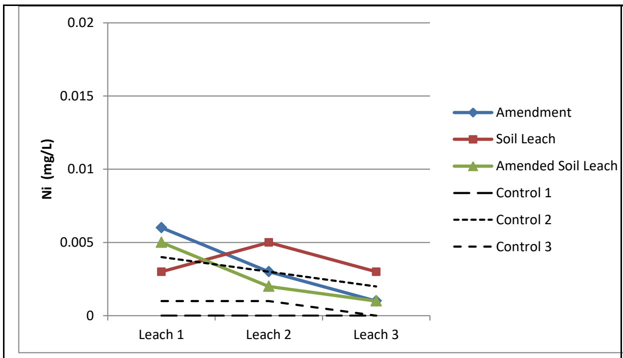
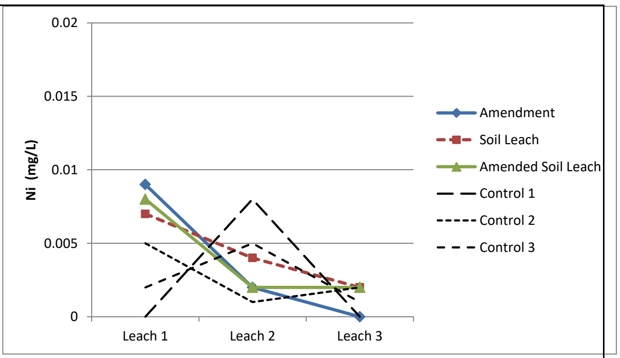
A12-6. Biosolids





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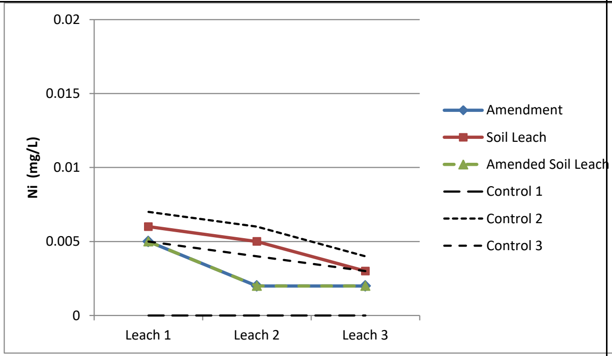

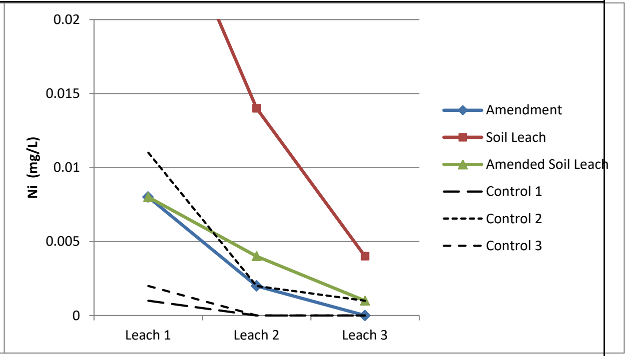

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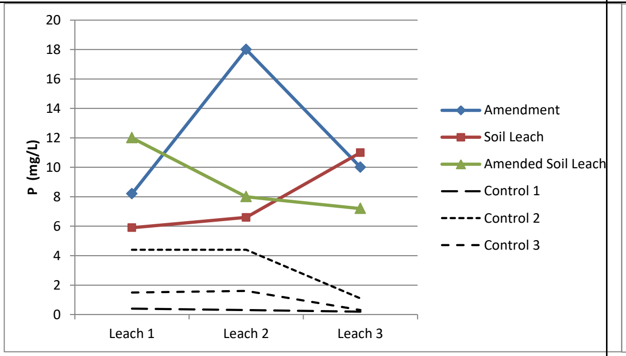

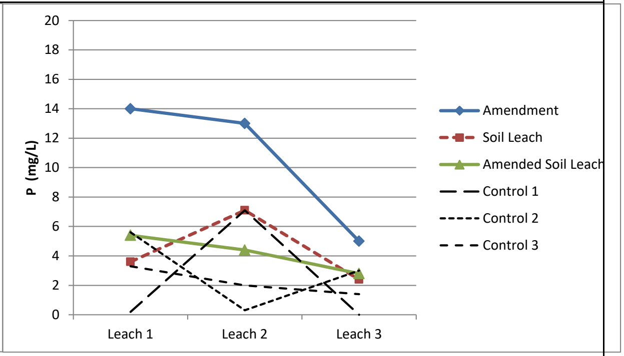

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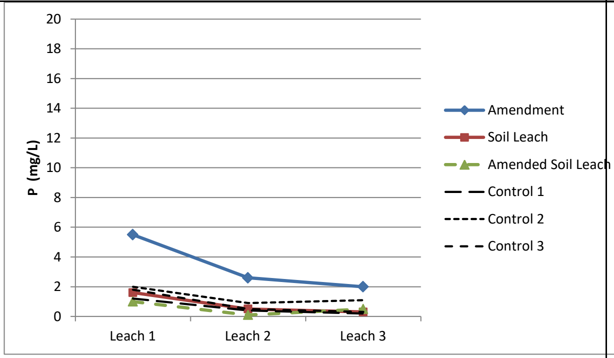

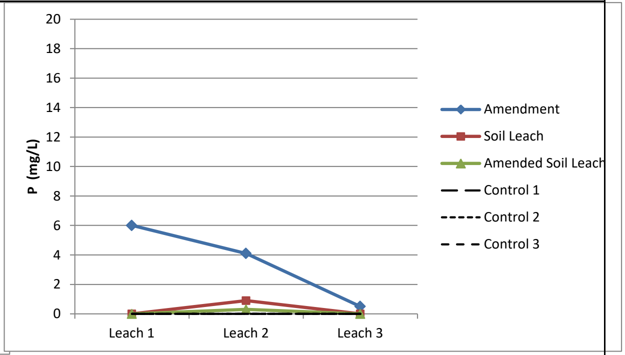

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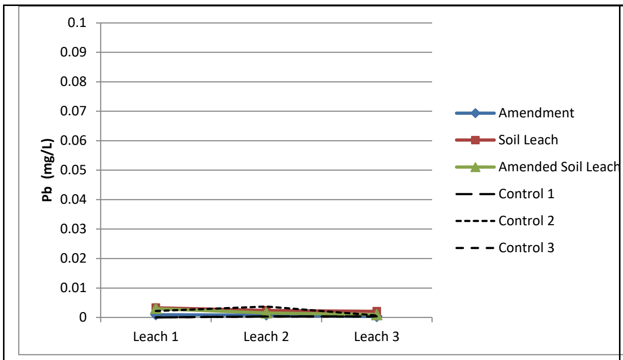
A12-6. Biosolids



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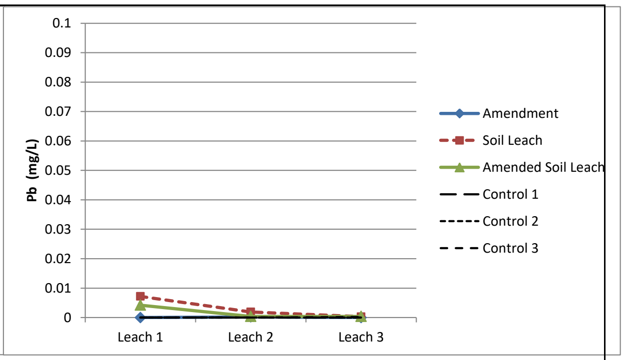

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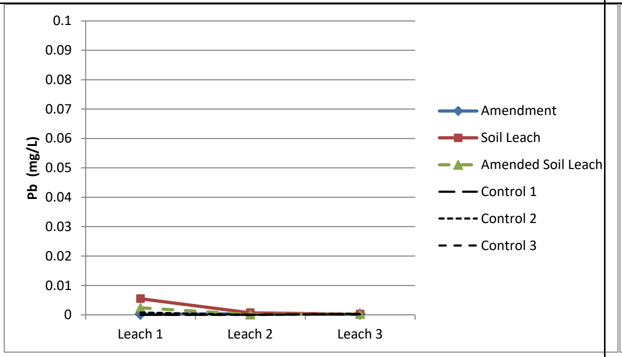

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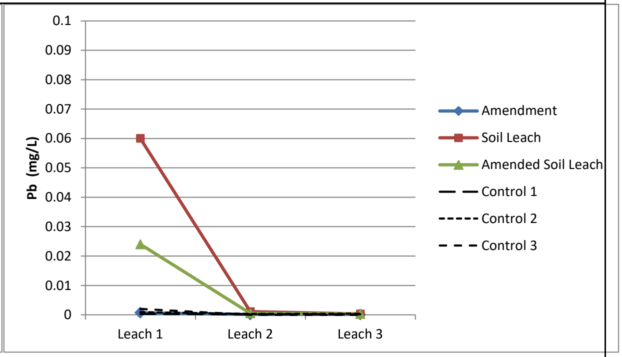

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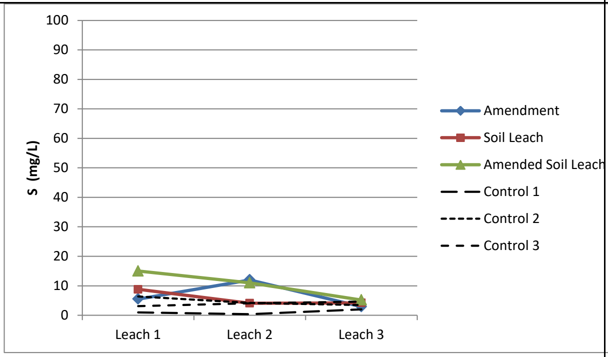

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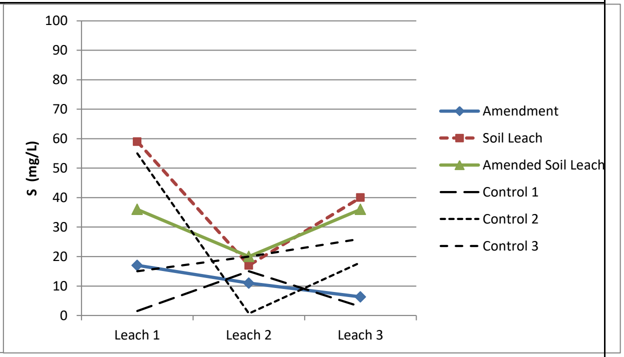

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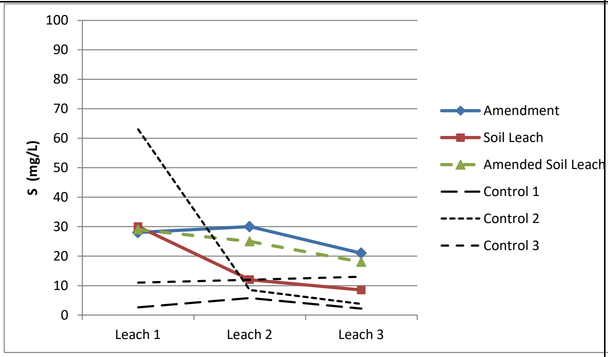

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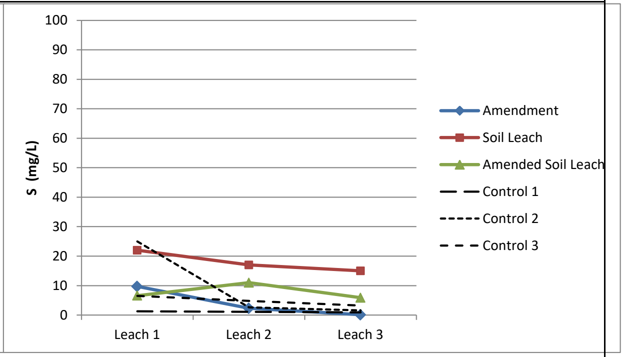

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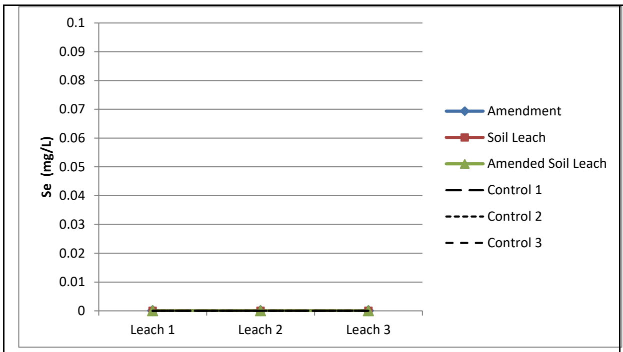
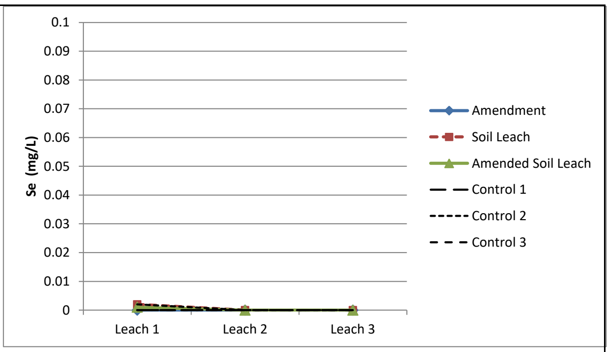
A12-6. Biosolids





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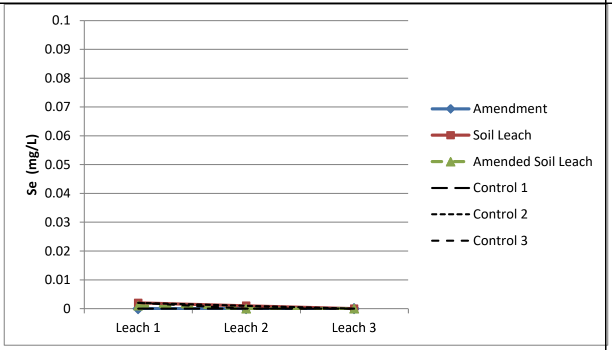

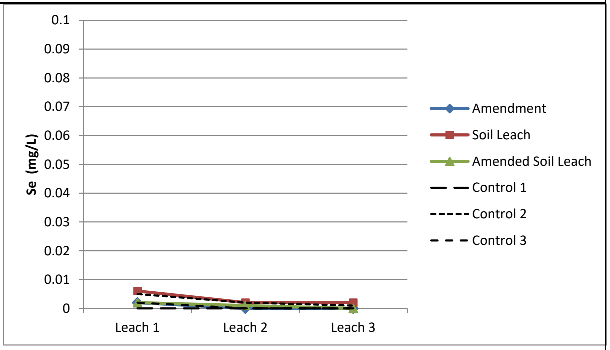

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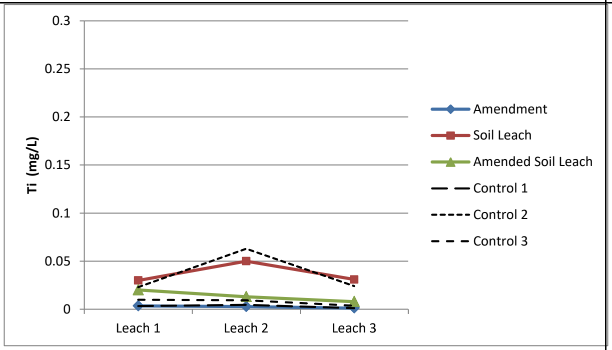

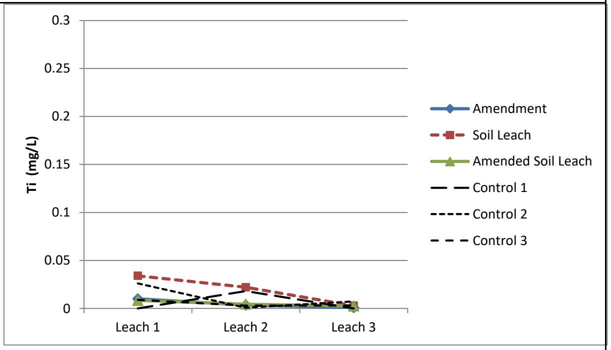

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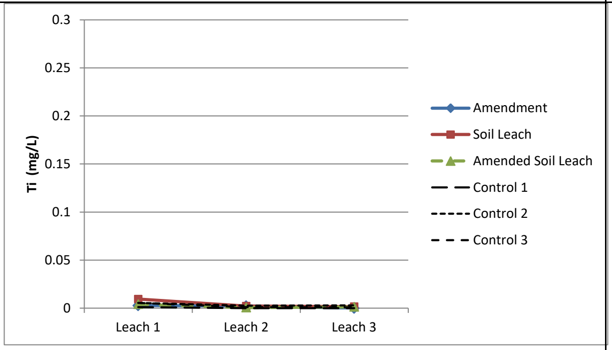

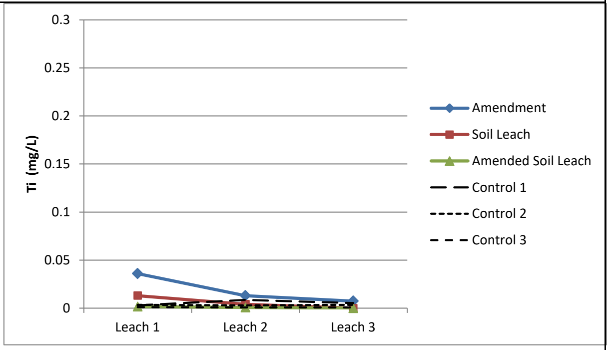

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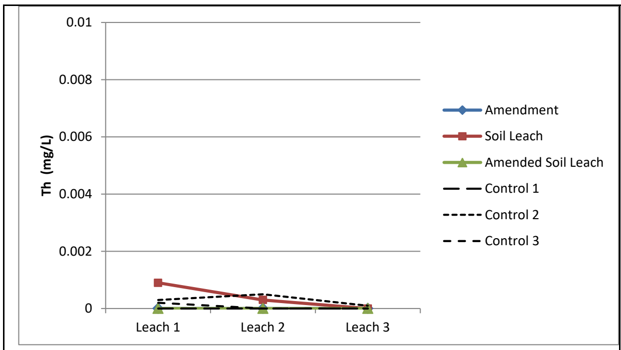
A12-6. Biosolids



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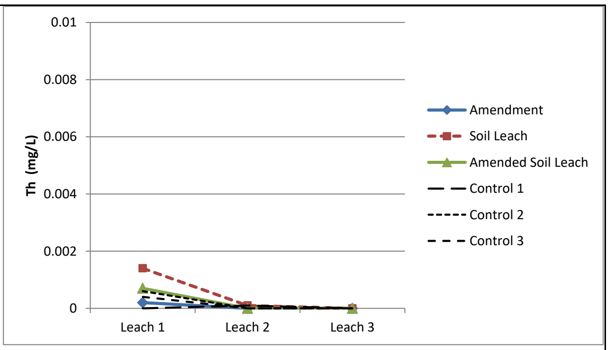

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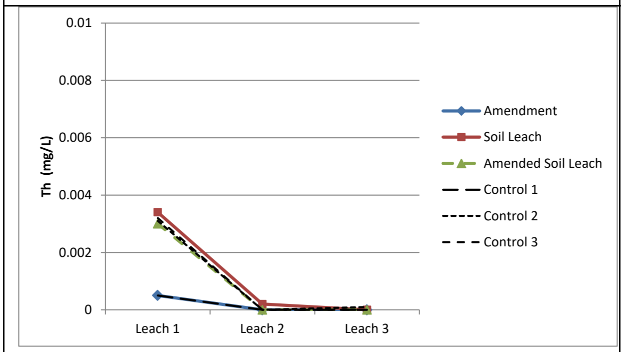

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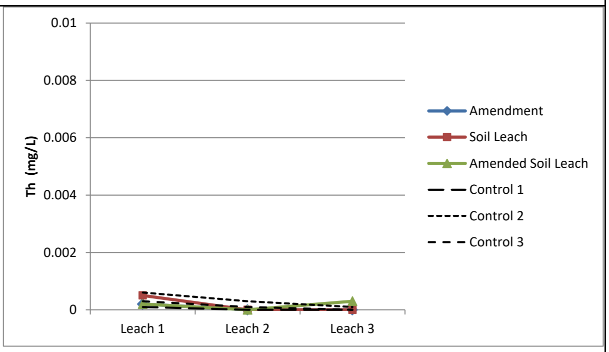

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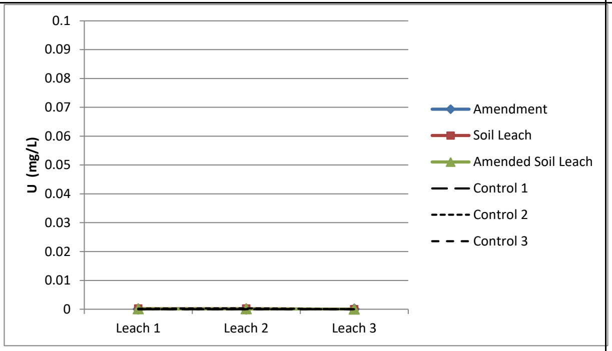

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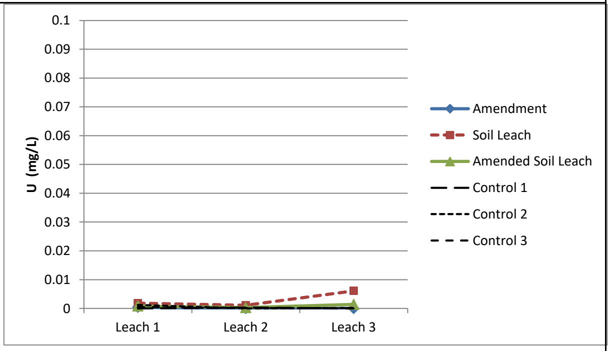

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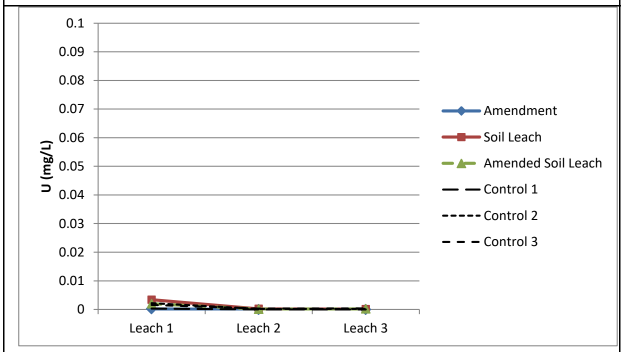

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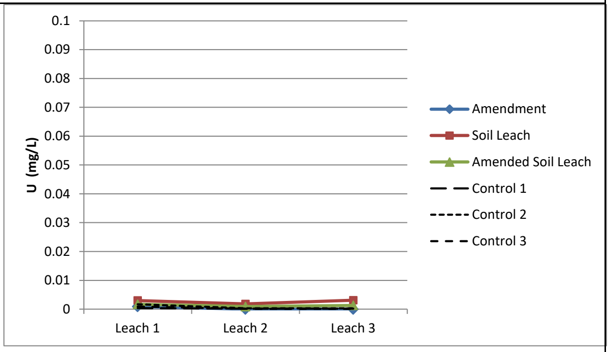

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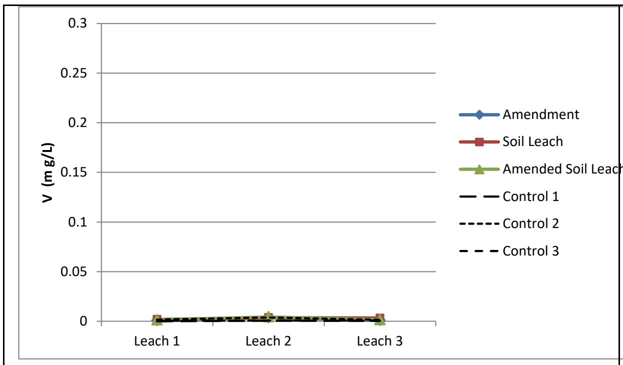
A12-6. Biosolids



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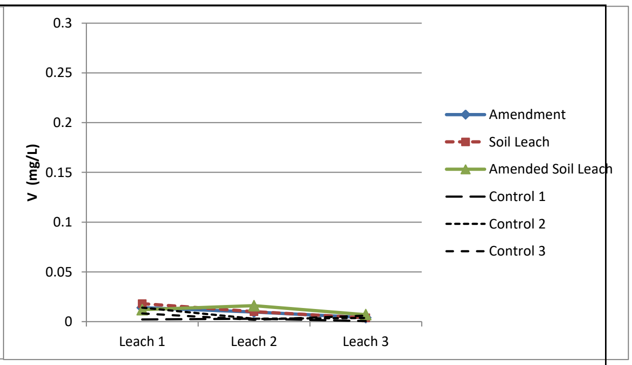

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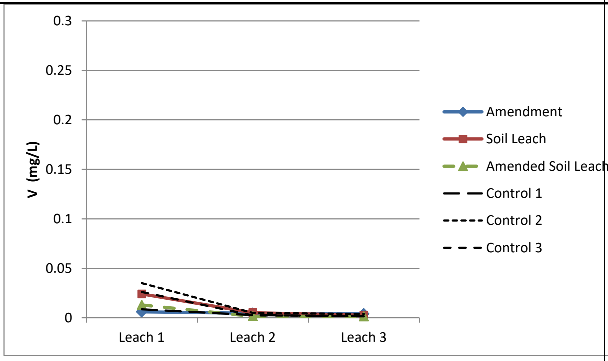

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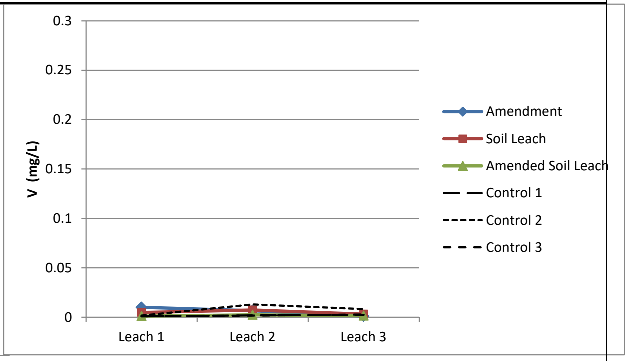
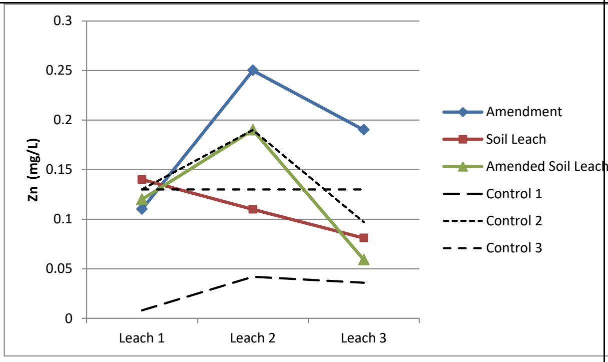
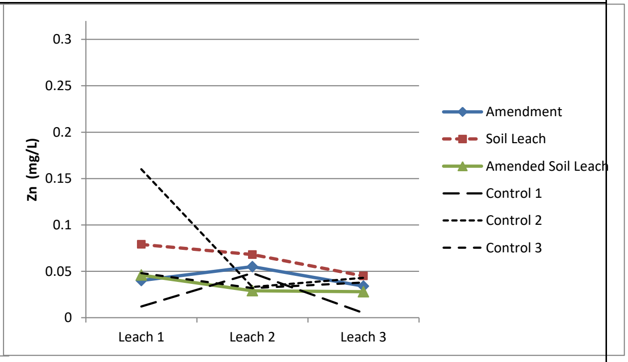


Spearwood



Bassendean Ellenbrook



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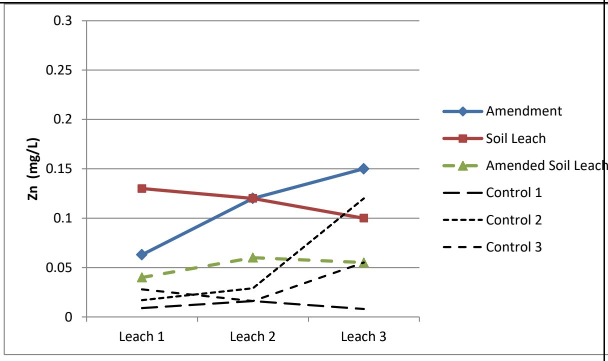

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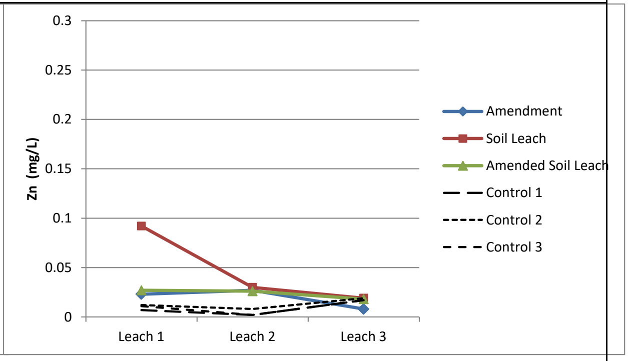
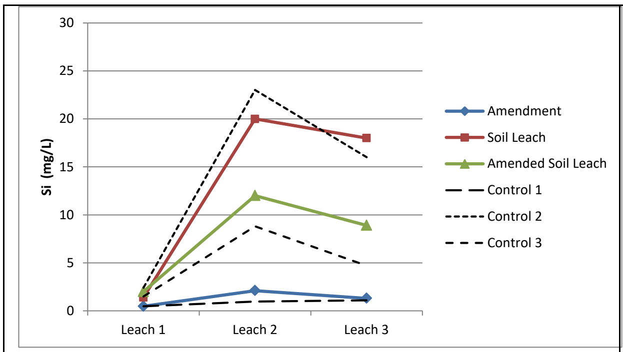


Spearwood

A12-6. Biosolids



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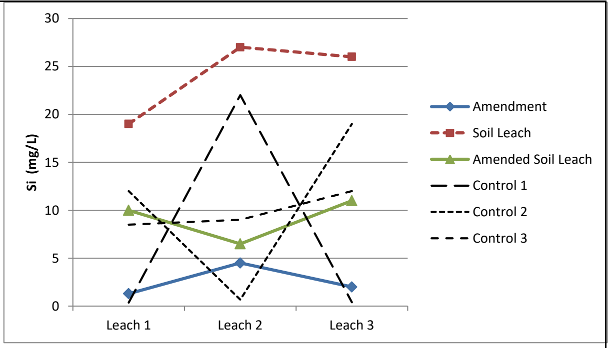

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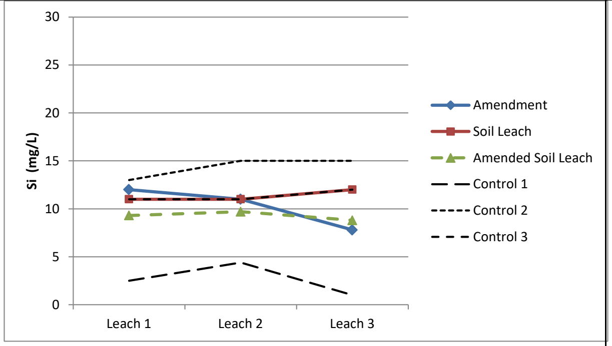

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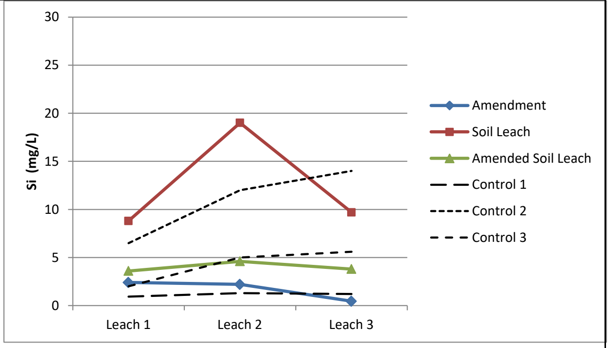

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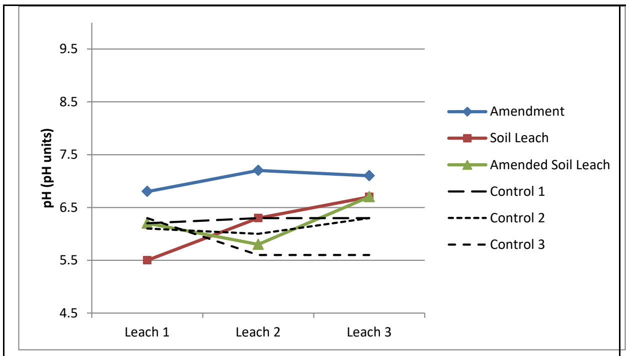
A12-7. Lime Amended Biosolids (LAB)



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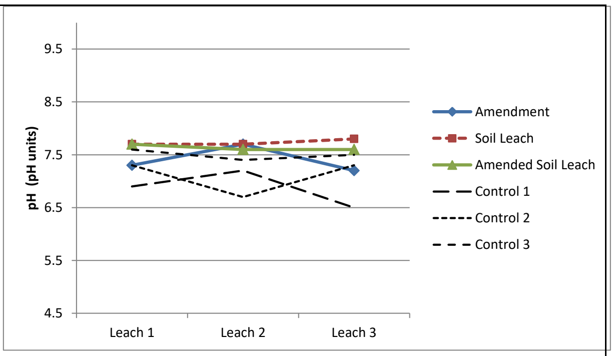

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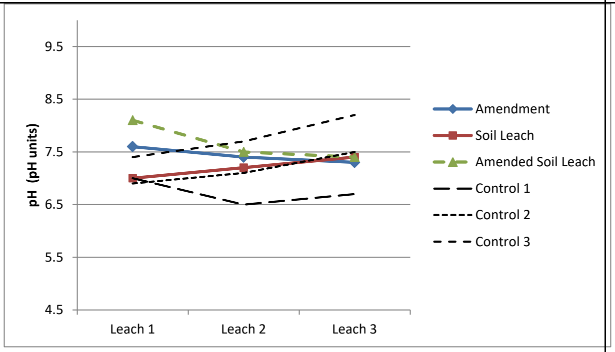

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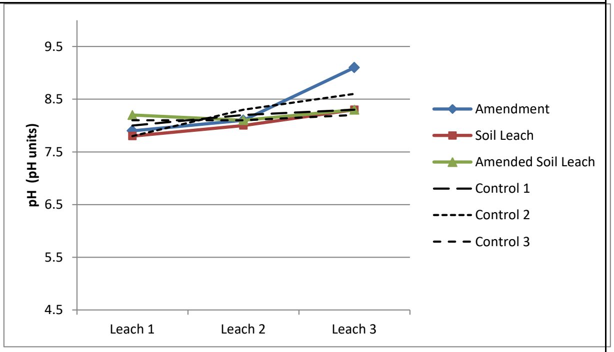

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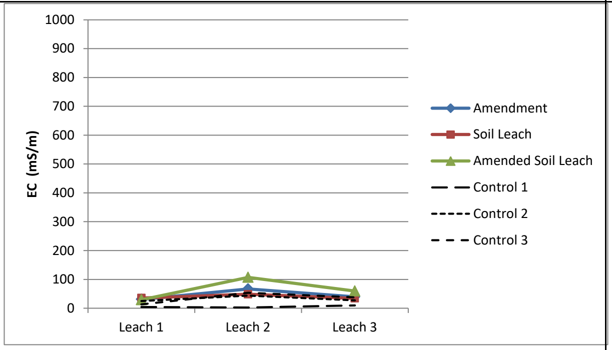

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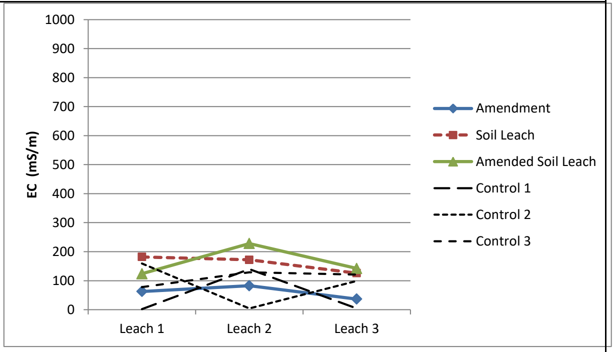

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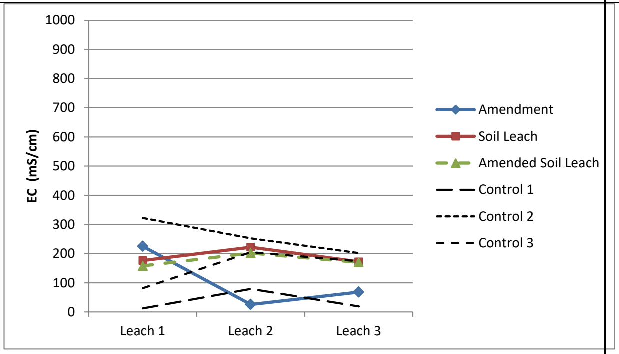

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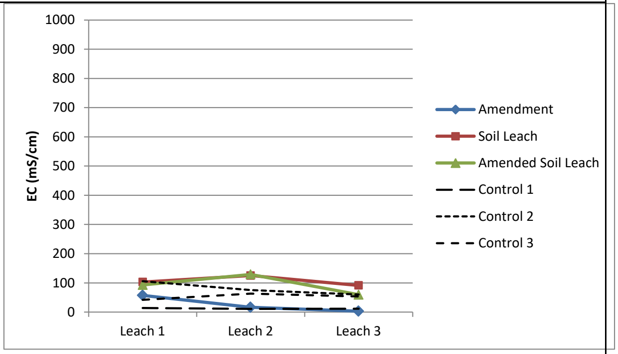
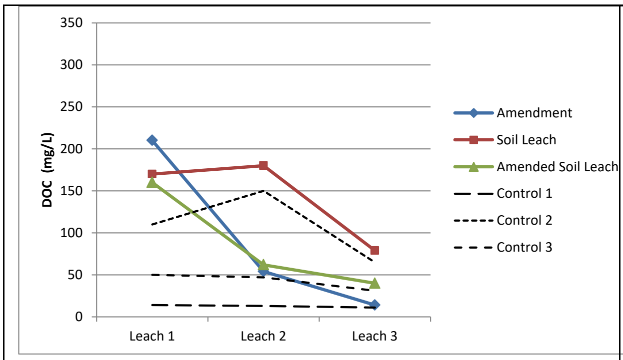
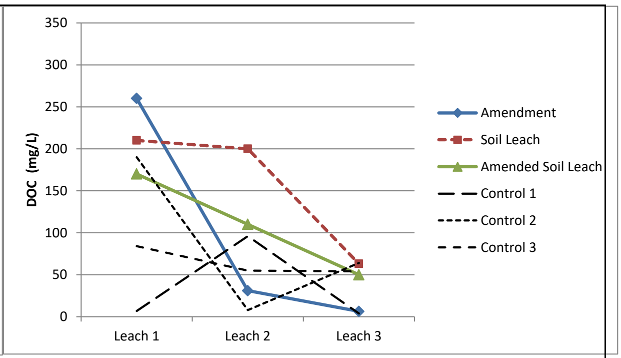


Spearwood

A12-7. Lime Amended Biosolids (LAB)





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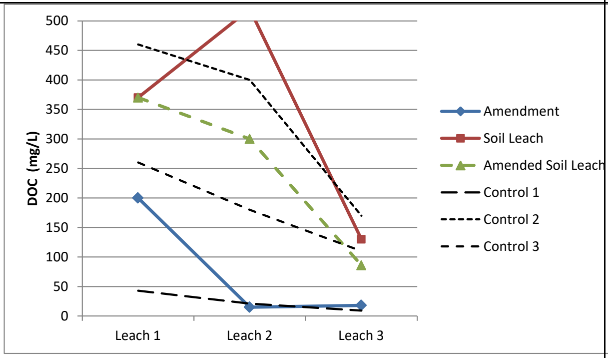
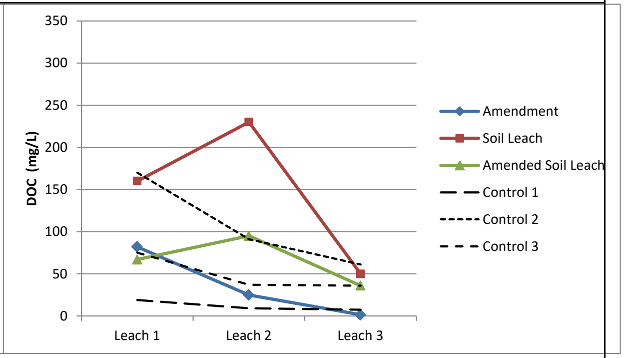
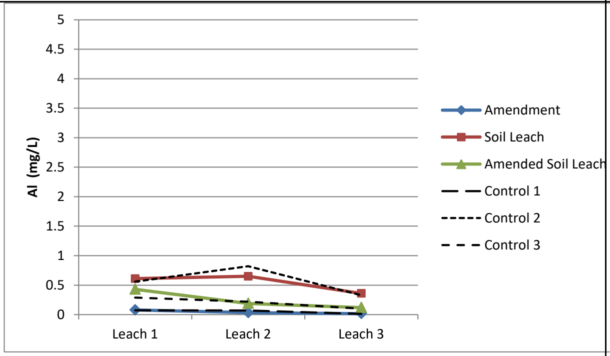
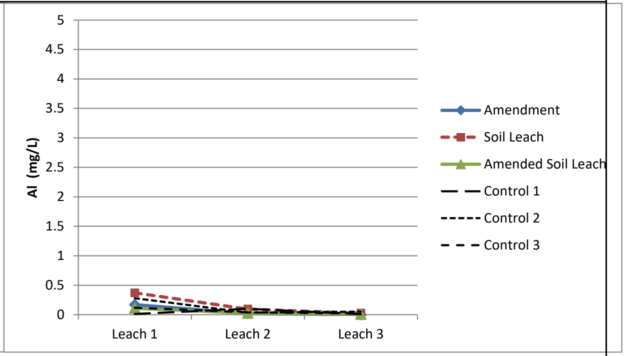




Fairbridge Duplex

Spearwood





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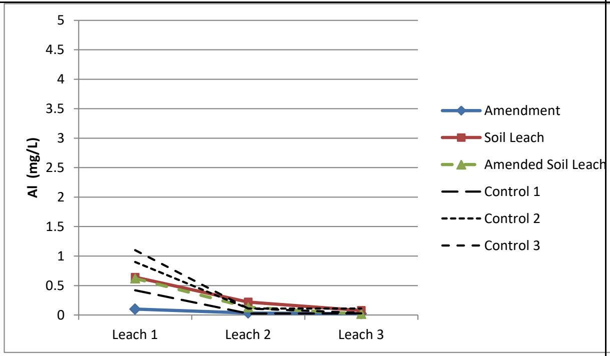
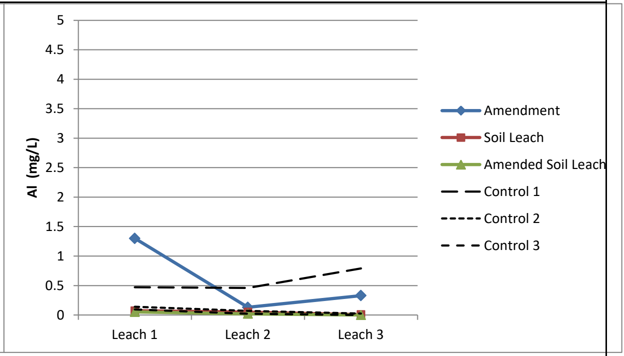
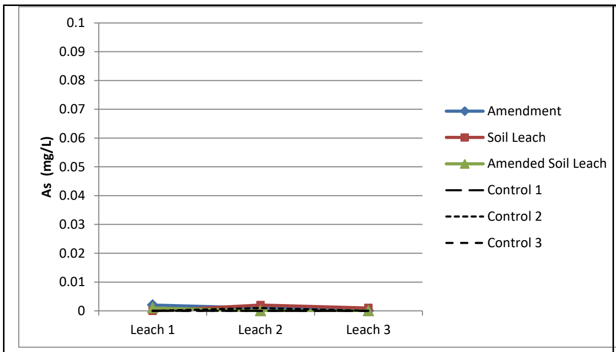




Fairbridge Duplex

Spearwood

A12-7. Lime Amended Biosolids (LAB)



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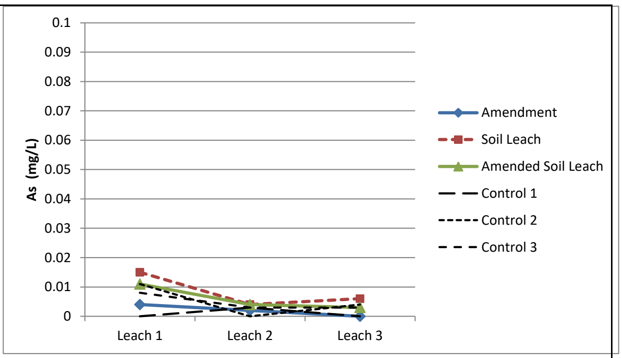

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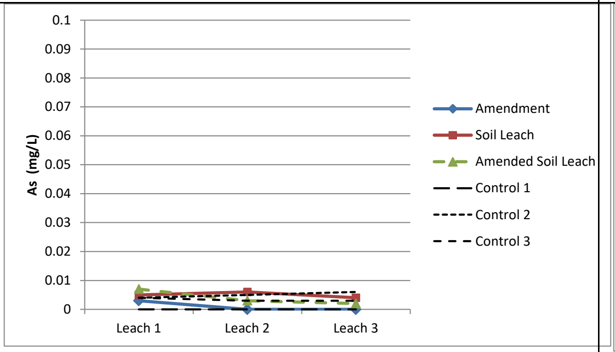

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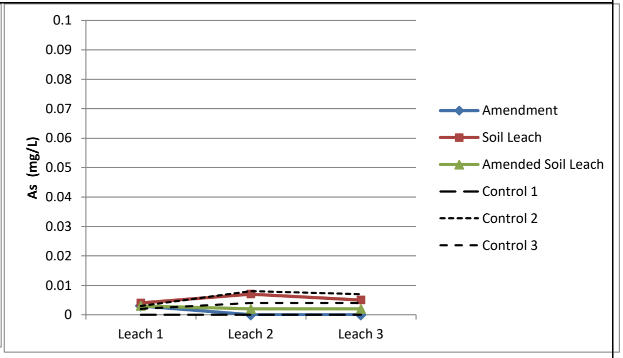

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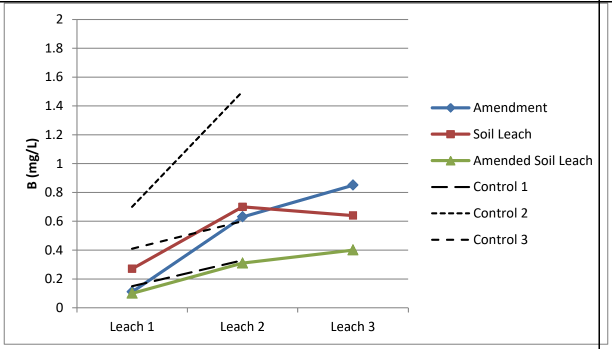

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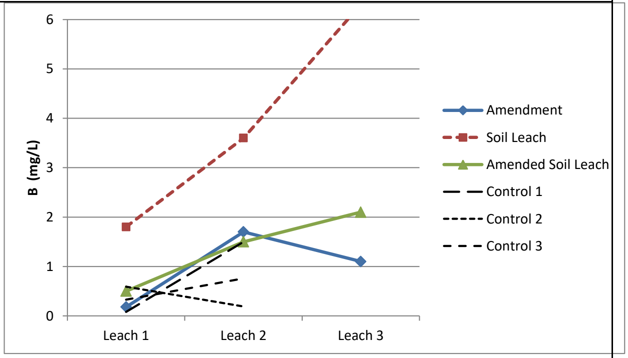

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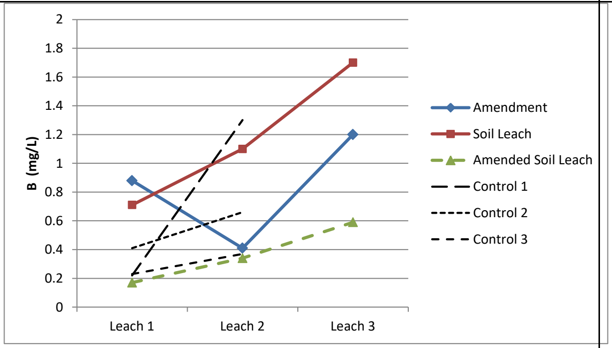

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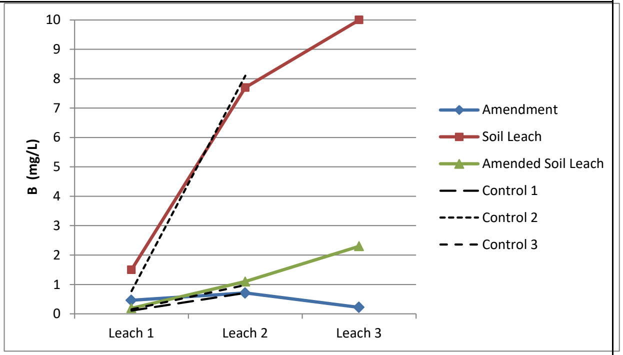

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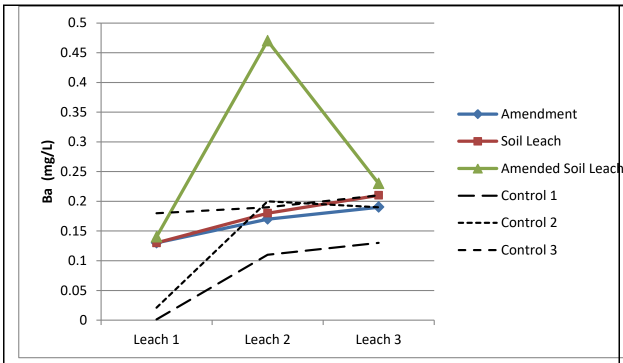
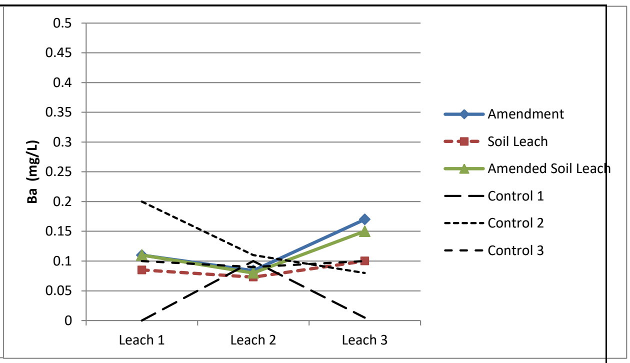
A12-7. Lime Amended Biosolids (LAB)





Bassendean Ellenbrook

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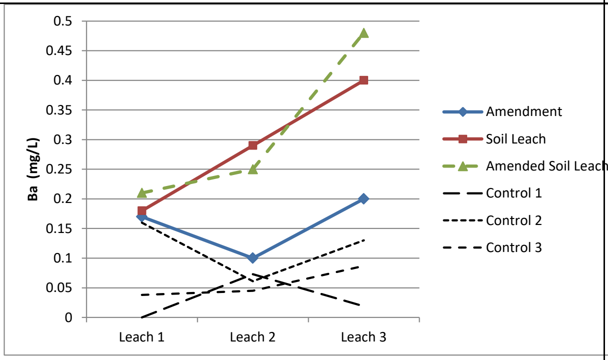

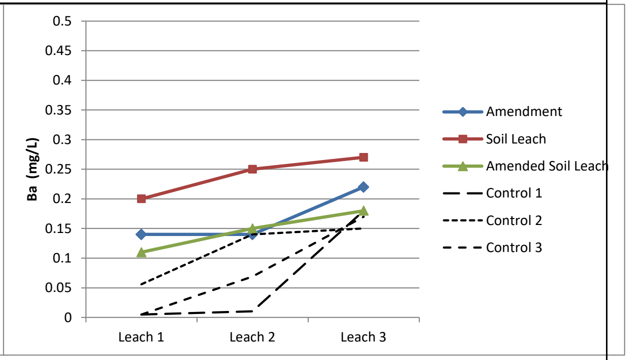

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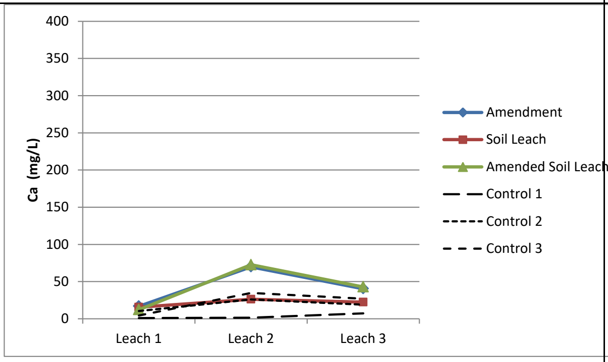

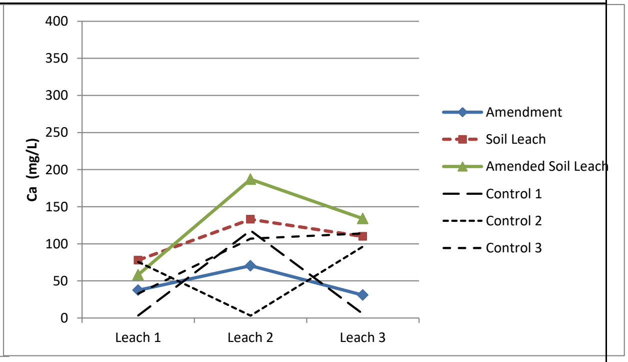

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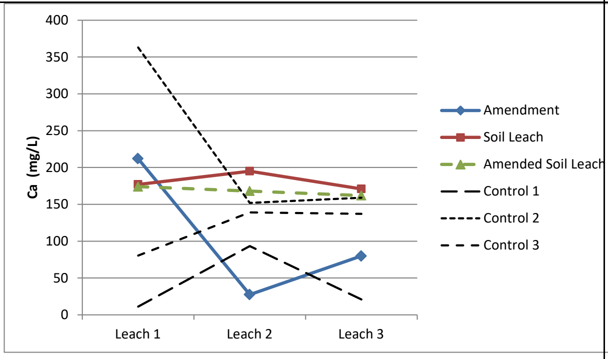
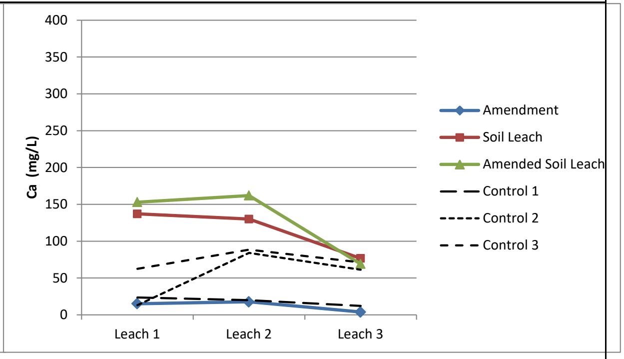
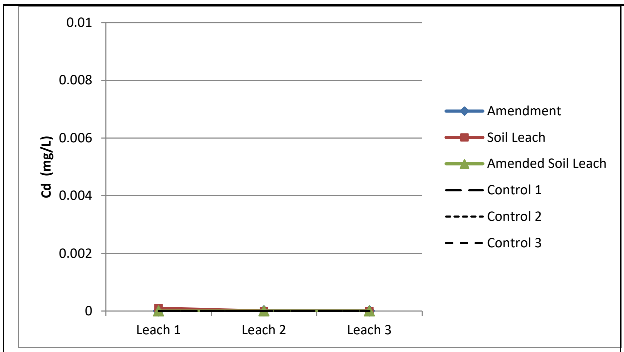




Fairbridge Duplex

Spearwood

A12-7. Lime Amended Biosolids (LAB)



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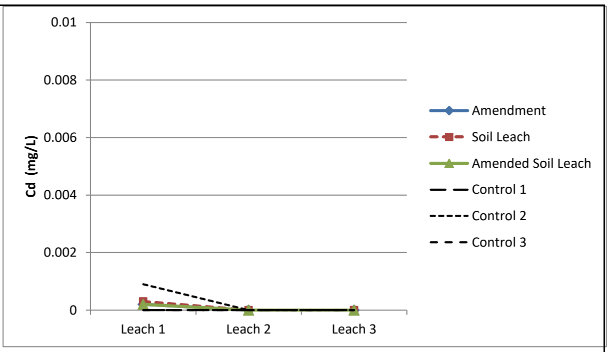

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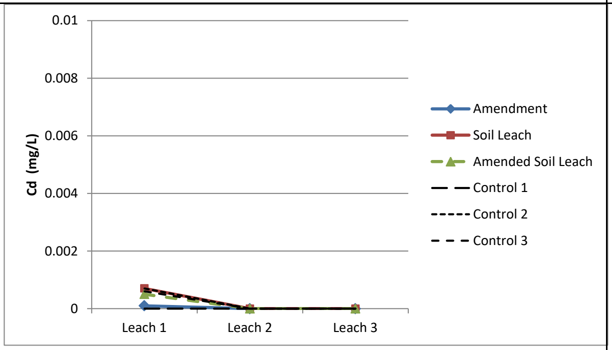

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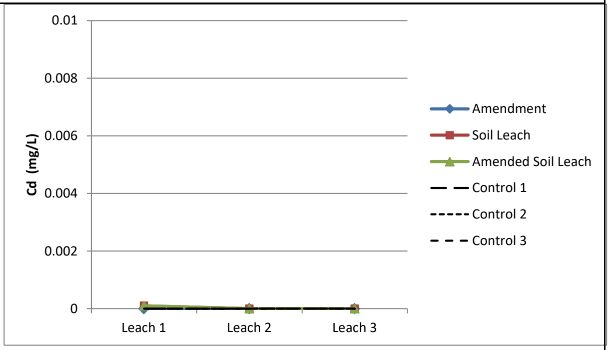

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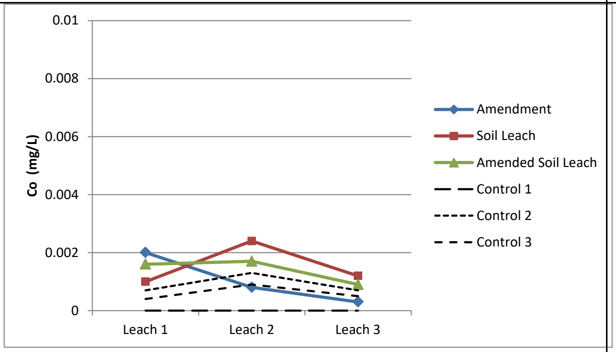

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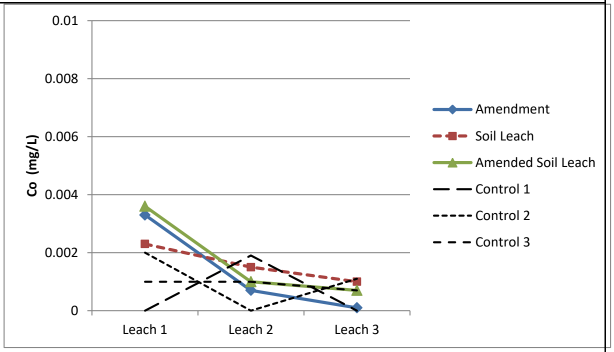

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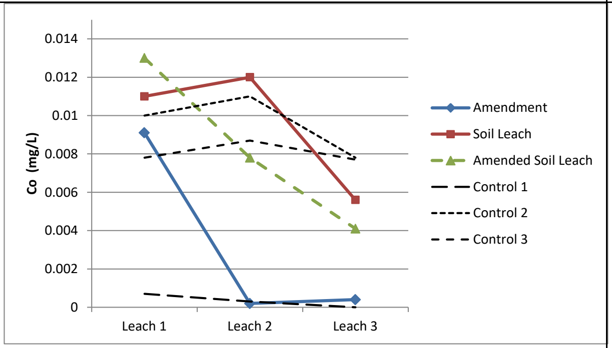

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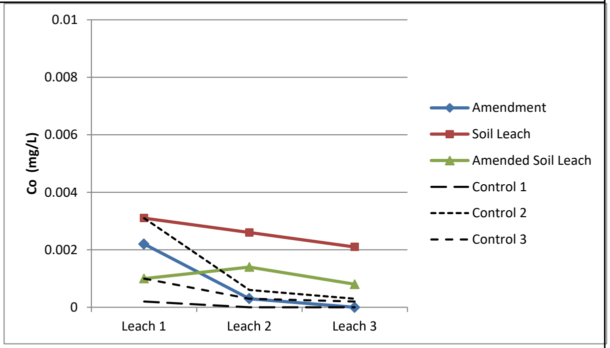

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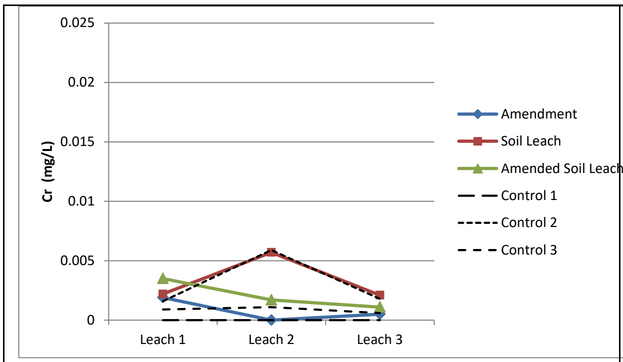
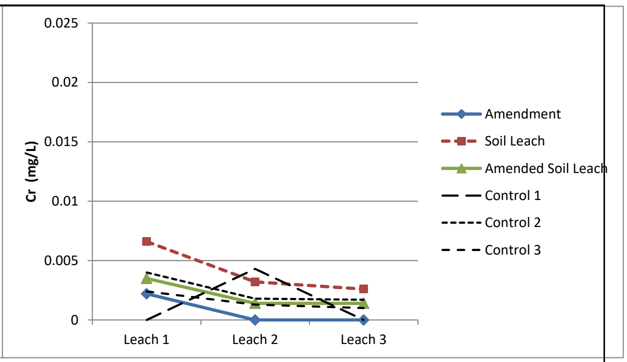
A12-7. Lime Amended Biosolids (LAB)





Bassendean Ellenbrook

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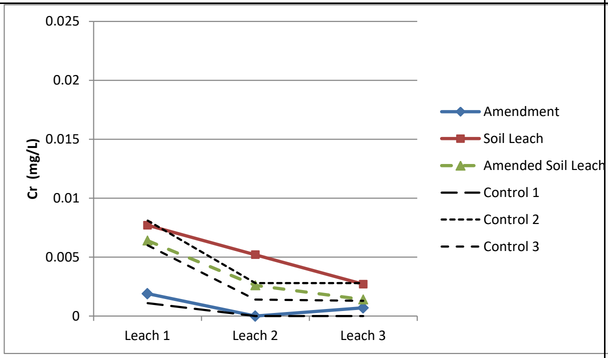
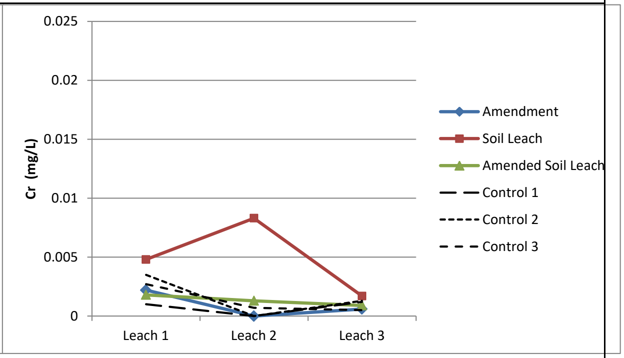
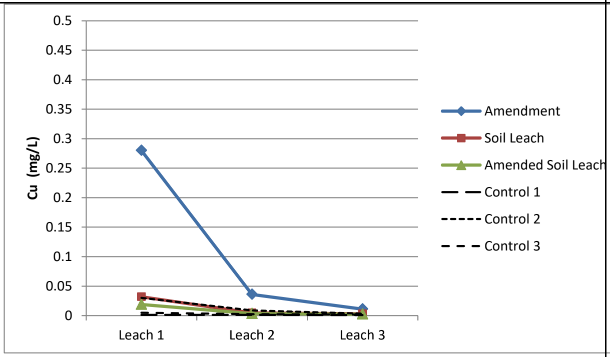
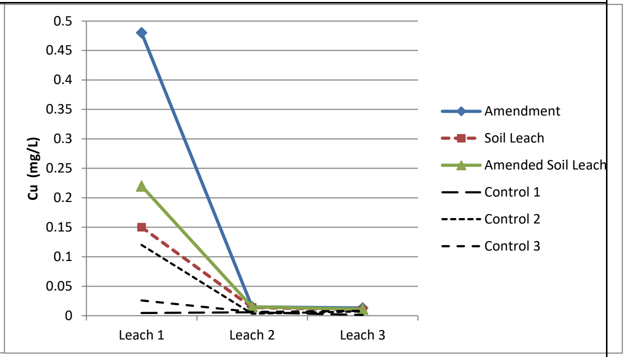




Fairbridge Duplex

Spearwood





Bassendean Ellenbrook

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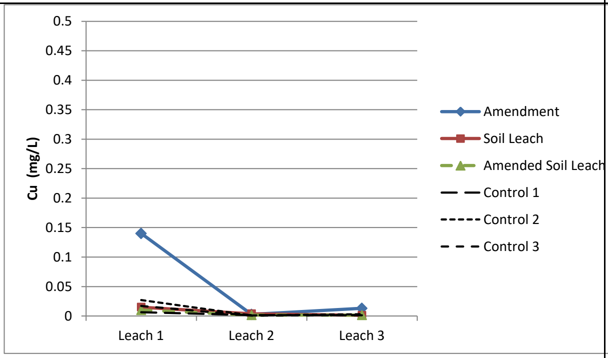
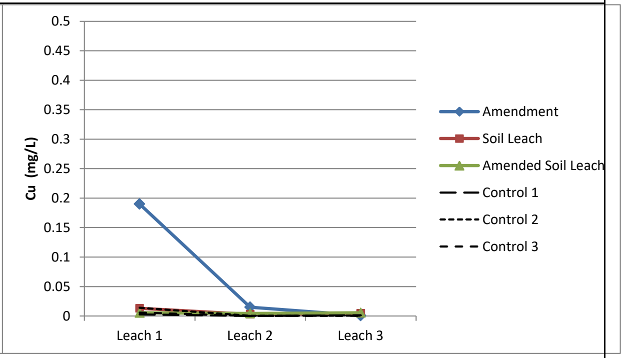
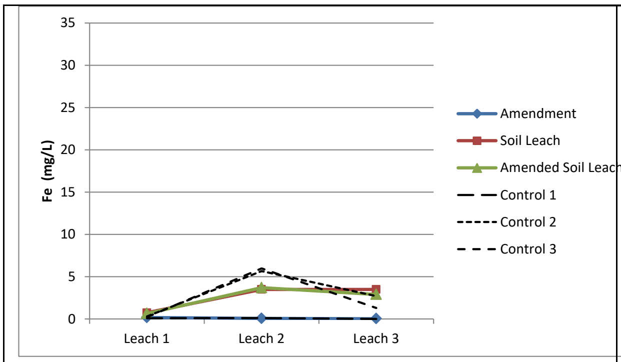


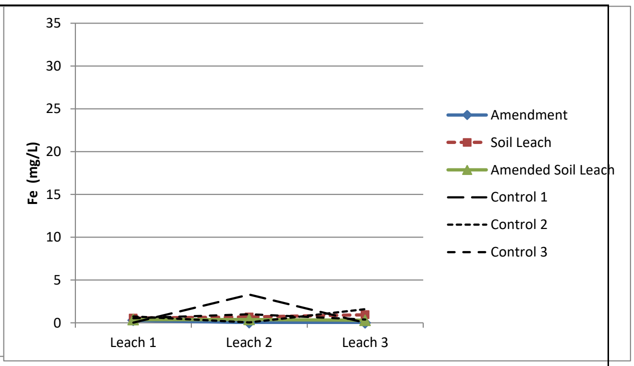


Fairbridge Duplex

Spearwood

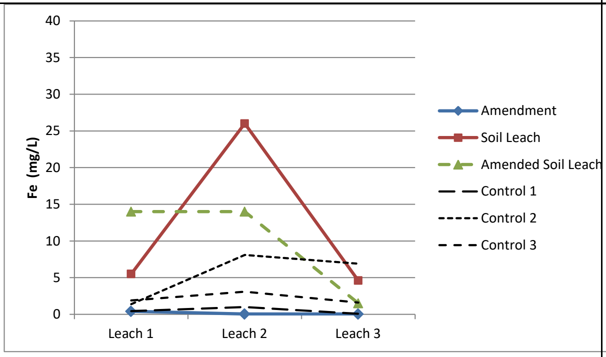
A12-7. Lime Amended Biosolids (LAB)

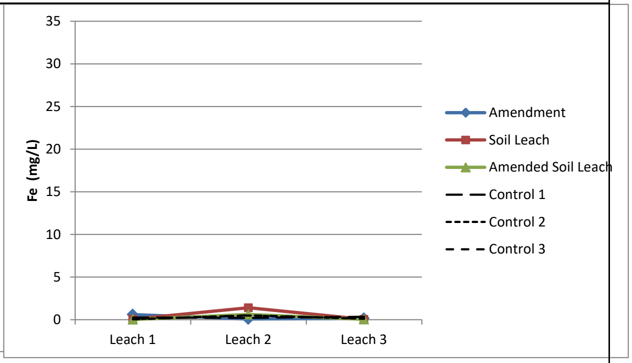




Bassendean Ellenbrook

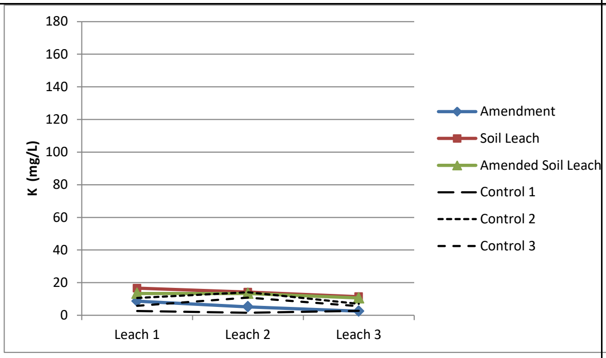
Bassendean Joel

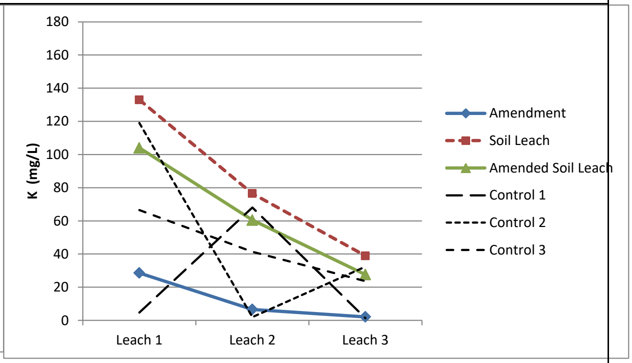




Fairbridge Duplex

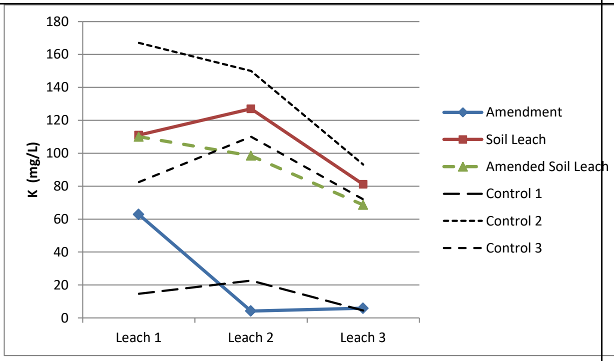
Spearwood

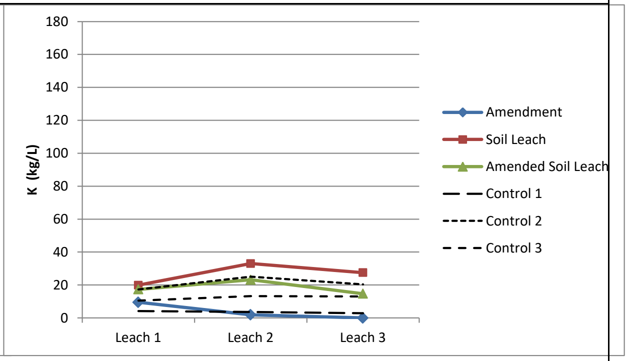




Bassendean Ellenbrook

Bassendean Joel





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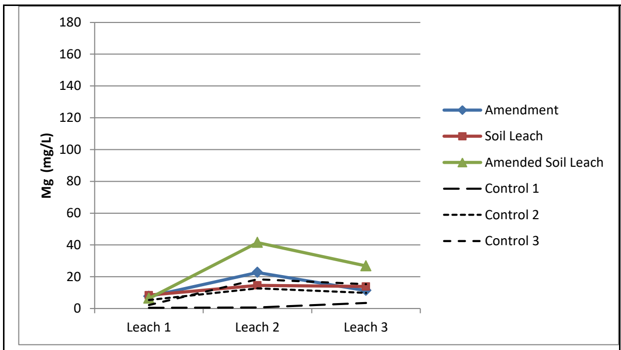
Spearwood

A12-7. Lime Amended Biosolids (LAB)



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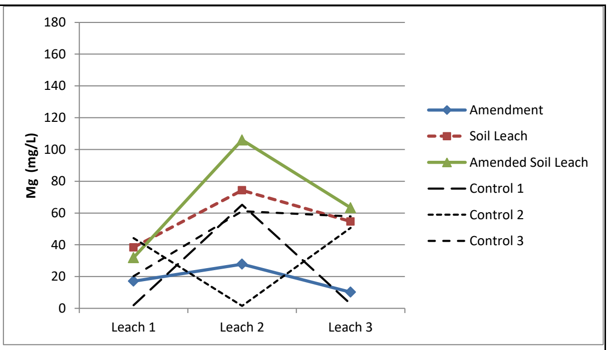

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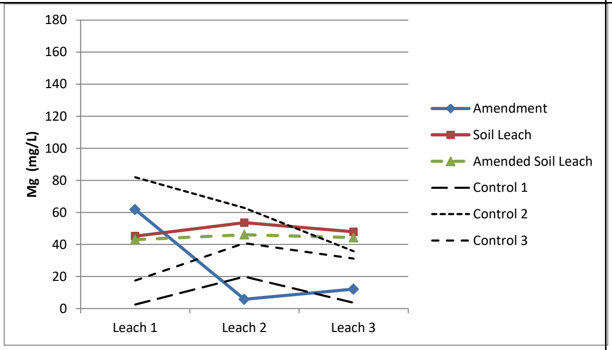

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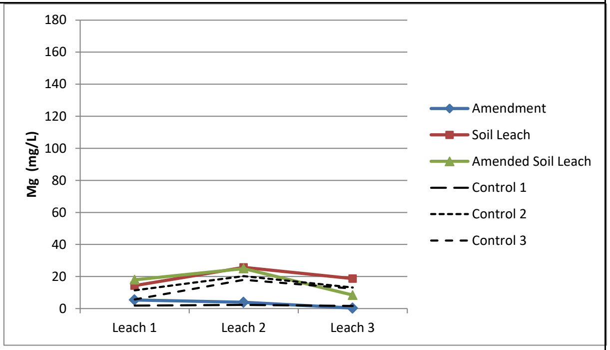

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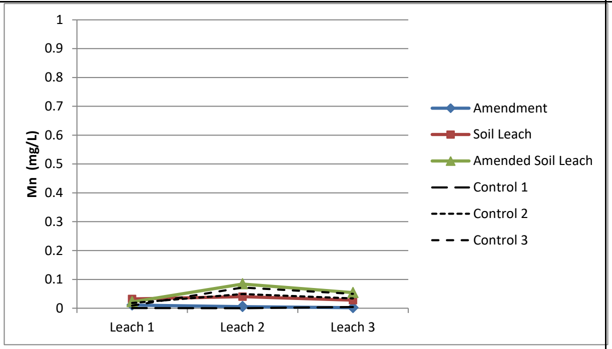

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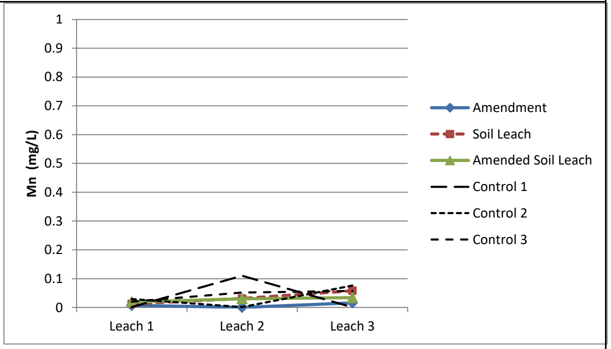

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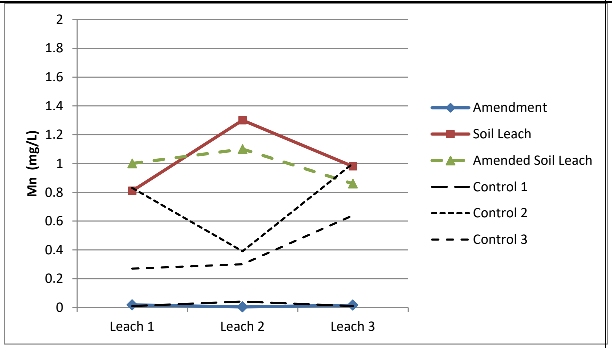

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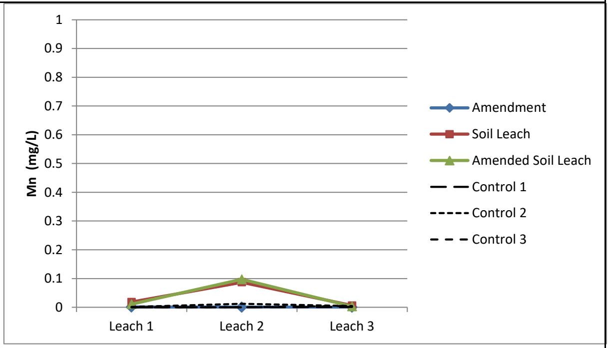
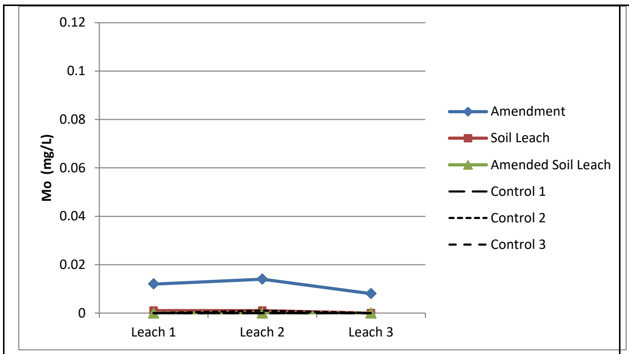


Spearwood

A12-7. Lime Amended Biosolids (LAB)



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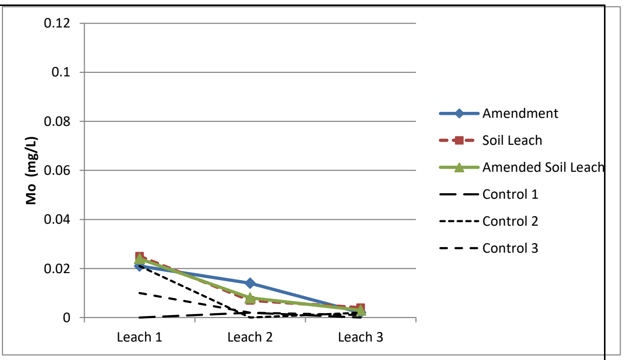

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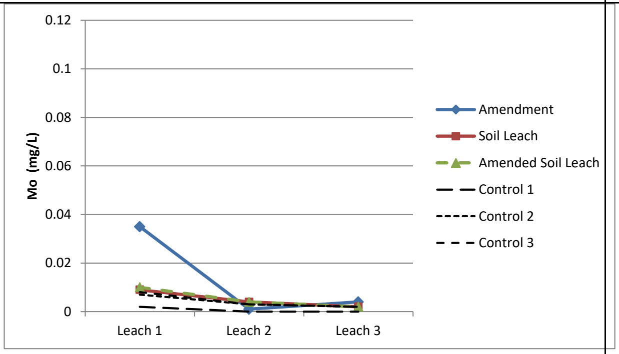

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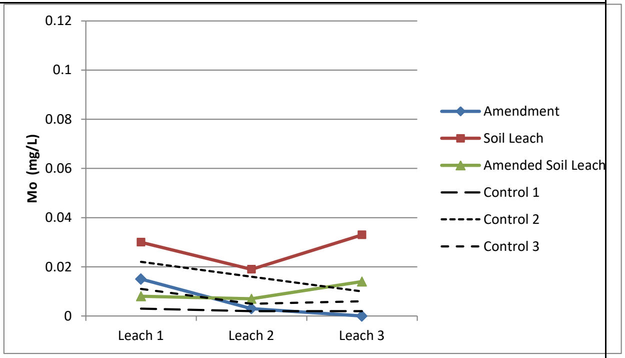

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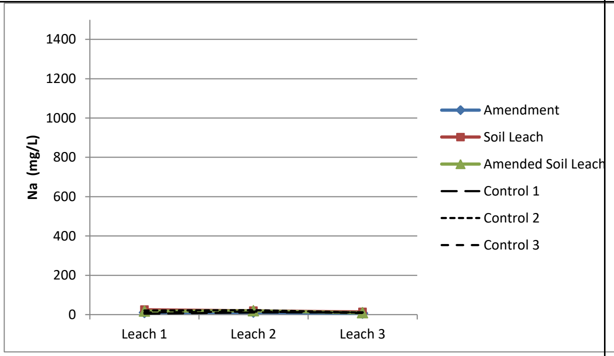

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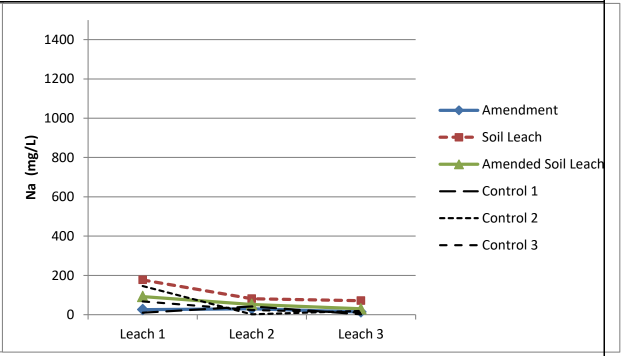

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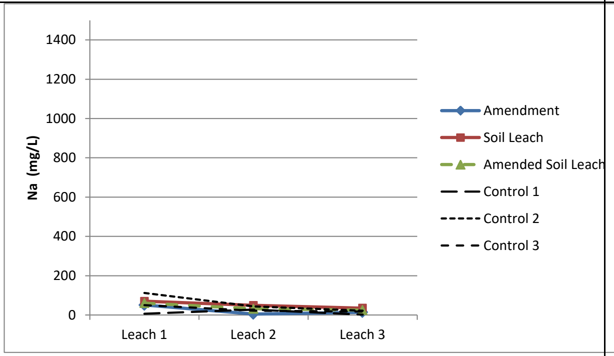

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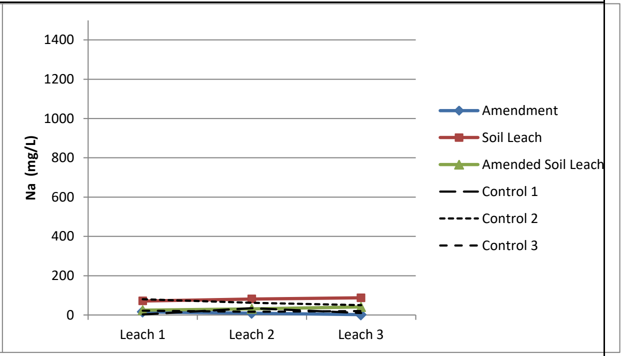

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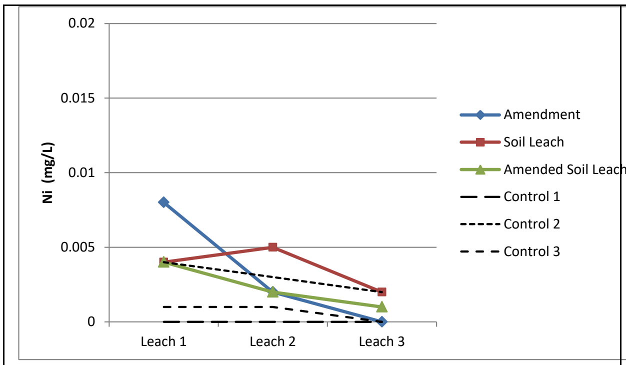
A12-7. Lime Amended Biosolids (LAB)



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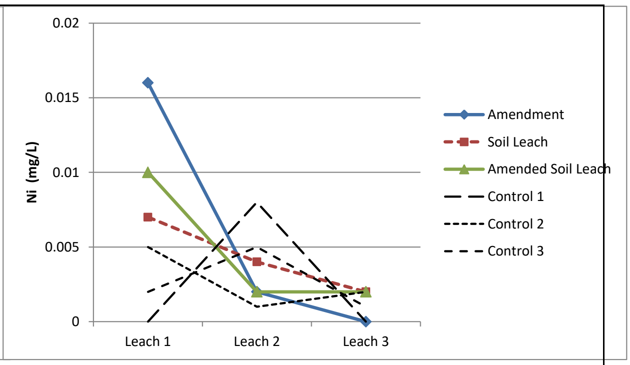

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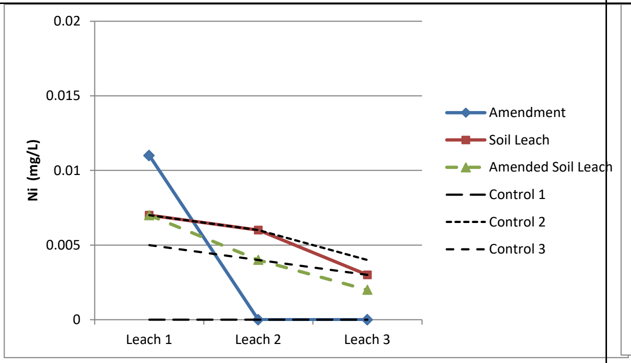

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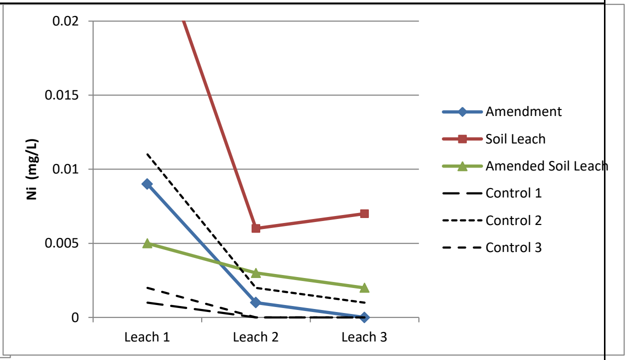

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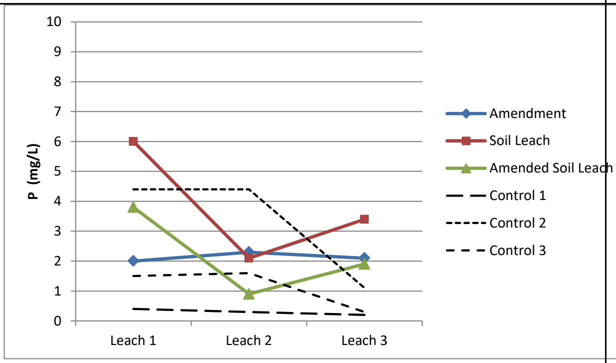

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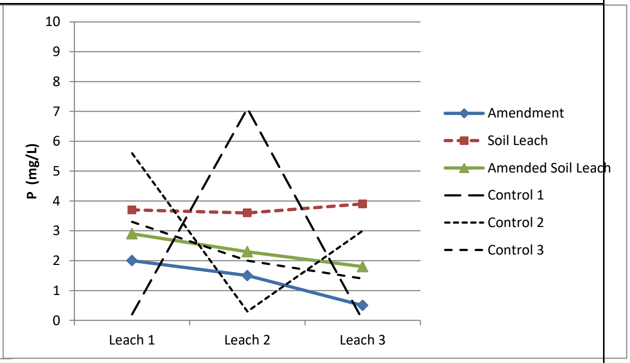

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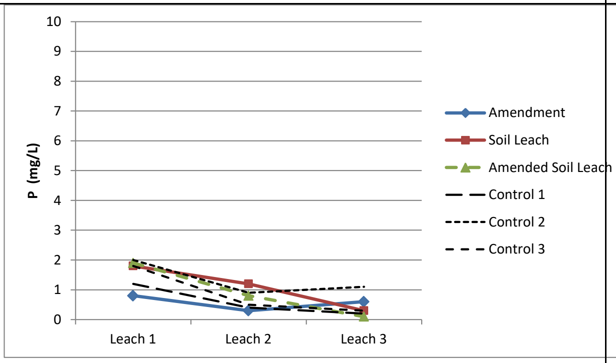

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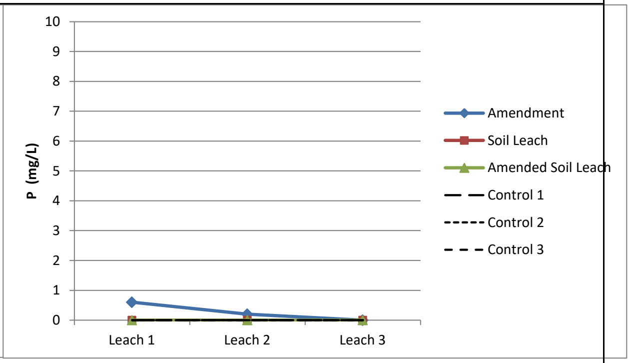

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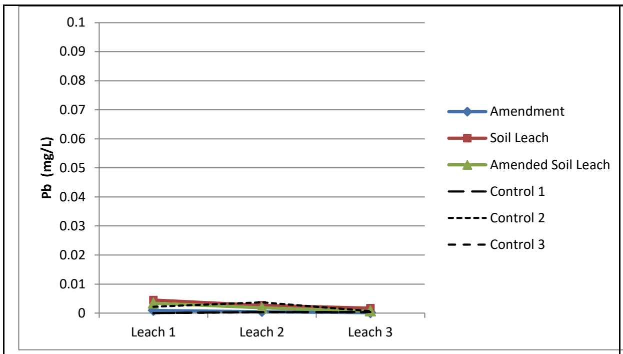
A12-7. Lime Amended Biosolids (LAB)



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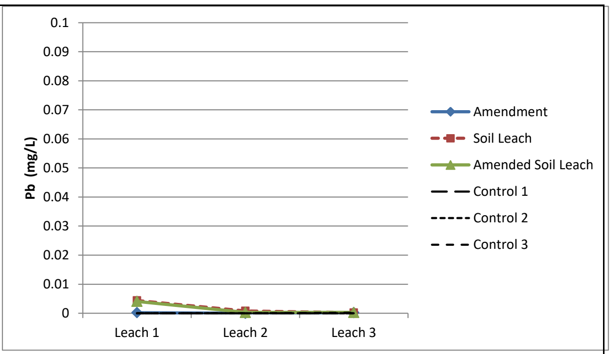

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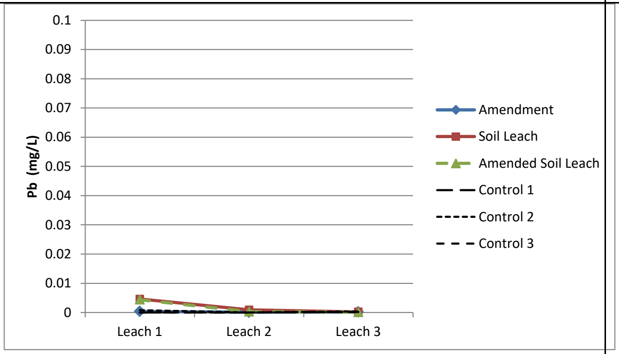

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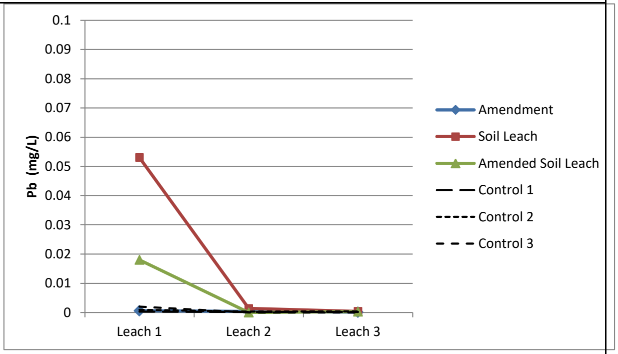

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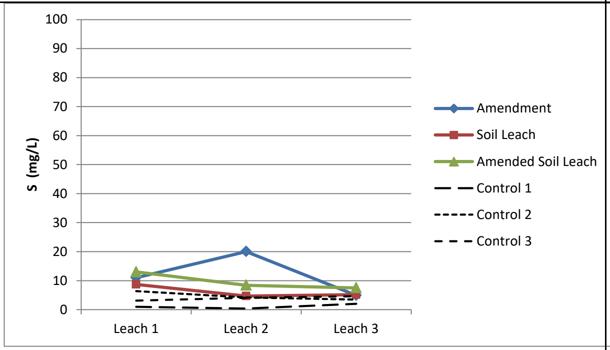

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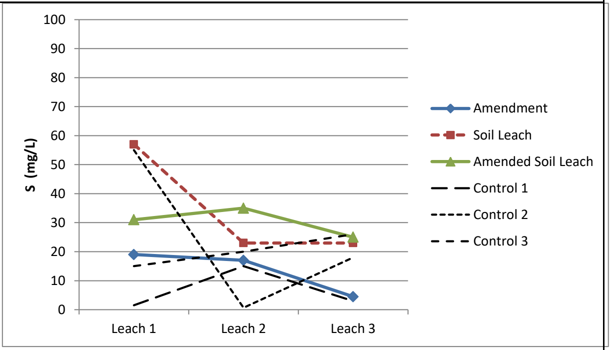

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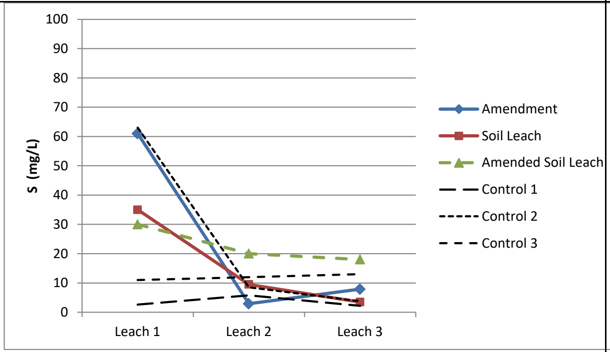

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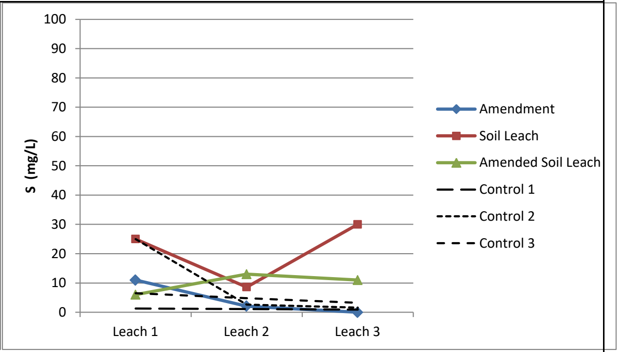
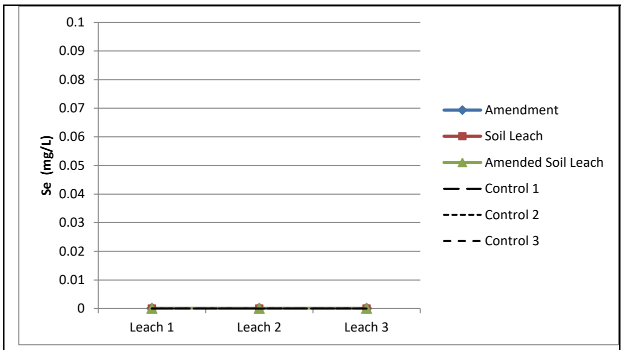


Spearwood

A12-7. Lime Amended Biosolids (LAB)



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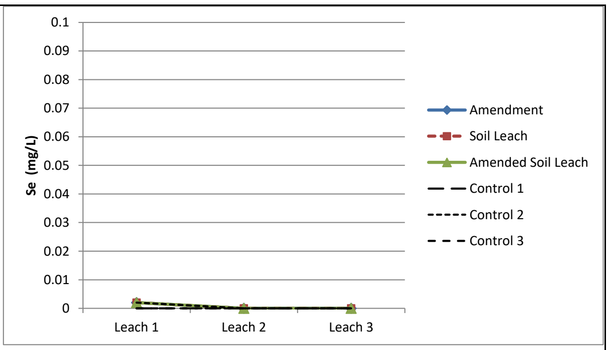

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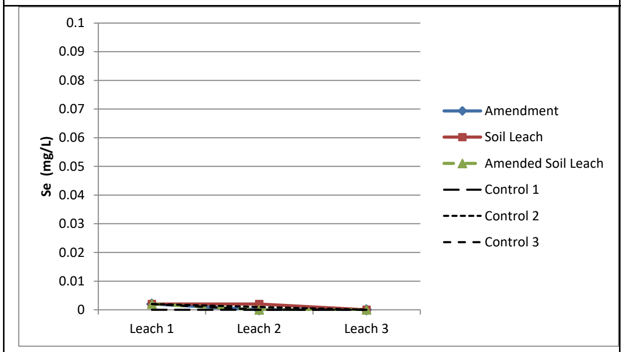

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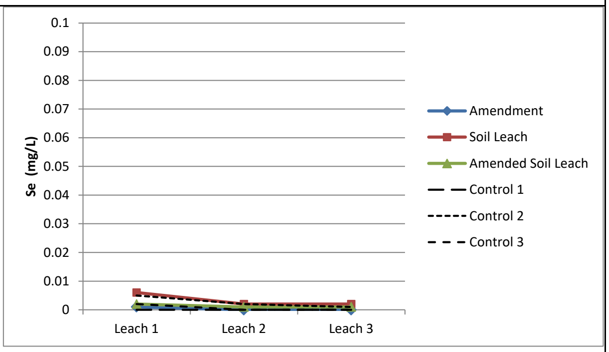

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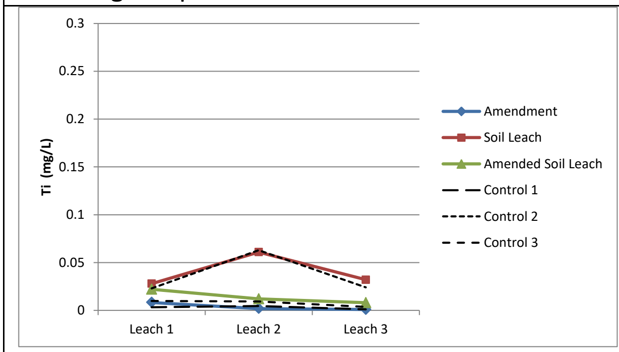

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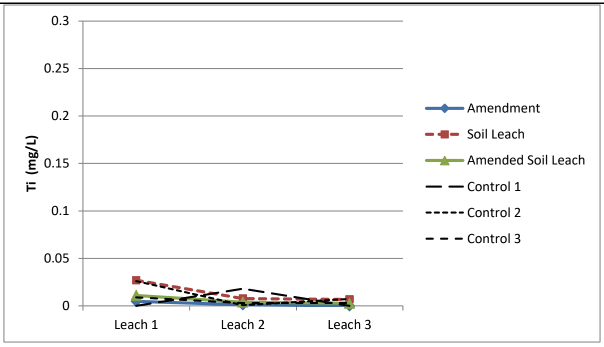

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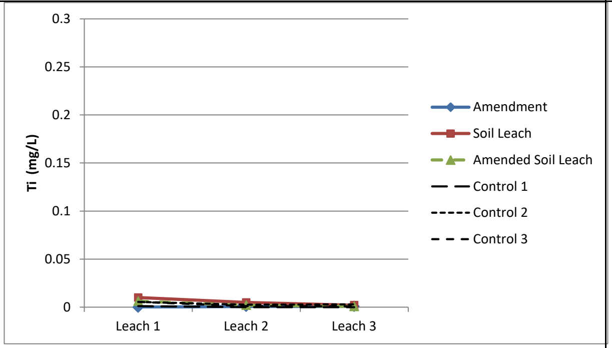

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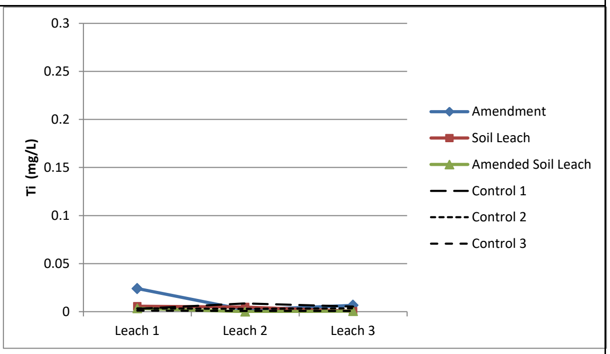

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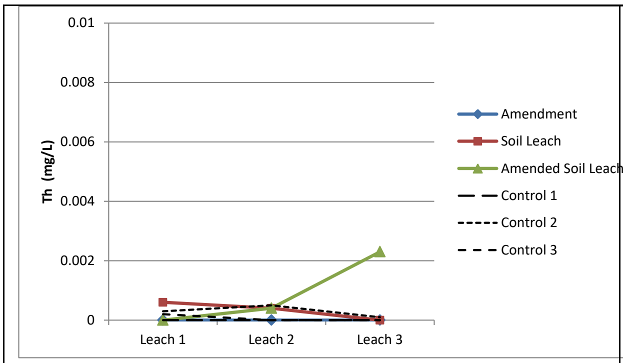
A12-7. Lime Amended Biosolids (LAB)



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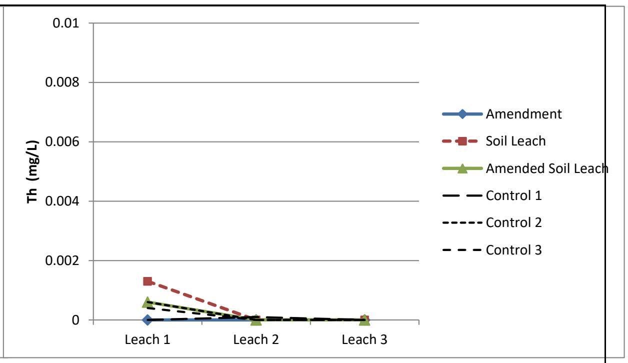

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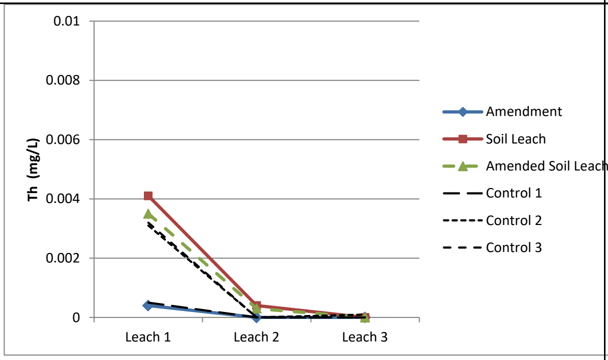

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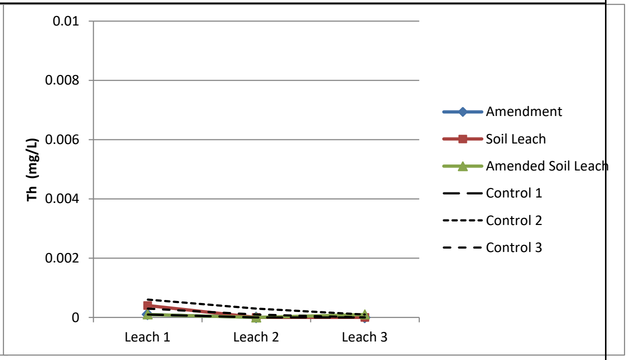

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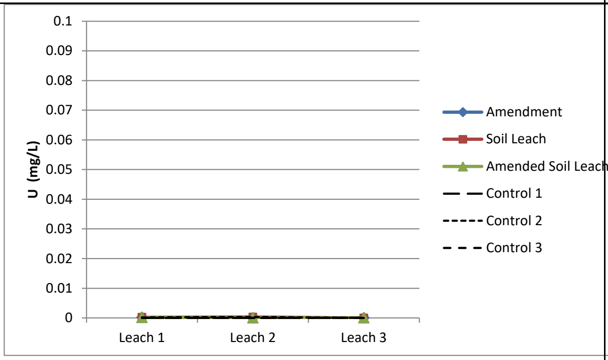

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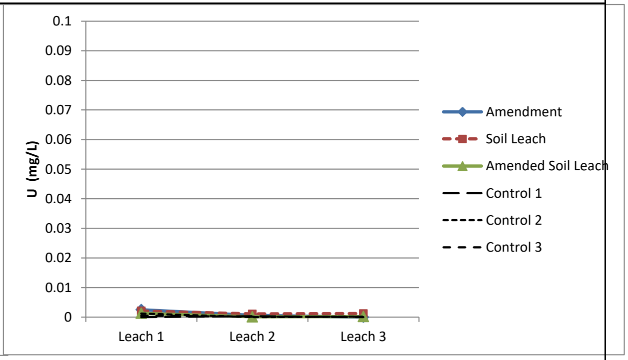

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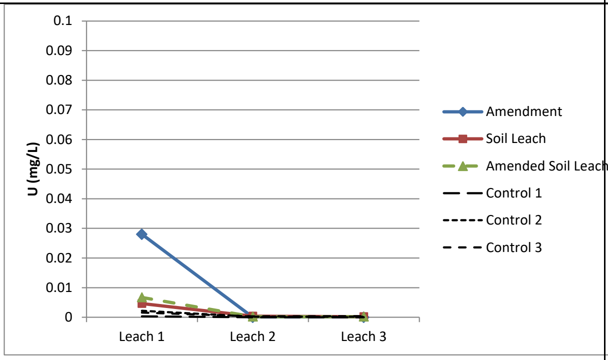

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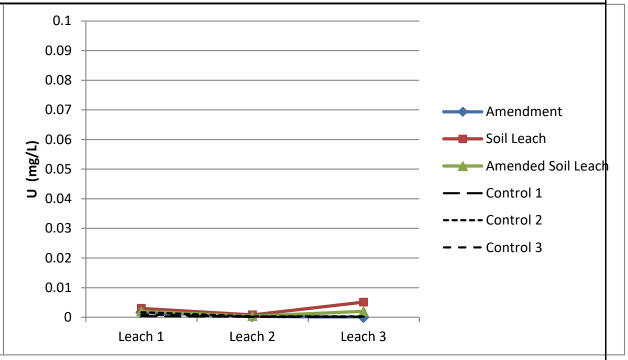
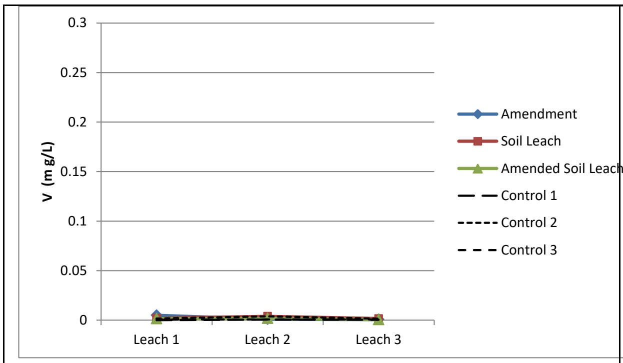


Spearwood

A12-7. Lime Amended Biosolids (LAB)



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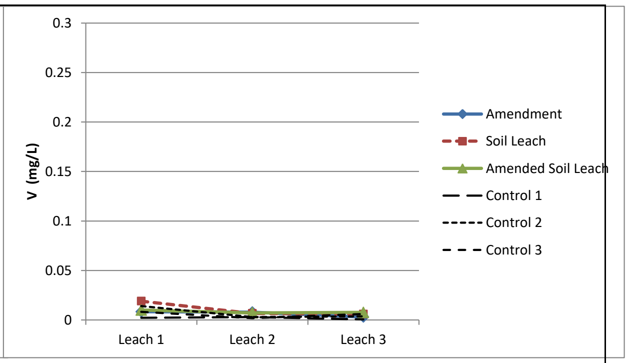

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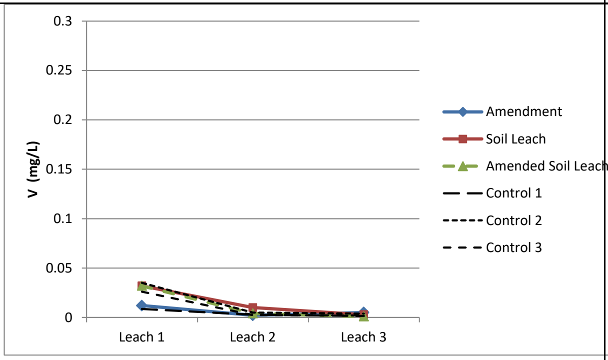

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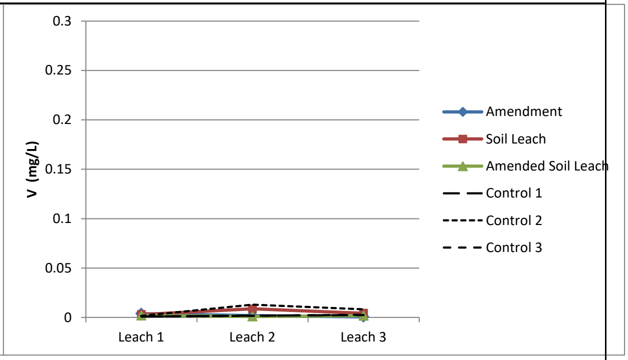

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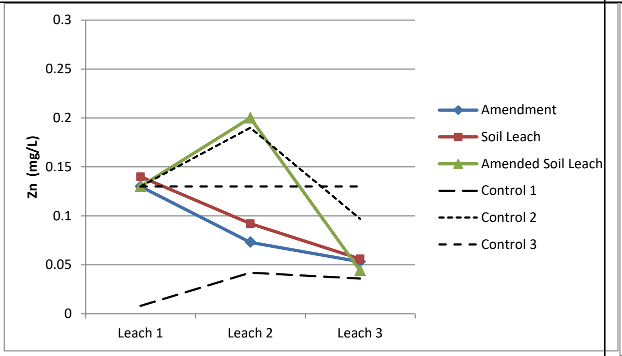

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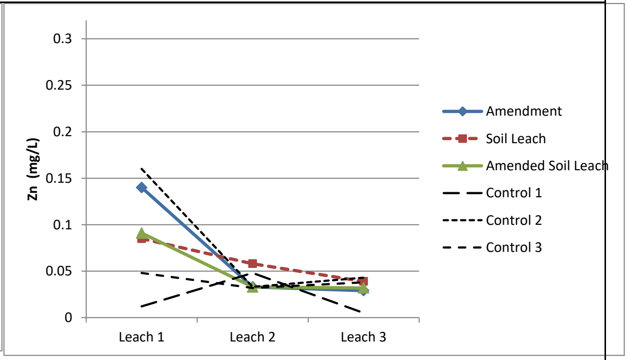

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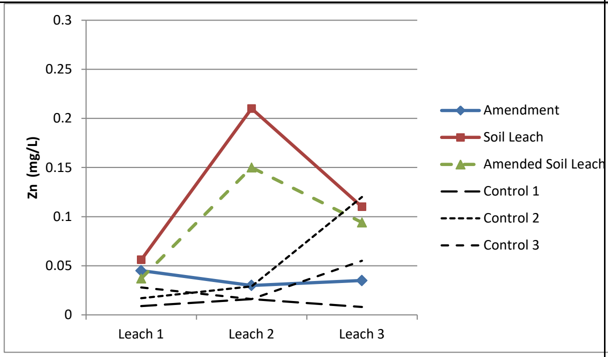

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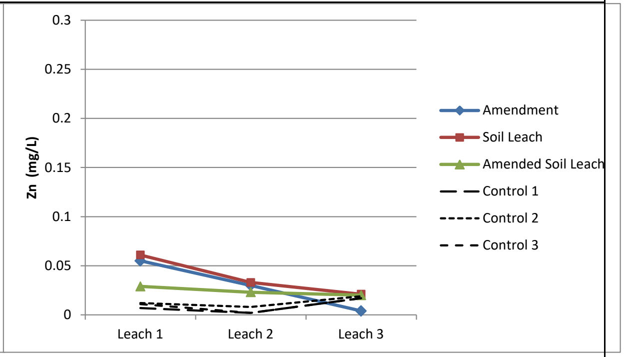
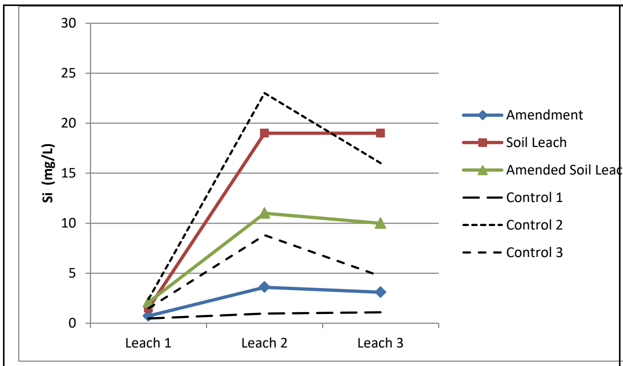
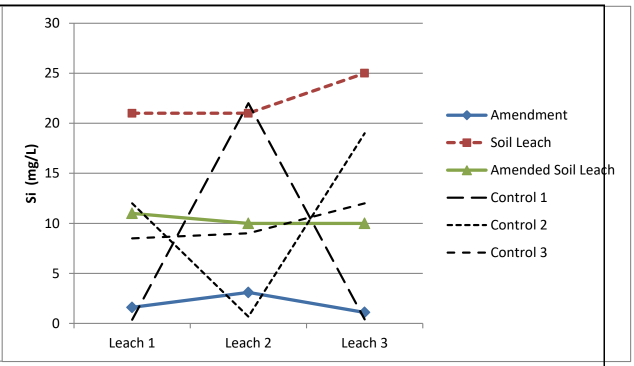


Spearwood

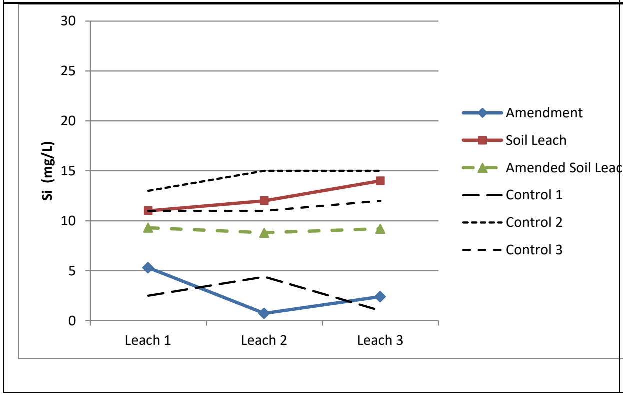
A12-7. Lime Amended Biosolids (LAB)

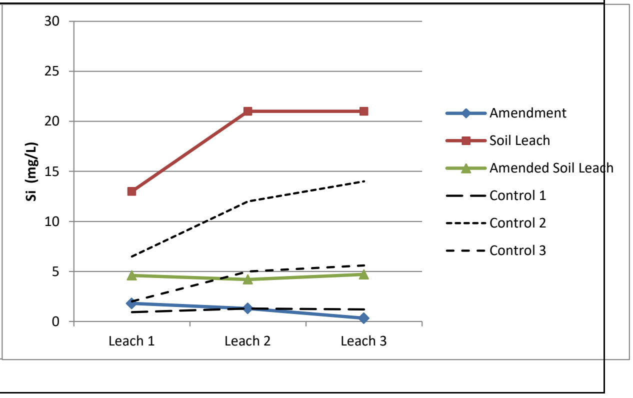




Bassendean Ellenbrook

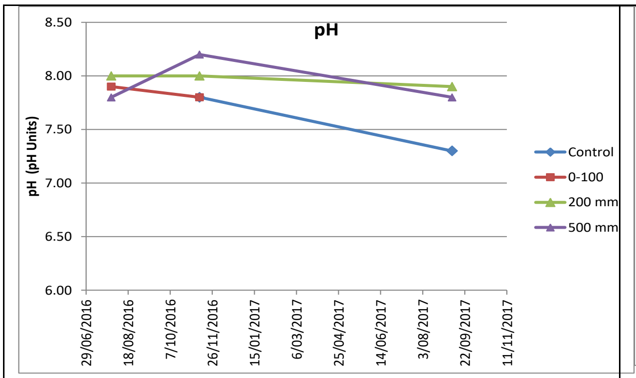
Bassendean Joel

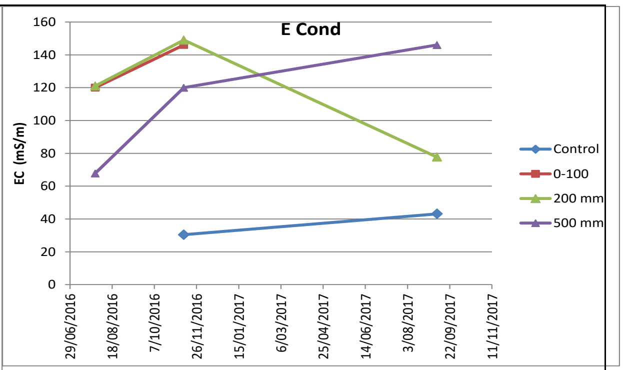


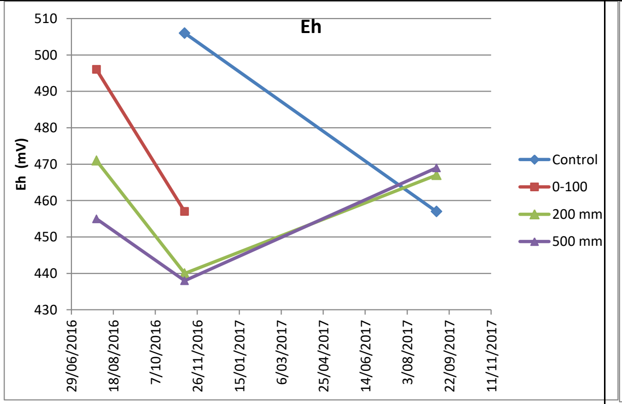


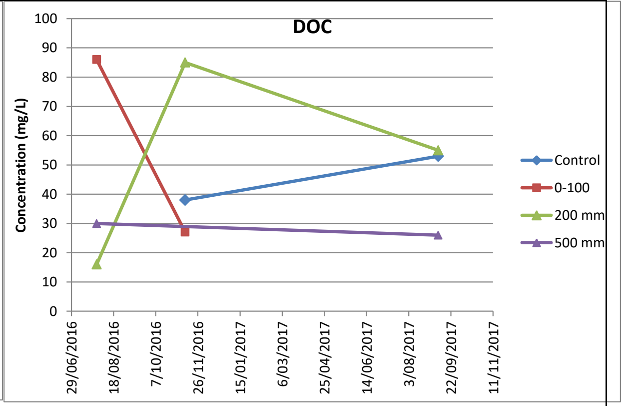
Appendix A13: Aroona Lysimeter Trial Data

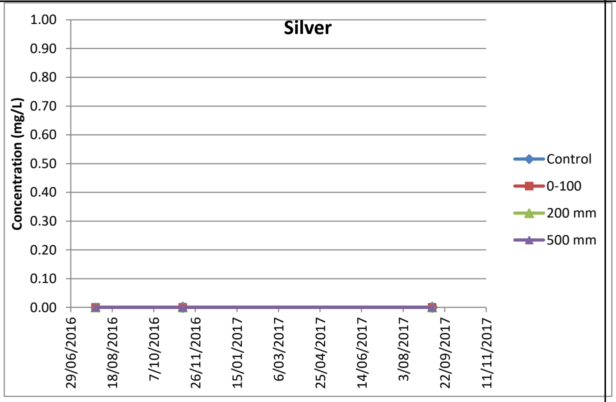
A 13-1. Wanneroo Residue

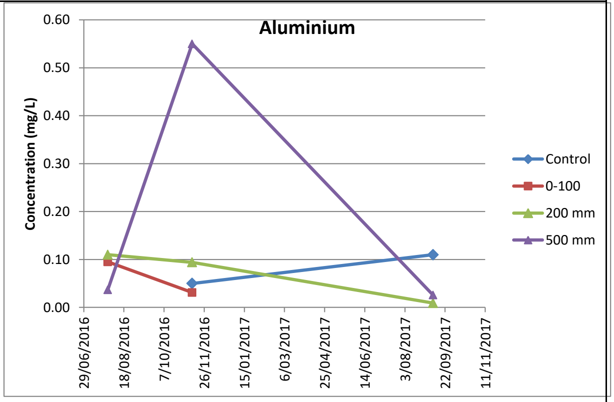


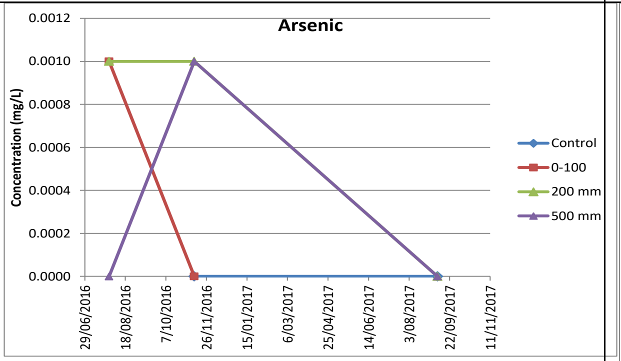


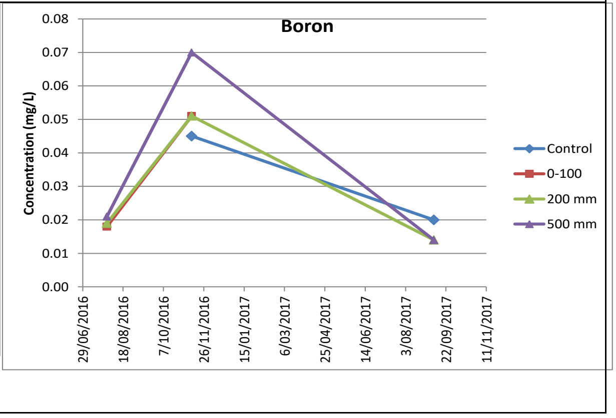




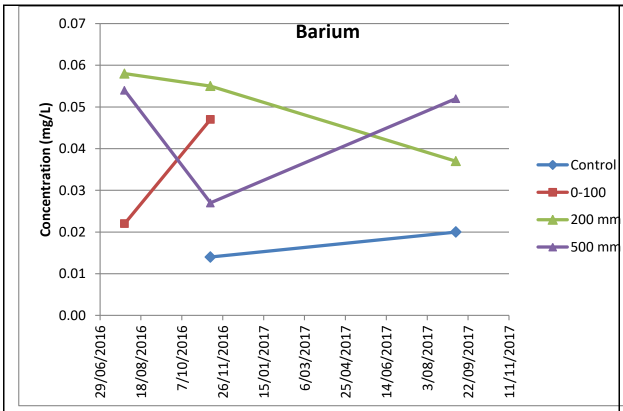


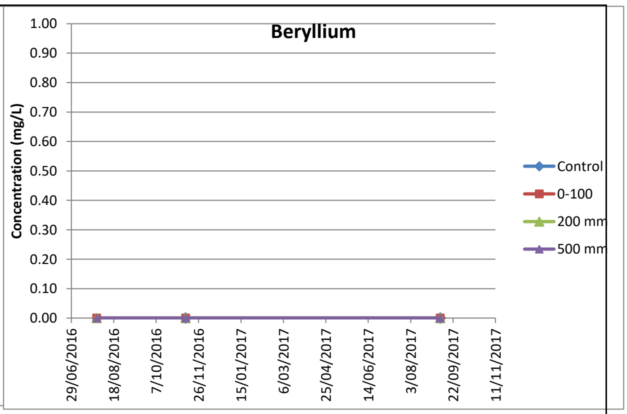


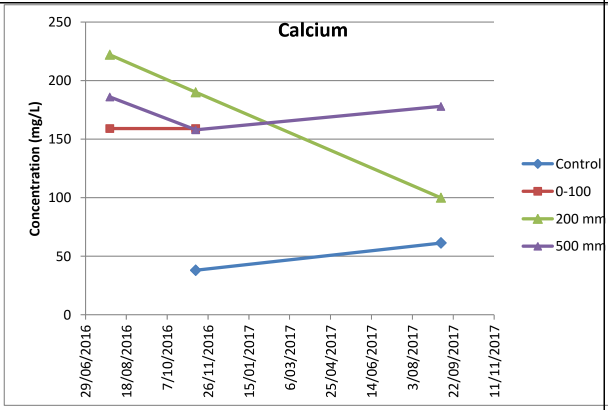


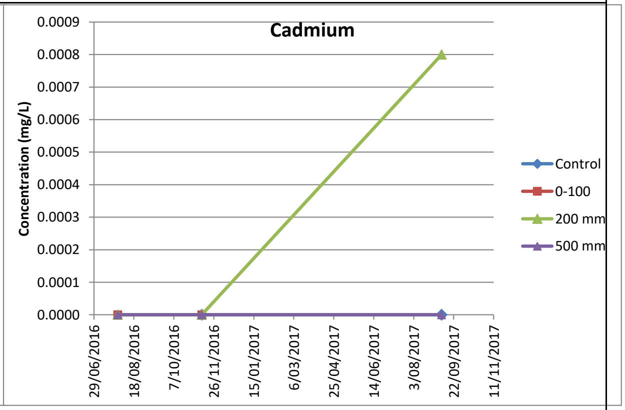


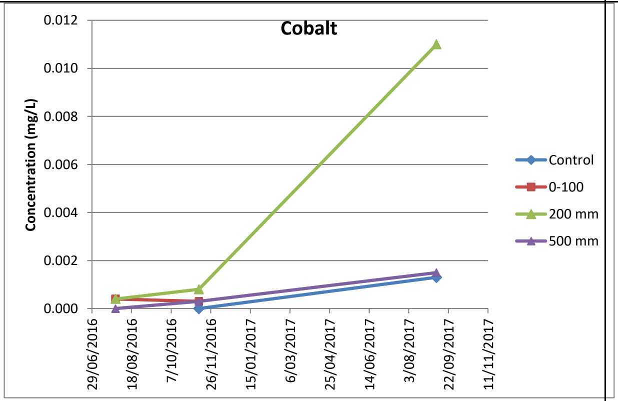
A 13-1. Wanneroo Residue

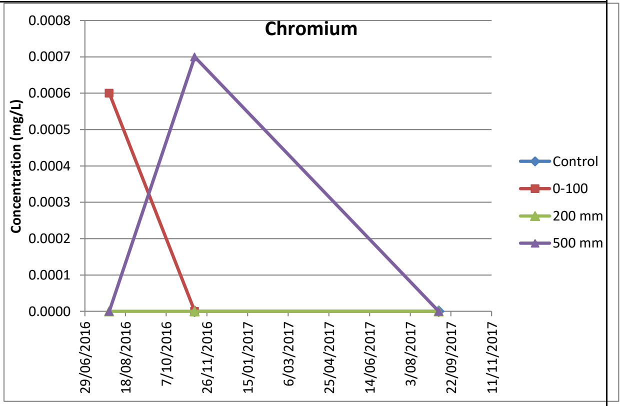


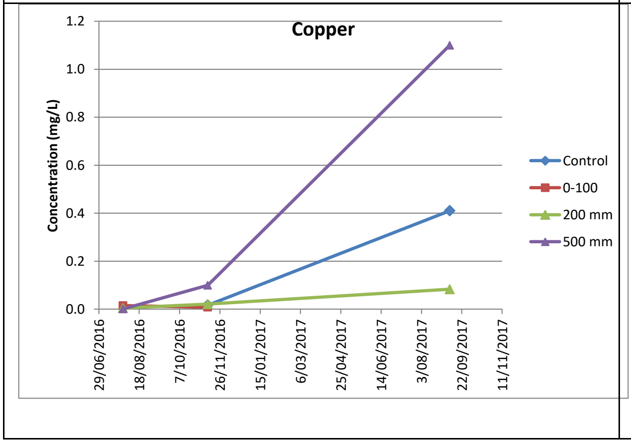


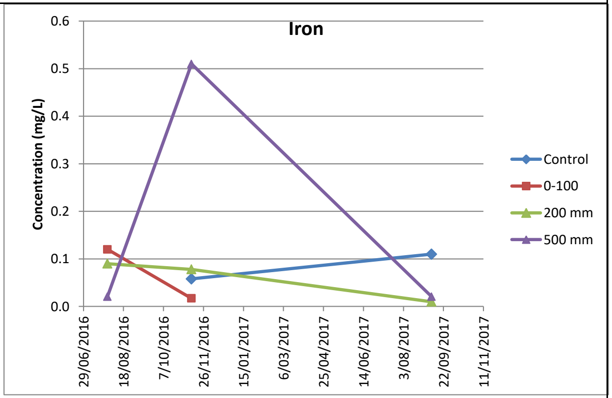




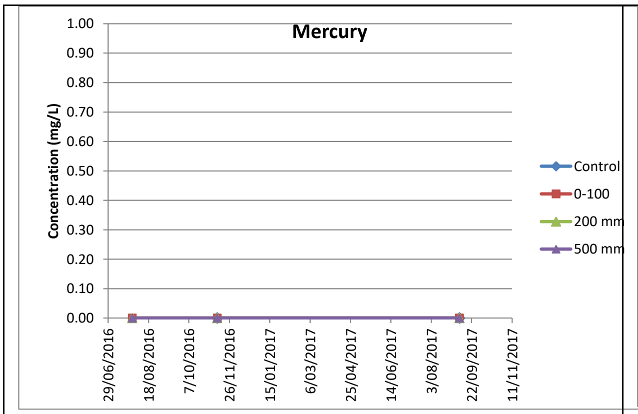


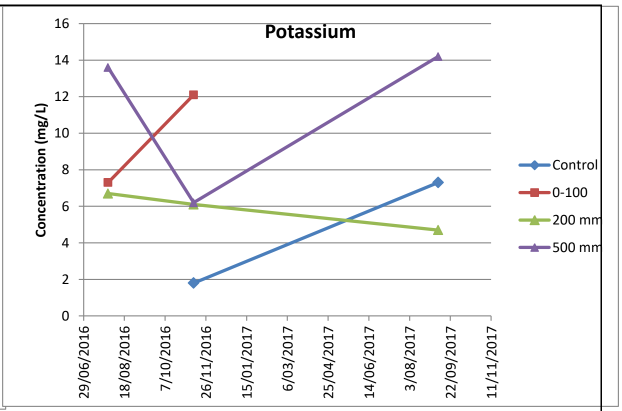


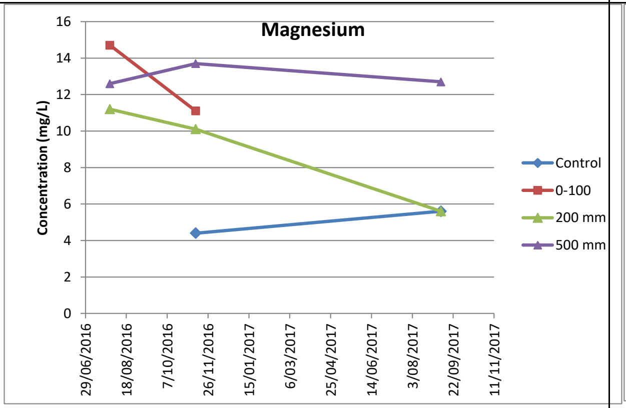


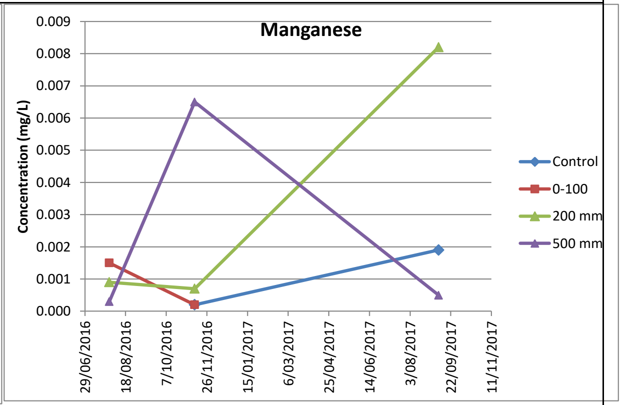


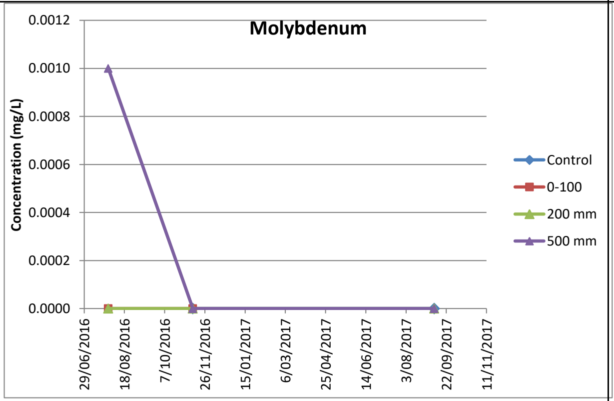
A 13-1. Wanneroo Residue

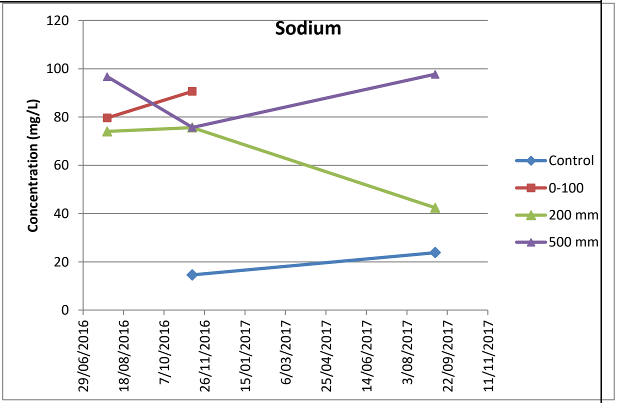


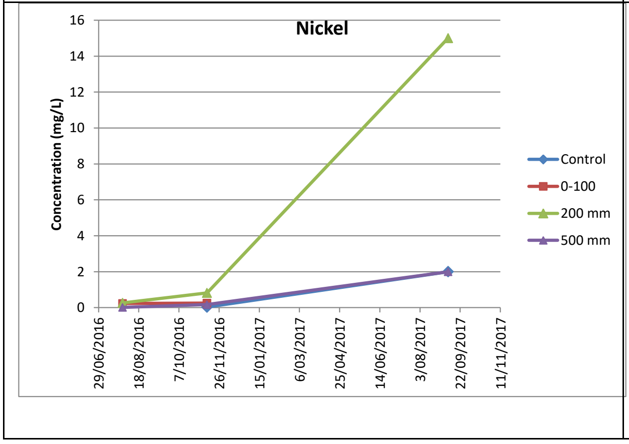


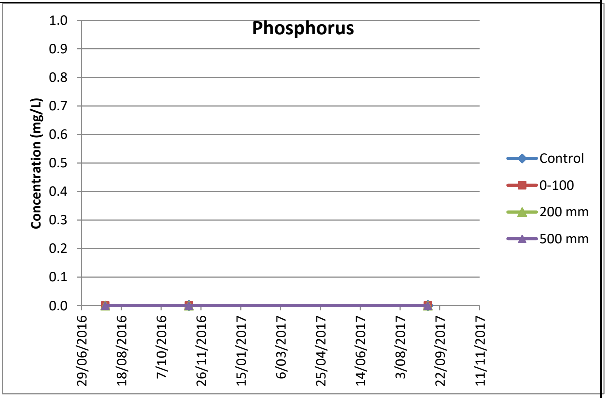












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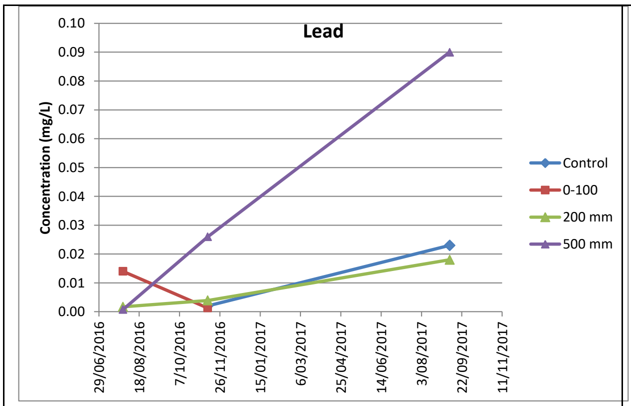
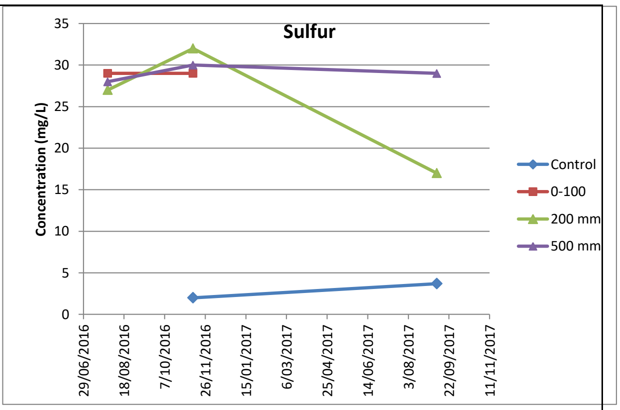
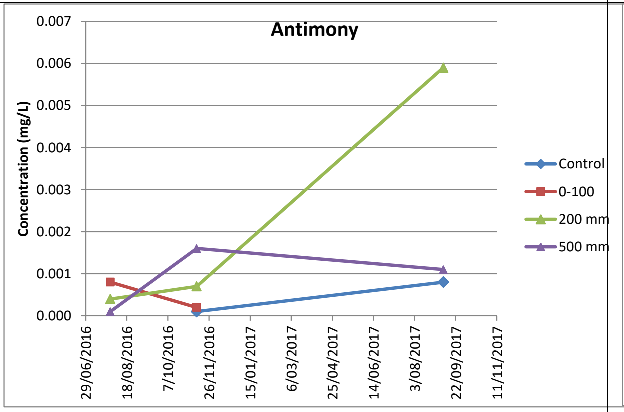
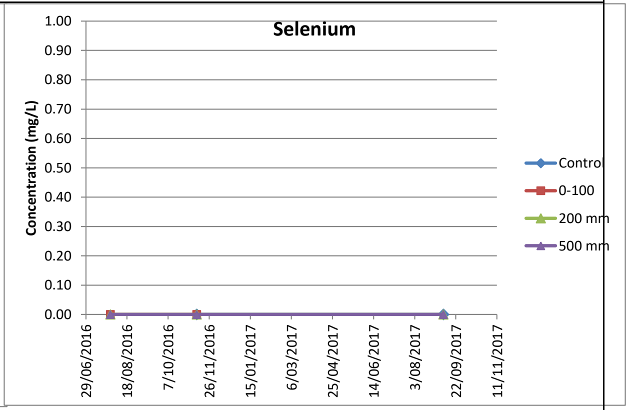
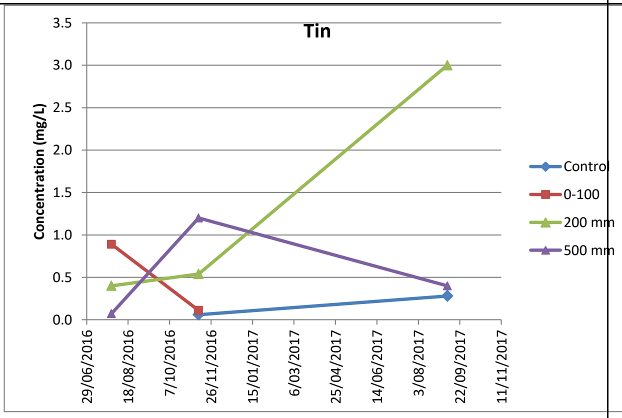
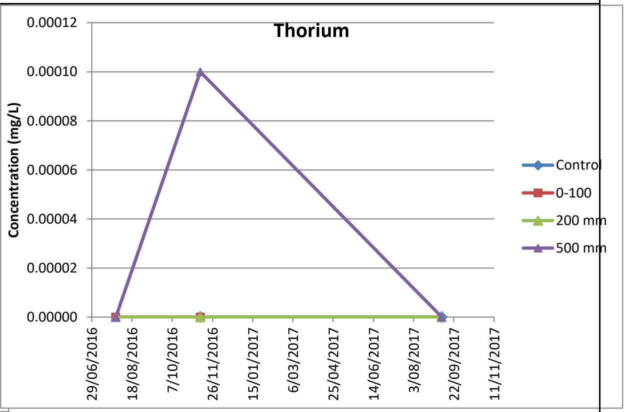


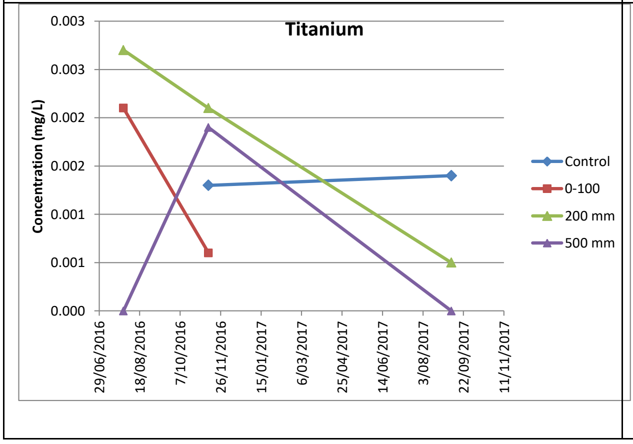


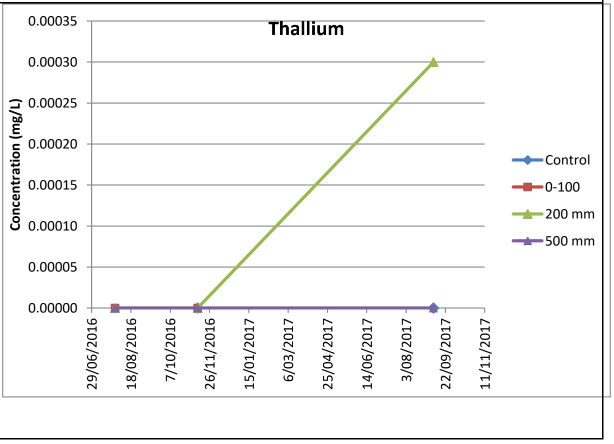




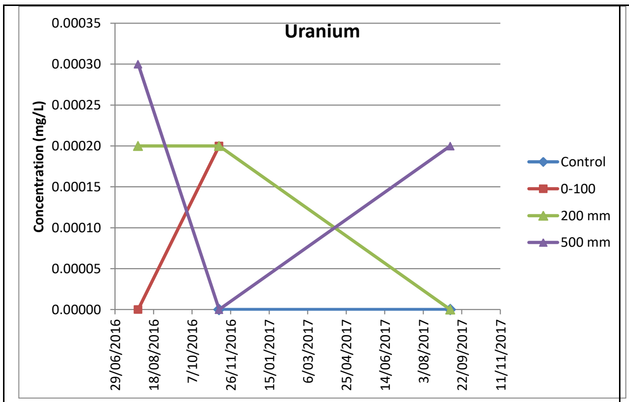


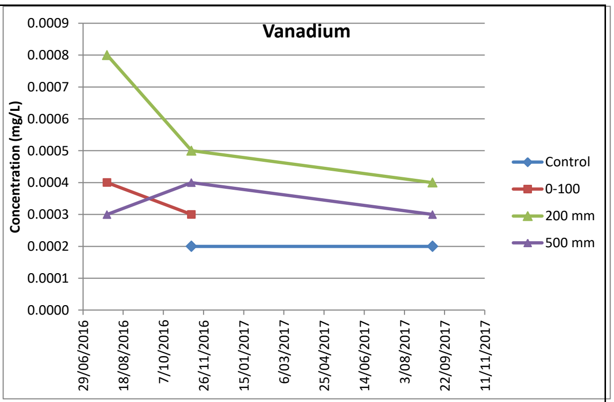


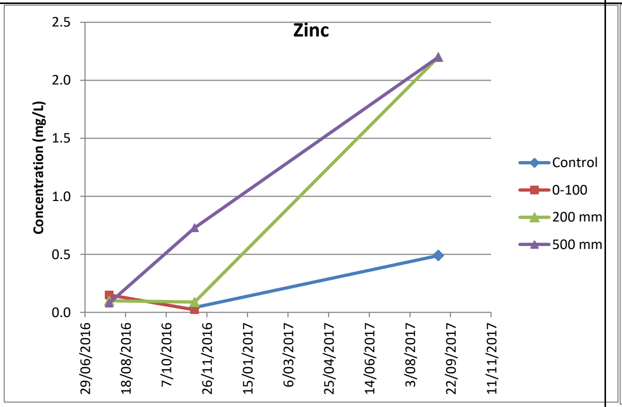


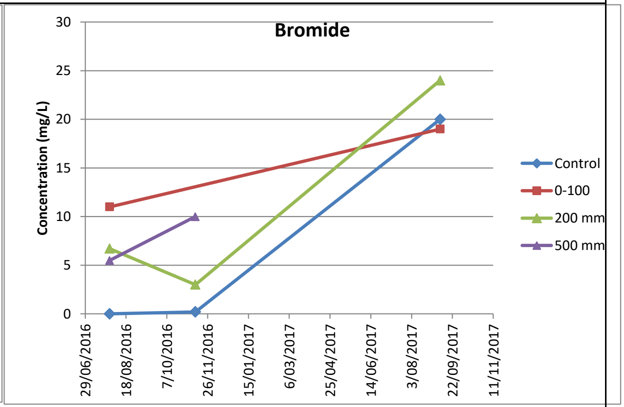


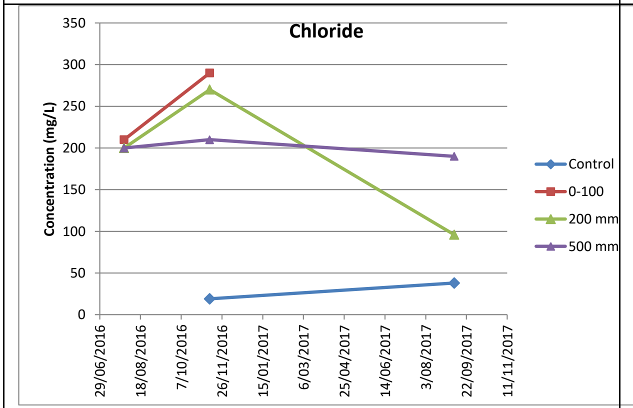
A 13-1. Wanneroo Residue

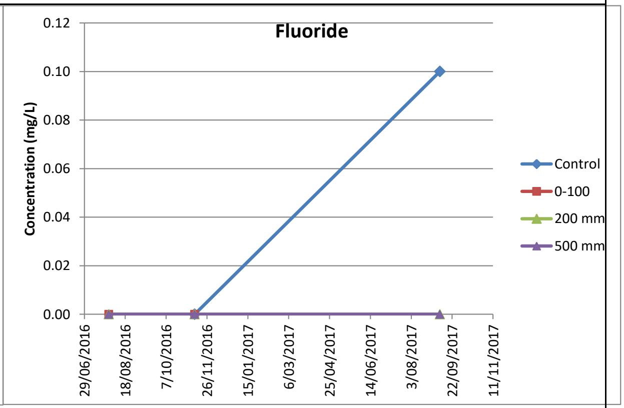


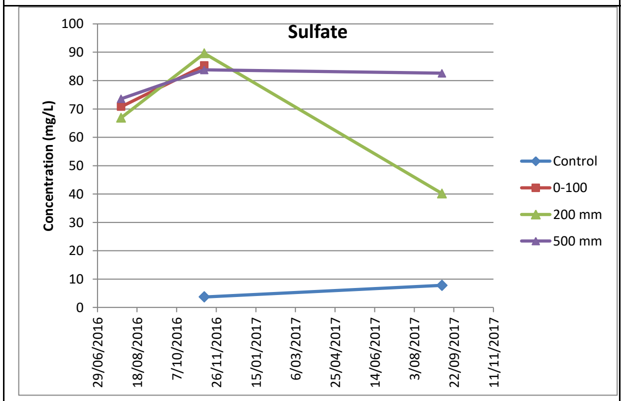


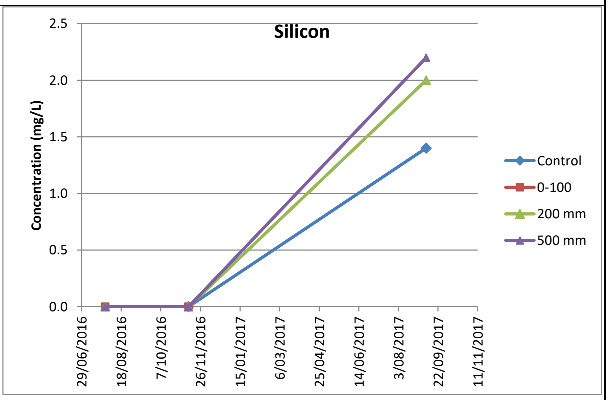












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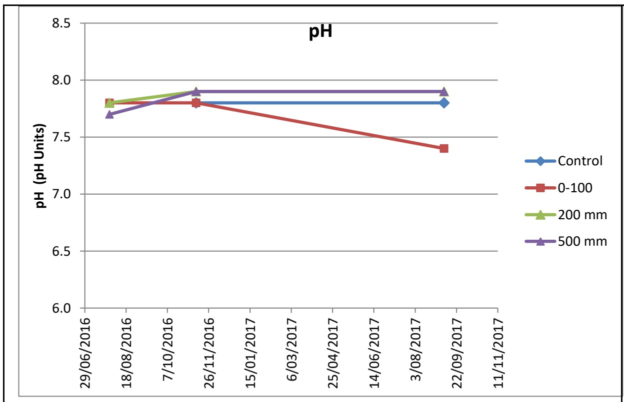

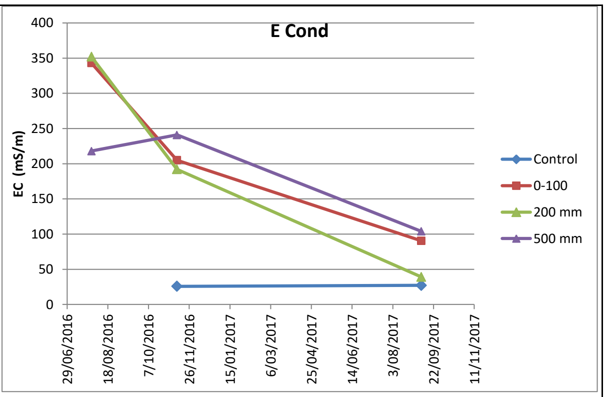

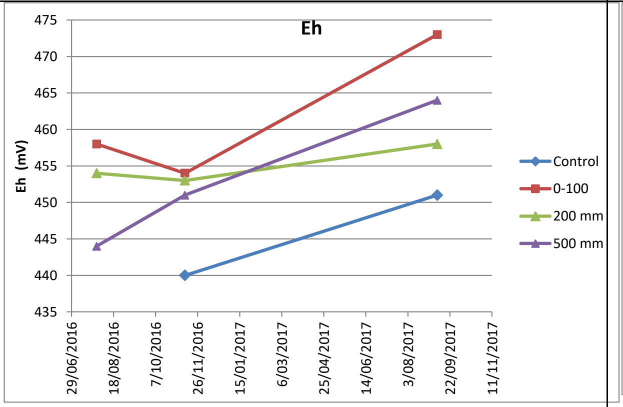

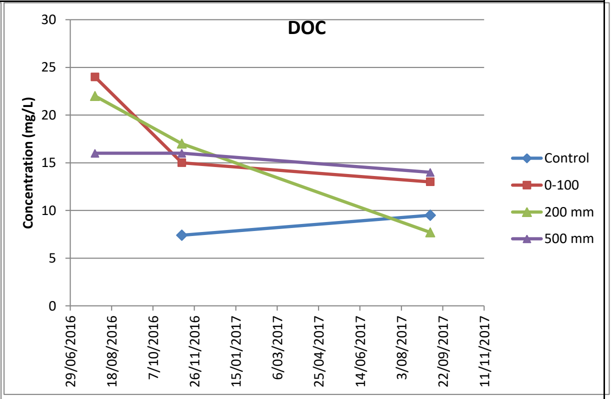

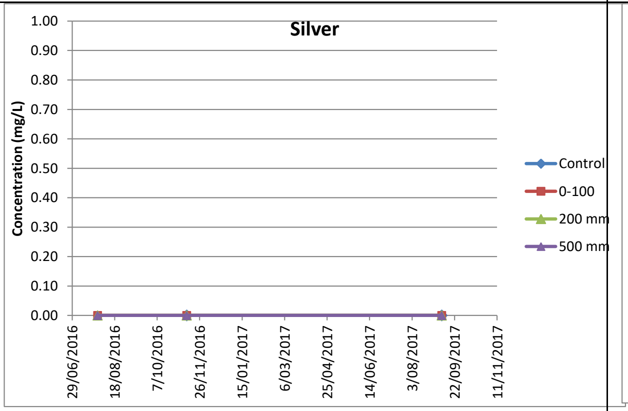

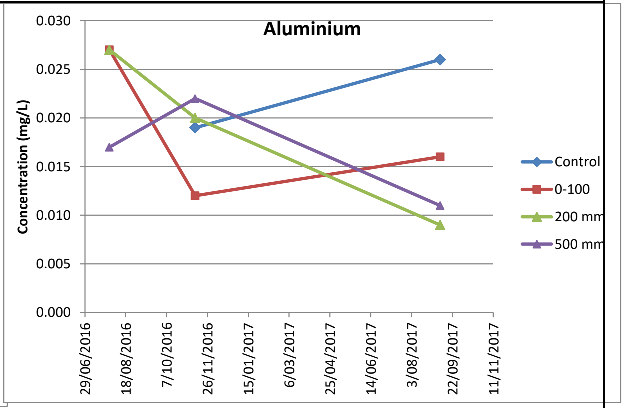

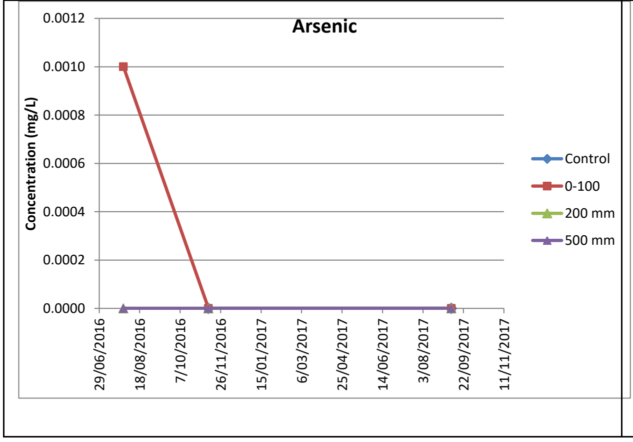

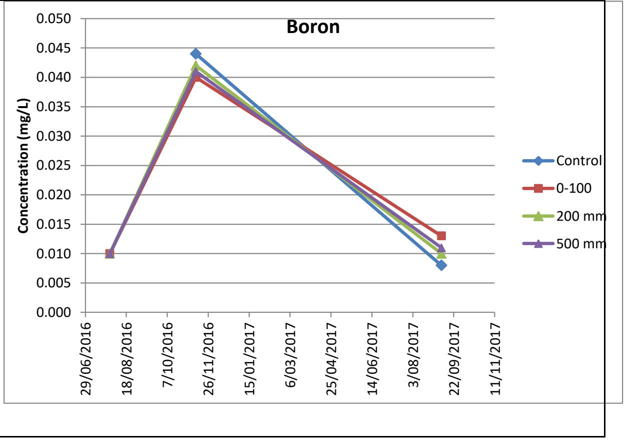

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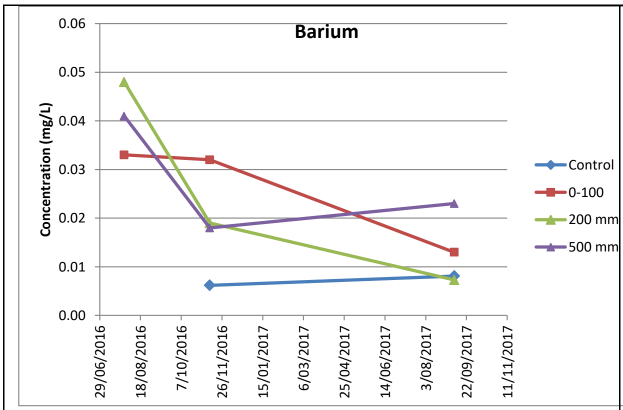

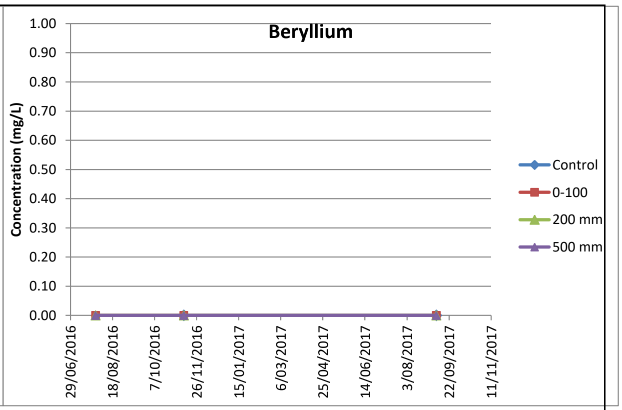

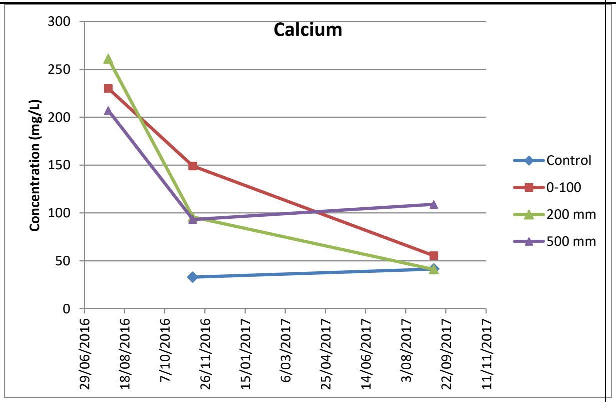

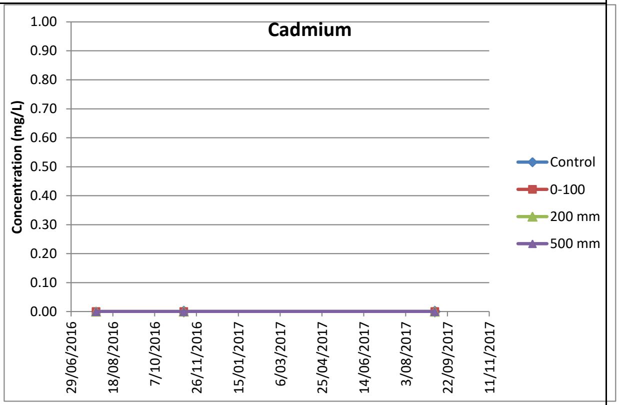

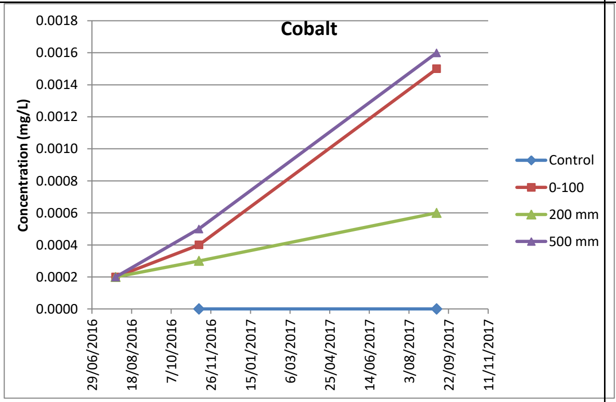

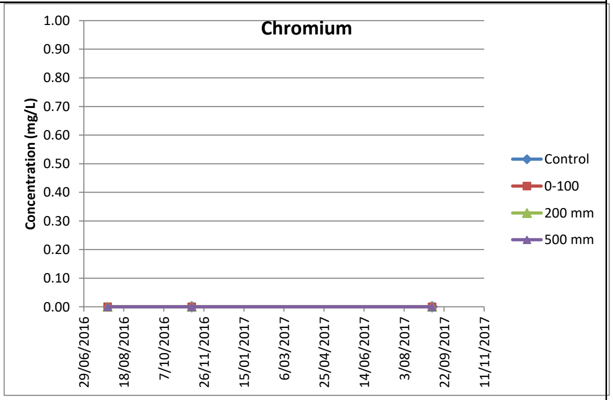

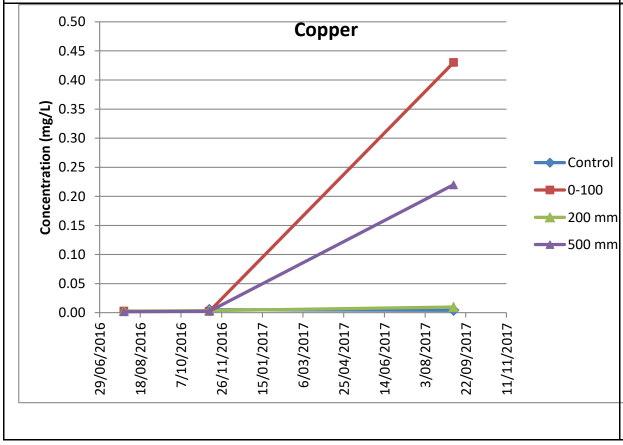

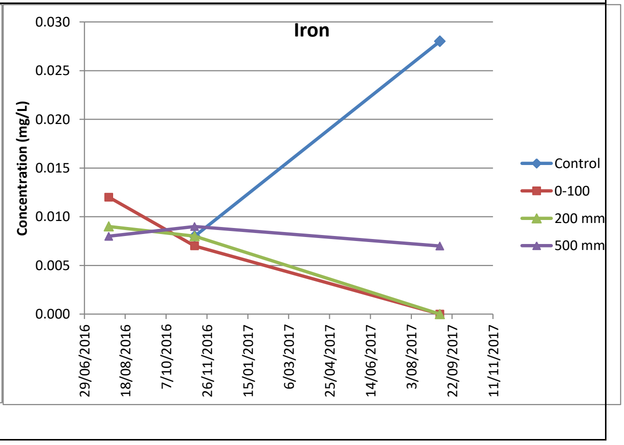

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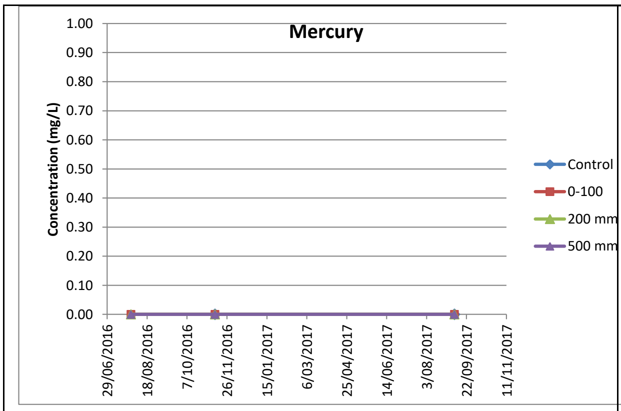

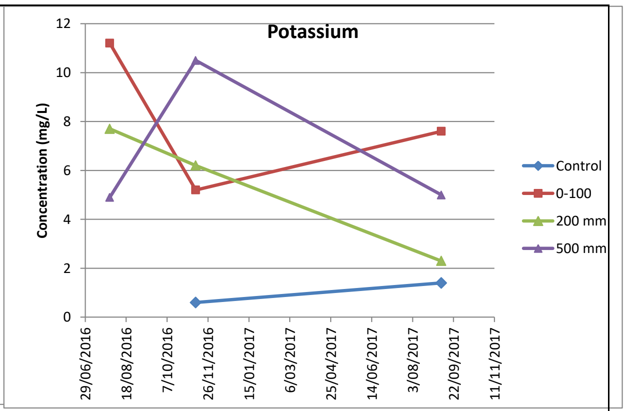

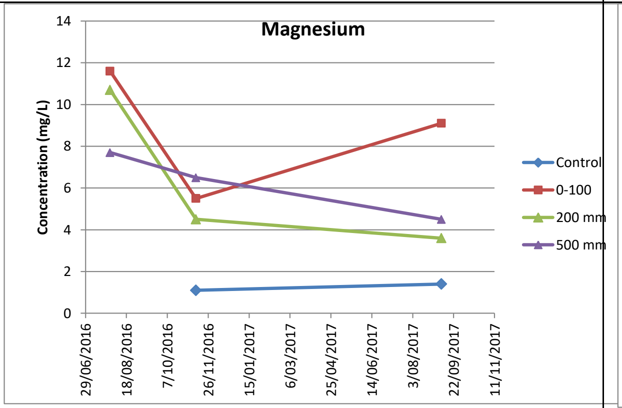

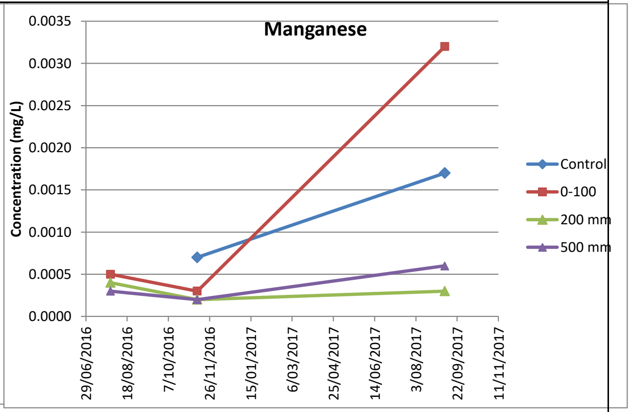

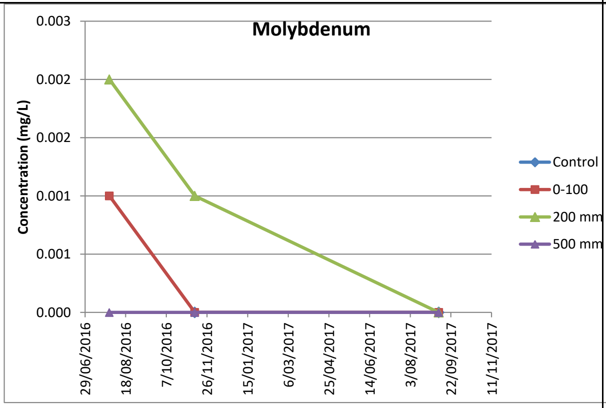

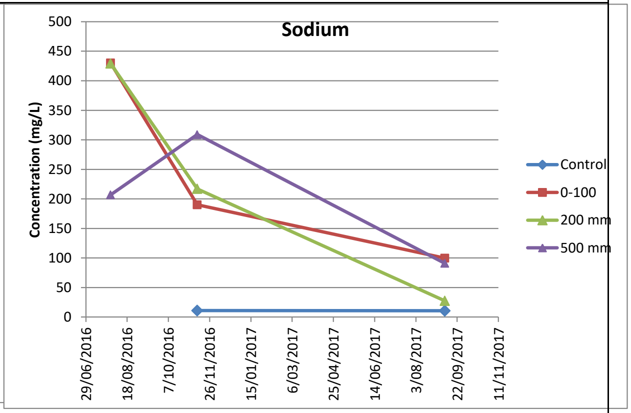

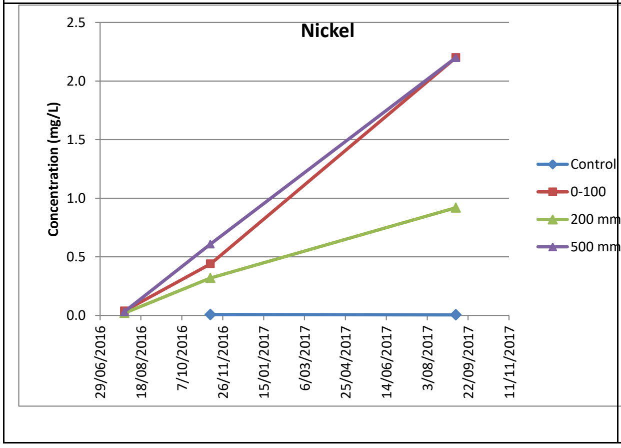

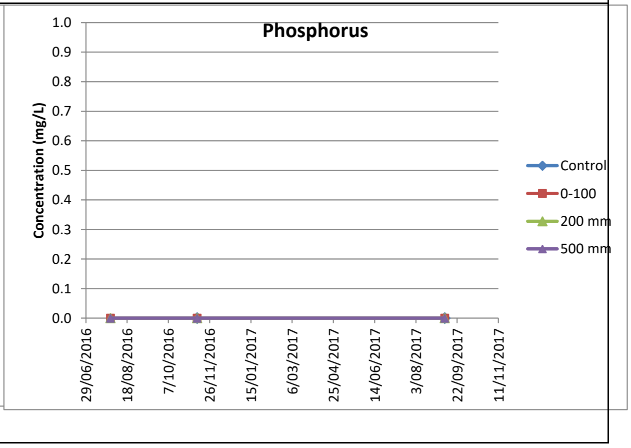

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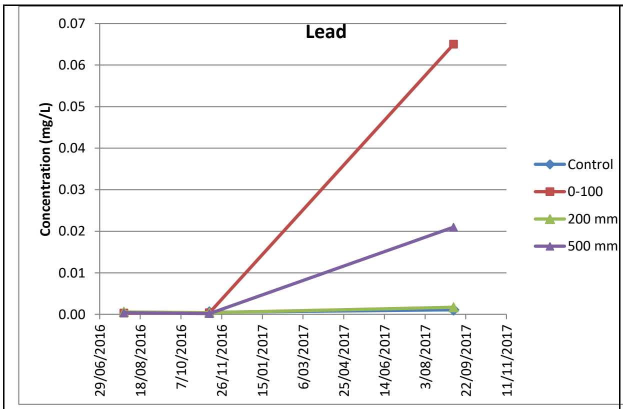

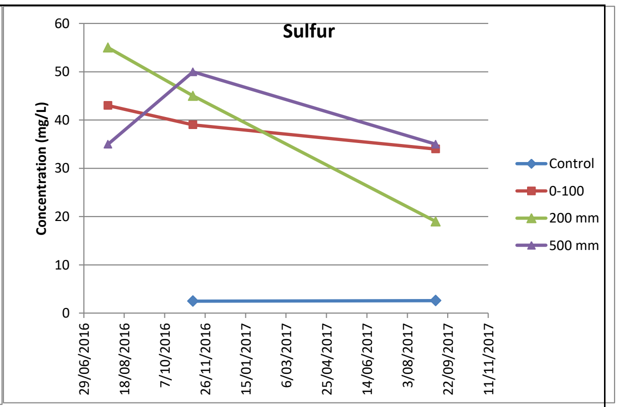

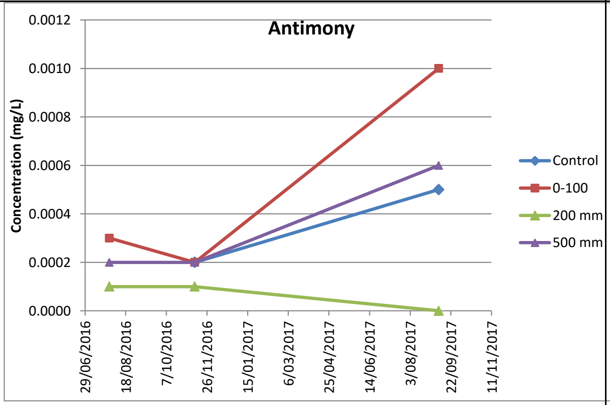

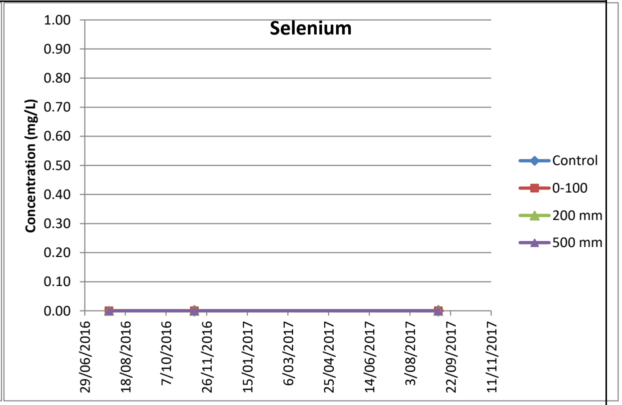

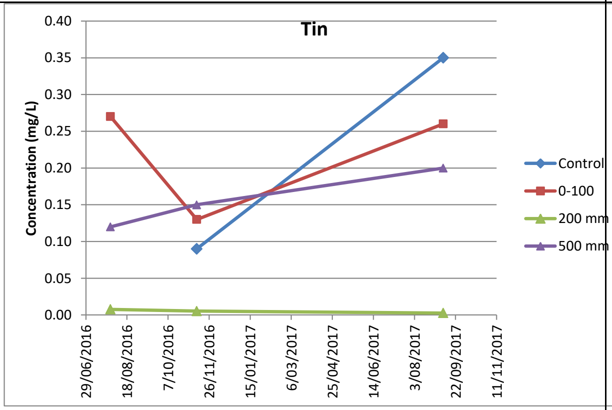

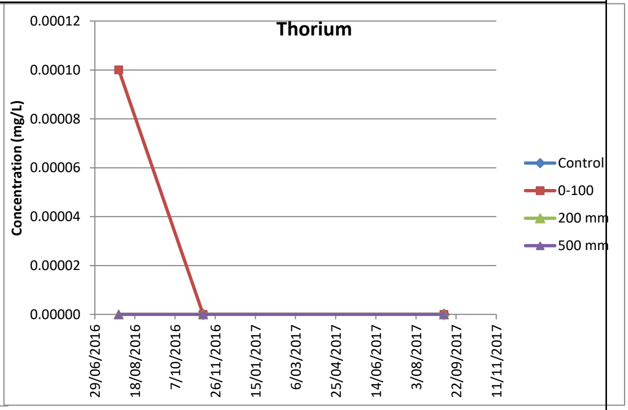

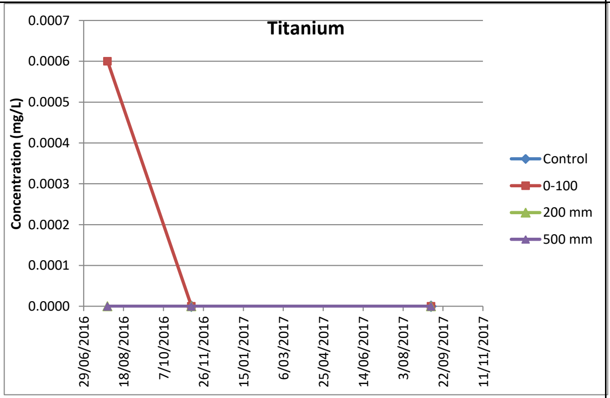

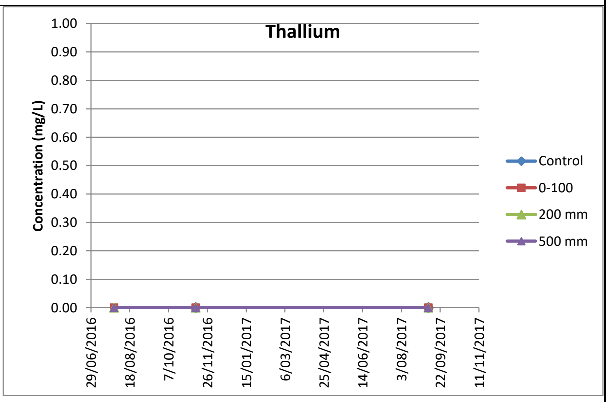

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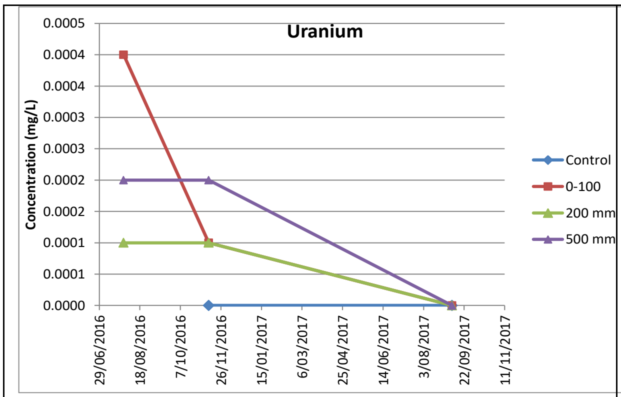
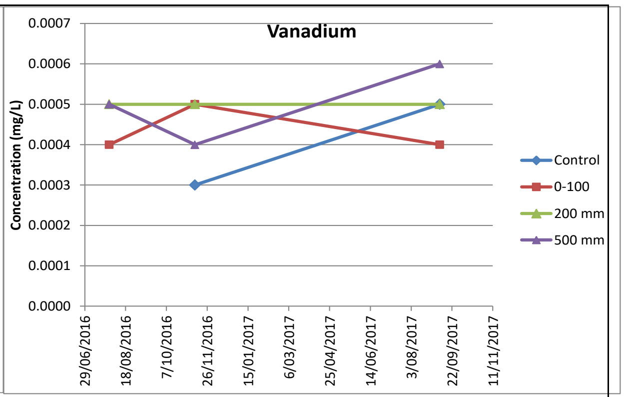
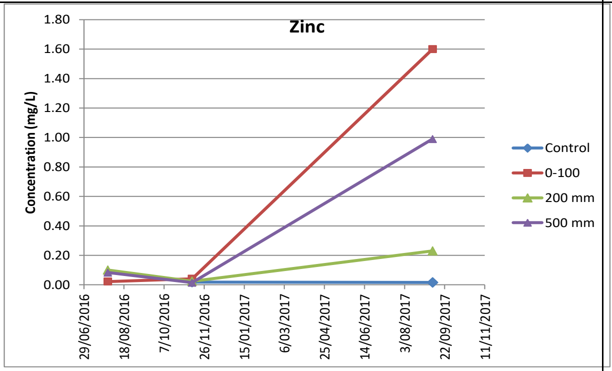
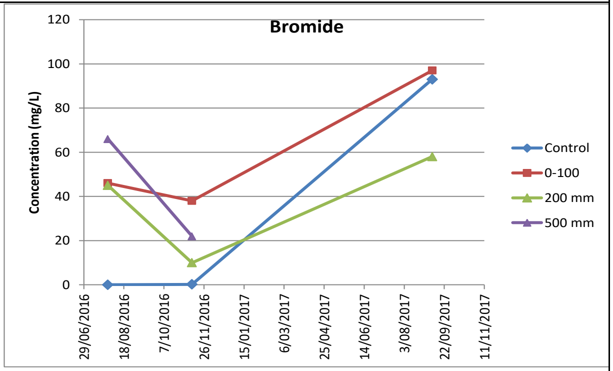
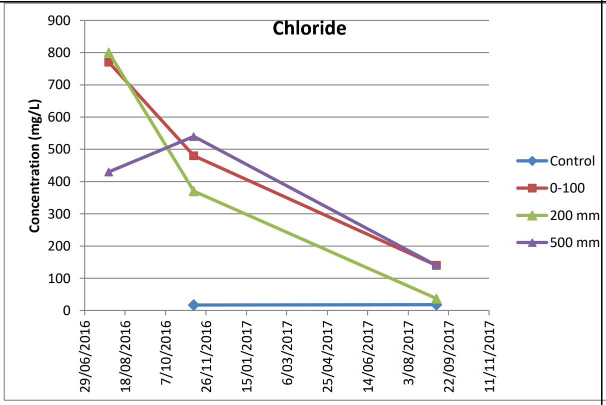
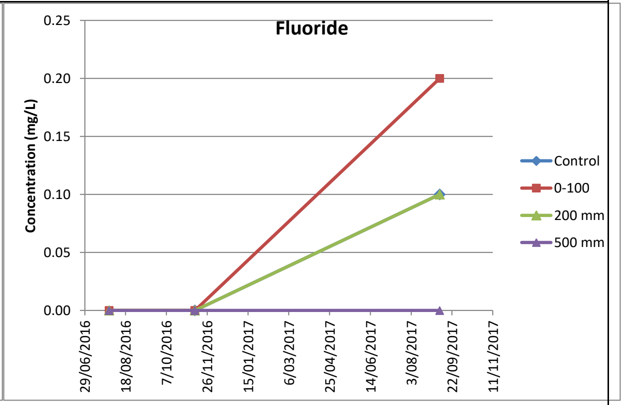


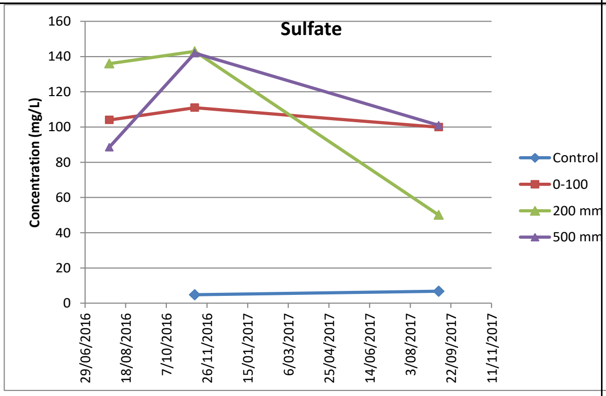


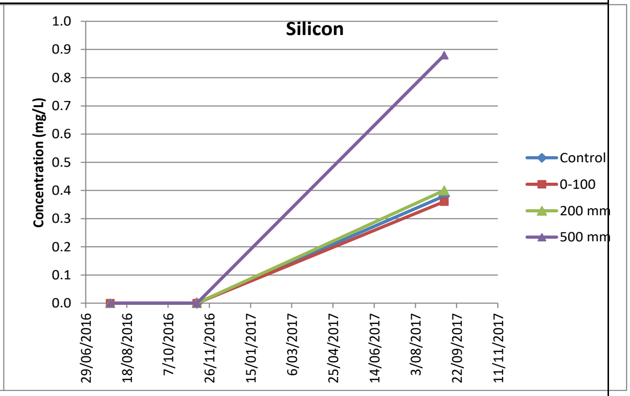








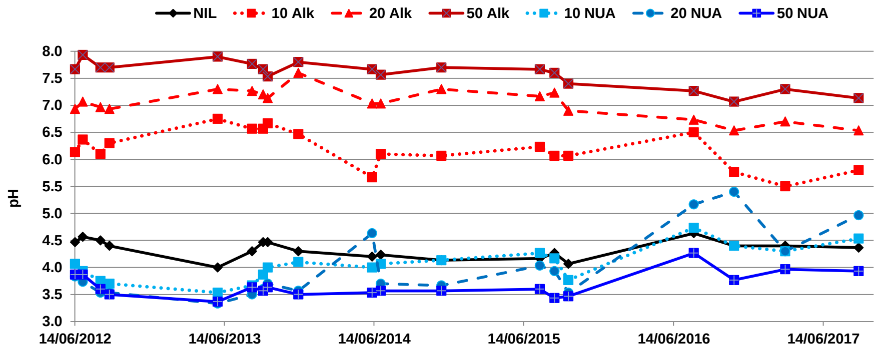




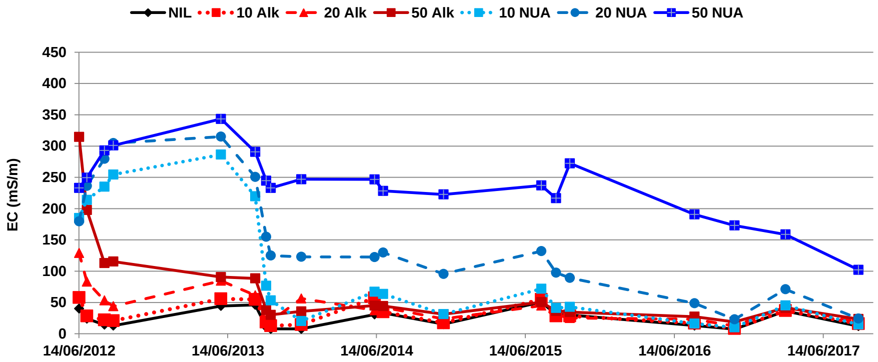
Fairbridge Duplex	Spearwood

Appendix A14: Ellen Brook Trial Data

pH



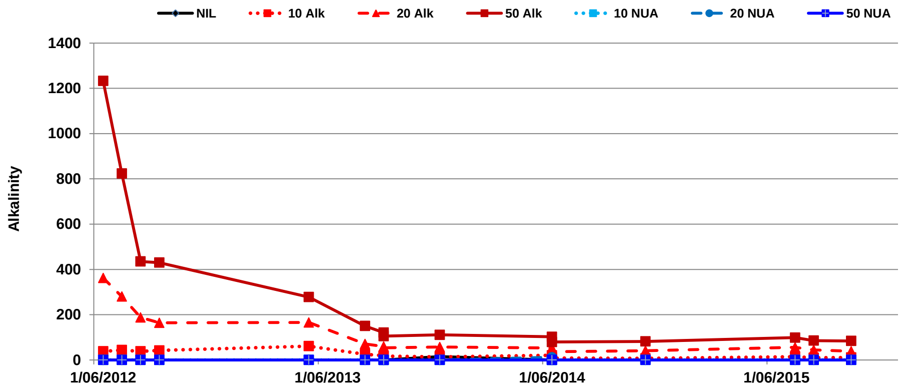
EC



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
17.3	19.8	17.2	16.9	18.7	17.7	16.6

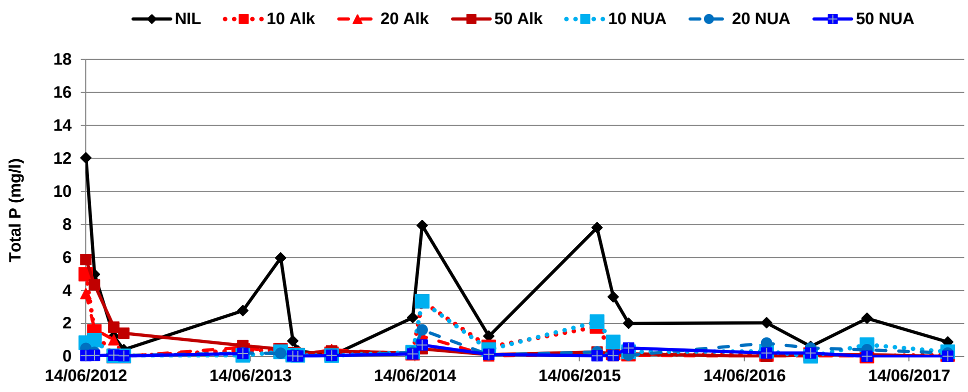
Alkalinity



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
< 1	3.00	< 1	3.00	3.00	3.00	4.33

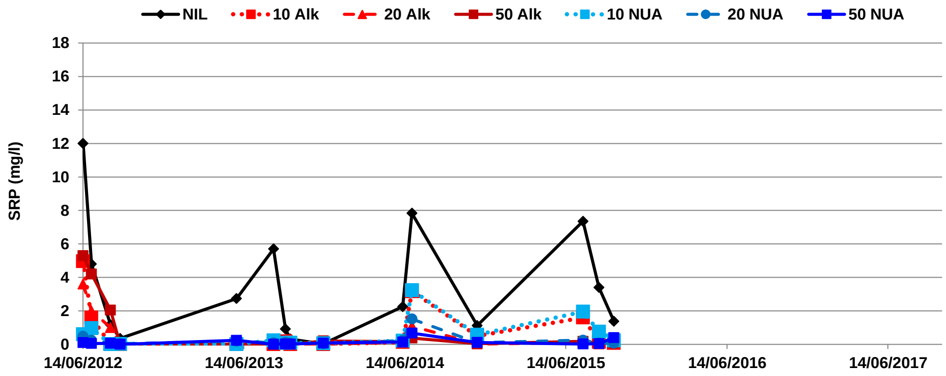
Total Phosphorus



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.25	0.36	0.40	0.24	0.25	0.41	0.61

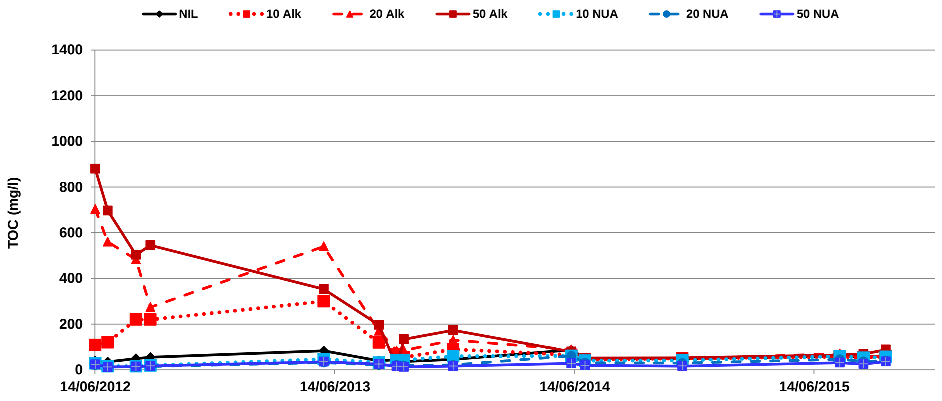
Soluble Reactive Phosphorus



Background values

NIL	10 Alk	20 Alk	50 Alk	0 NUA	20 NUA	50 NUA
0.19	0.31	0.32	0.16	0.14	0.37	0.27

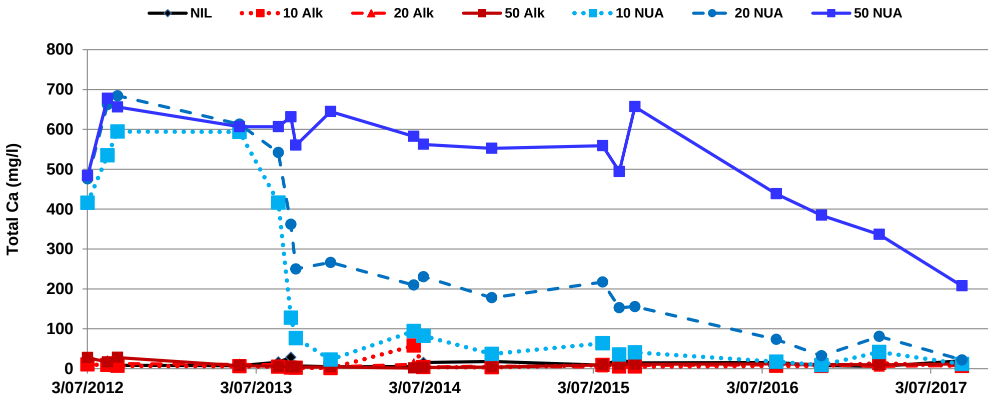
Total Organic Carbon



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
49	48	52.7	49.7	57.3	44.0	56.3

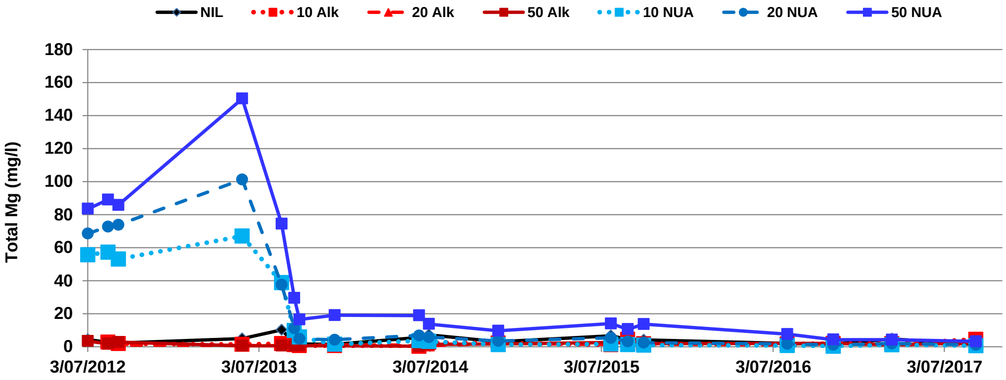
Calcium



Background values

NIL	10 Alk	20 Alk	50 Alk1	10 NUA	20 NUA	50 NUA
6.73	8.40	5.53	6.73	8.23	7.37	5.67

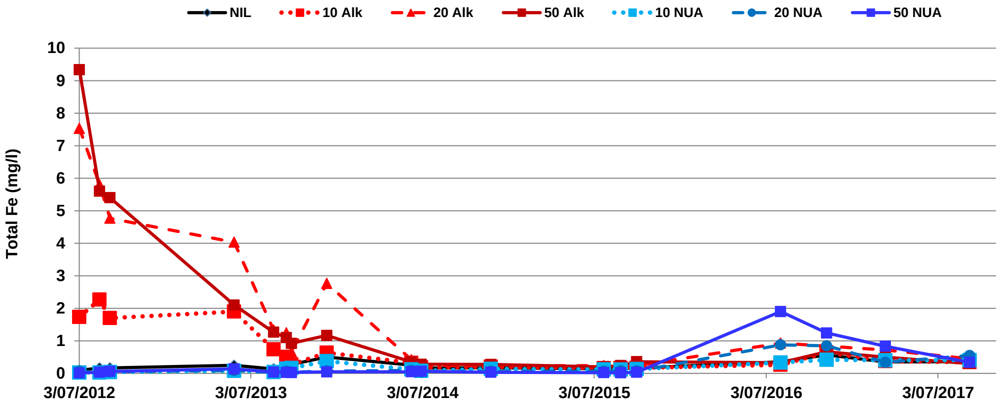
Magnesium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
2.00	2.93	1.33	255	2.40	1.93	1.90

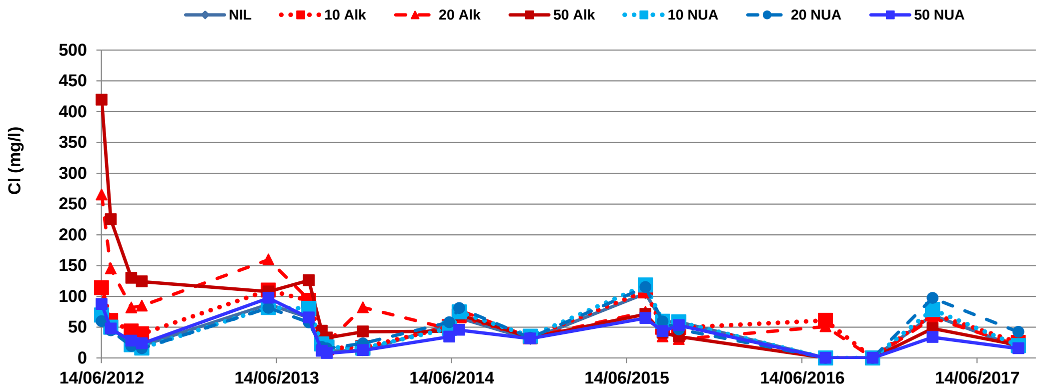
Iron



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.25	0.22	0.31	0.25	0.28	0.26	0.39

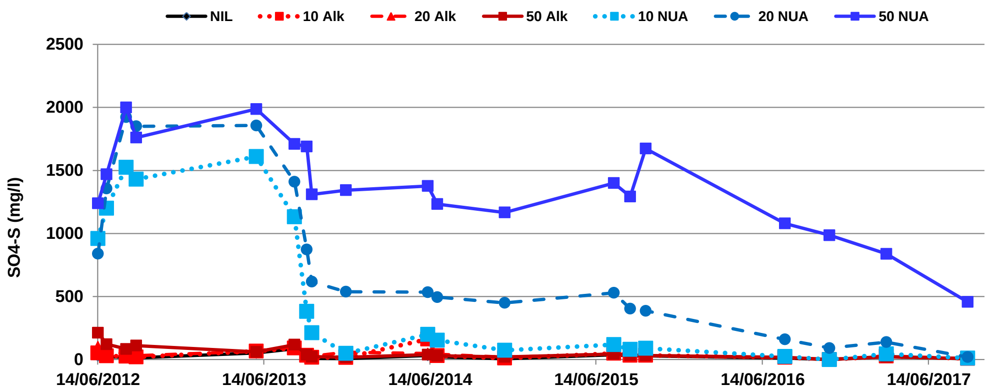
Chloride



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
32.3	39.0	32.7	32.0	37.7	34.7	32.3

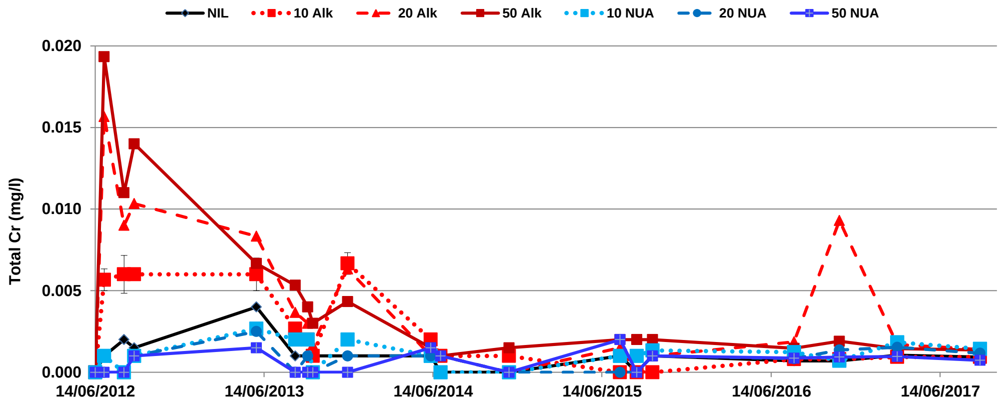
Sulfate



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
22.3	23.0	24.3	21.0	24.0	15.3	20.0

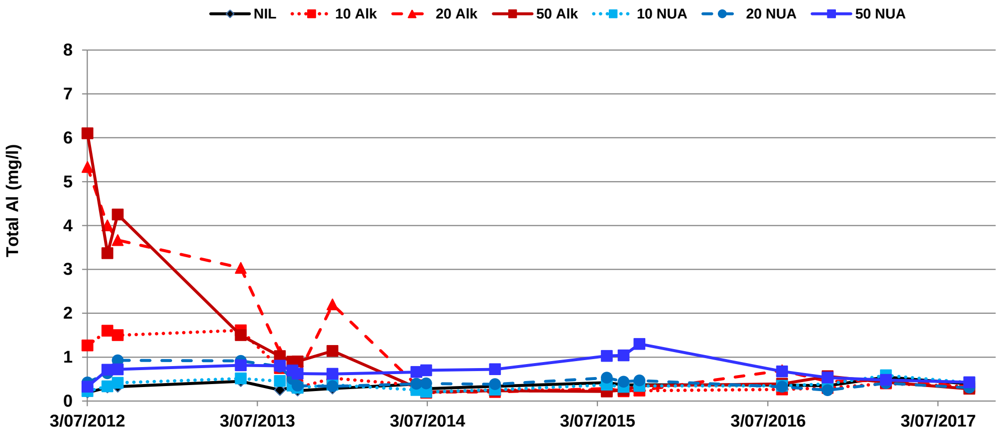
Chromium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.001	0.002	0.001	0.001	0.002	0.001	0.001

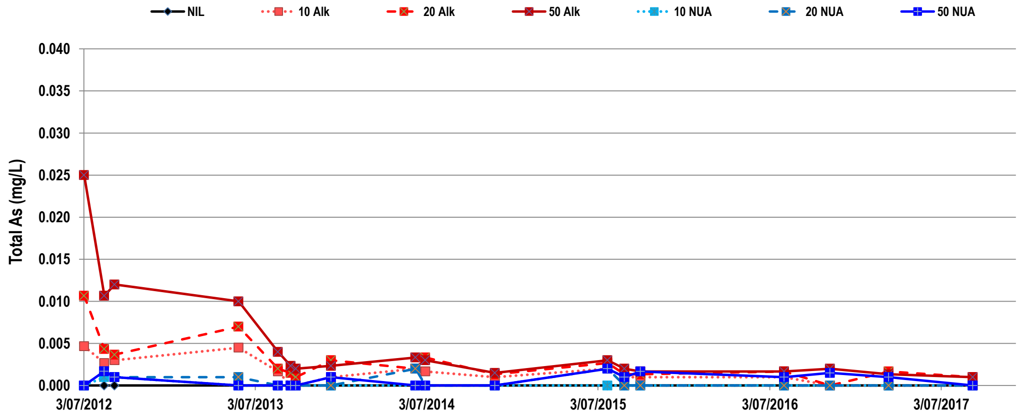
Aluminium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.42	0.32	0.39	0.43	0.41	0.32	0.54

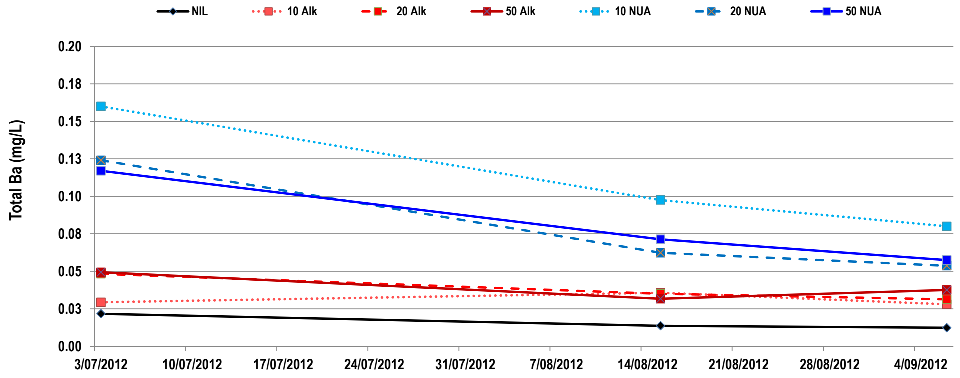
Arsenic



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

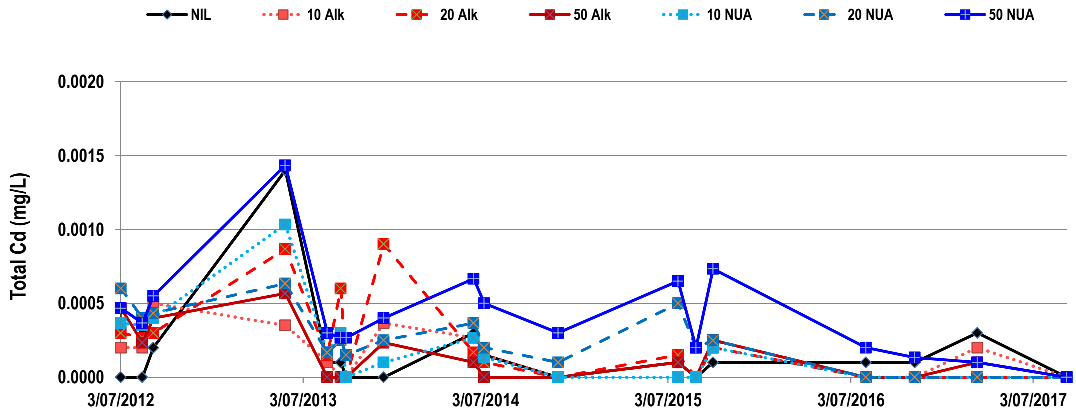
Barium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.01	0.02	0.01	0.01	0.02	0.01	0.01

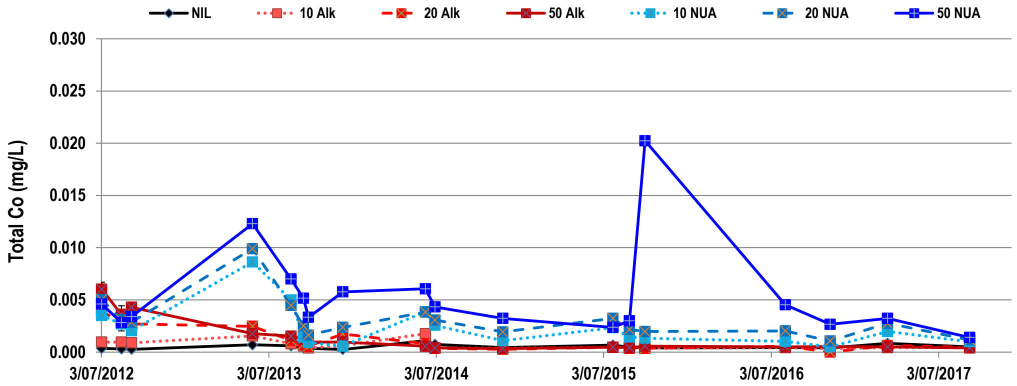
Cadmium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.0005	0.0001	<0.0001	0.0003	0.0004	0.0001	0.0005

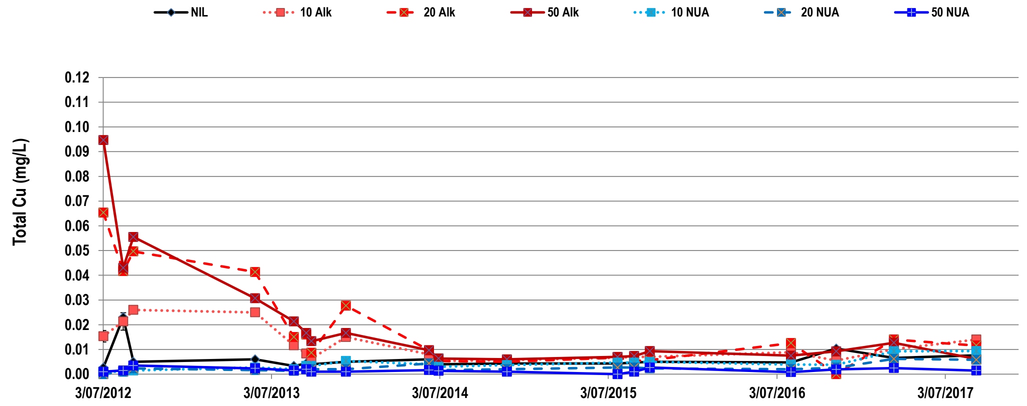
Cobalt



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.0005	0.0005	0.0005	0.0006	0.0006	0.0005	0.0006

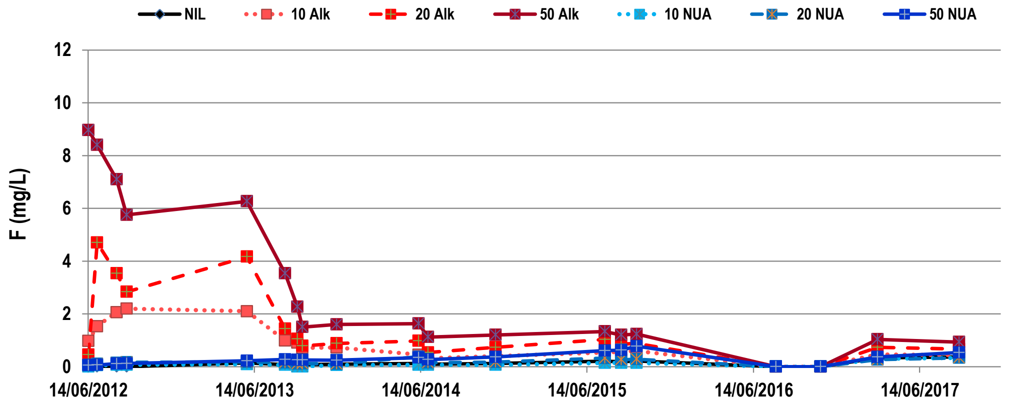
Copper



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.005	0.004	0.004	0.005	0.005	0.004	0.006

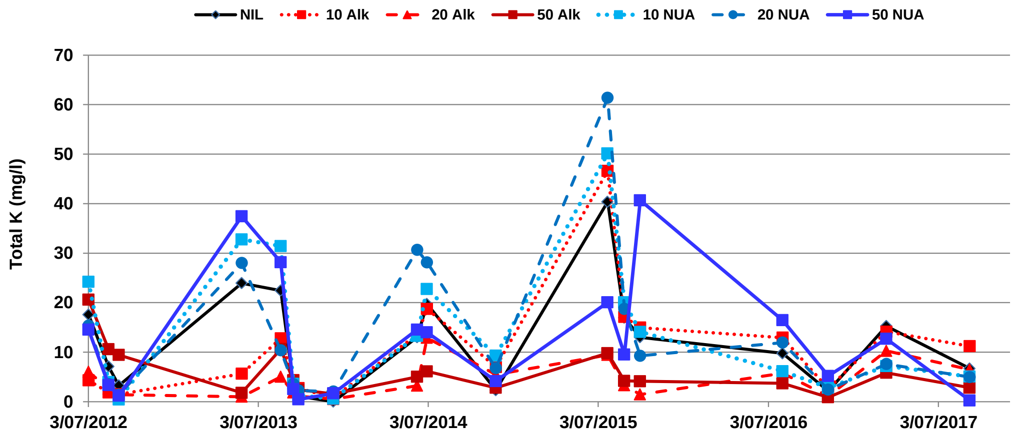
Fluoride



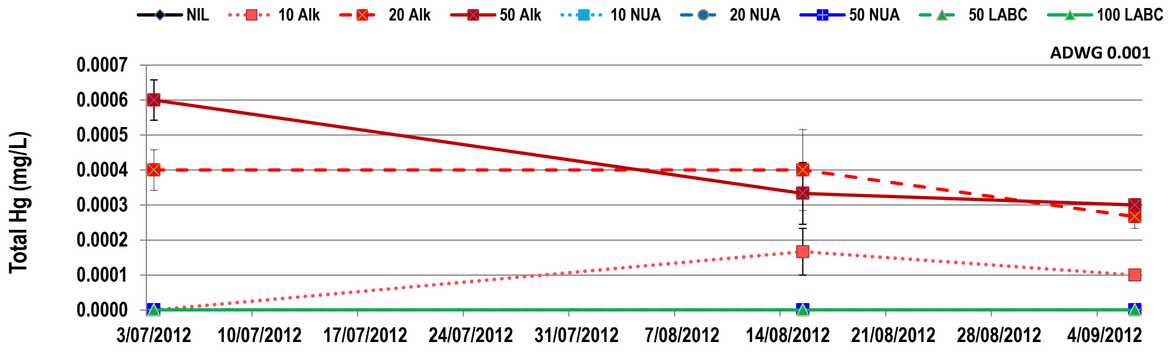
Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.20	0.15	0.15	0.08	<0.05	0.07	0.08

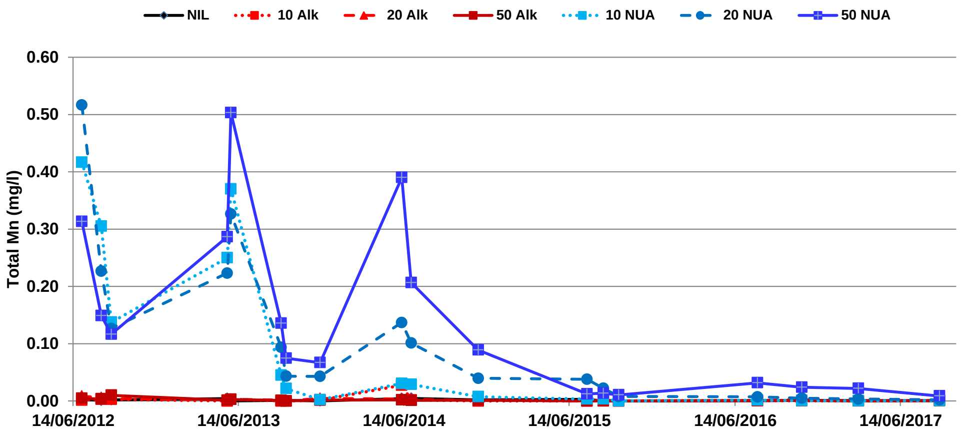
Potassium



Mercury



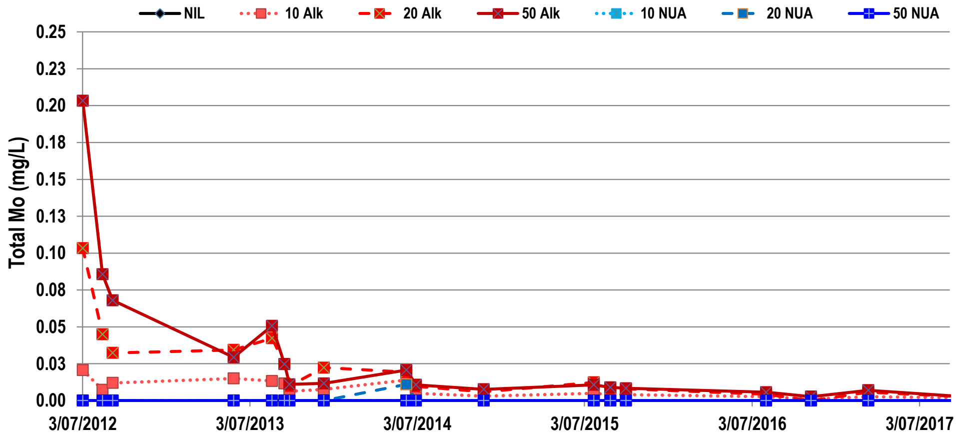
Manganese



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.003	0.002	0.002	0.004	0.004	0.002	0.004

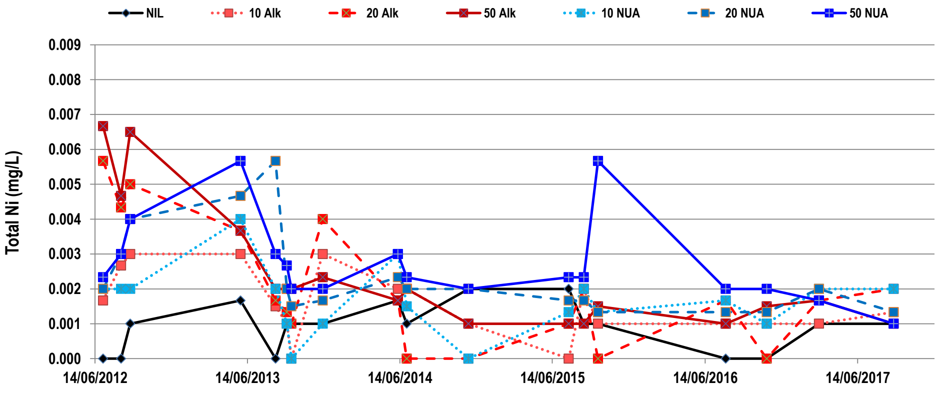
Molybdenum



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

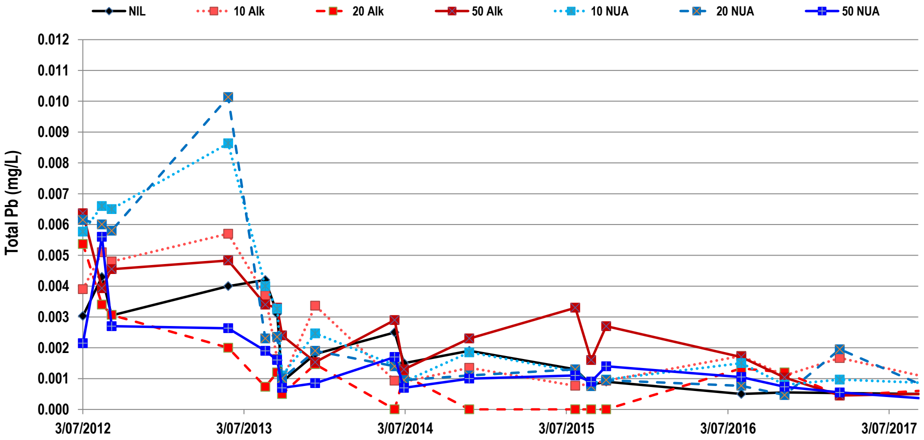
Nickel



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001

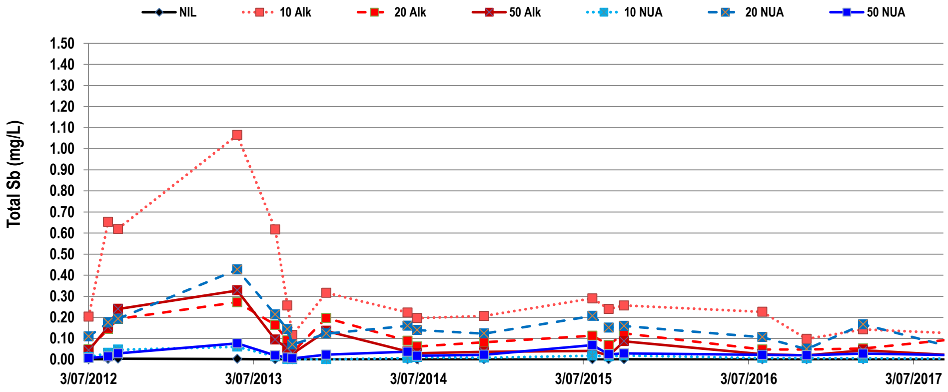
Lead



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.002	0.005	<0.0005	0.004	0.005	0.002	0.002

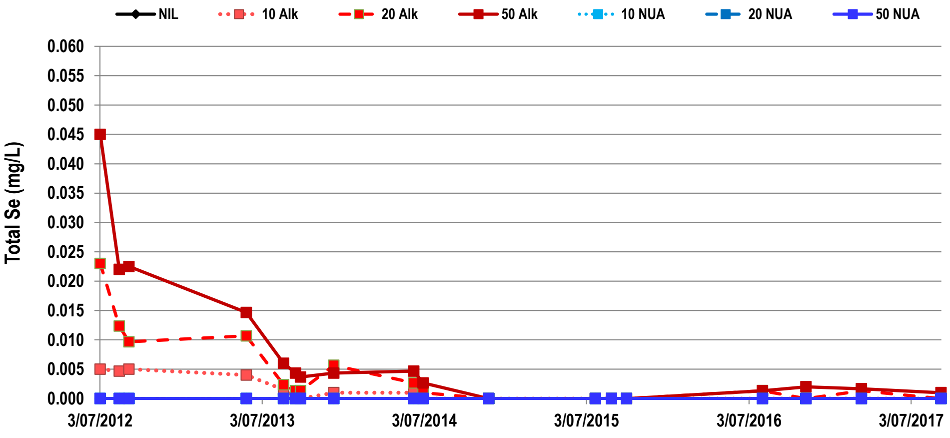
Antimony



Background value

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.001	0.06	0.03	0.002	0.001	0.09	0.004

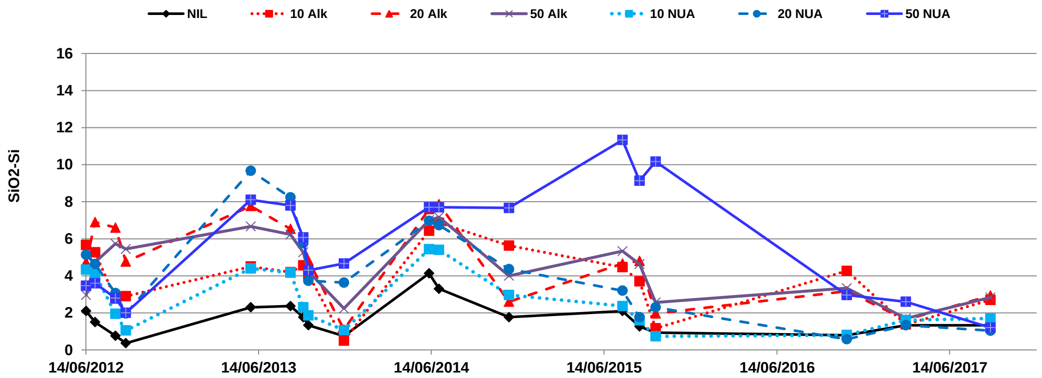
Selenium



Background value

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

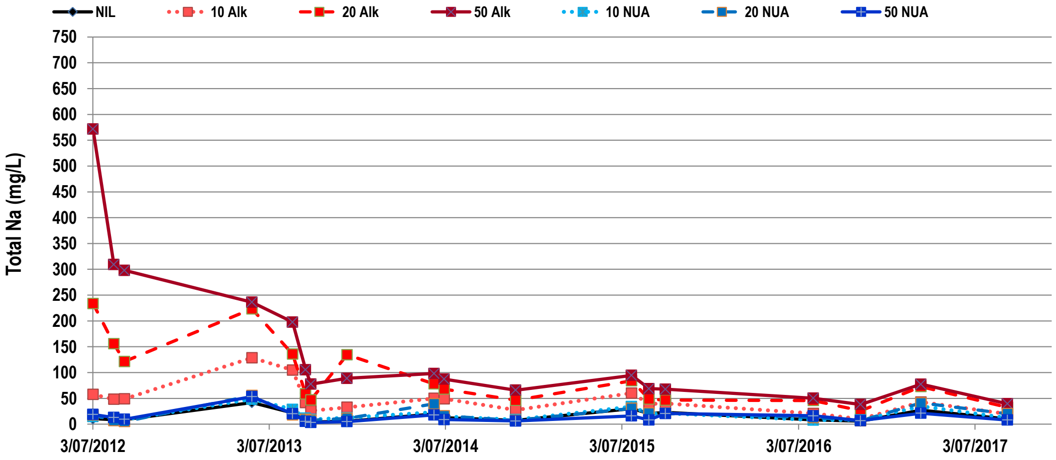
Silica



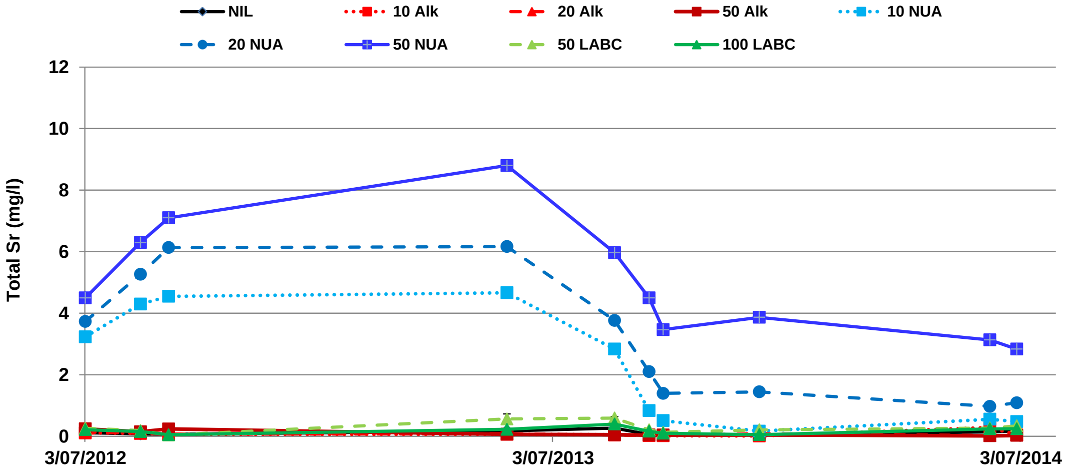
Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
2.57	3.03	2.33	3.17	2.77	2.23	2.93

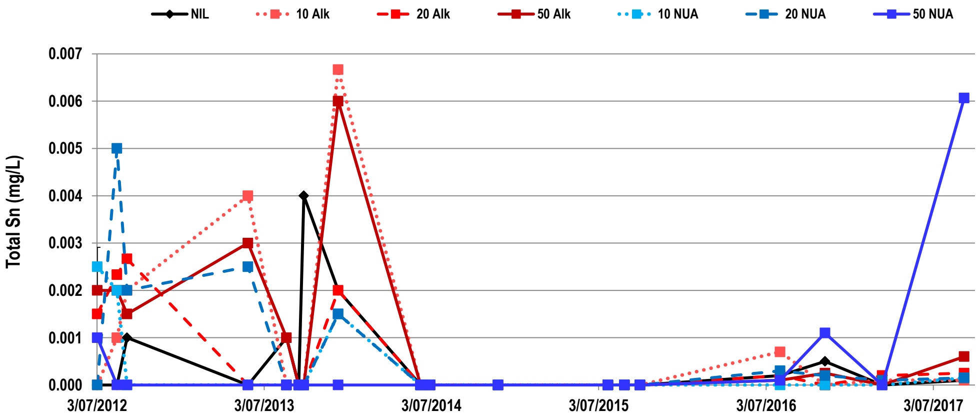
Sodium



Strontium



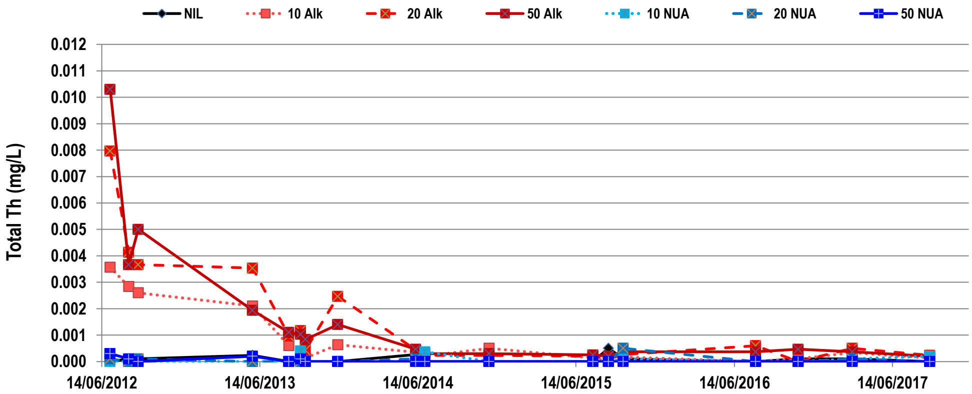
Tin



Background value

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

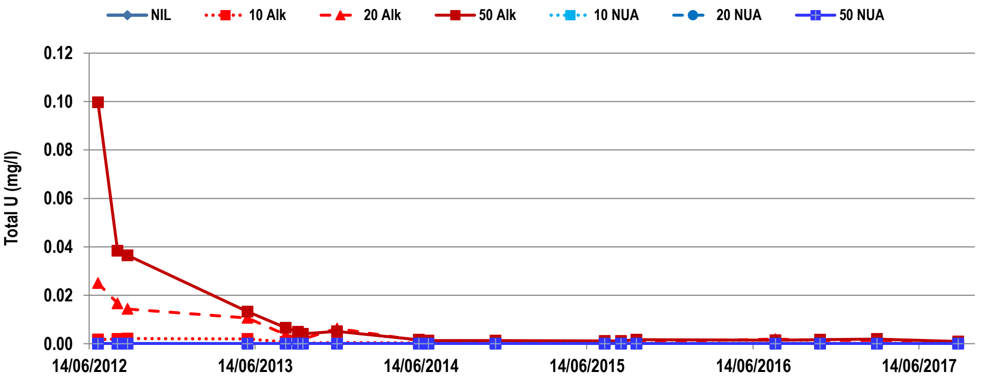
Thorium



Background value

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0003

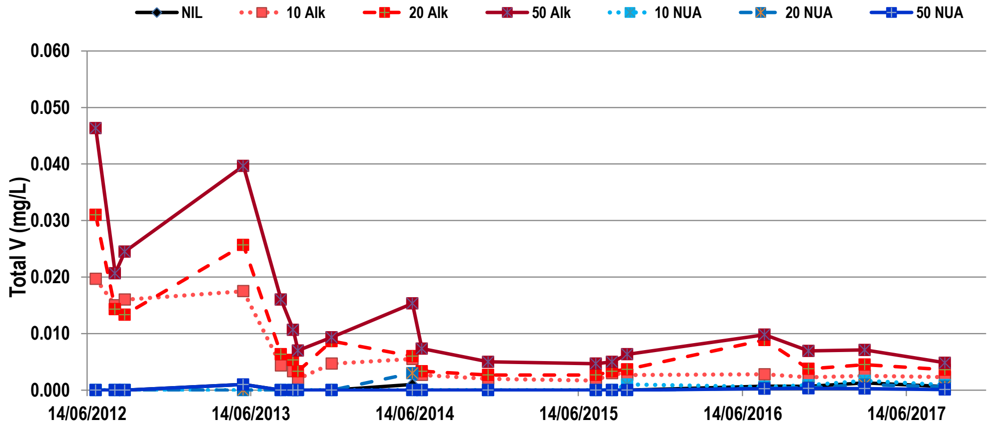
Uranium



Background values

NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

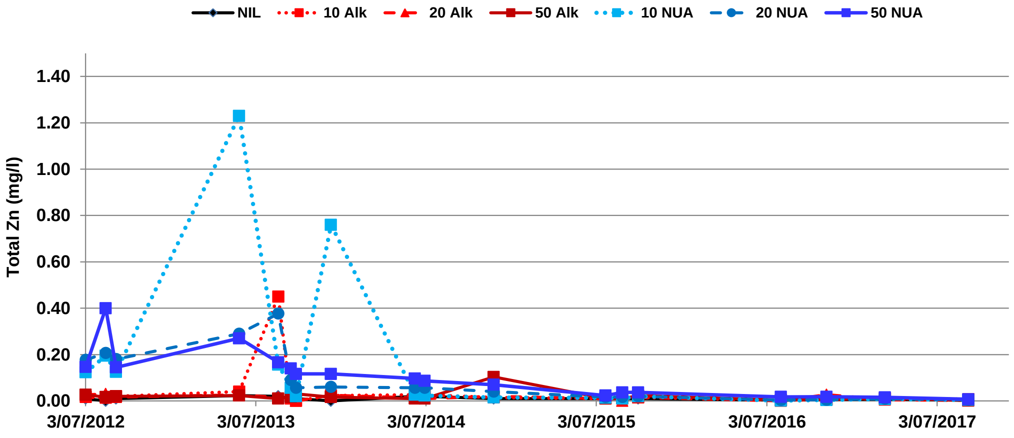
Vanadium



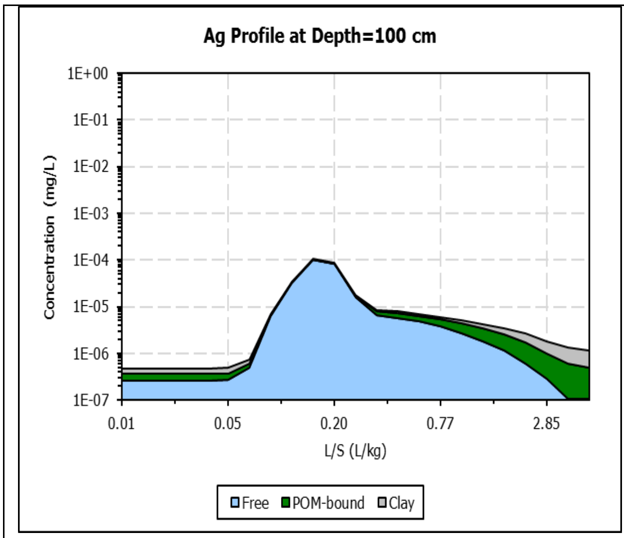
Background values

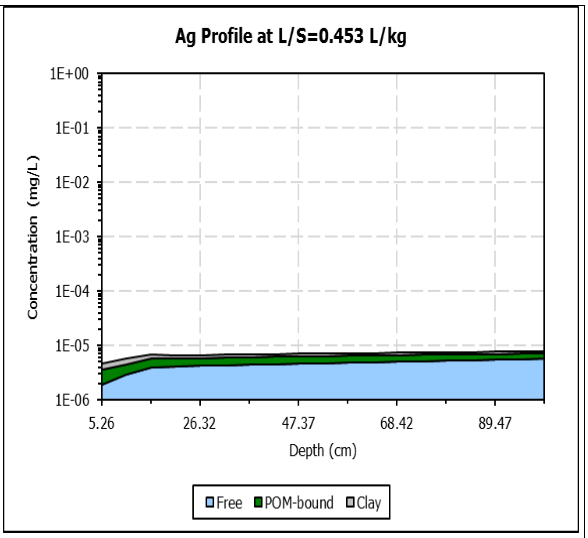
NIL	10 Alk	20 Alk	50 Alk	10 NUA	20 NUA	50 NUA
<0.001	<0.001	<0.001	<0.01	<0.001	<0.0701	<0.001

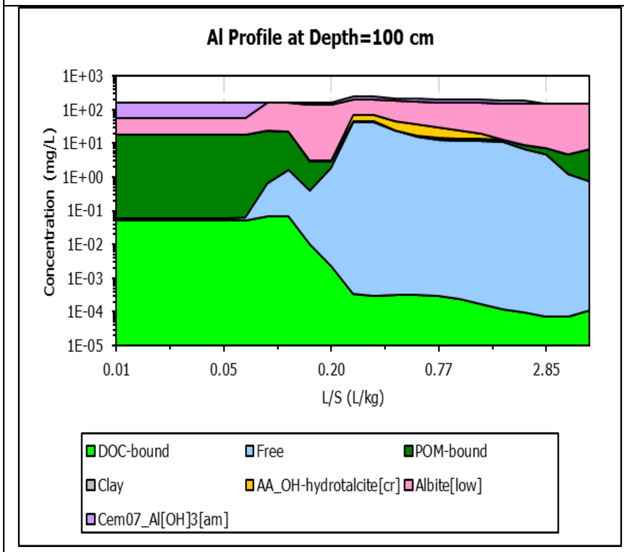
Zinc

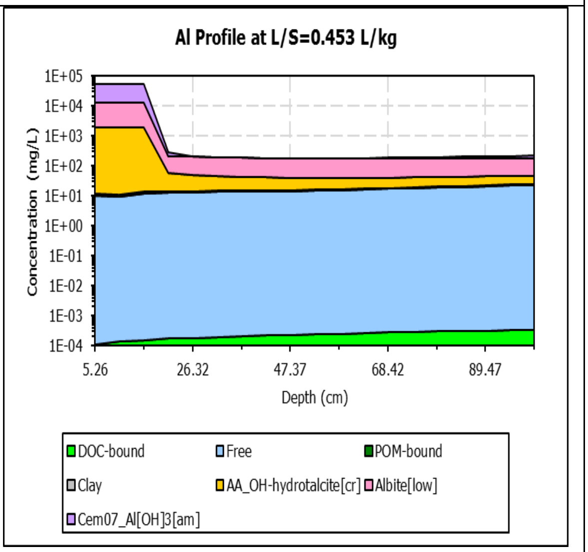


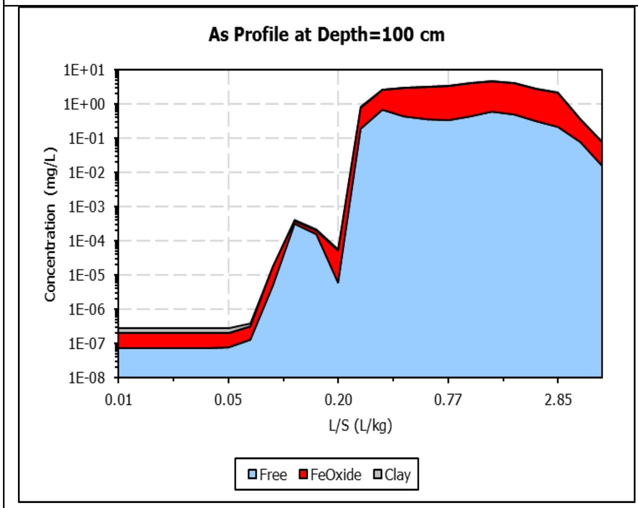
Appendix A15: LeachXS 20 Cell Model by Using 1st four Cells with Virtual material (5% Alkaloam and 95% Bassendean sand Ellenbrook) and 16 Cell with Bassendean Sand.

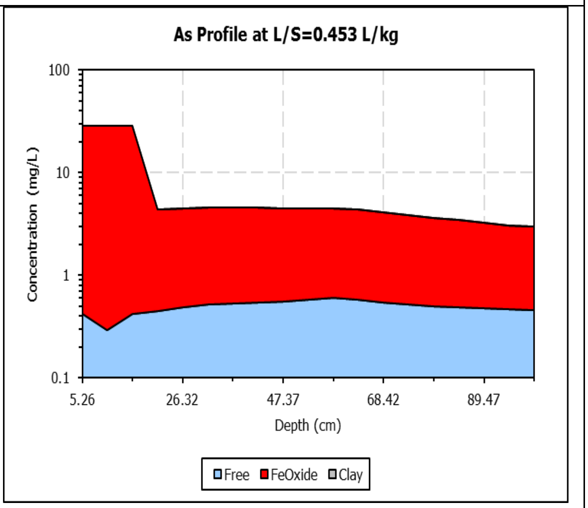

Ag Profile at Depth=100 cm

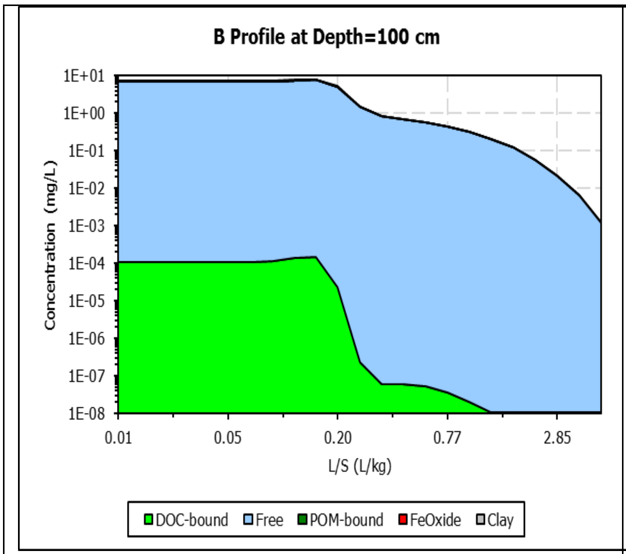

Ag Profile at L/S=0.453 L/kg

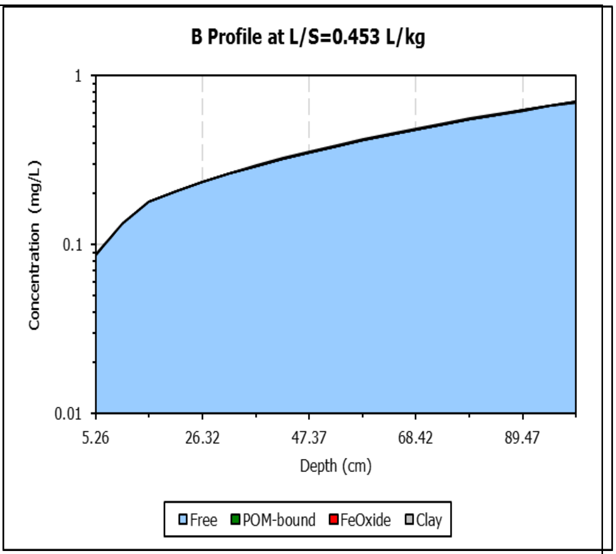

Al Profile at Depth=100 cm

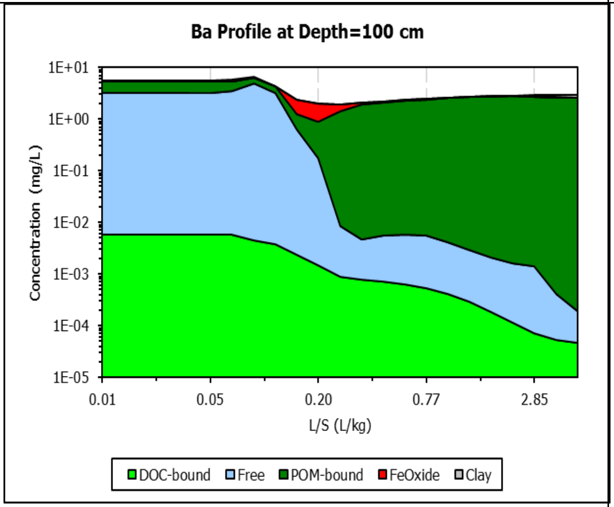

Al Profile at L/S=0.453 L/kg

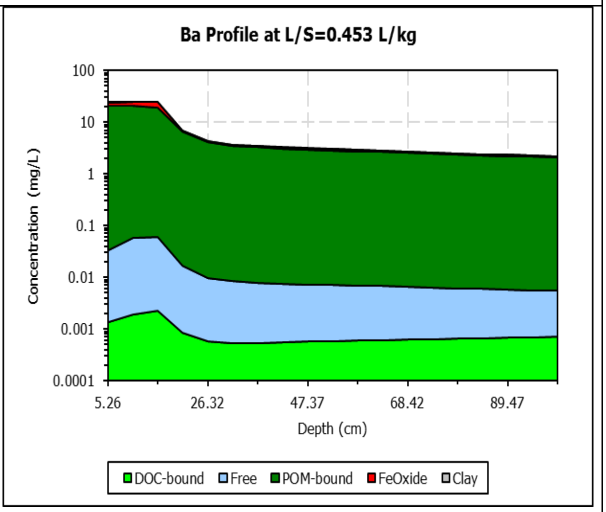

As Profile at Depth=100 cm

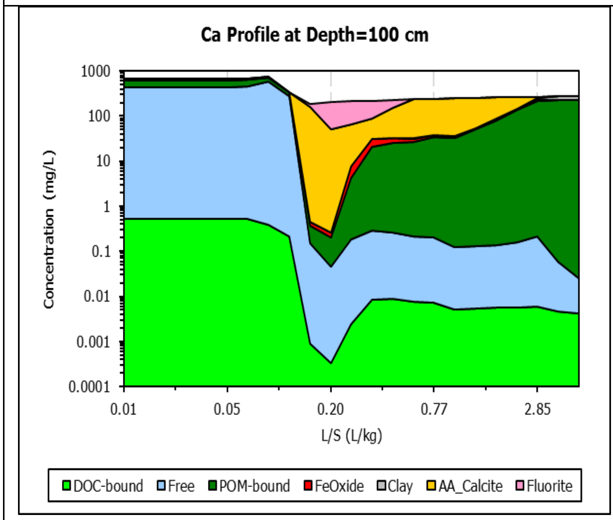

As Profile at L/S=0.453 L/kg

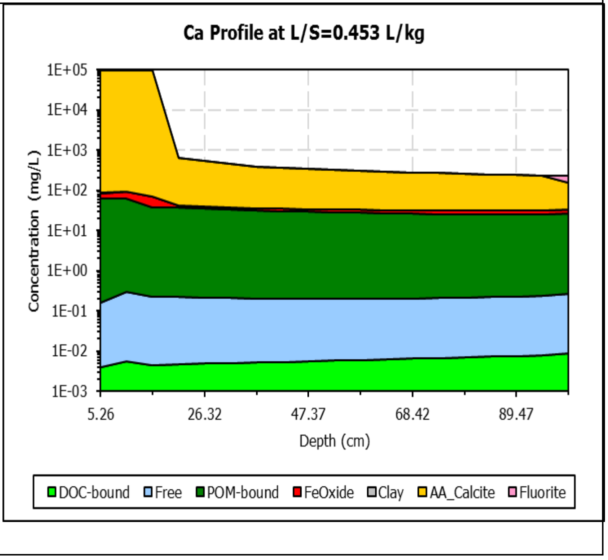

B Profile at Depth=100 cm

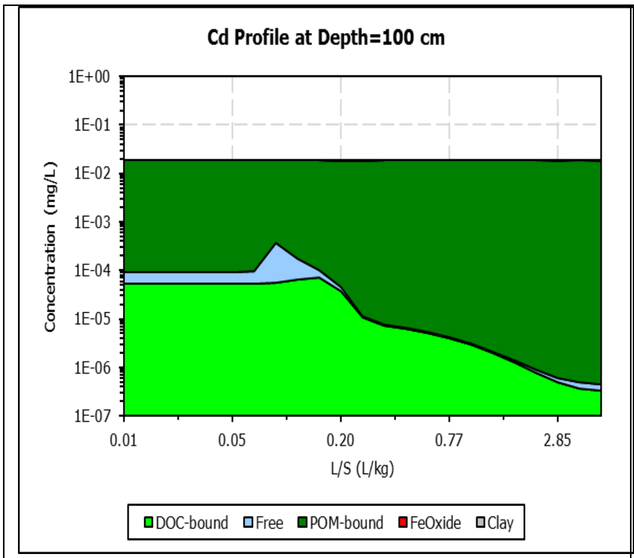

B Profile at L/S=0.453 L/kg

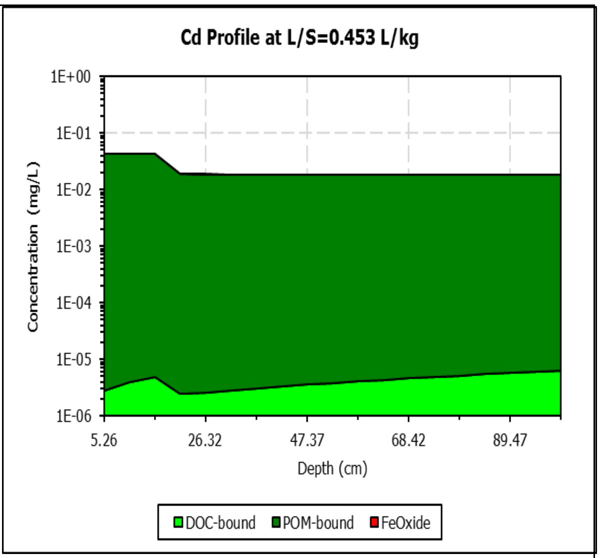

Ba Profile at Depth=100 cm

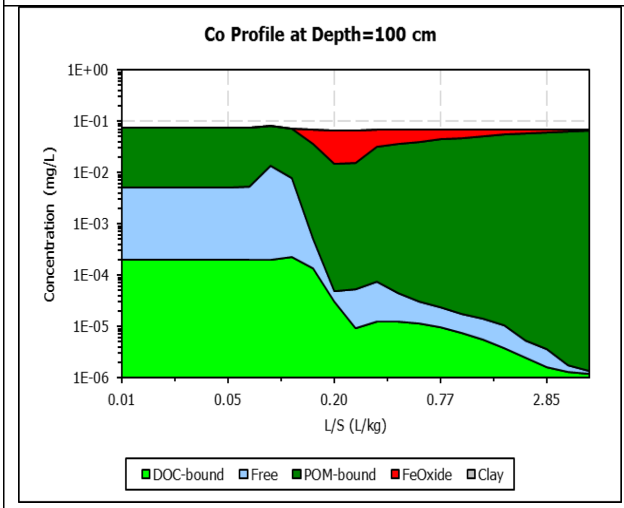

Ba Profile at L/S=0.453 L/kg

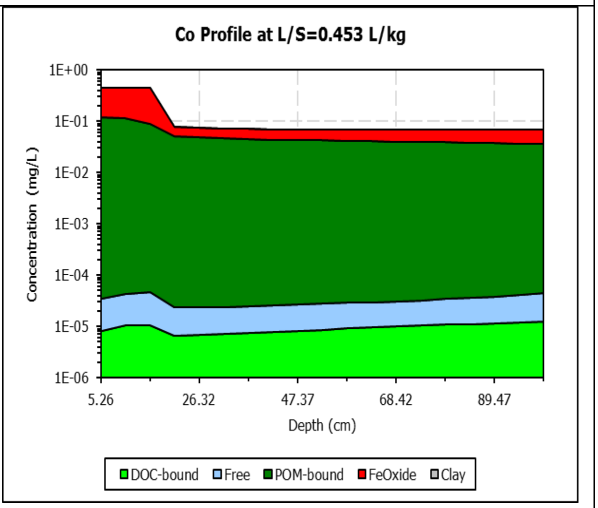

Ca Profile at Depth=100 cm

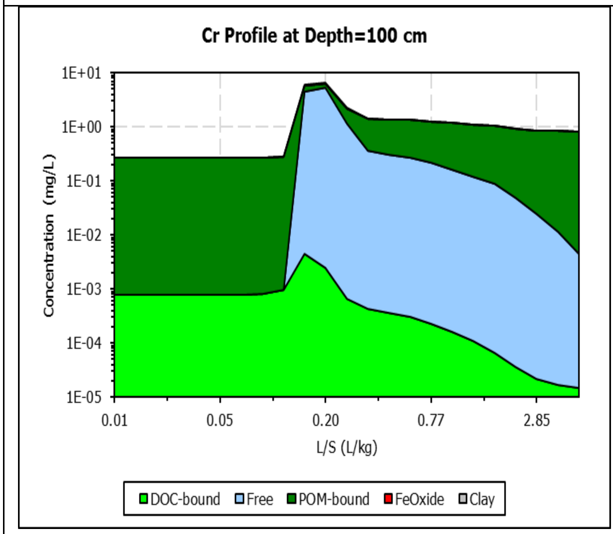

Ca Profile at L/S=0.453 L/kg

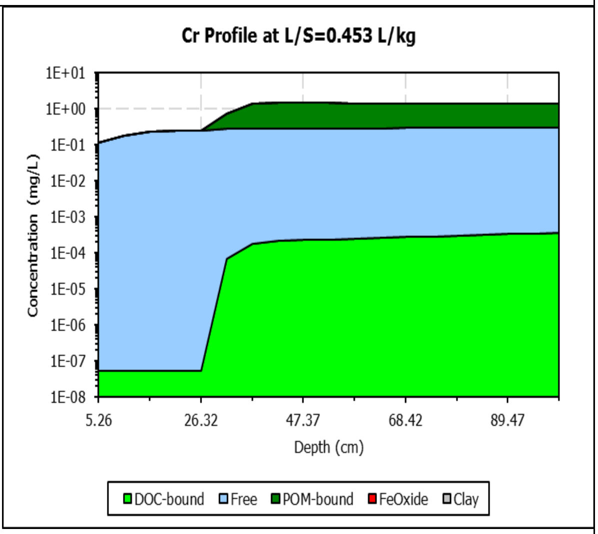

Cd Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

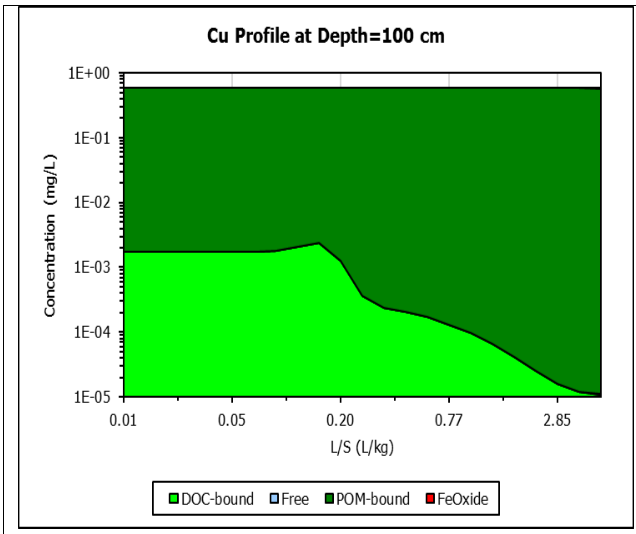

Cd Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
POM-bound
FeOxide

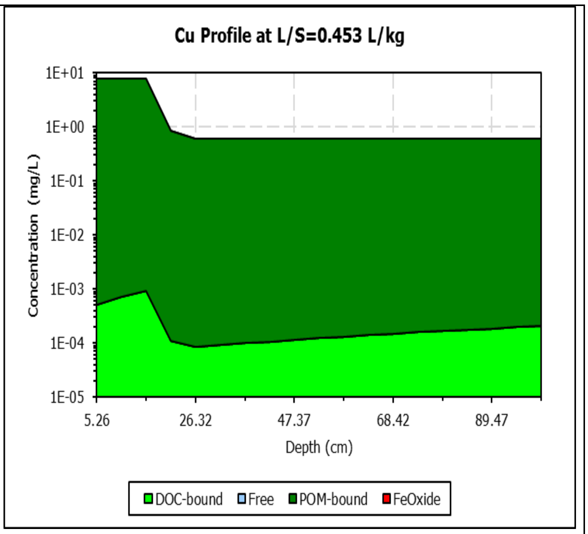

Co Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

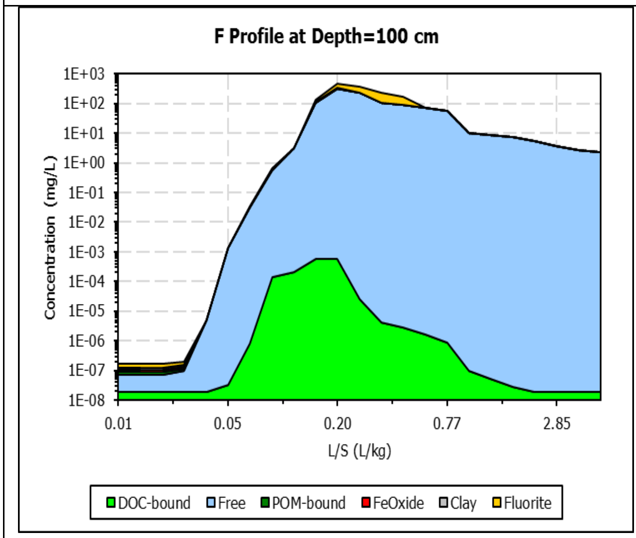

Co Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

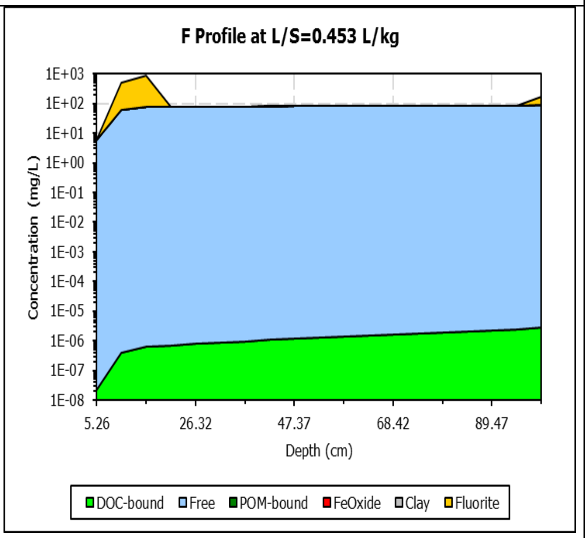

Cr Profile at Depth=100 cm
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

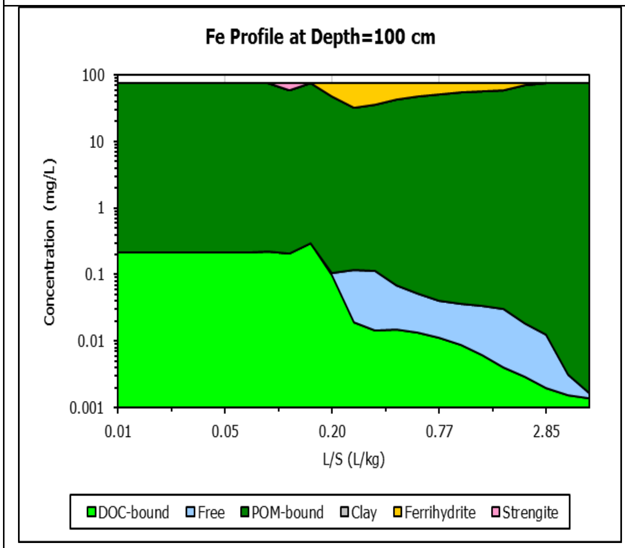

Cr Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

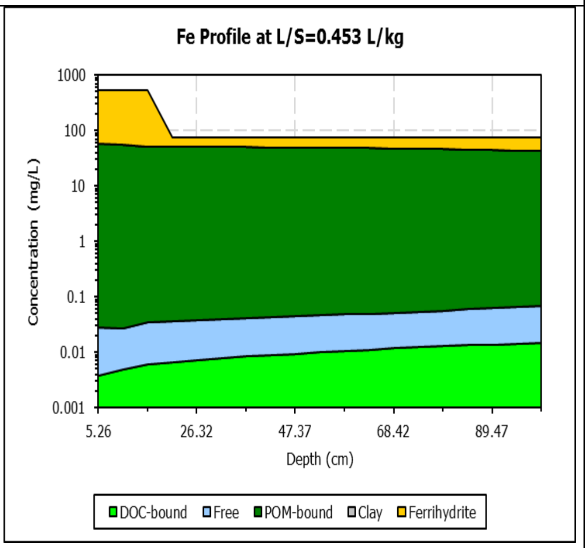

Cu Profile at Depth=100 cm

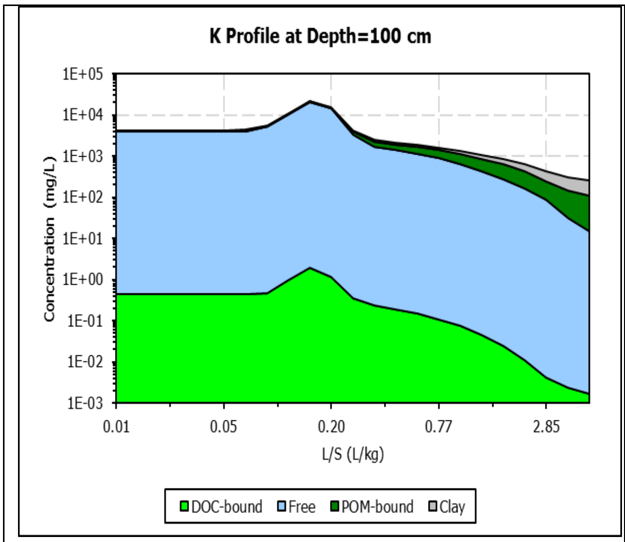

Cu Profile at L/S=0.453 L/kg

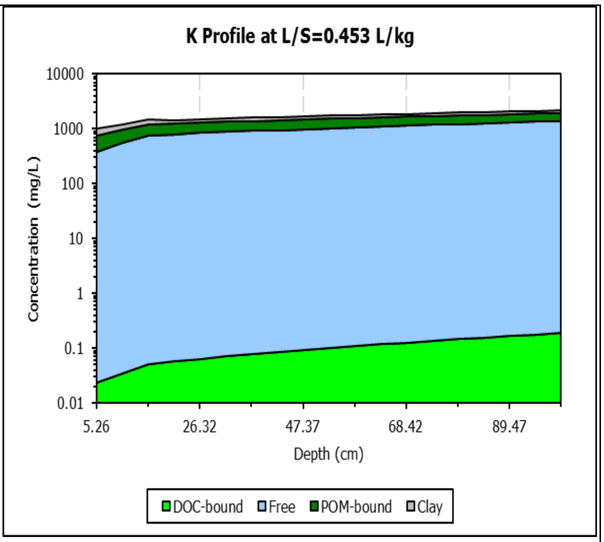

F Profile at Depth=100 cm

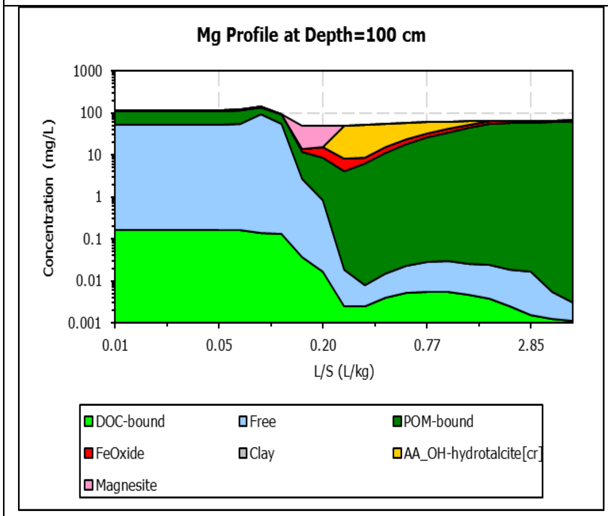

F Profile at L/S=0.453 L/kg

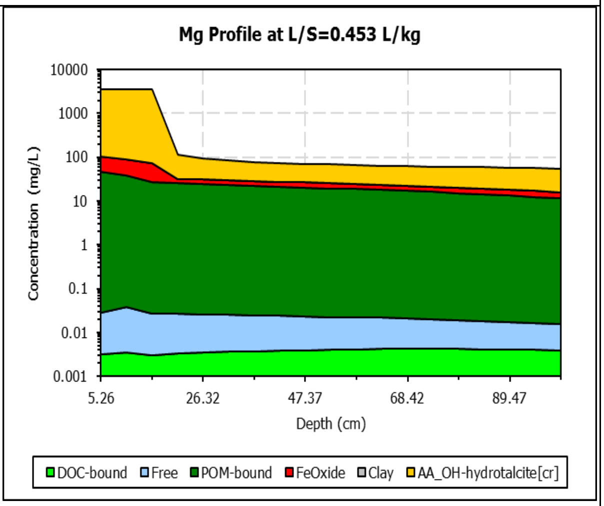

Fe Profile at Depth=100 cm

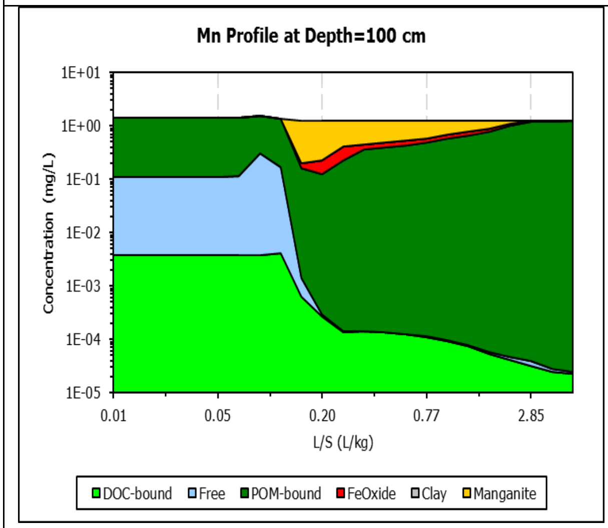

Fe Profile at L/S=0.453 L/kg

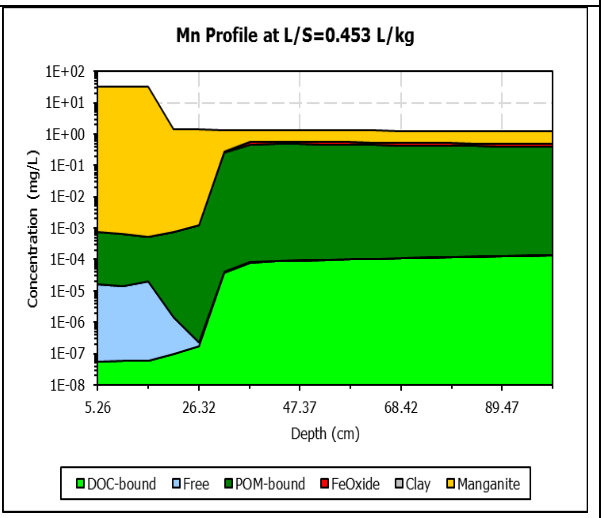

K Profile at Depth=100 cm

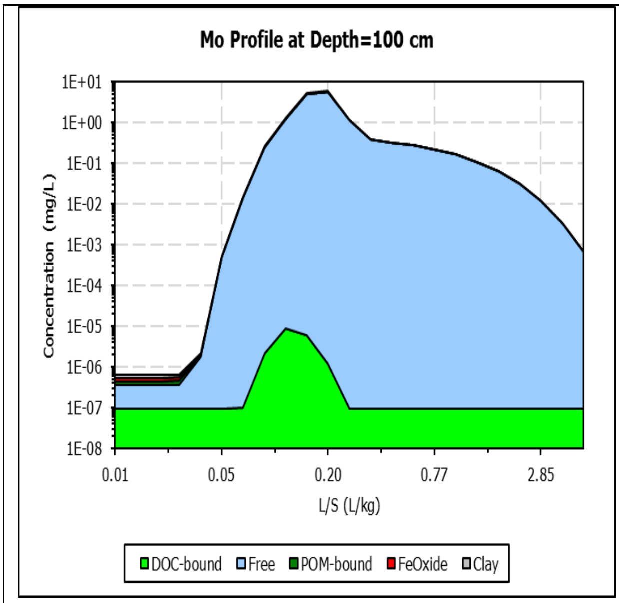

K Profile at L/S=0.453 L/kg

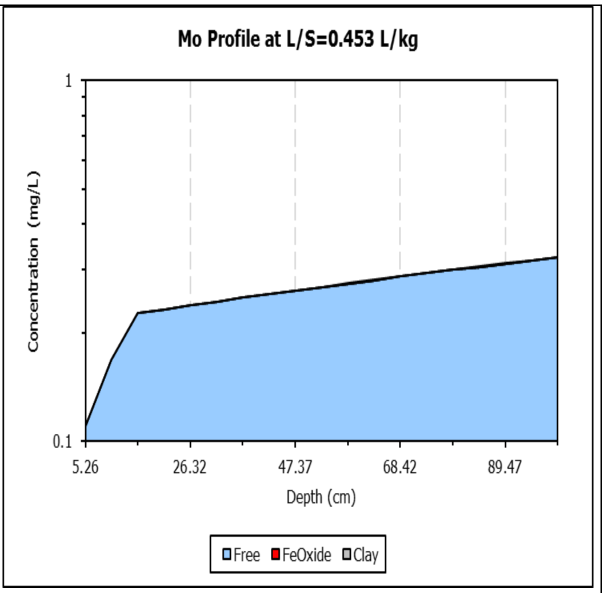

Mg Profile at Depth=100 cm

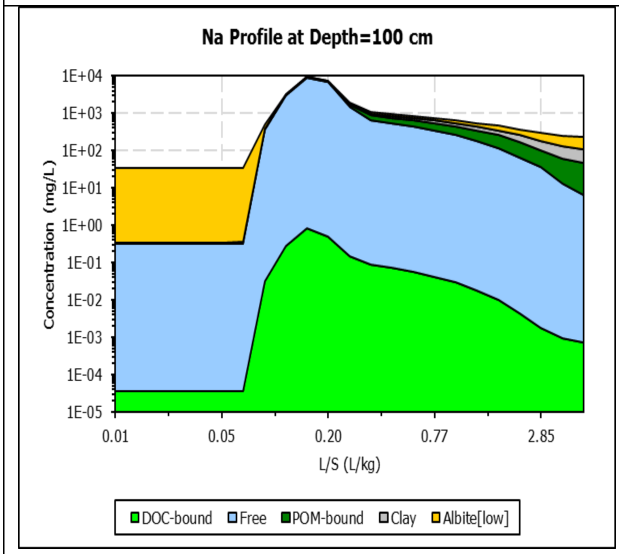

Mg Profile at L/S=0.453 L/kg

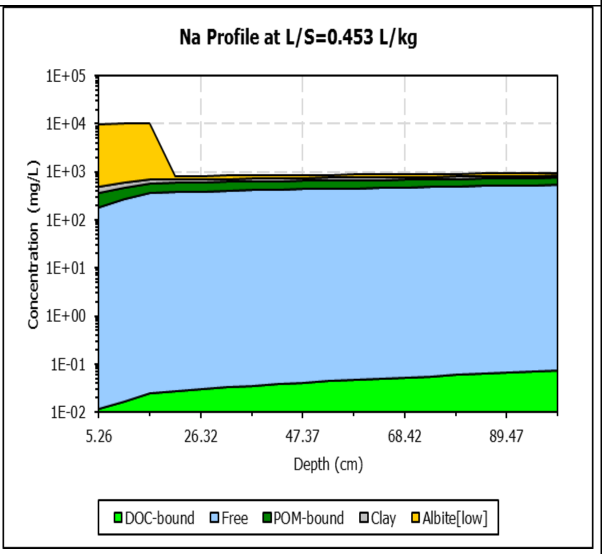

Mn Profile at Depth=100 cm

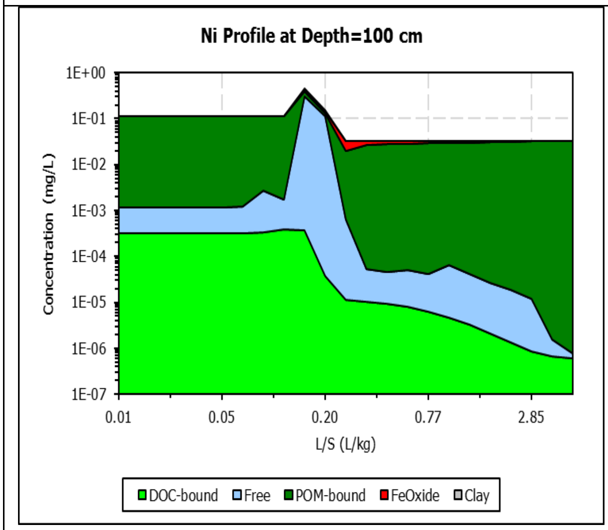

Mn Profile at L/S=0.453 L/kg

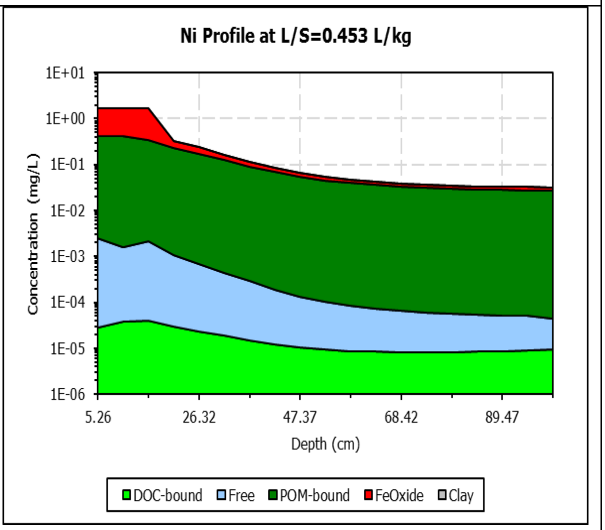

Mo Profile at Depth=100 cm
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

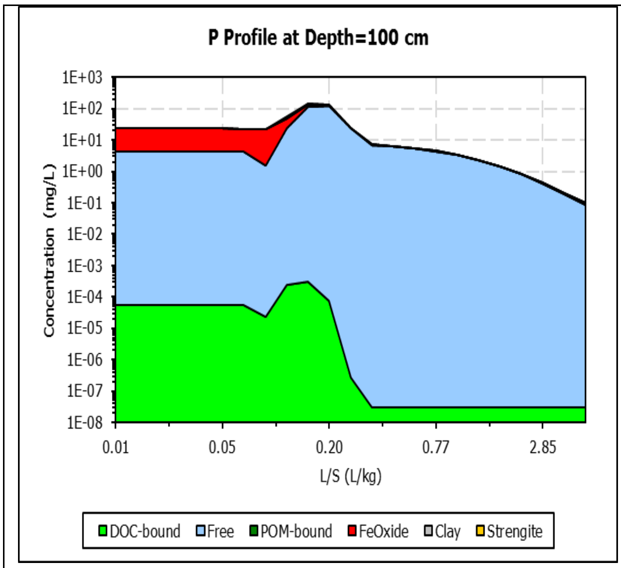

Mo Profile at L/S=0.453 L/kg
Concentration (mg/L)
1
0.1
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
FeOxide
Clay

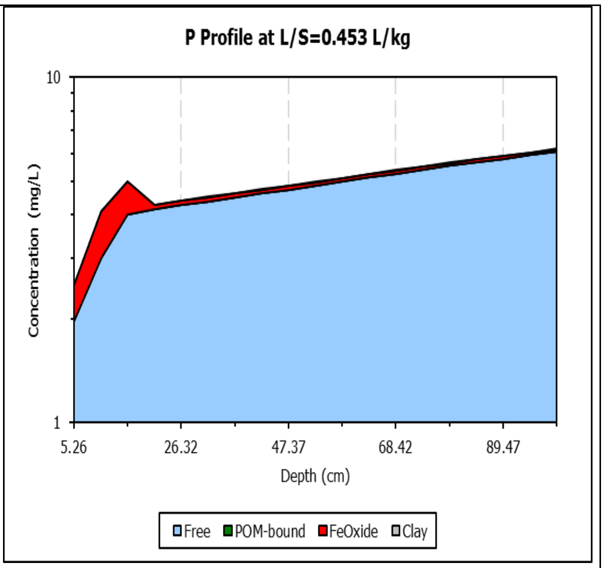

Na Profile at Depth=100 cm
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay
Albite[low]

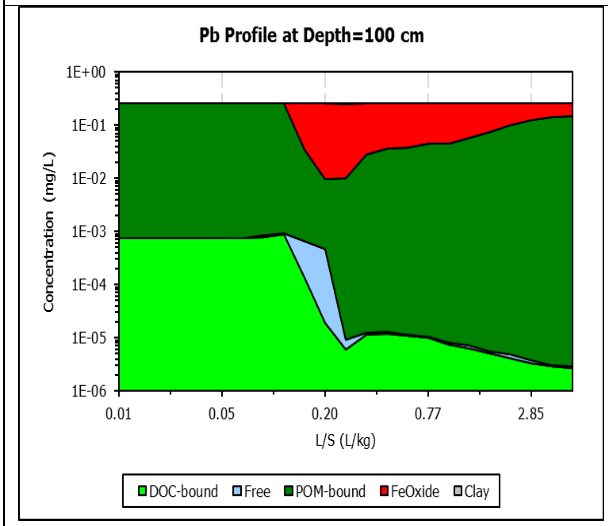

Na Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
Clay
Albite[low]

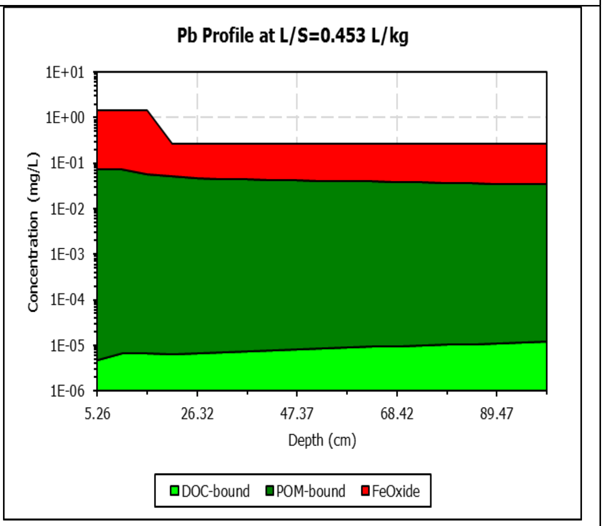

Ni Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

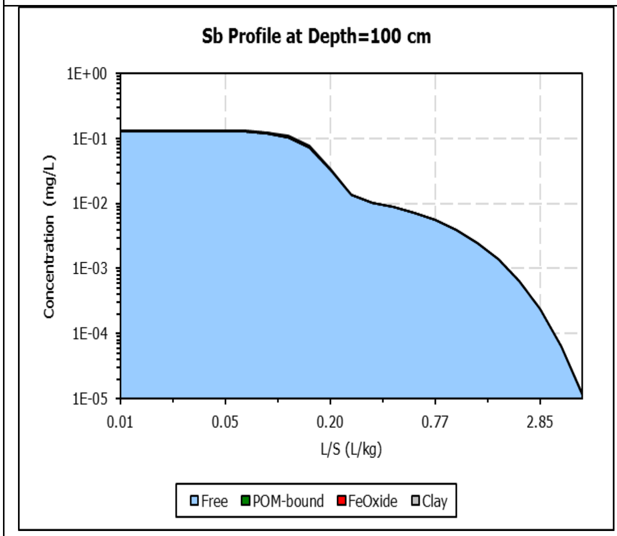

Ni Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

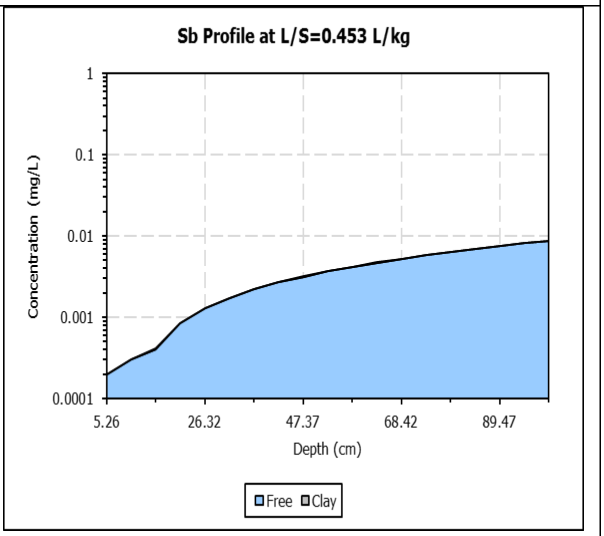

P Profile at Depth=100 cm

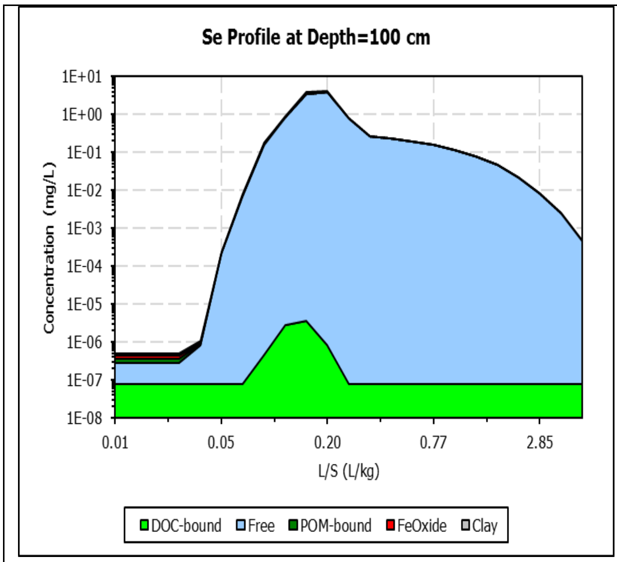

P Profile at L/S=0.453 L/kg

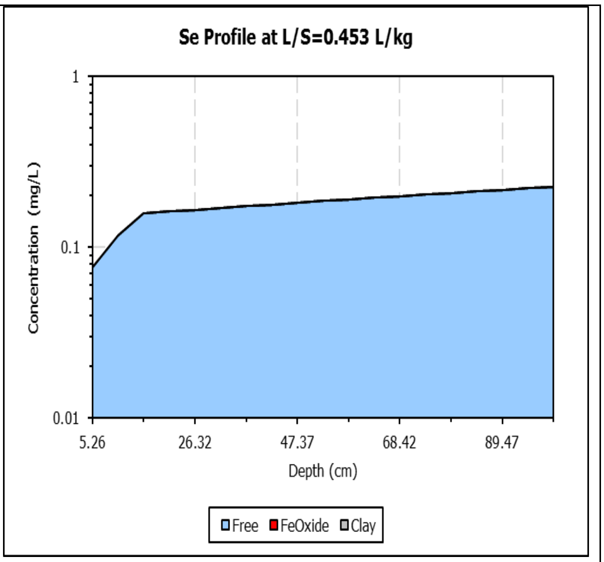

Pb Profile at Depth=100 cm

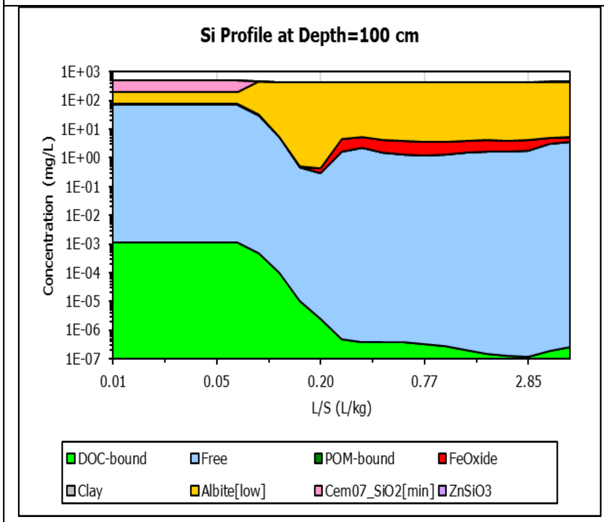

Pb Profile at L/S=0.453 L/kg

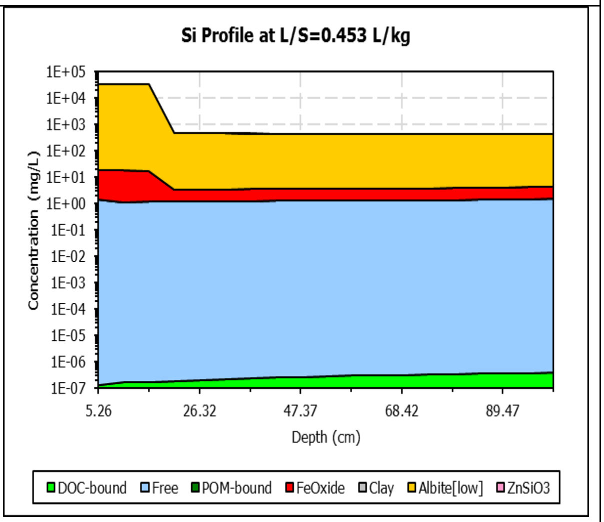

Sb Profile at Depth=100 cm

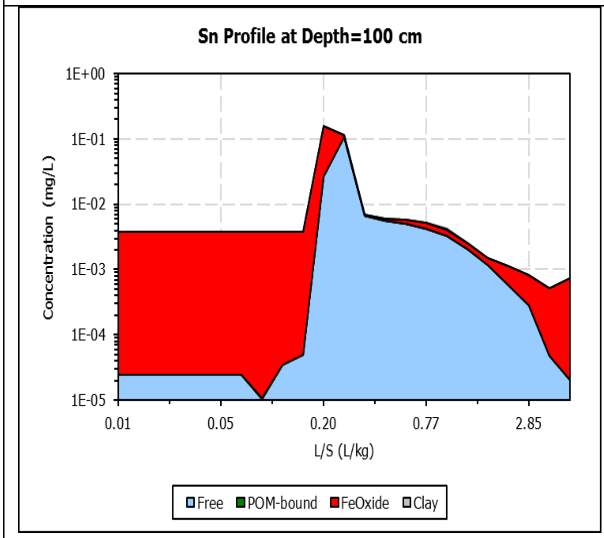

Sb Profile at L/S=0.453 L/kg

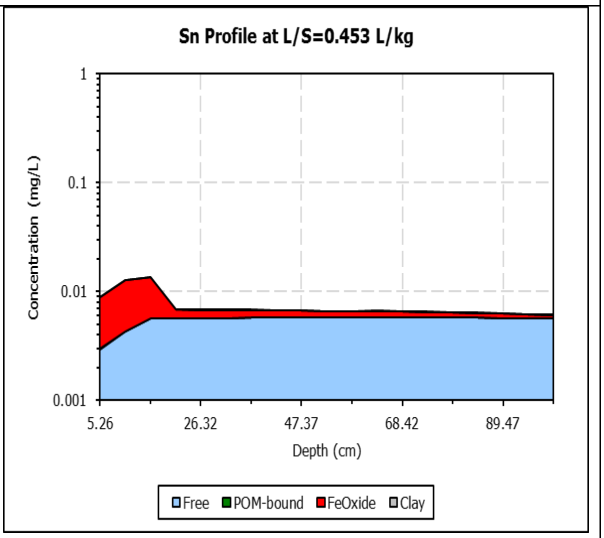

Se Profile at Depth=100 cm
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

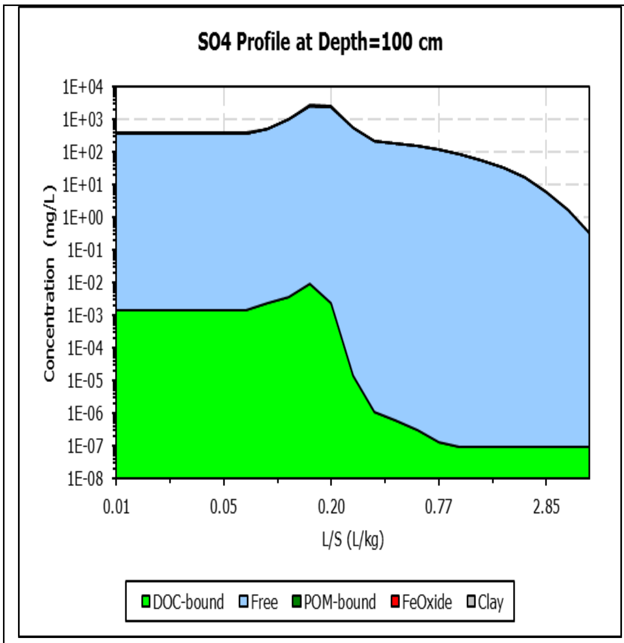

Se Profile at L/S=0.453 L/kg
Concentration (mg/L)
1
0.1
0.01
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
FeOxide
Clay

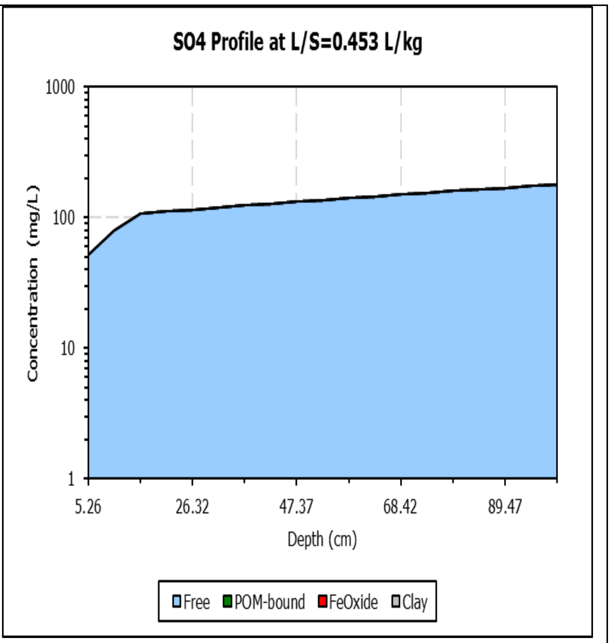

Si Profile at Depth=100 cm
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay
Albite[low]
Cem07_SiO2[min]
ZnSiO3

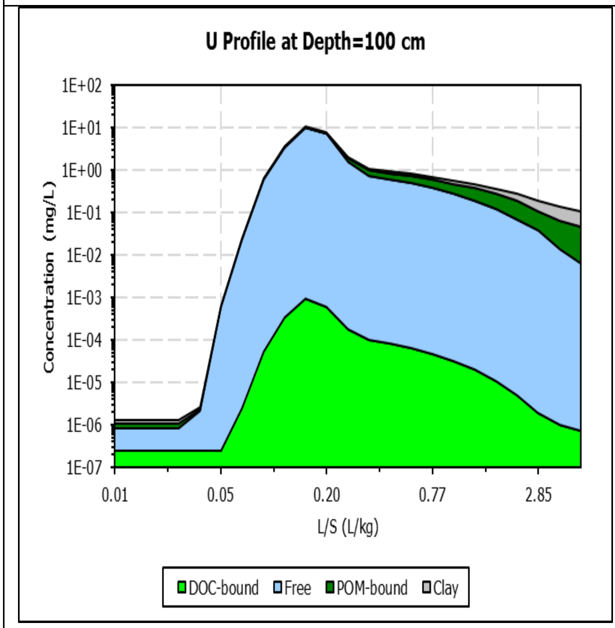

Si Profile at L/S=0.453 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay
Albite[low]
ZnSiO3

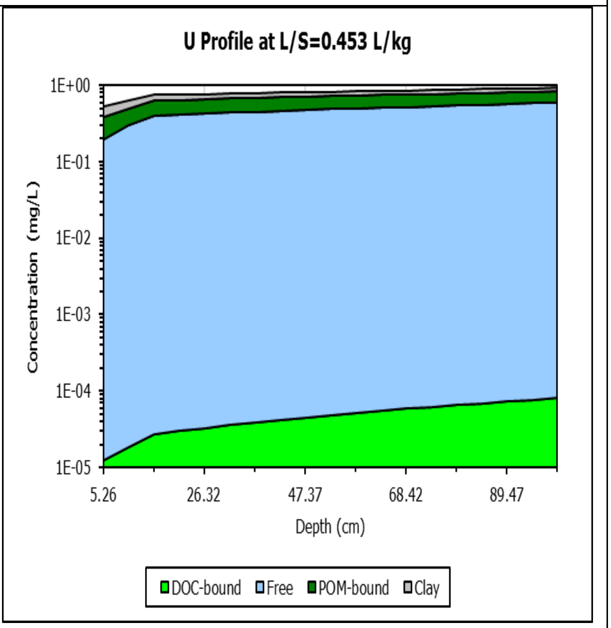

Sn Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.01
0.05
0.20
0.77
2.85
L/S (L/kg)
Free
POM-bound
FeOxide
Clay

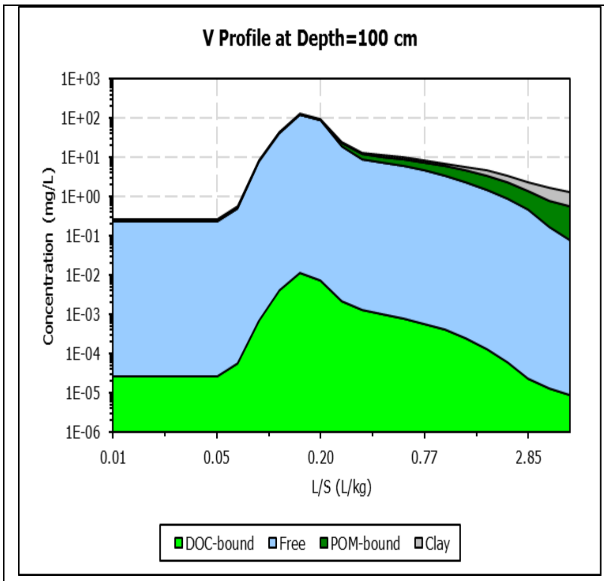

Sn Profile at L/S=0.453 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
POM-bound
FeOxide
Clay

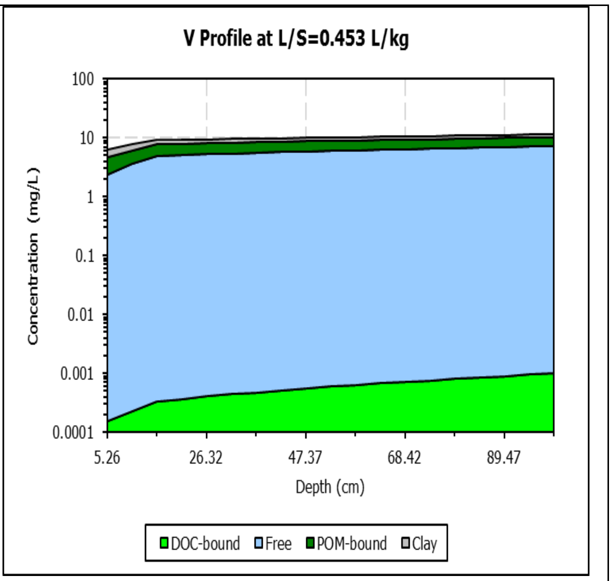

SO4 Profile at Depth=100 cm

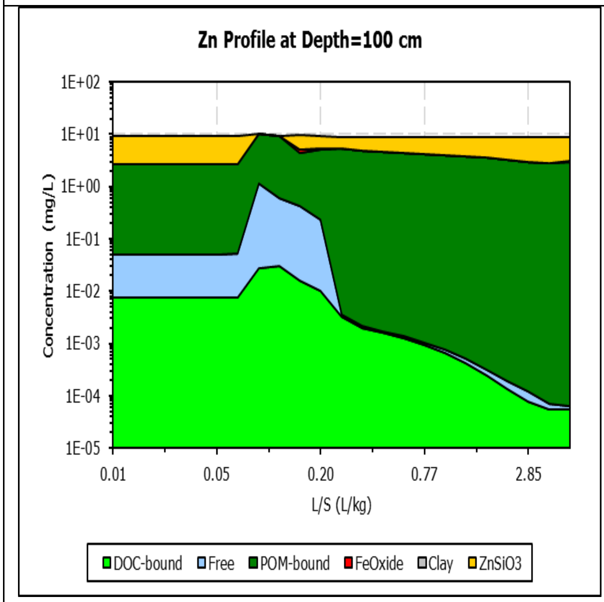

SO4 Profile at L/S=0.453 L/kg

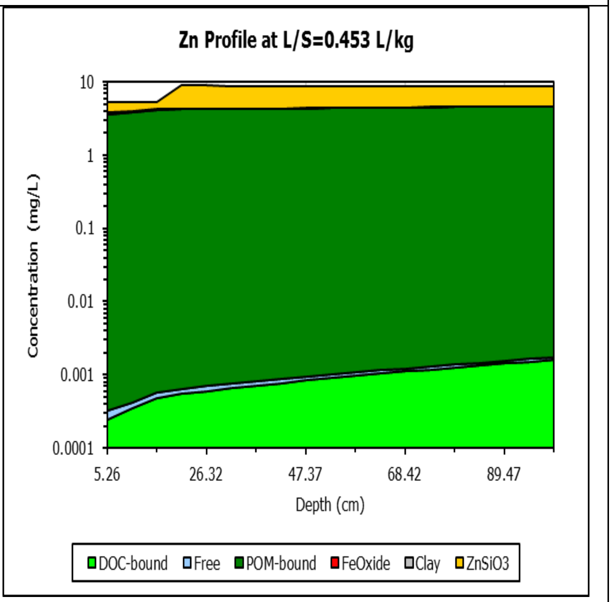

U Profile at Depth=100 cm


U Profile at L/S=0.453 L/kg

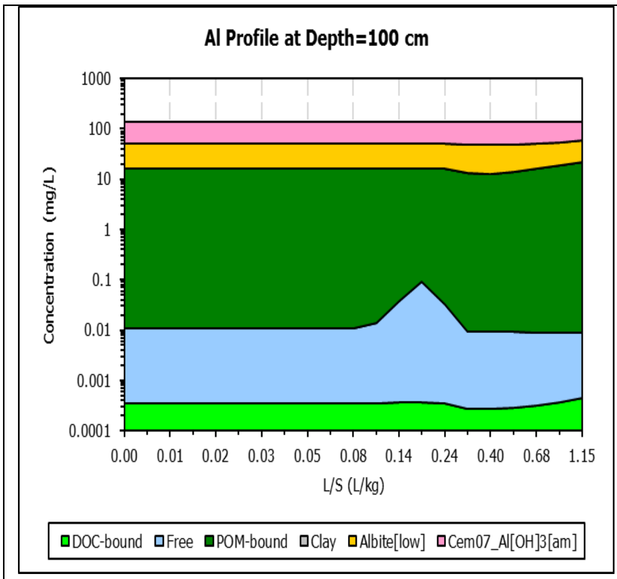

V Profile at Depth=100 cm

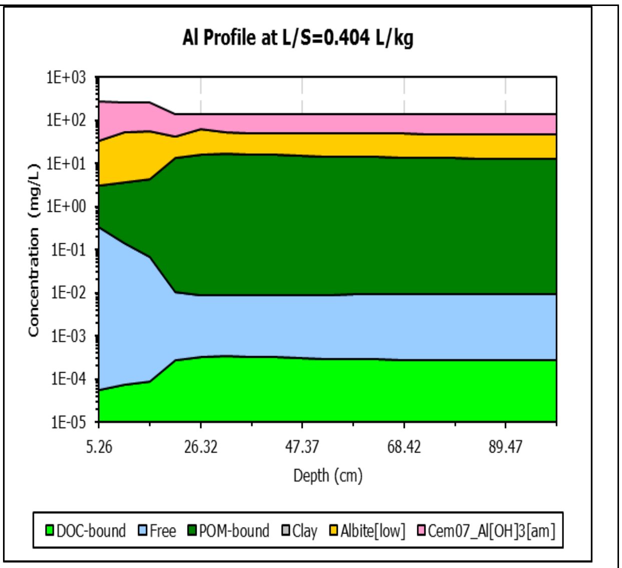

V Profile at L/S=0.453 L/kg

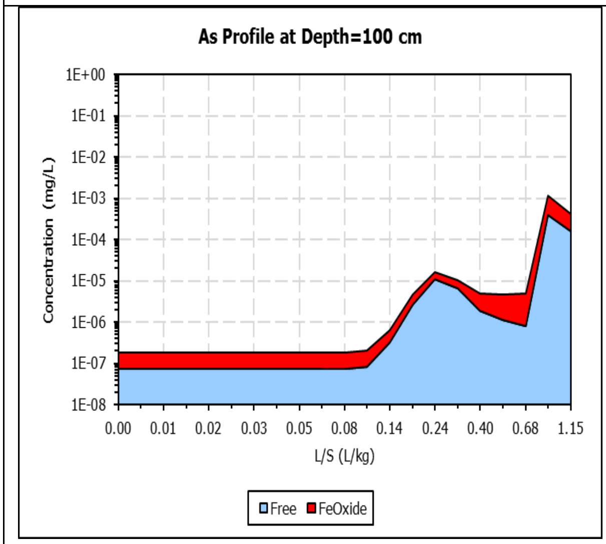

Zn Profile at Depth=100 cm

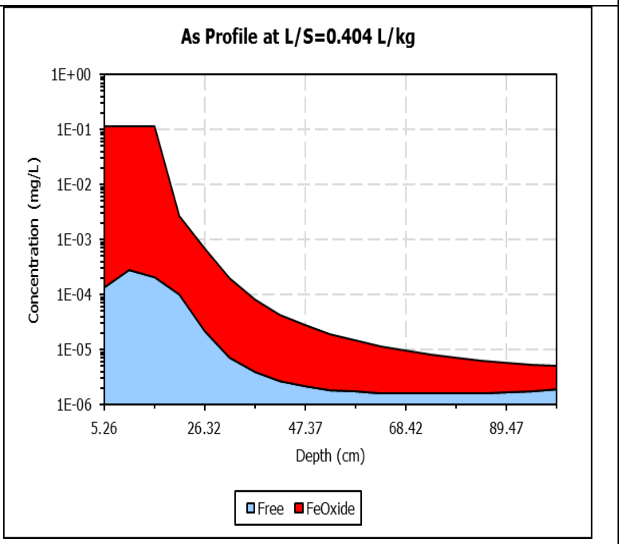

Zn Profile at L/S=0.453 L/kg

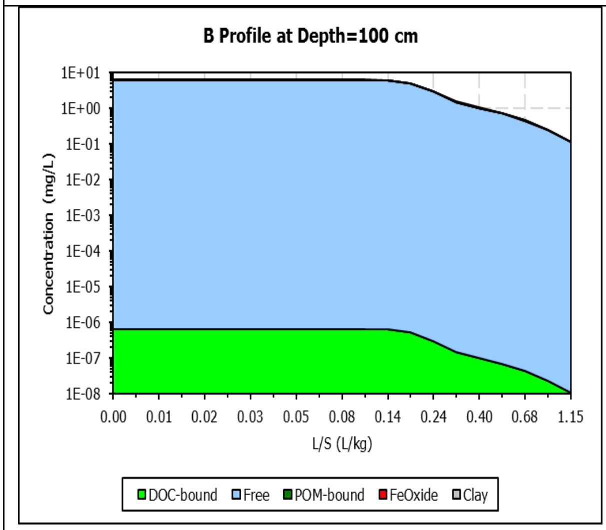
Appendix A16: LeachXS 20 Cell Model by Using 1st four Cells with Virtual material (5% Ironman gypsum (IMG) and 95 % Bassendean sand Ellenbrook) and 16 Cell with Bassendean Sand.

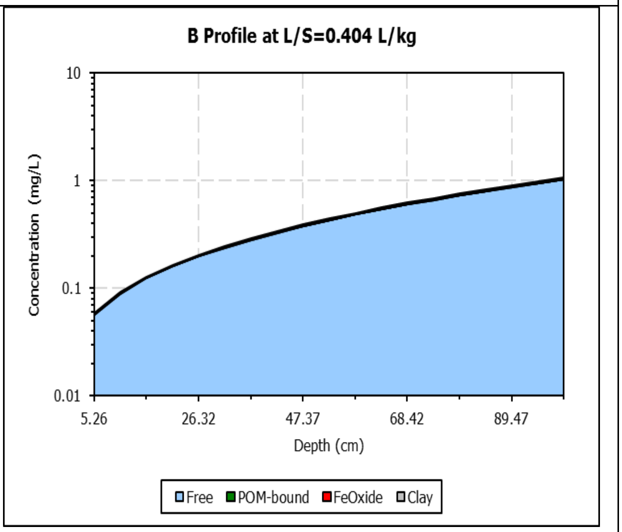


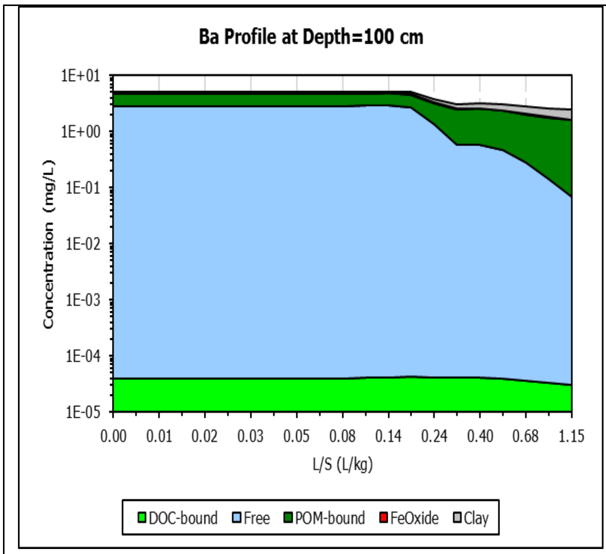


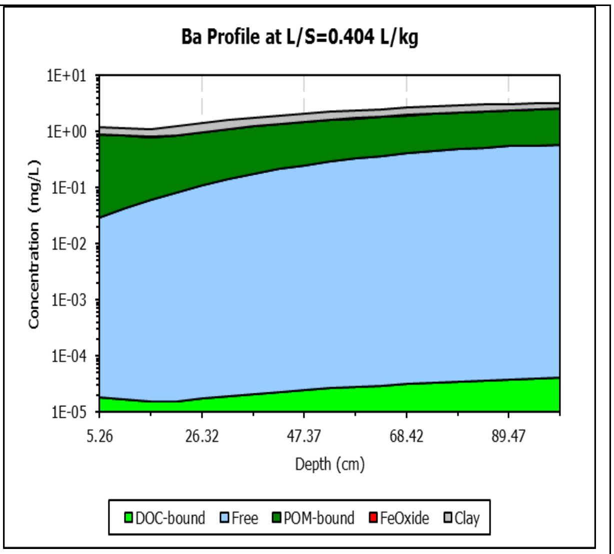


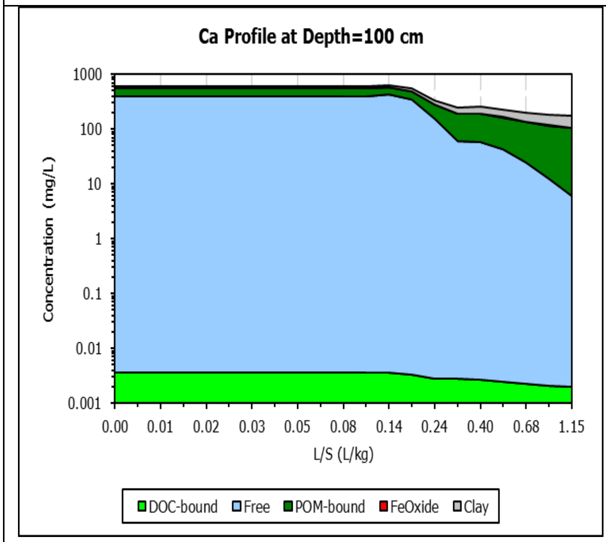


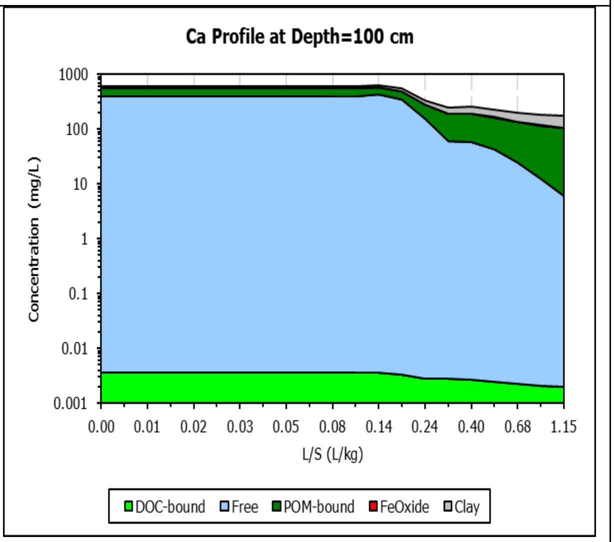


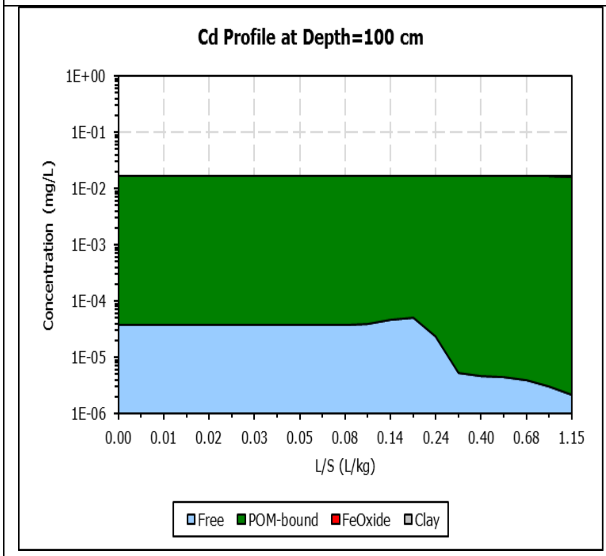


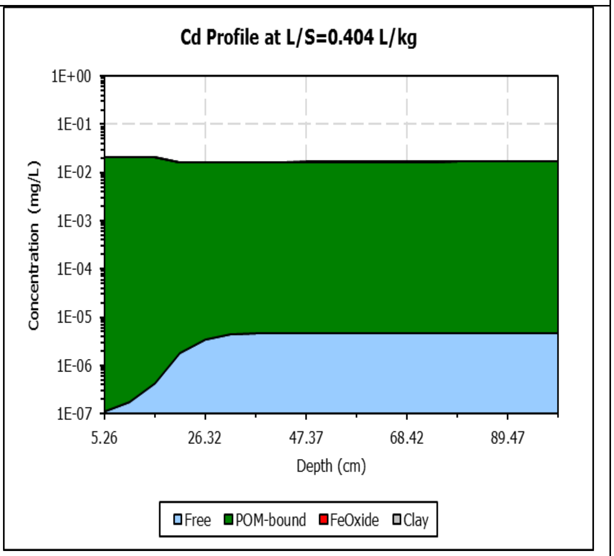

Ba Profile at Depth=100 cm
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
0.00 0.01 0.02 0.03 0.05 0.08 0.14 0.24 0.40 0.68 1.15
L/S (L/kg)
DOC-bound Free POM-bound FeOxide Clay

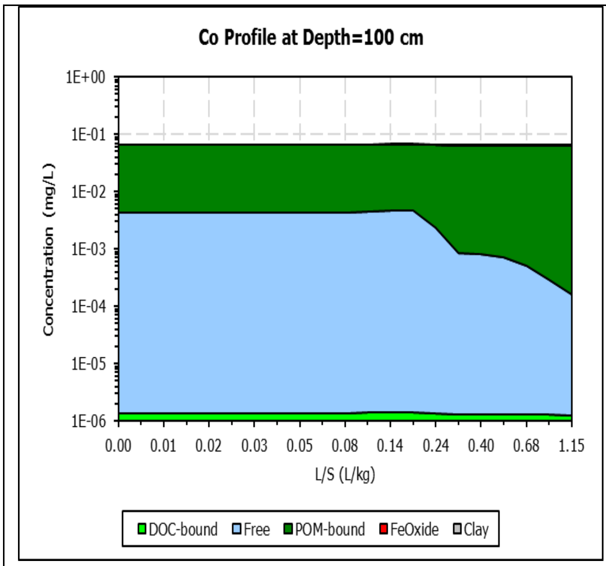

Ba Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
5.26 26.32 47.37 68.42 89.47
Depth (cm)
DOC-bound Free POM-bound FeOxide Clay

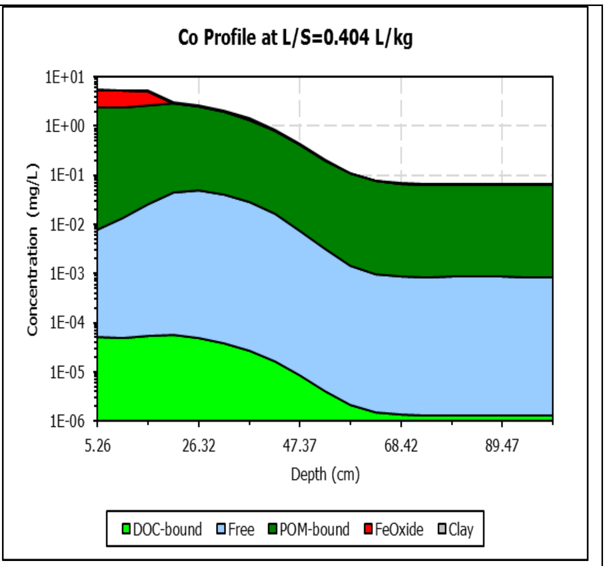

Ca Profile at Depth=100 cm
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.00 0.01 0.02 0.03 0.05 0.08 0.14 0.24 0.40 0.68 1.15
L/S (L/kg)
DOC-bound Free POM-bound FeOxide Clay

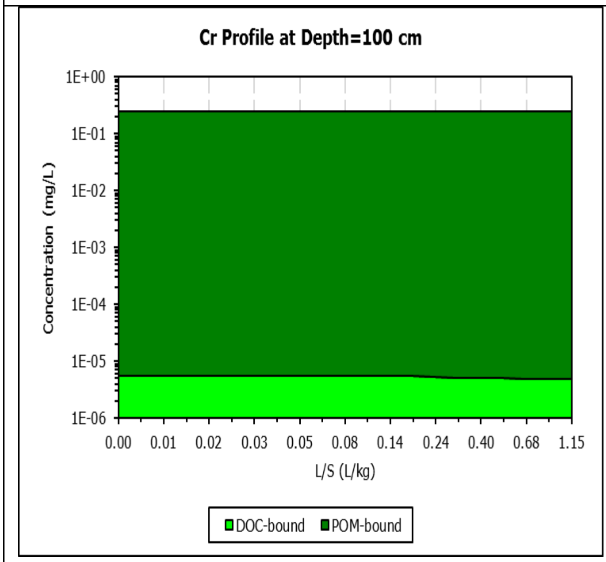

Ca Profile at Depth=100 cm
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.00 0.01 0.02 0.03 0.05 0.08 0.14 0.24 0.40 0.68 1.15
L/S (L/kg)
DOC-bound Free POM-bound FeOxide Clay

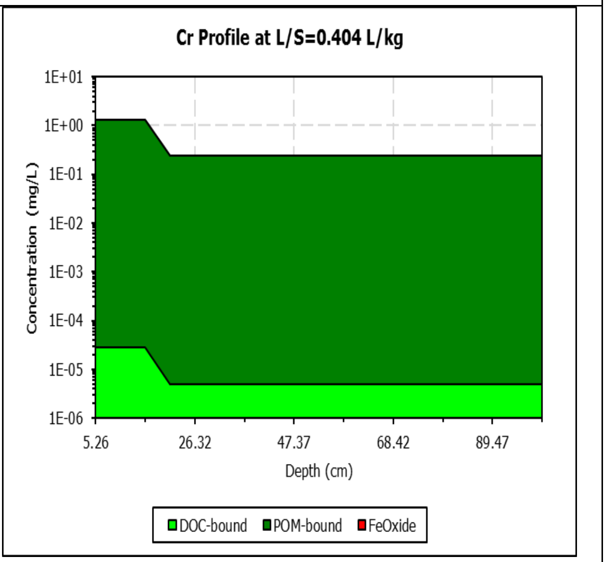

Cd Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.00 0.01 0.02 0.03 0.05 0.08 0.14 0.24 0.40 0.68 1.15
L/S (L/kg)
Free POM-bound FeOxide Clay

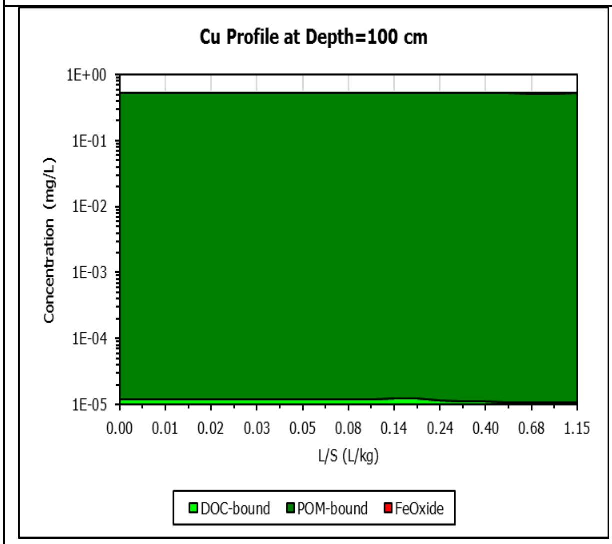

Cd Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
5.26 26.32 47.37 68.42 89.47
Depth (cm)
Free POM-bound FeOxide Clay

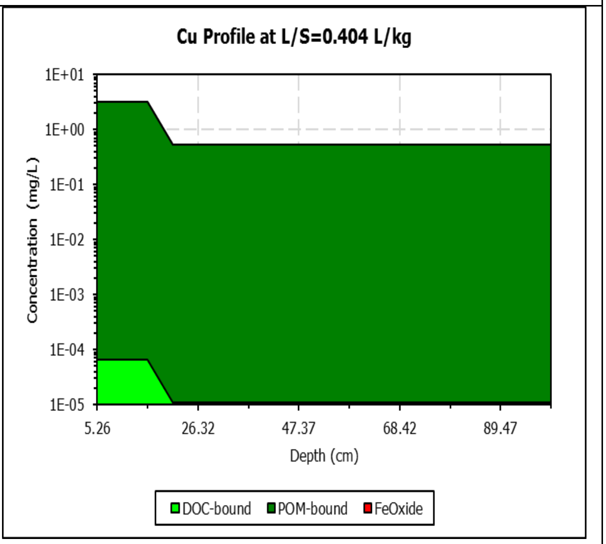

Co Profile at Depth=100 cm

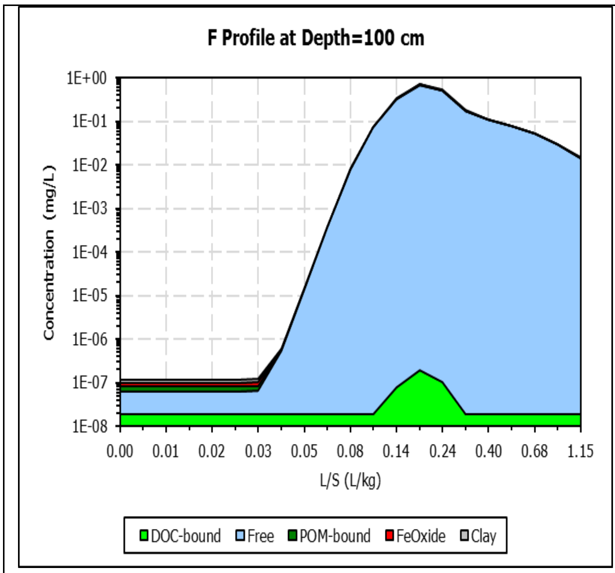

Co Profile at L/S=0.404 L/kg


Cr Profile at Depth=100 cm

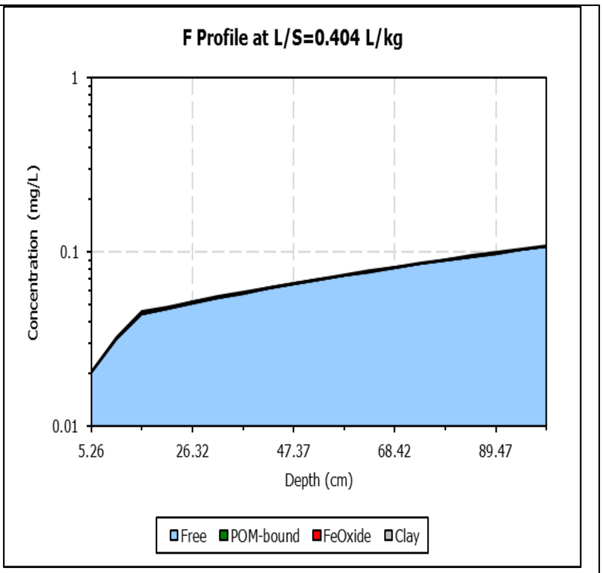

Cr Profile at L/S=0.404 L/kg


Cu Profile at Depth=100 cm

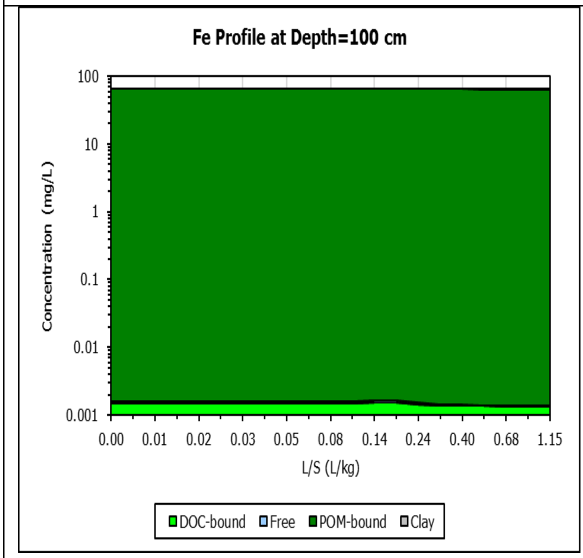

Cu Profile at L/S=0.404 L/kg



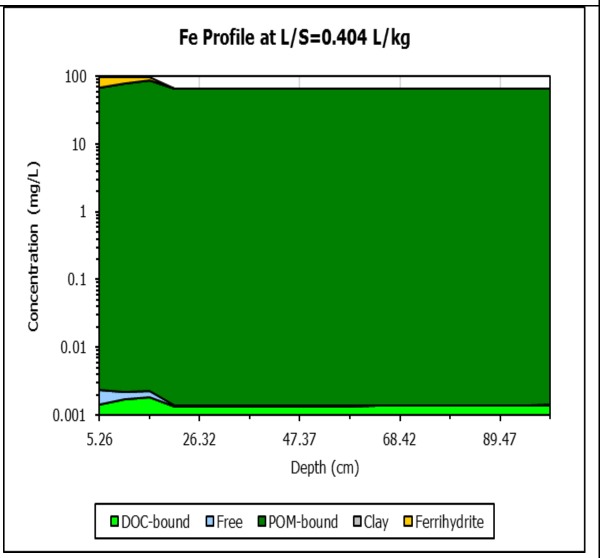
F Profile at Depth=100 cm



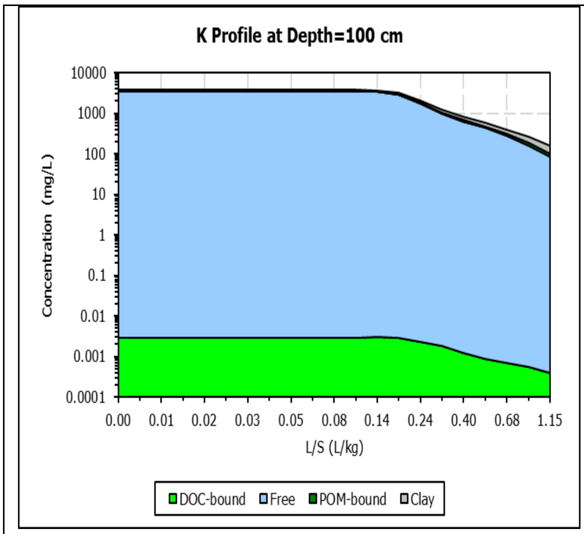
F Profile at L/S=0.404 L/kg

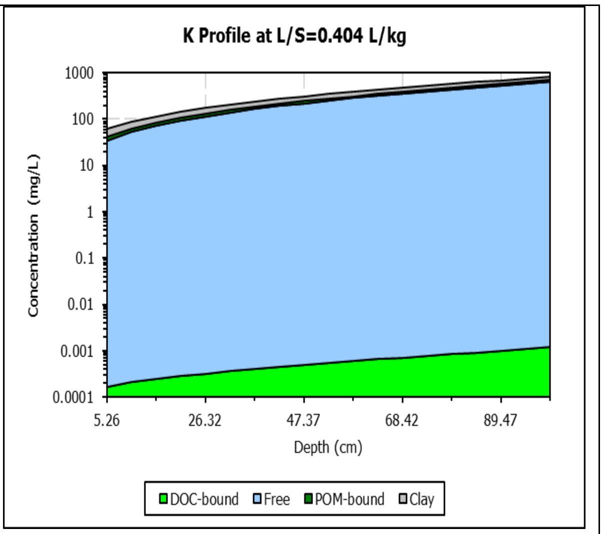


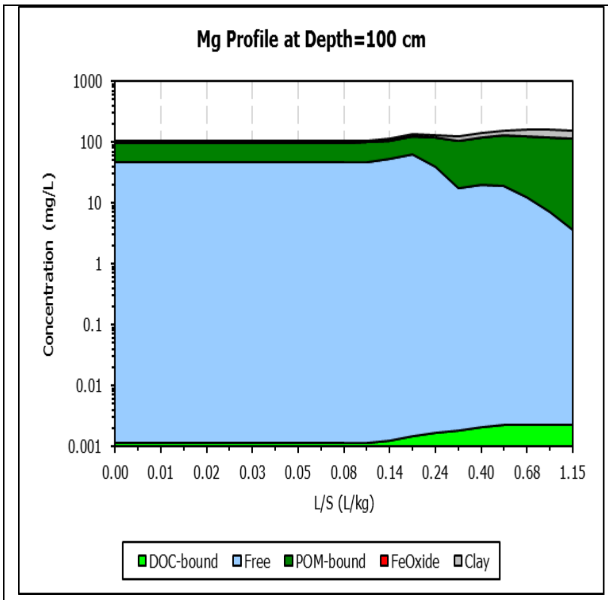
Fe Profile at Depth=100 cm

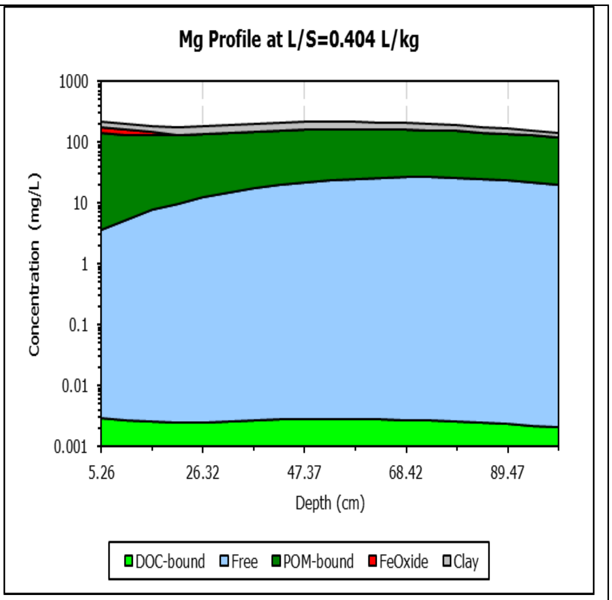


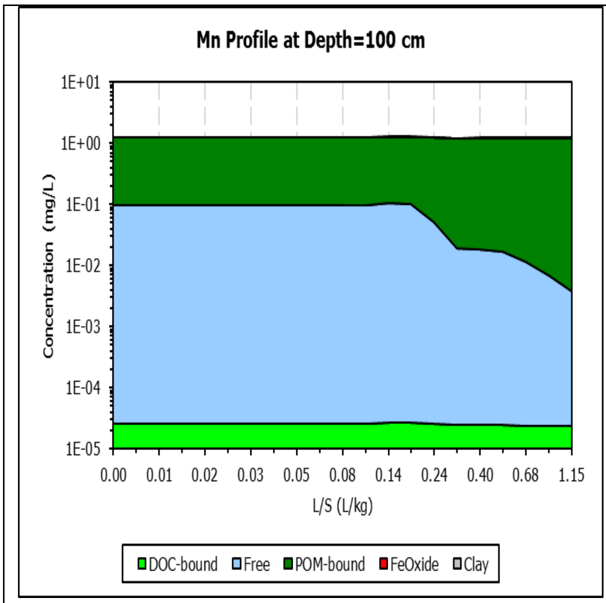
Fe Profile at L/S=0.404 L/kg


K Profile at Depth=100 cm
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay

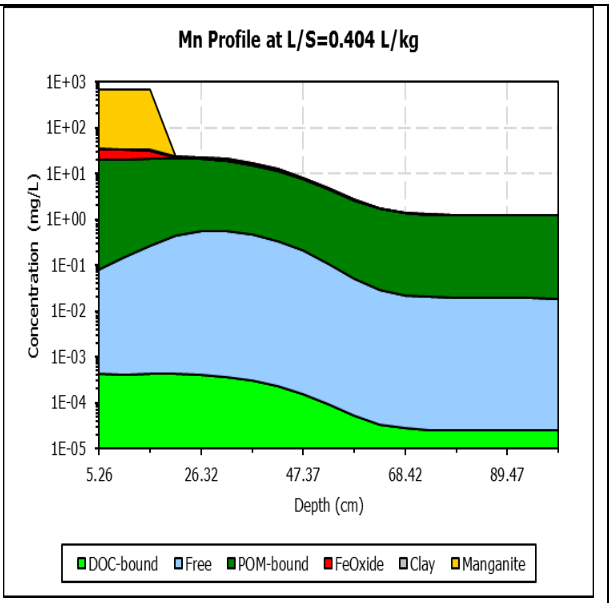

K Profile at L/S=0.404 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
Clay


Mg Profile at Depth=100 cm
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

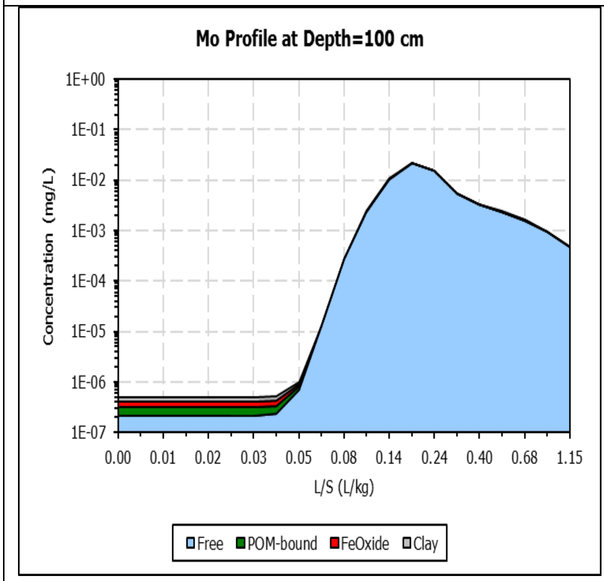

Mg Profile at L/S=0.404 L/kg
Concentration (mg/L)
1000
100
10
1
0.1
0.01
0.001
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay



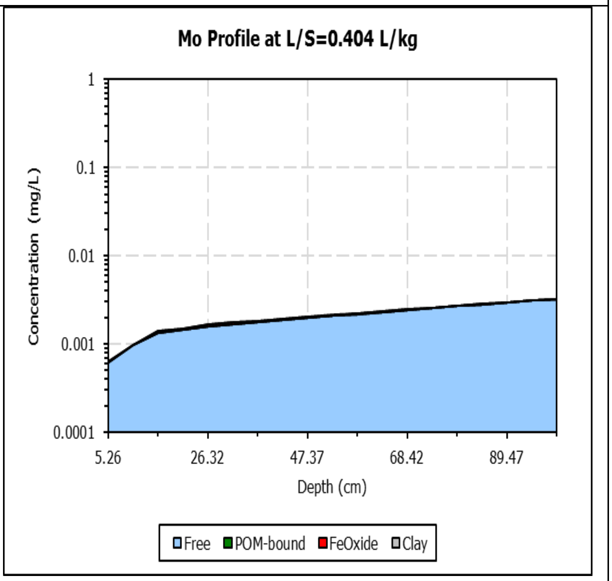
Mn Profile at Depth=100 cm



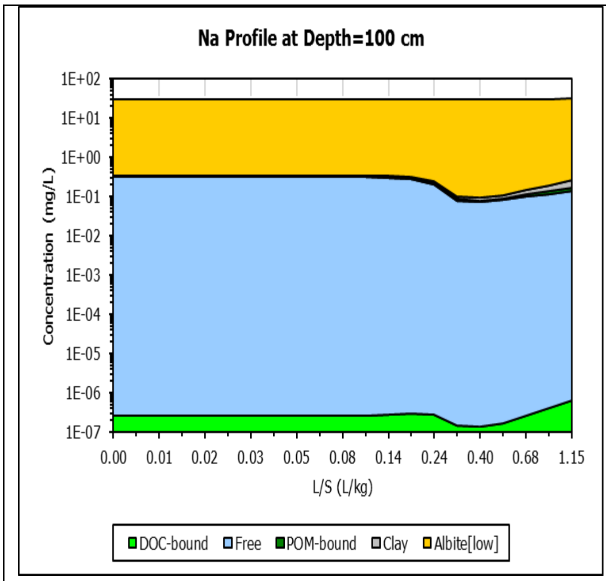
Mn Profile at L/S=0.404 L/kg

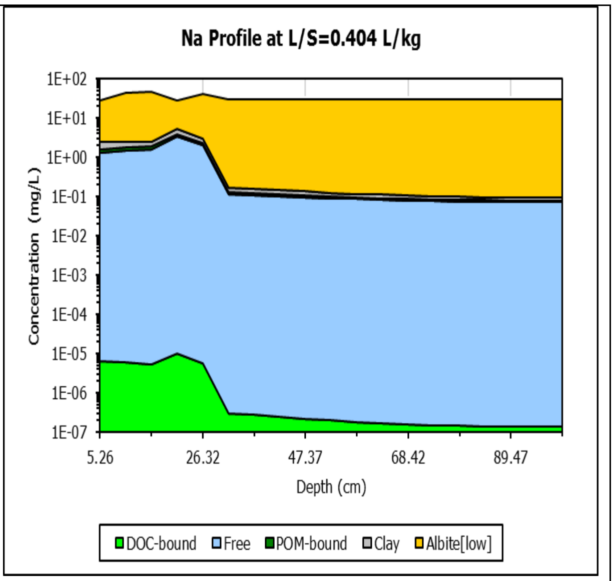


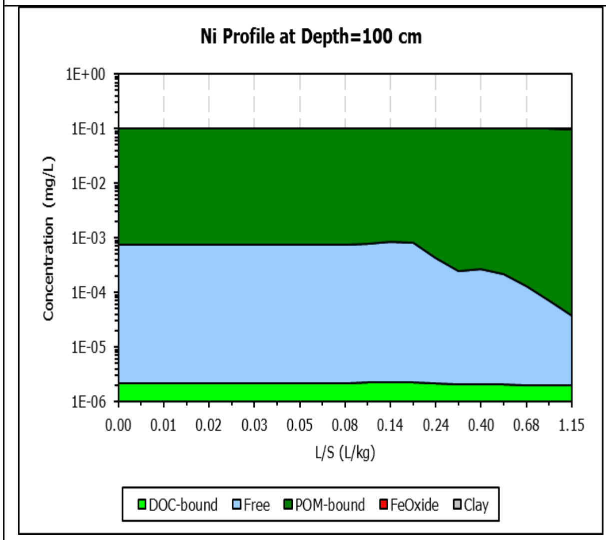
Mo Profile at Depth=100 cm

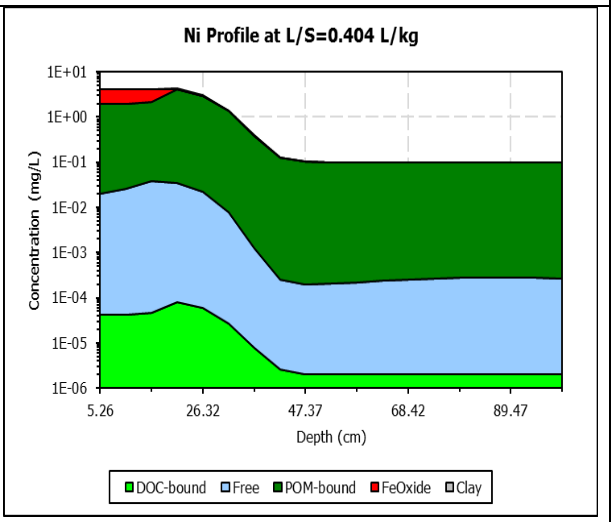


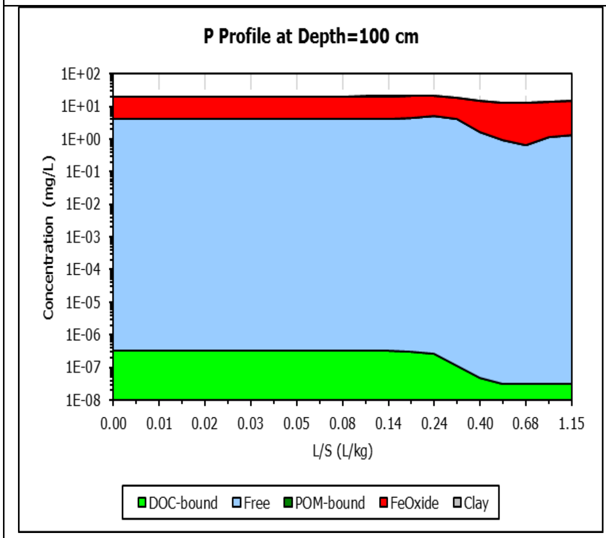
Mo Profile at L/S=0.404 L/kg

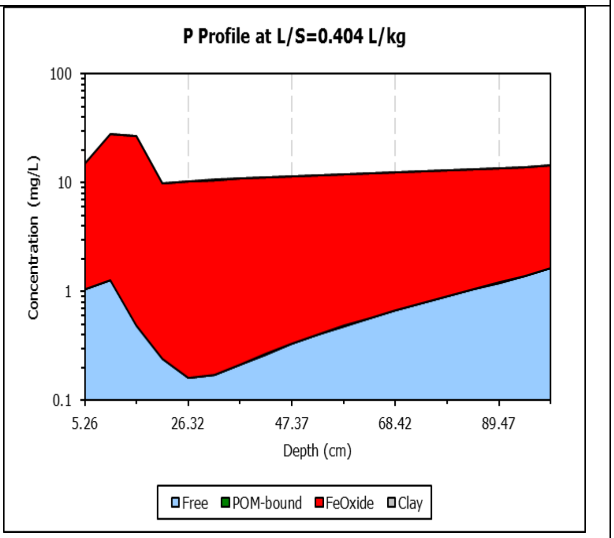

Na Profile at Depth=100 cm
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay
Albite[low]

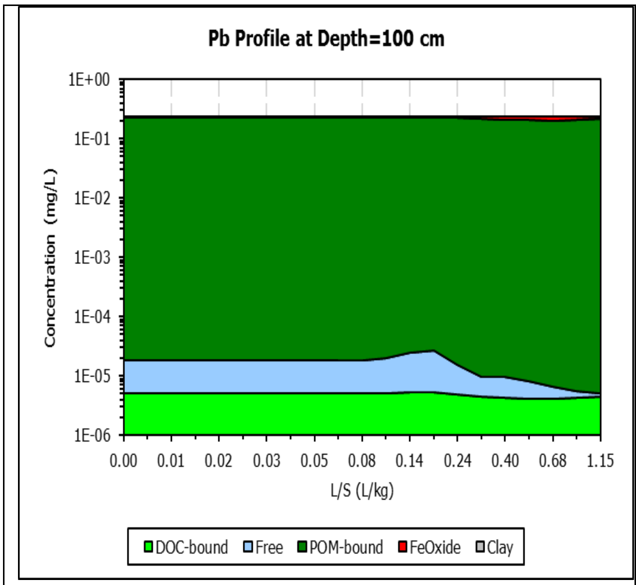

Na Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
Clay
Albite[low]

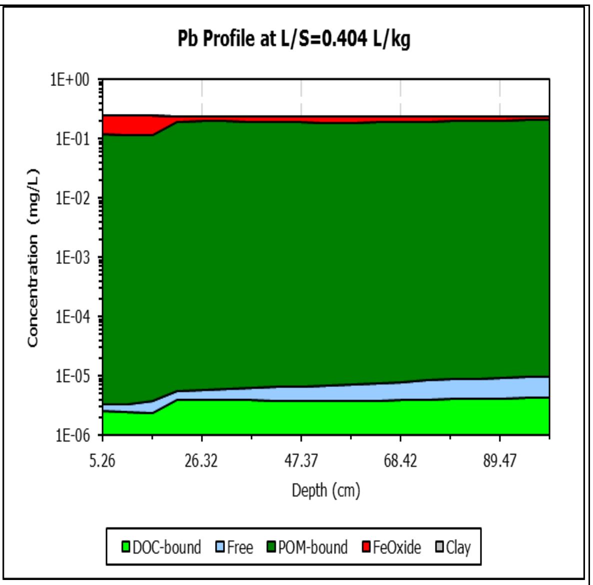

Ni Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

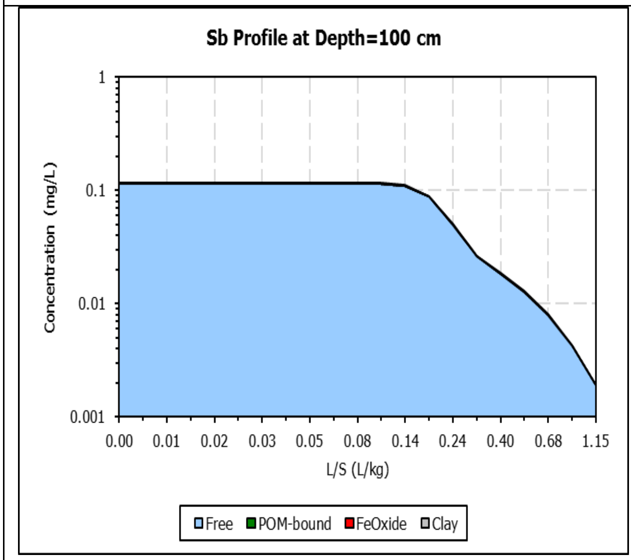

Ni Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

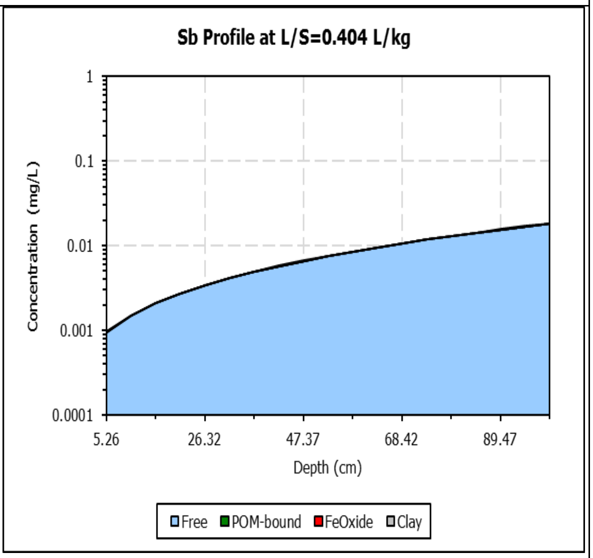

P Profile at Depth=100 cm
Concentration (mg/L)
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

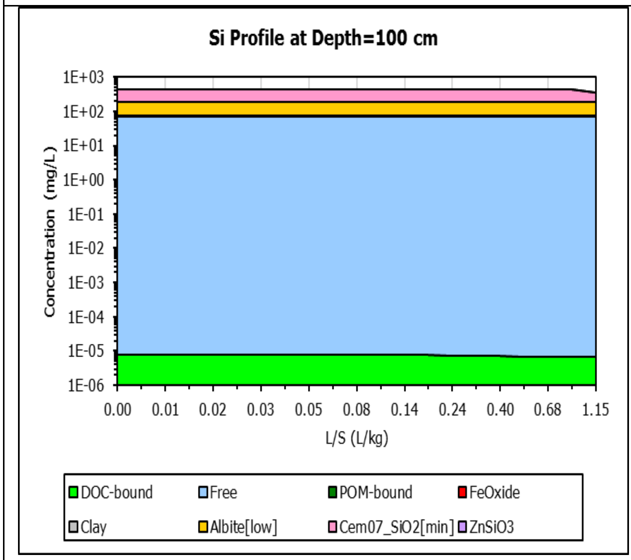

P Profile at L/S=0.404 L/kg
Concentration (mg/L)
100
10
1
0.1
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
POM-bound
FeOxide
Clay

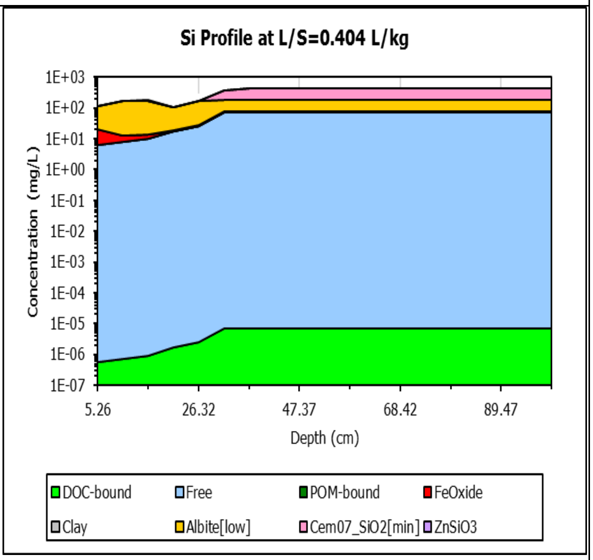

Pb Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
🟩 DOC-bound
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay

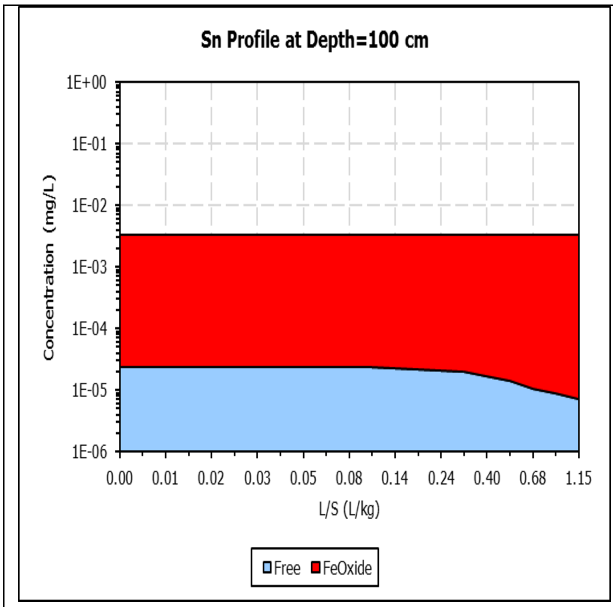

Pb Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
🟩 DOC-bound
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay

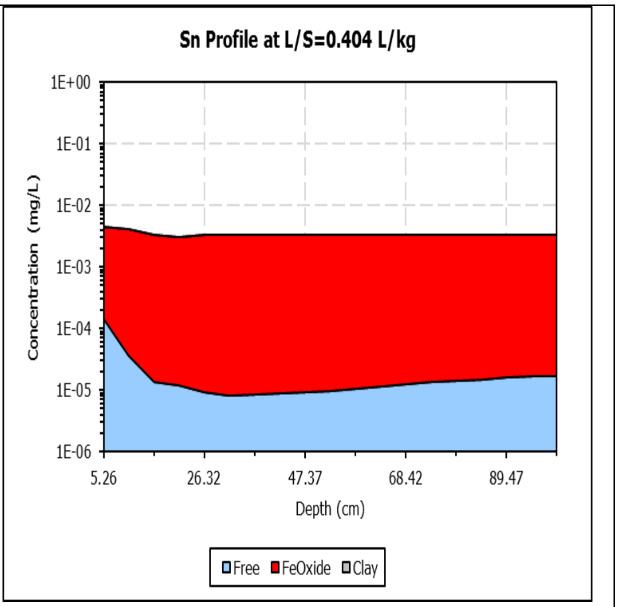

Sb Profile at Depth=100 cm
Concentration (mg/L)
1
0.1
0.01
0.001
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay

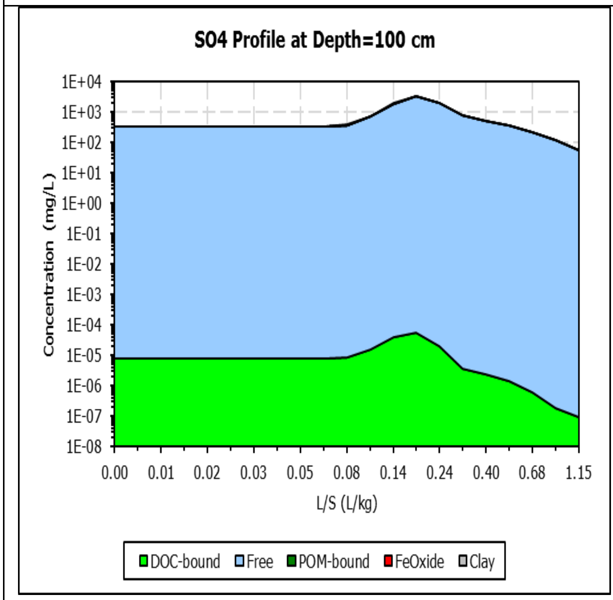

Sb Profile at L/S=0.404 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
0.0001
5.26
26.32
47.37
68.42
89.47
Depth (cm)
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay

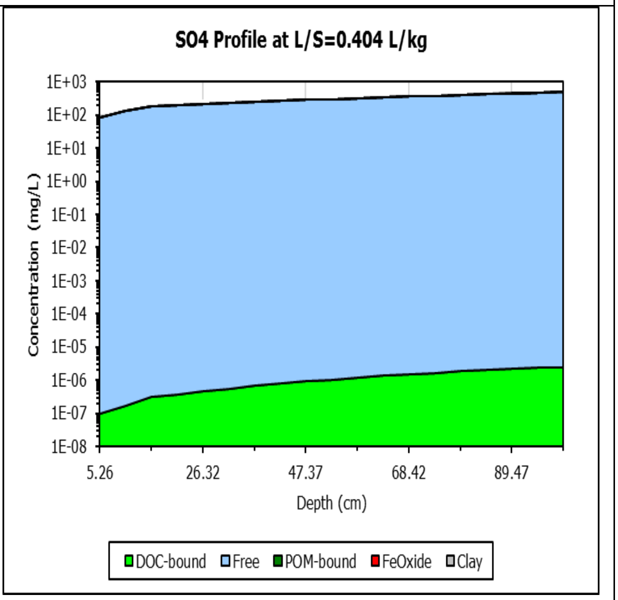

Si Profile at Depth=100 cm
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.00
0.01
0.02
0.03
0.05
0.08
0.14
0.24
0.40
0.68
1.15
L/S (L/kg)
🟩 DOC-bound
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay
🟨 Albite[low]
🟪 Cem07_SiO2[min]
🟪 ZnSiO3

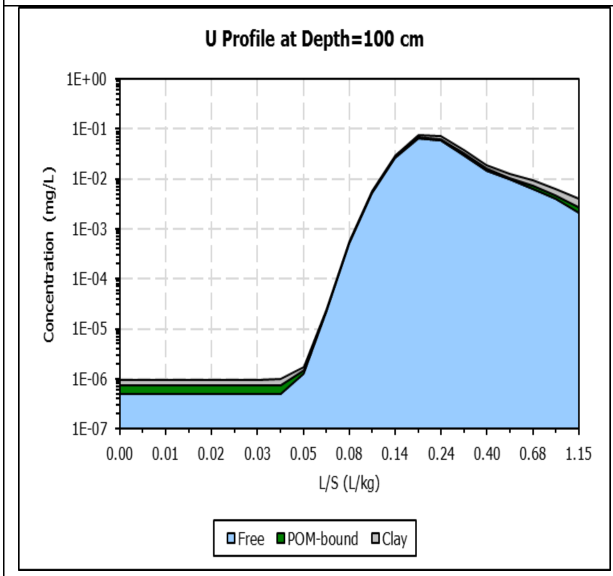

Si Profile at L/S=0.404 L/kg
Concentration (mg/L)
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
5.26
26.32
47.37
68.42
89.47
Depth (cm)
🟩 DOC-bound
🟦 Free
🟩 POM-bound
🟥 FeOxide
☐ Clay
🟨 Albite[low]
🟪 Cem07_SiO2[min]
🟪 ZnSiO3

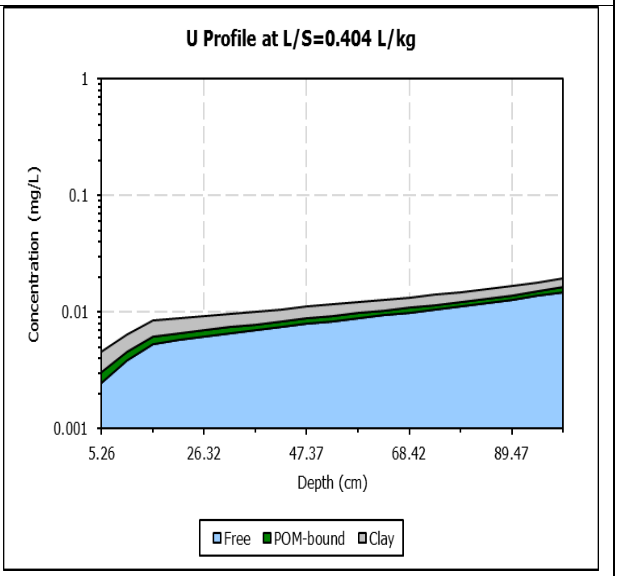

Sn Profile at Depth=100 cm

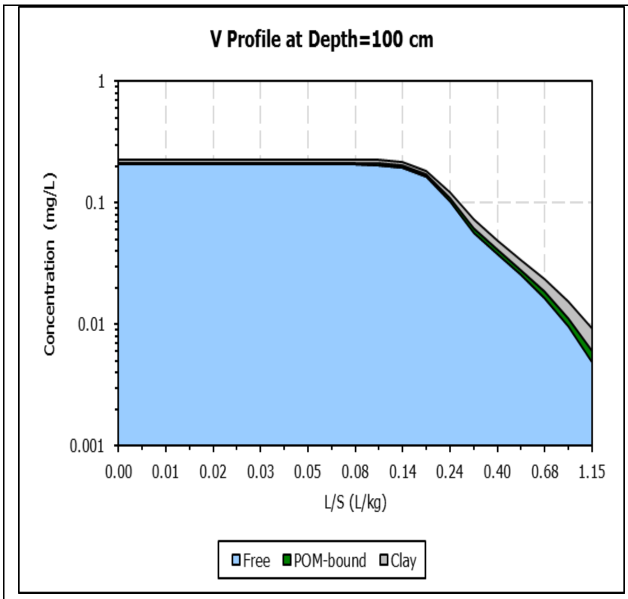

Sn Profile at L/S=0.404 L/kg

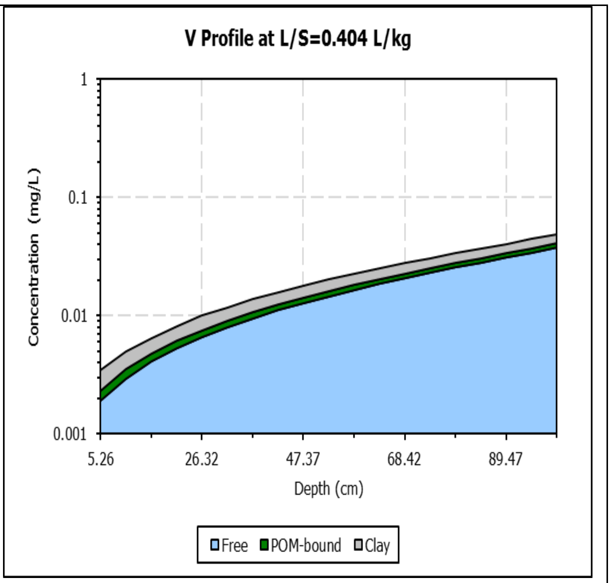

SO4 Profile at Depth=100 cm

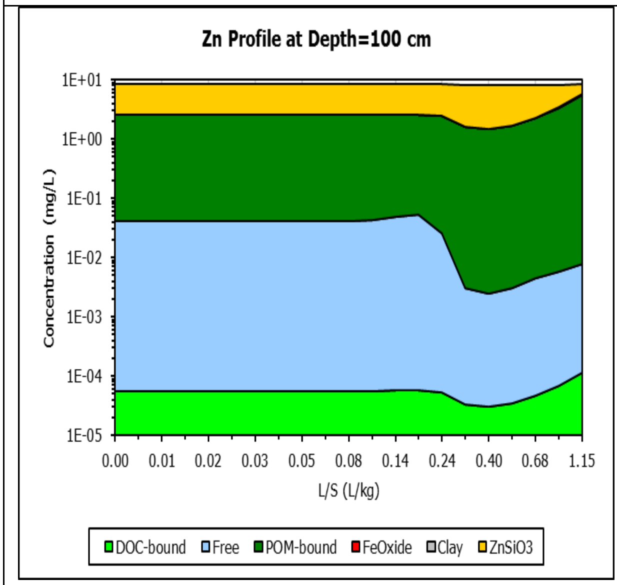

SO4 Profile at L/S=0.404 L/kg

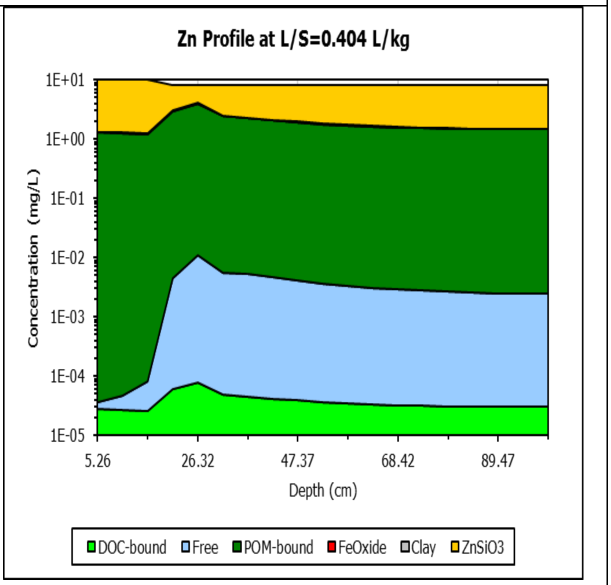

U Profile at Depth=100 cm


U Profile at L/S=0.404 L/kg

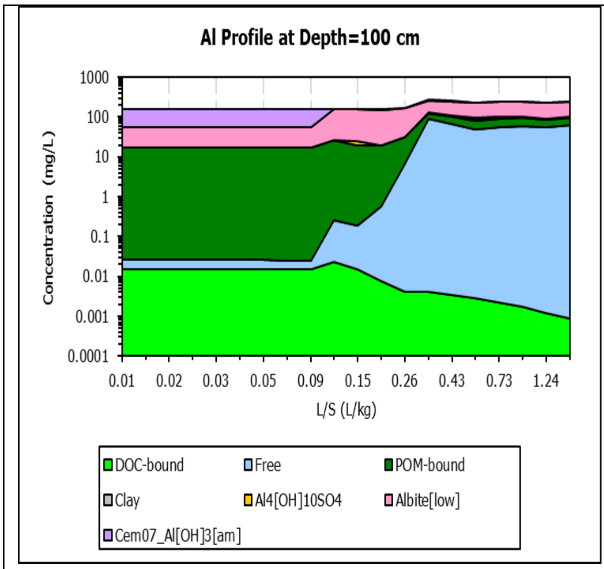

V Profile at Depth=100 cm

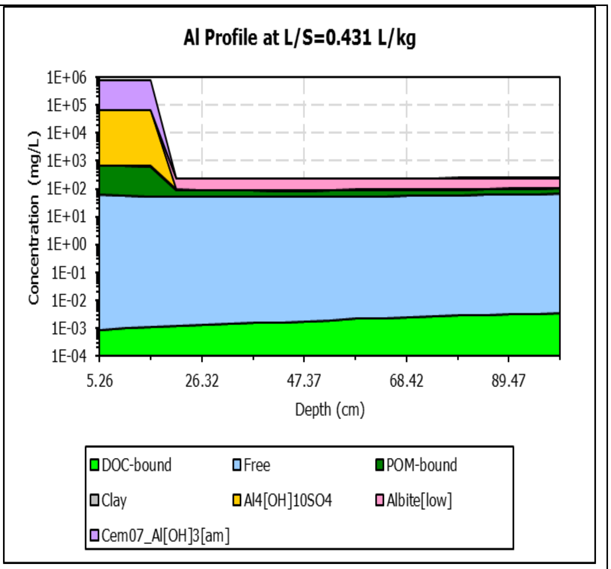

V Profile at L/S=0.404 L/kg

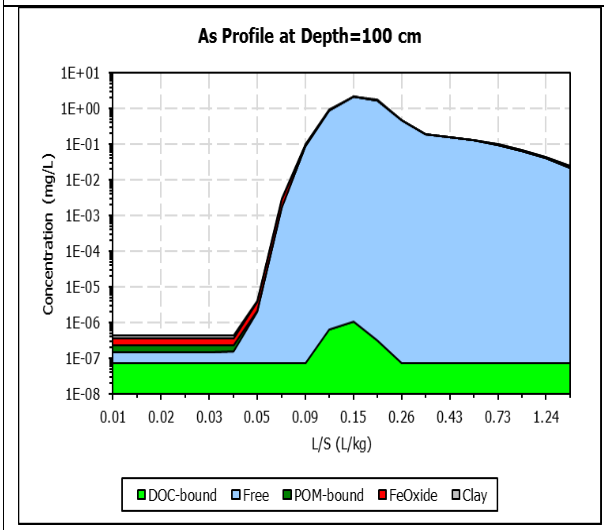

Zn Profile at Depth=100 cm

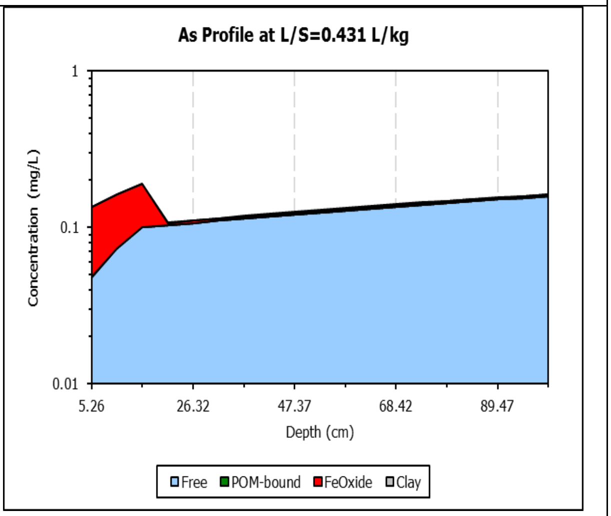

Zn Profile at L/S=0.404 L/kg

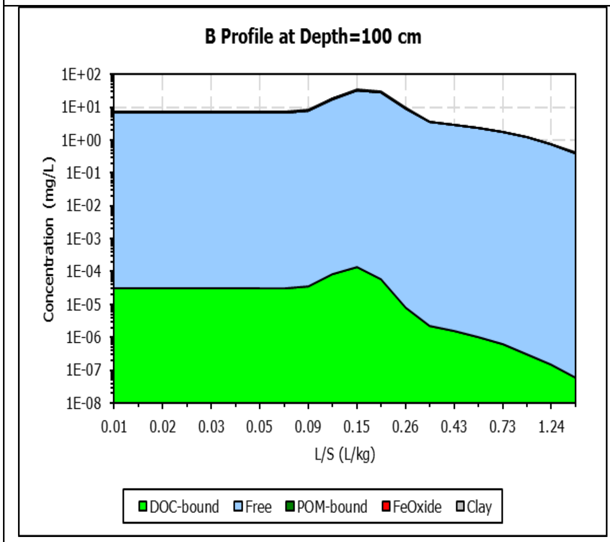
Appendix A17: LeachXS 20 Cell Model by Using 1st Four Cells with Inert Fill Jandakot Residue and 518 Cell with Bassendean Sand.

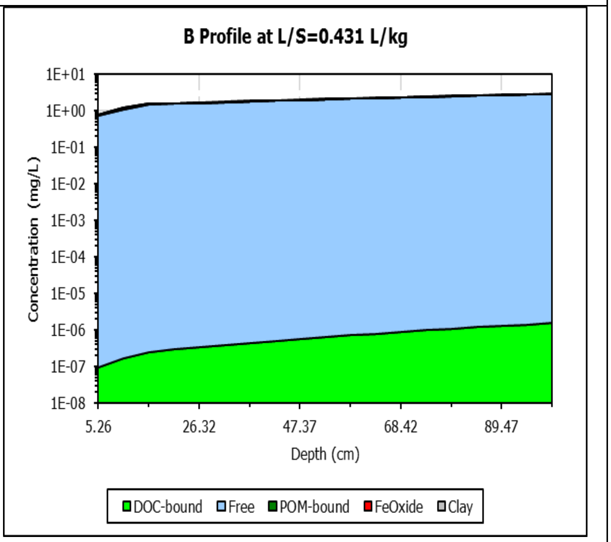


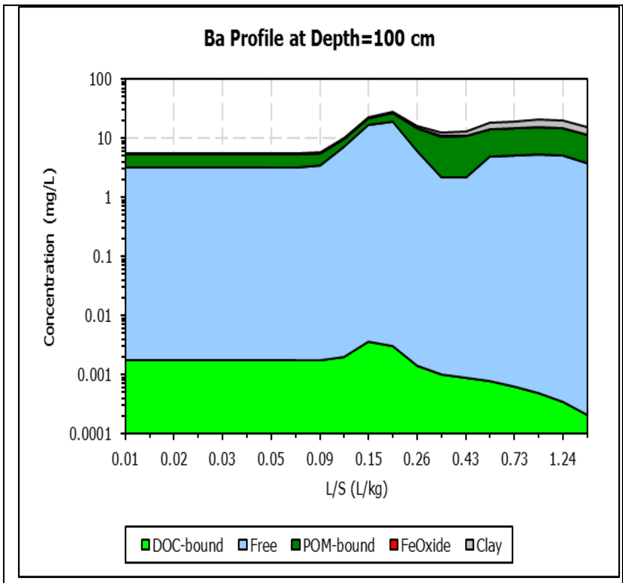


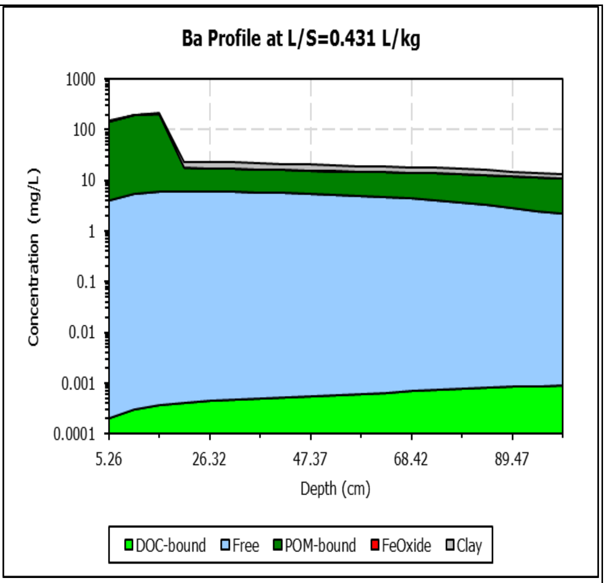


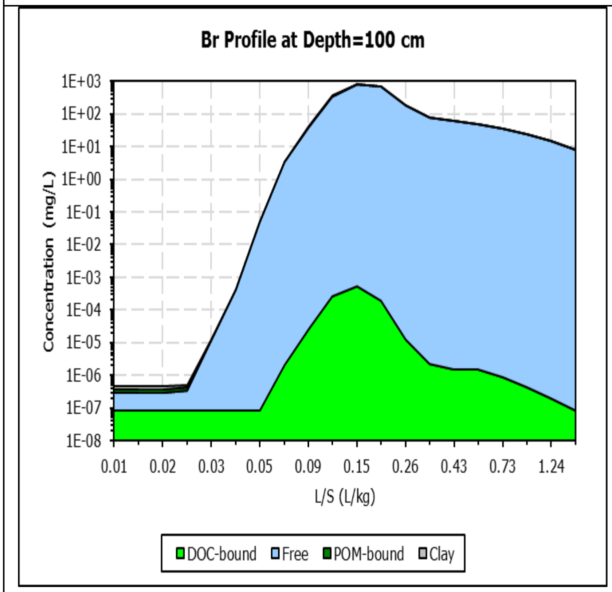


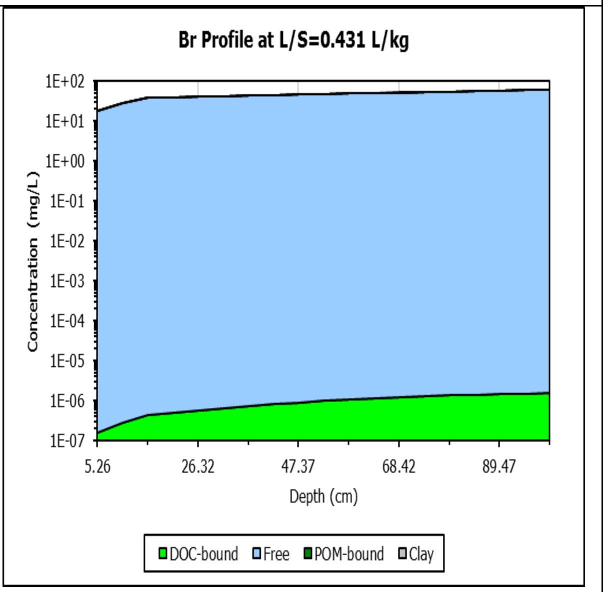


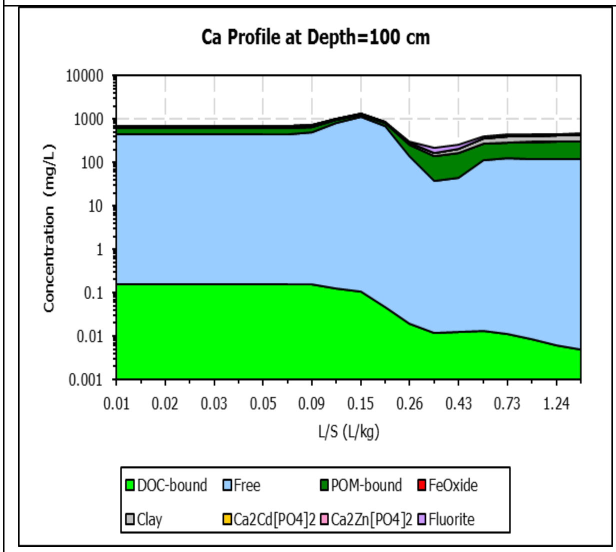


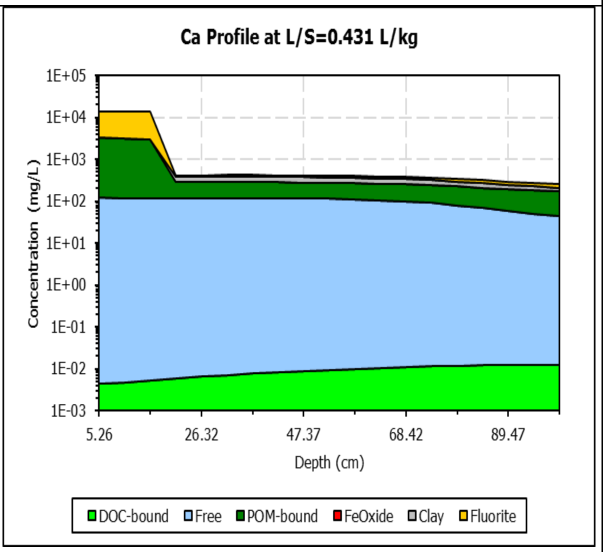

Ba Profile at Depth=100 cm

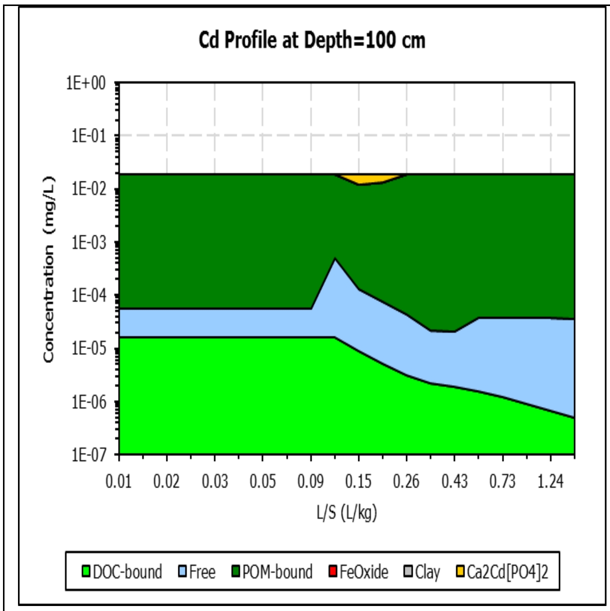

Ba Profile at L/S=0.431 L/kg

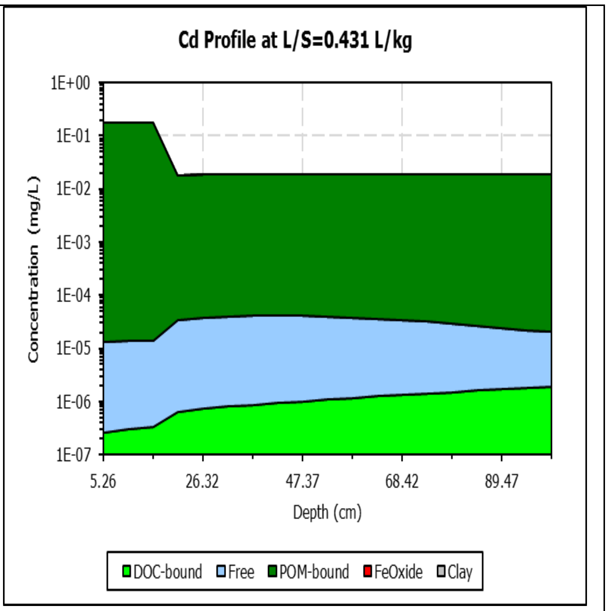

Br Profile at Depth=100 cm

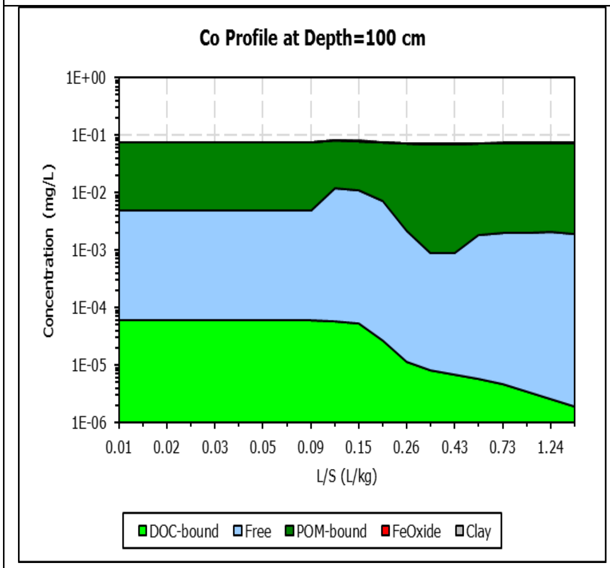

Br Profile at L/S=0.431 L/kg

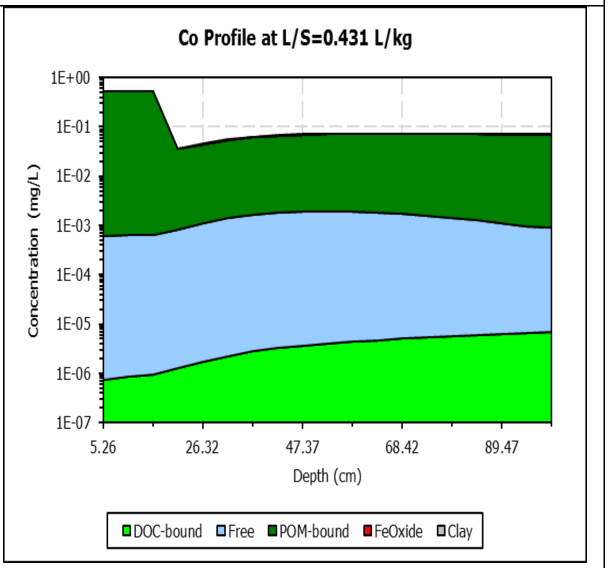

Ca Profile at Depth=100 cm

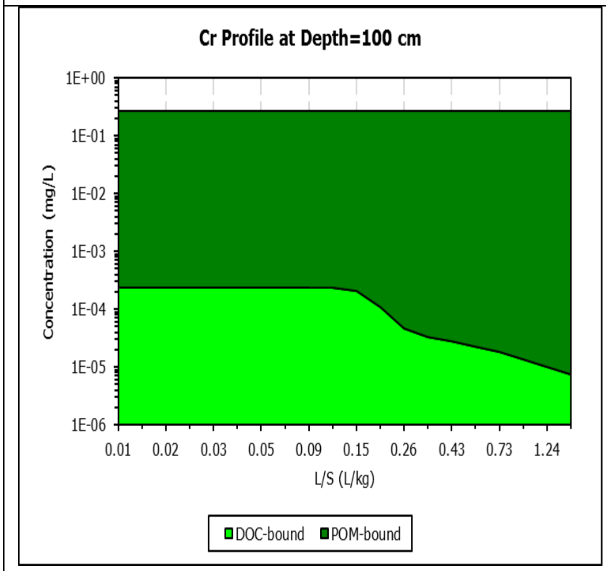

Ca Profile at L/S=0.431 L/kg

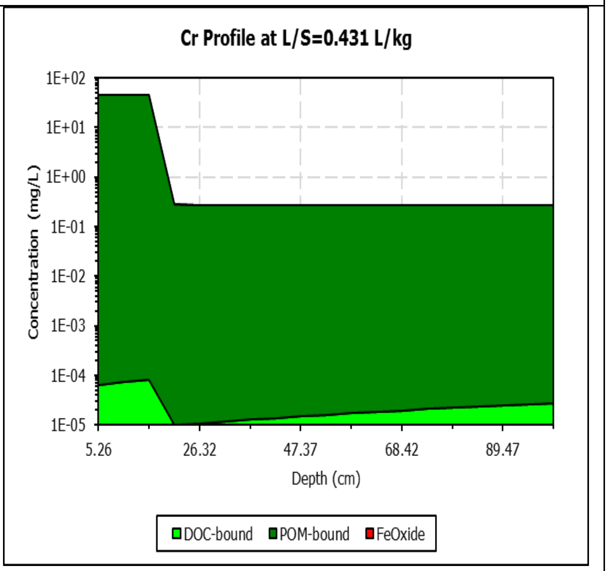

Cd Profile at Depth=100 cm

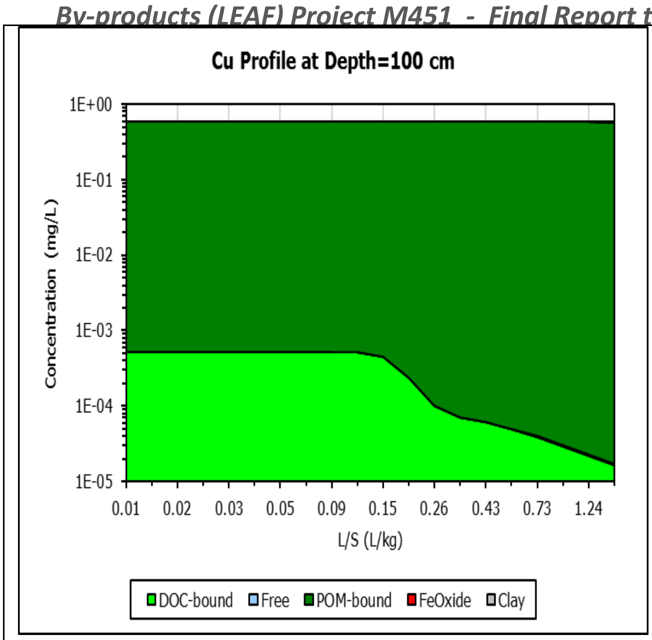

Cd Profile at L/S=0.431 L/kg

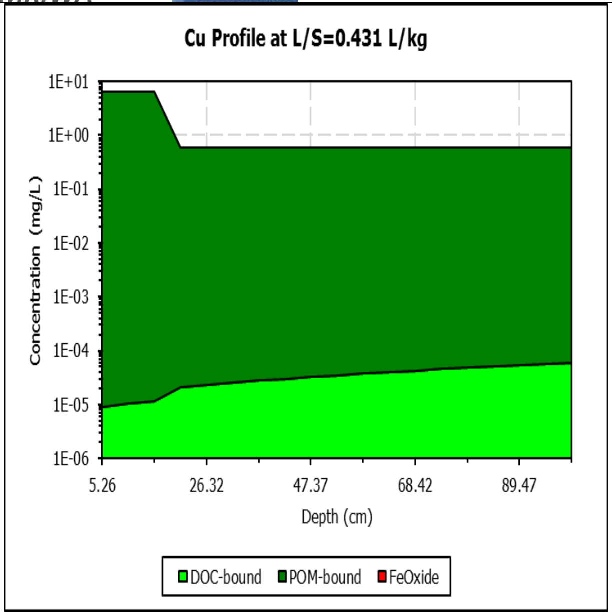

Co Profile at Depth=100 cm

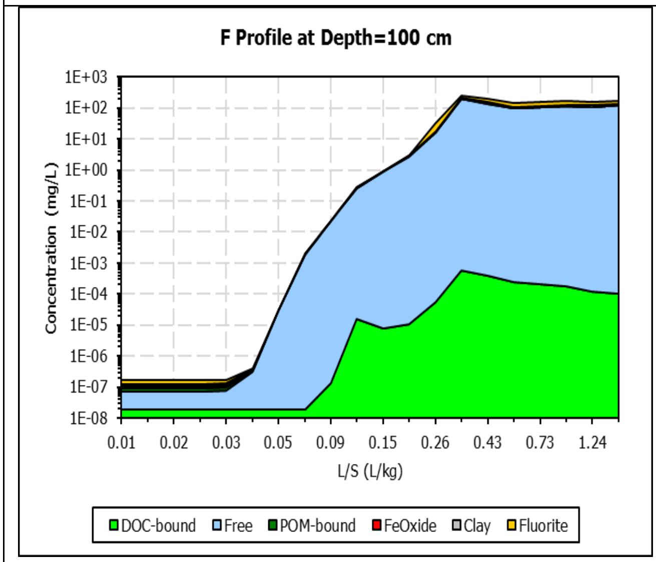

Co Profile at L/S=0.431 L/kg

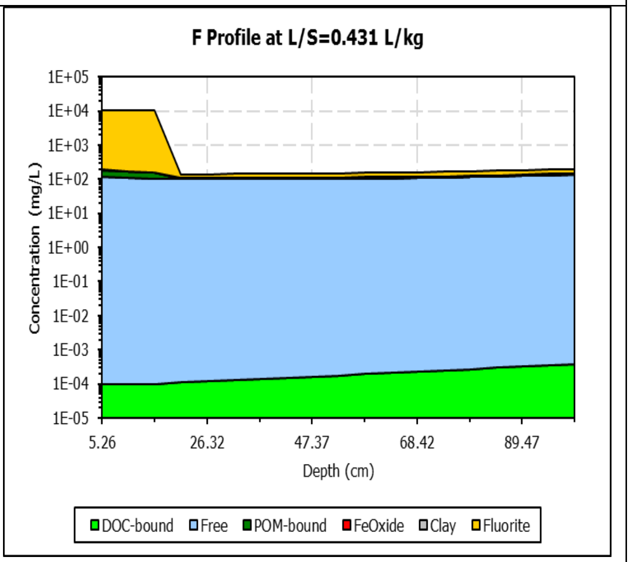

Cr Profile at Depth=100 cm

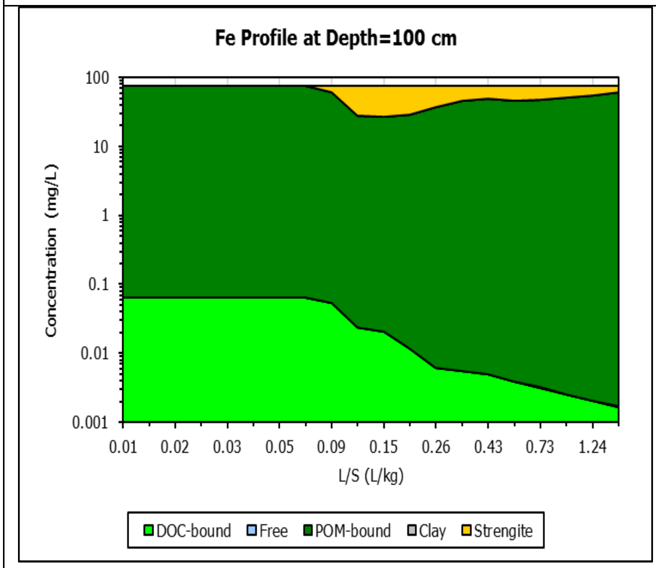

Cr Profile at L/S=0.431 L/kg

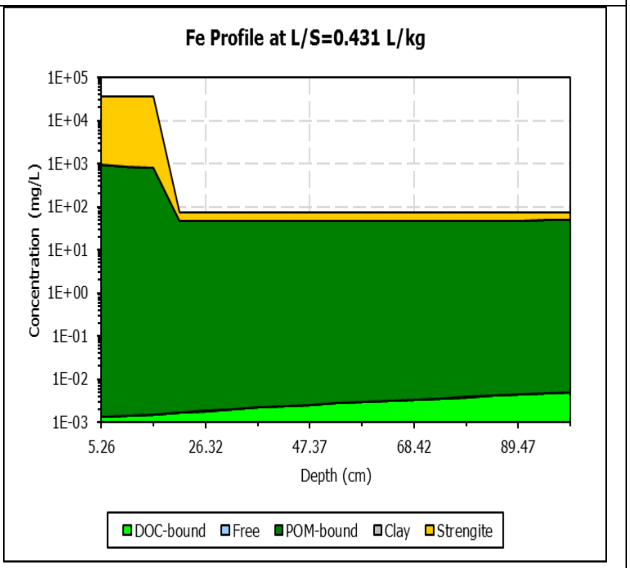

Cu Profile at Depth=100 cm

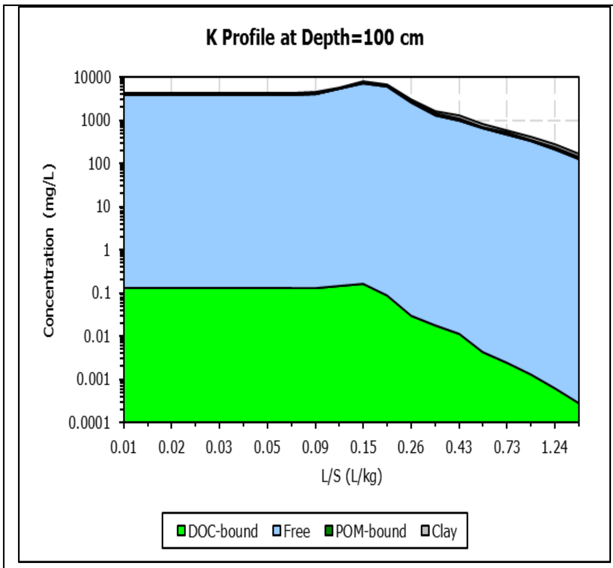

Cu Profile at L/S=0.431 L/kg

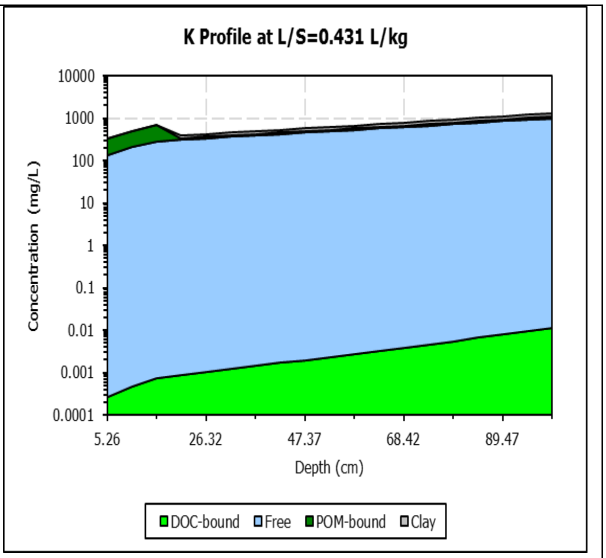

F Profile at Depth=100 cm

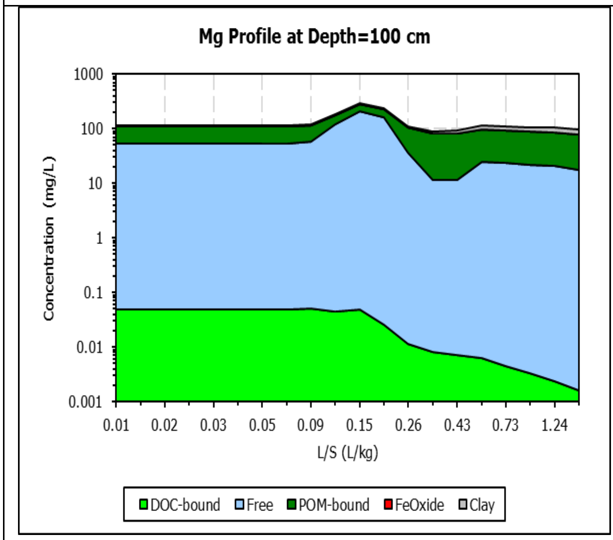

F Profile at L/S=0.431 L/kg

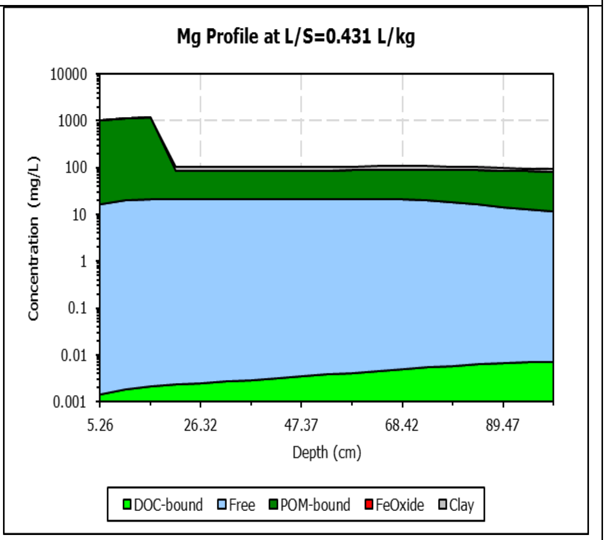

Fe Profile at Depth=100 cm

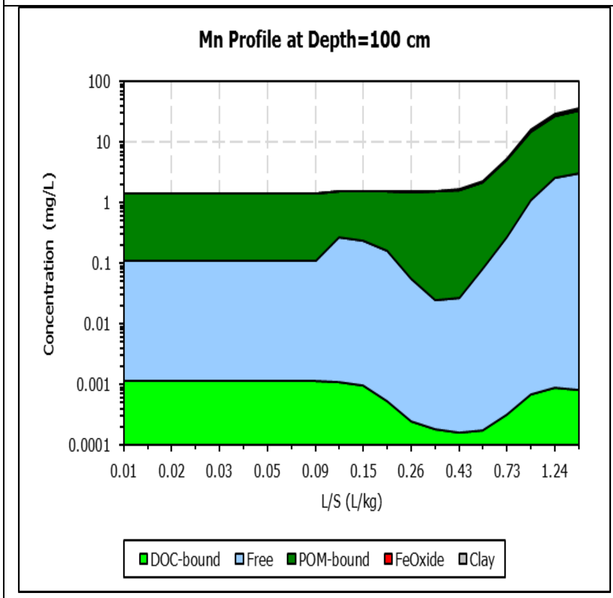

Fe Profile at L/S=0.431 L/kg

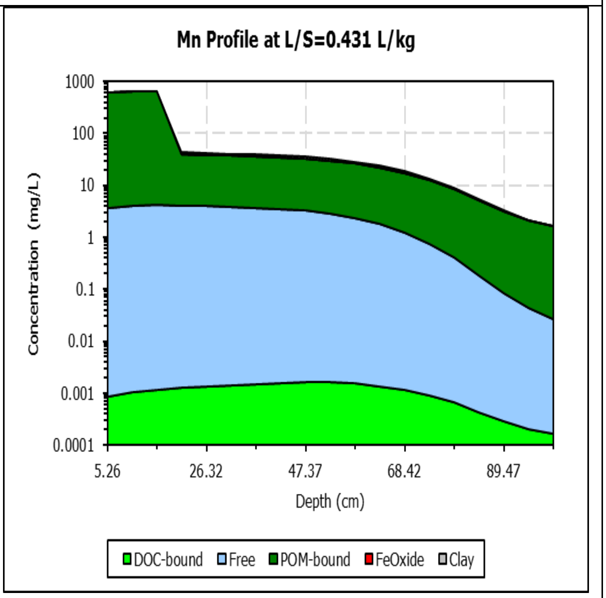

K Profile at Depth=100 cm

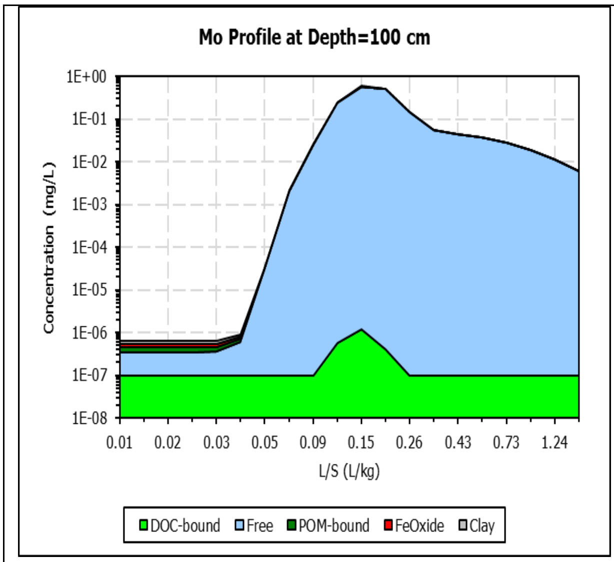

K Profile at L/S=0.431 L/kg

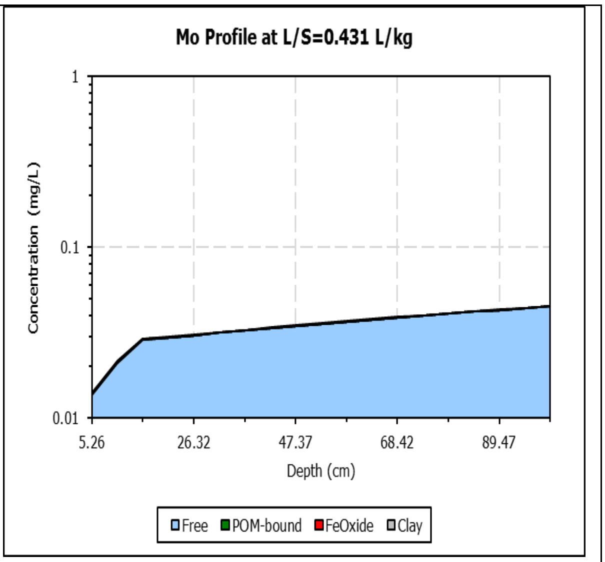

Mg Profile at Depth=100 cm

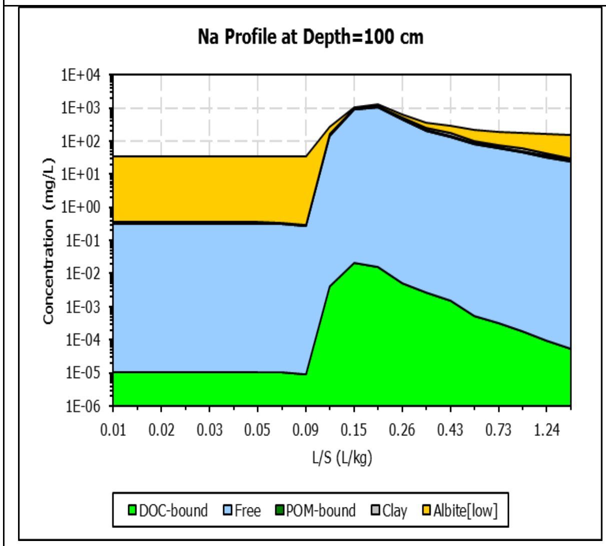

Mg Profile at L/S=0.431 L/kg

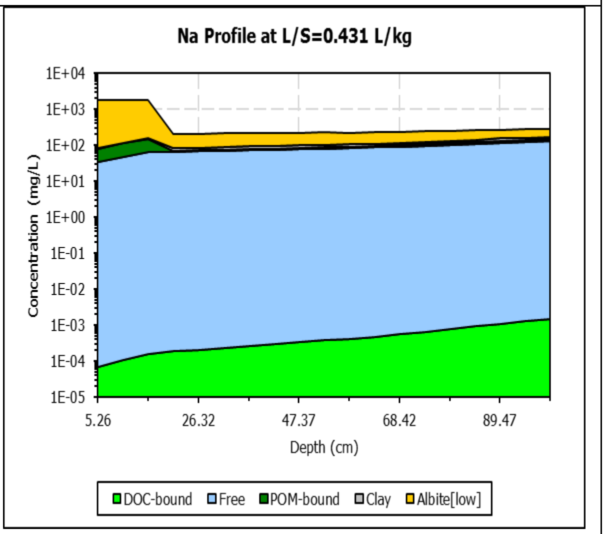

Mn Profile at Depth=100 cm

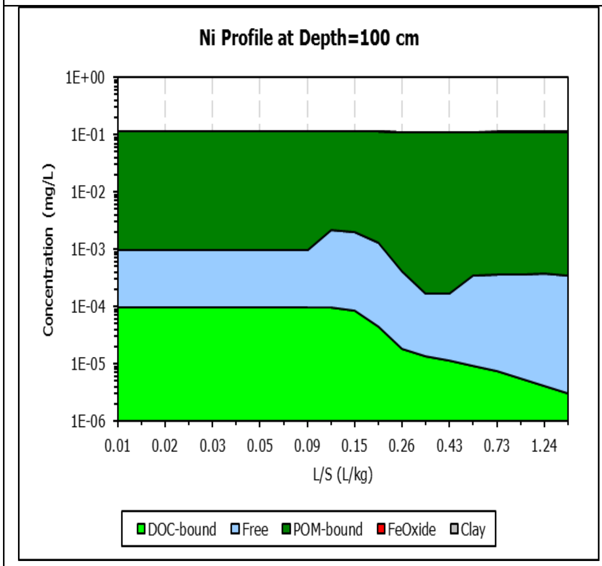

Mn Profile at L/S=0.431 L/kg

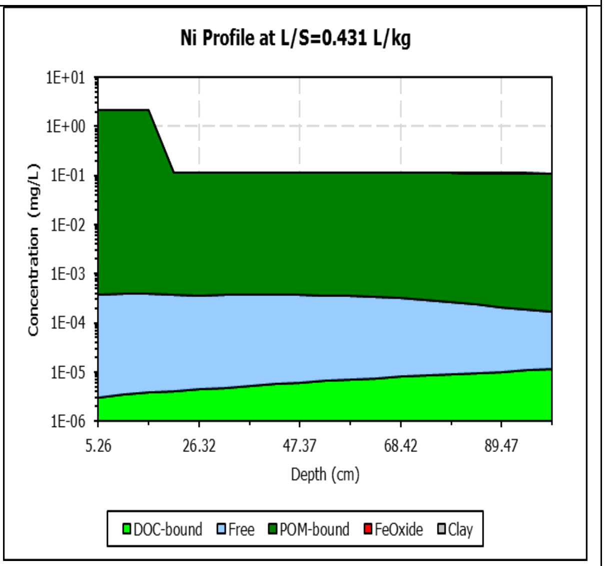

Mo Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

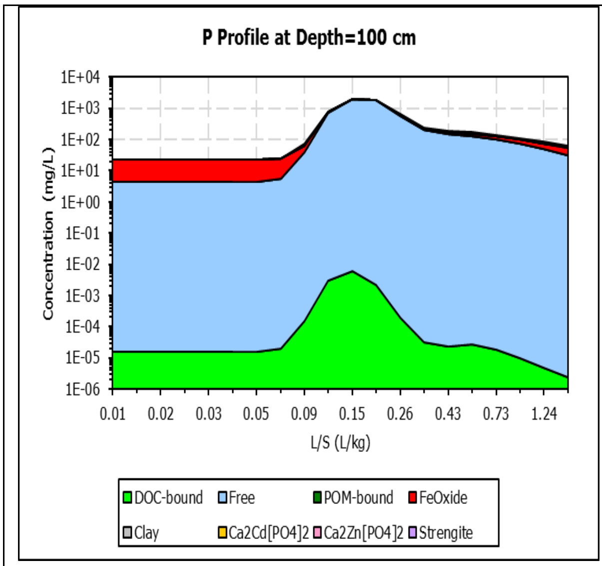

Mo Profile at L/S=0.431 L/kg
Concentration (mg/L)
1
0.1
0.01
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
POM-bound
FeOxide
Clay

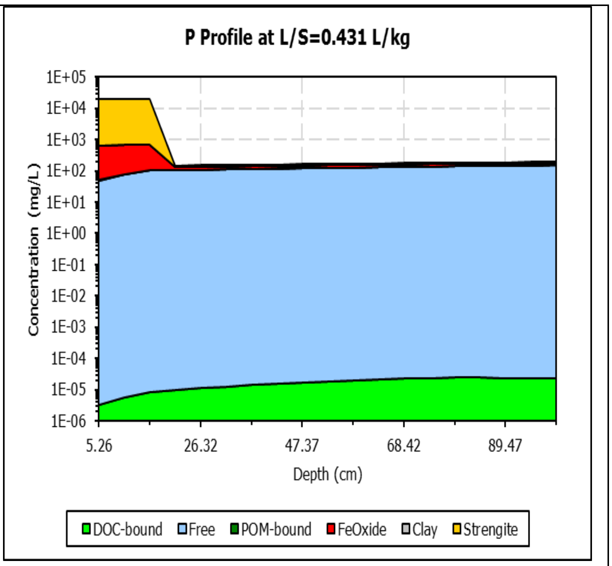

Na Profile at Depth=100 cm
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay
Albite[low]

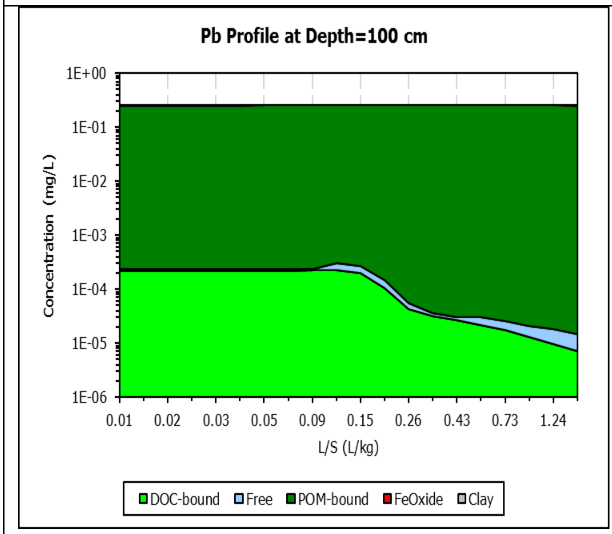

Na Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
Clay
Albite[low]

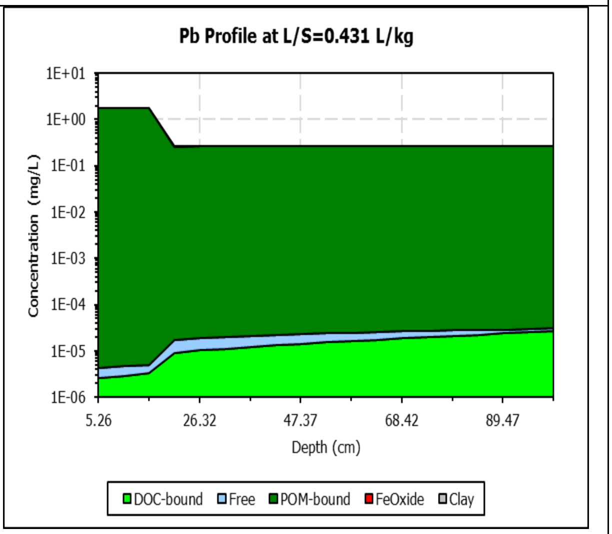

Ni Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

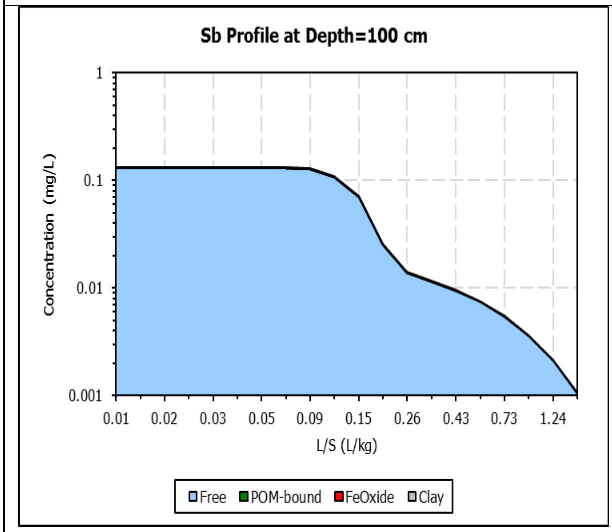

Ni Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

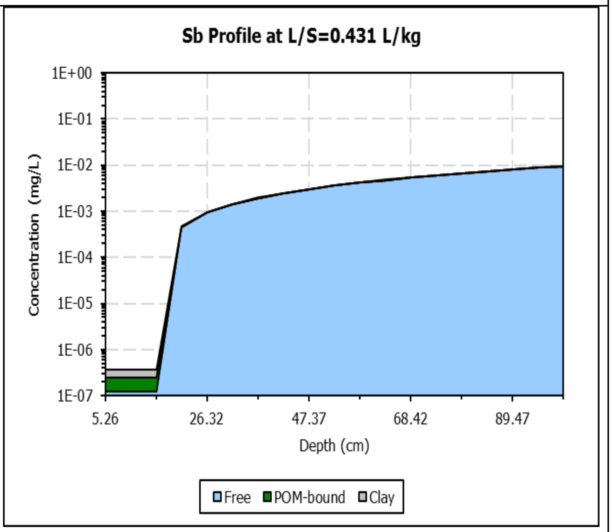

P Profile at Depth=100 cm
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay
Ca2Cd[PO4]2
Ca2Zn[PO4]2
Strengite

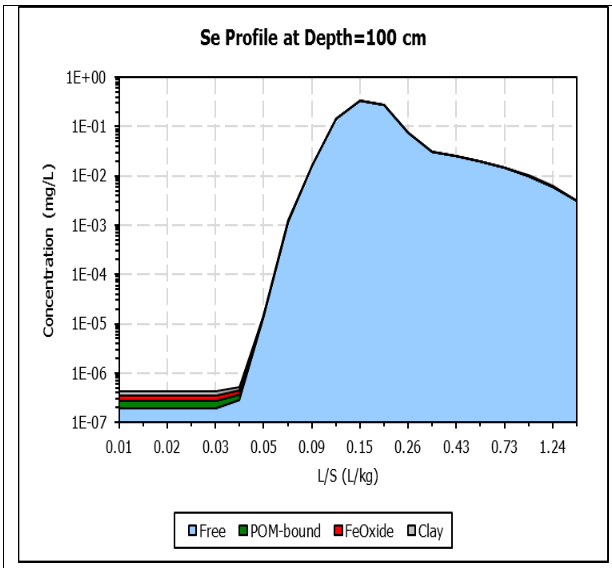

P Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay
Strengite


Pb Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay

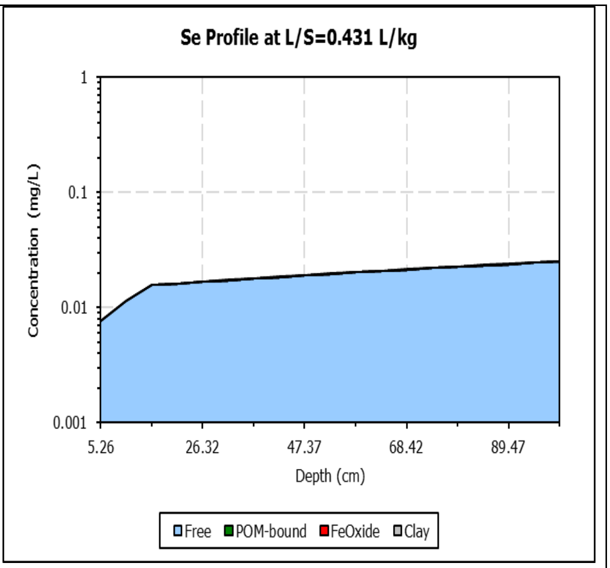

Pb Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay


Sb Profile at Depth=100 cm
Concentration (mg/L)
1
0.1
0.01
0.001
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
Free
POM-bound
FeOxide
Clay

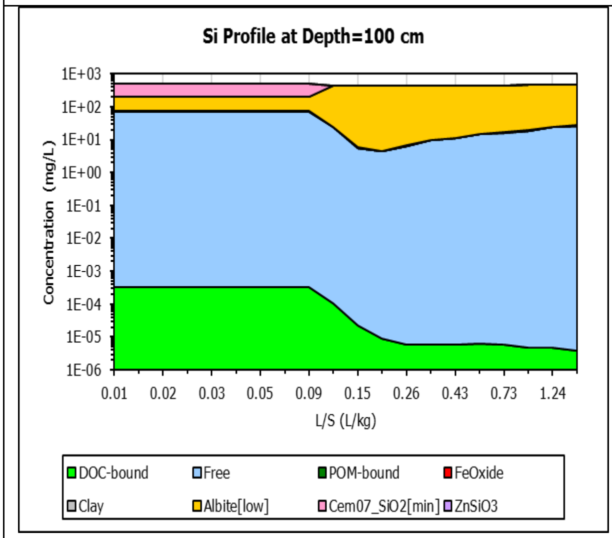

Sb Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
POM-bound
Clay



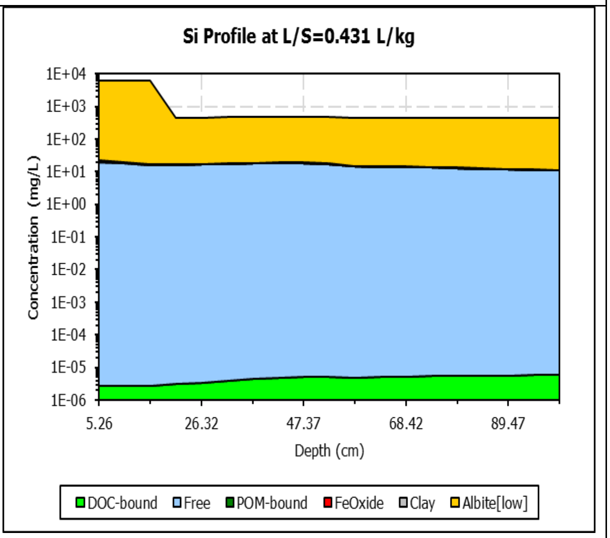
Se Profile at Depth=100 cm



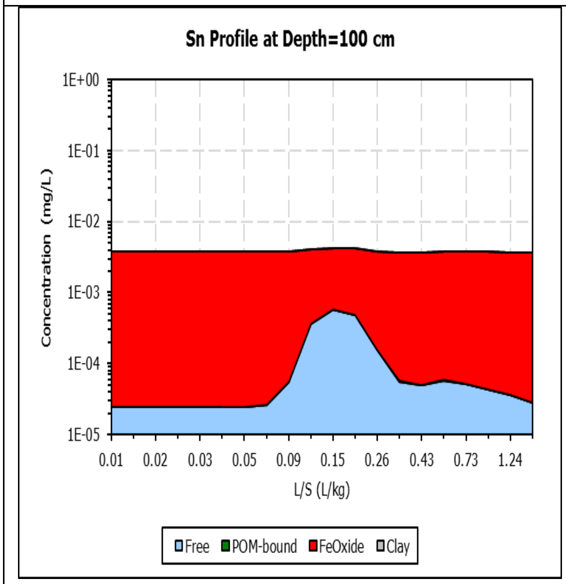
Se Profile at L/S=0.431 L/kg



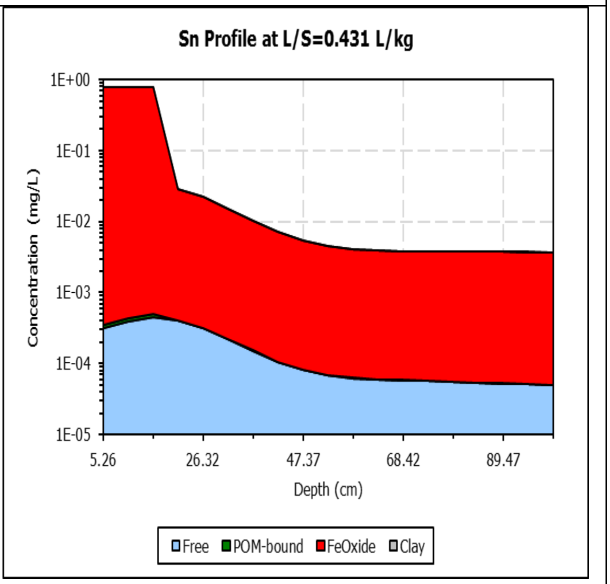
Si Profile at Depth=100 cm



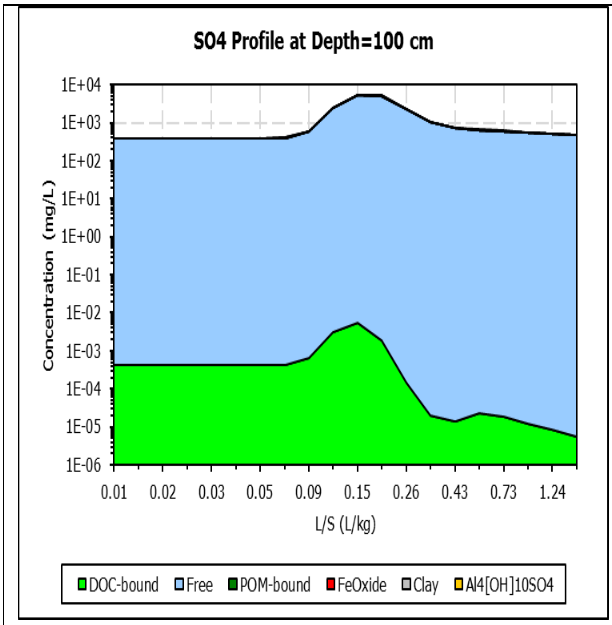
Si Profile at L/S=0.431 L/kg

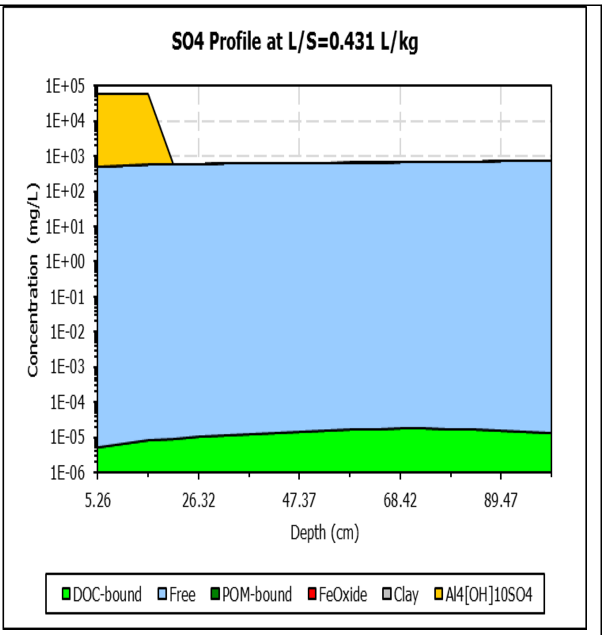


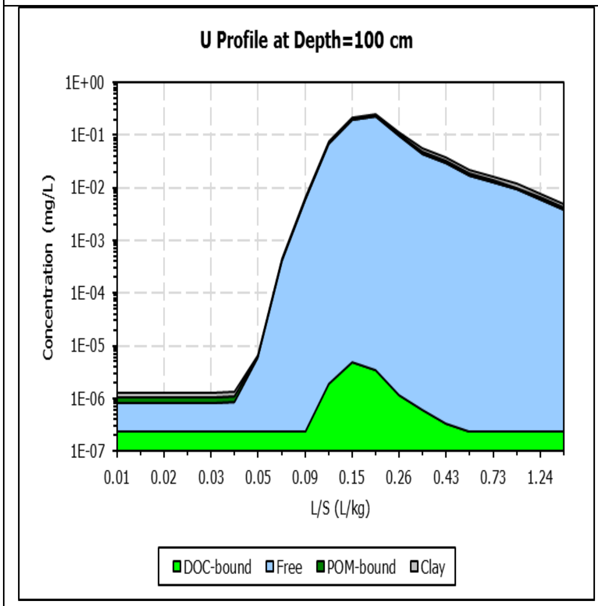
Sn Profile at Depth=100 cm

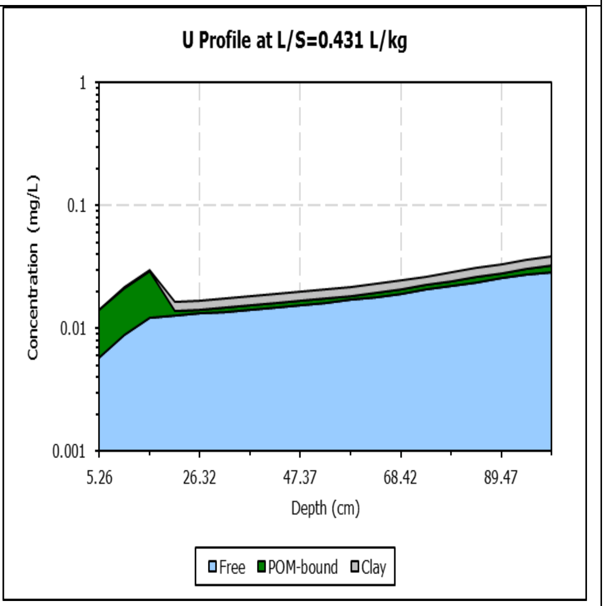


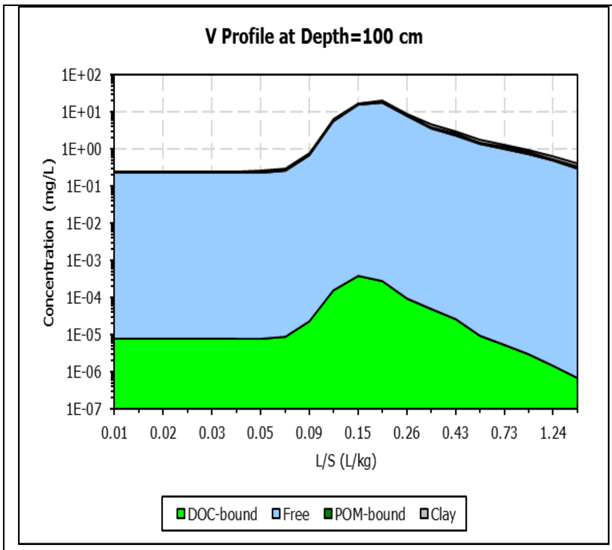
Sn Profile at L/S=0.431 L/kg

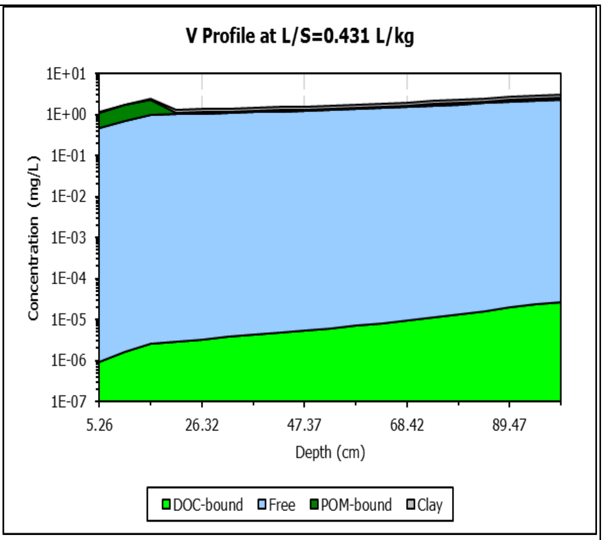

SO4 Profile at Depth=100 cm
Concentration (mg/L)
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay
Al4[OH]10SO4

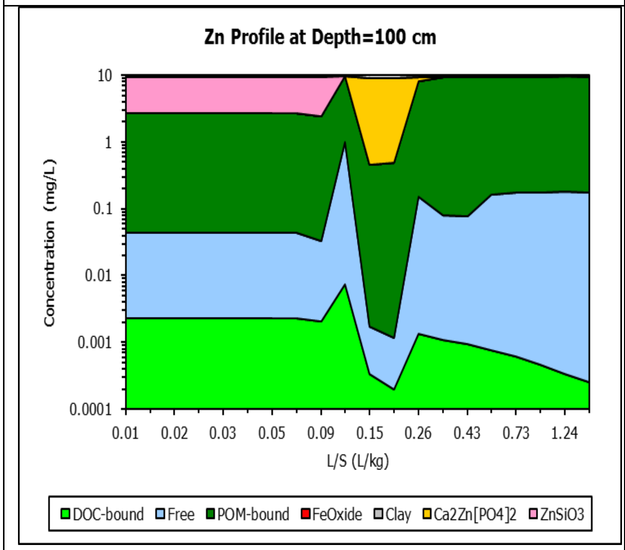

SO4 Profile at L/S=0.431 L/kg
Concentration (mg/L)
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay
Al4[OH]10SO4

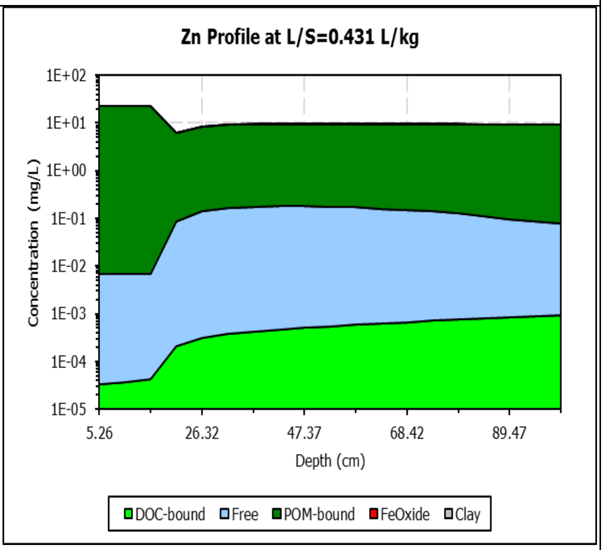

U Profile at Depth=100 cm
Concentration (mg/L)
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay


U Profile at L/S=0.431 L/kg
Concentration (mg/L)
1
0.1
0.01
0.001
5.26
26.32
47.37
68.42
89.47
Depth (cm)
Free
POM-bound
Clay

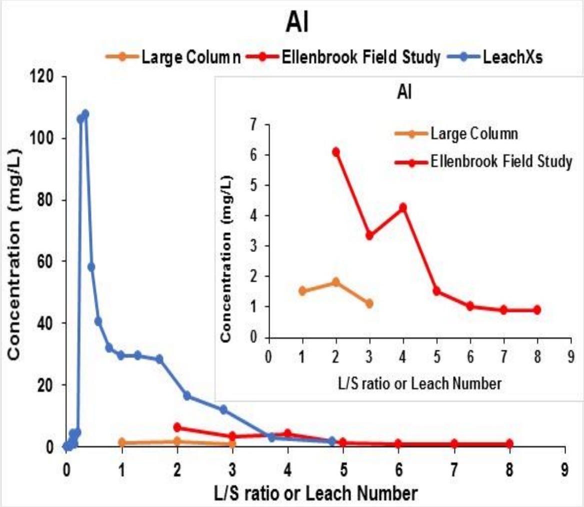

V Profile at Depth=100 cm
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
Concentration (mg/L)
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
Clay

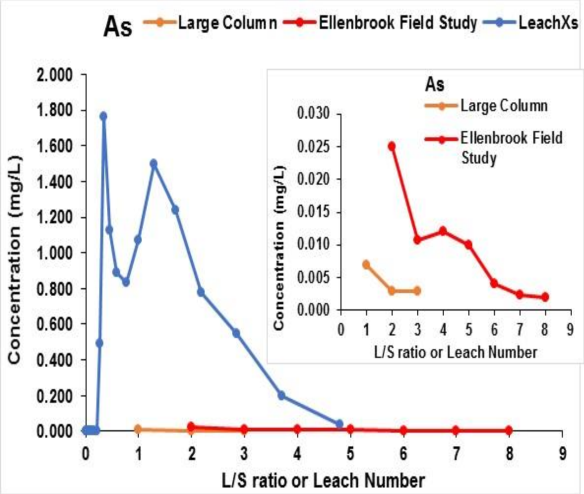

V Profile at L/S=0.431 L/kg
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
Concentration (mg/L)
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
Clay

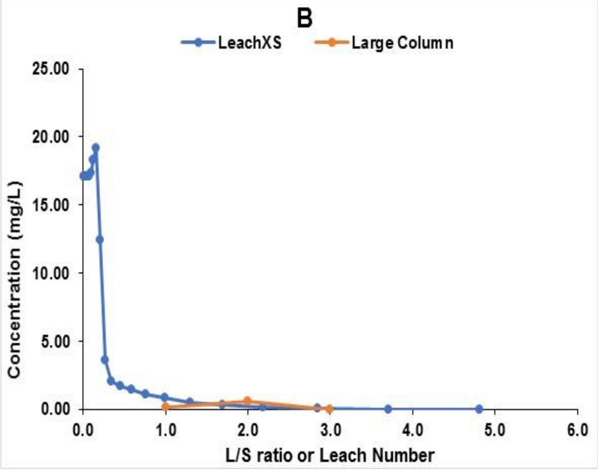

Zn Profile at Depth=100 cm
10
1
0.1
0.01
0.001
0.0001
Concentration (mg/L)
0.01
0.02
0.03
0.05
0.09
0.15
0.26
0.43
0.73
1.24
L/S (L/kg)
DOC-bound
Free
POM-bound
FeOxide
Clay
Ca2Zn[PO4]2
ZnSiO3

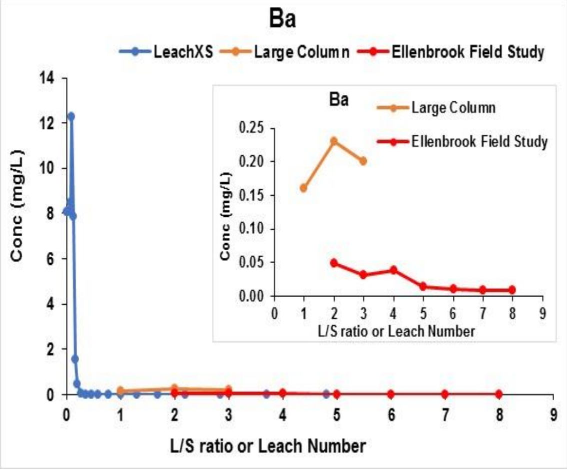

Zn Profile at L/S=0.431 L/kg
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
Concentration (mg/L)
5.26
26.32
47.37
68.42
89.47
Depth (cm)
DOC-bound
Free
POM-bound
FeOxide
Clay

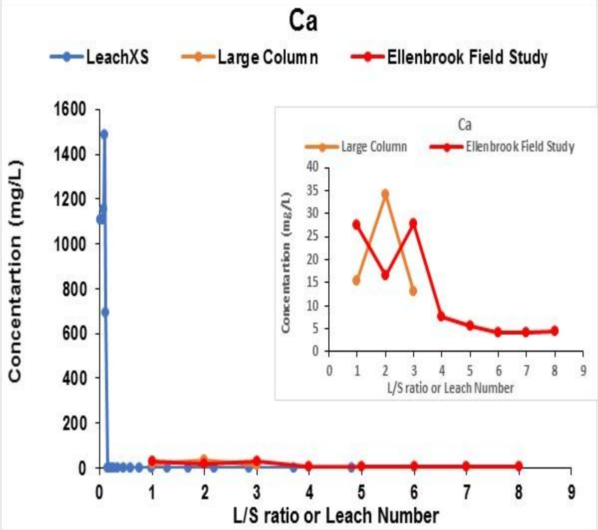
Appendix A18: Comparison between LeachXS model data (20 Cell Model), field study and Large Column Study for Alkaloam.

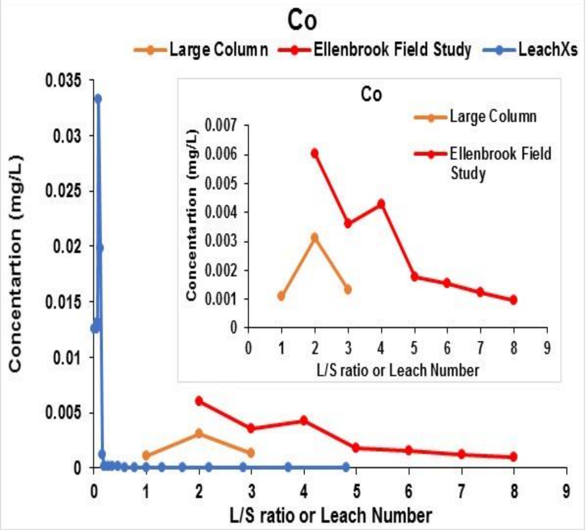


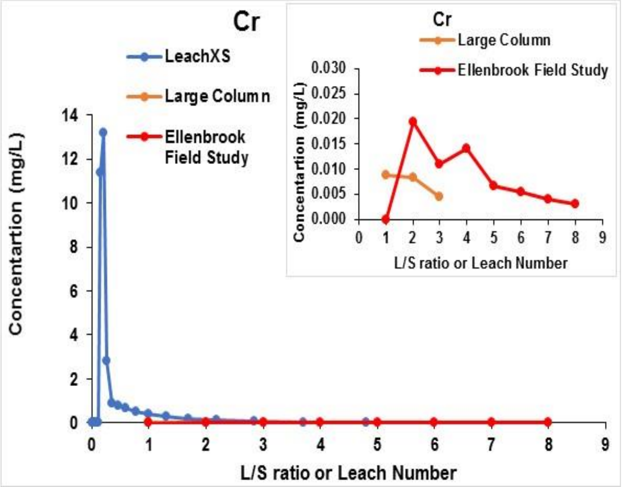


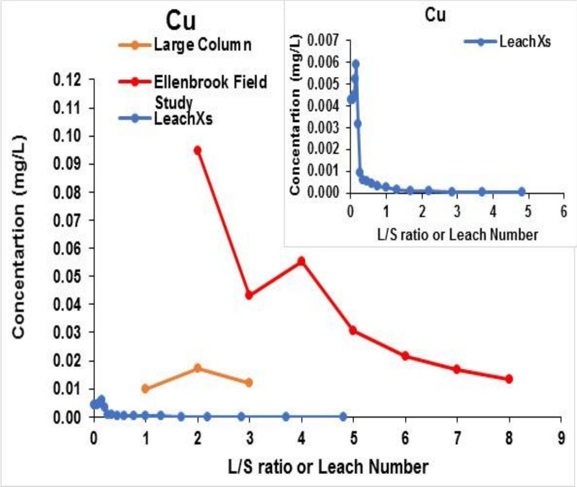


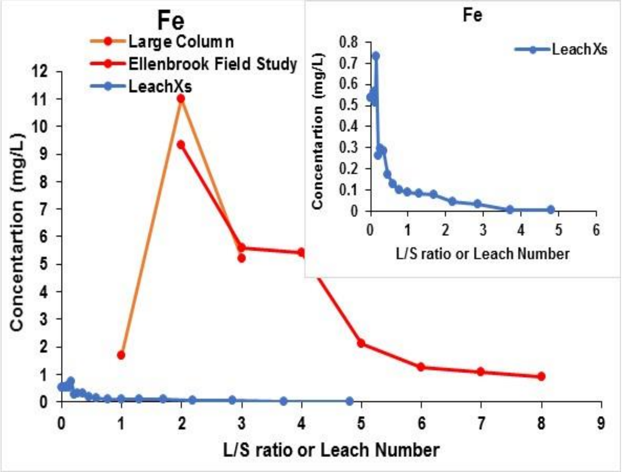


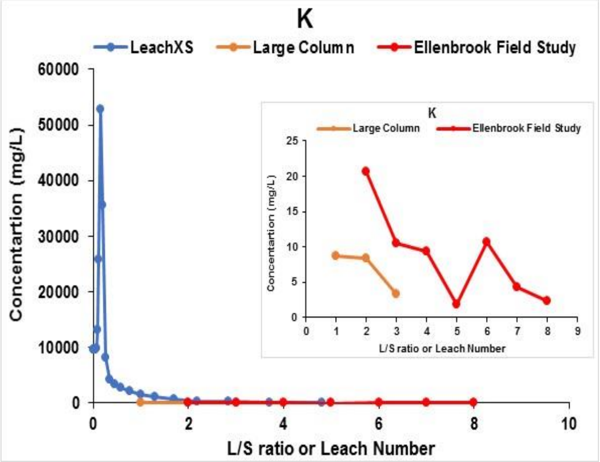


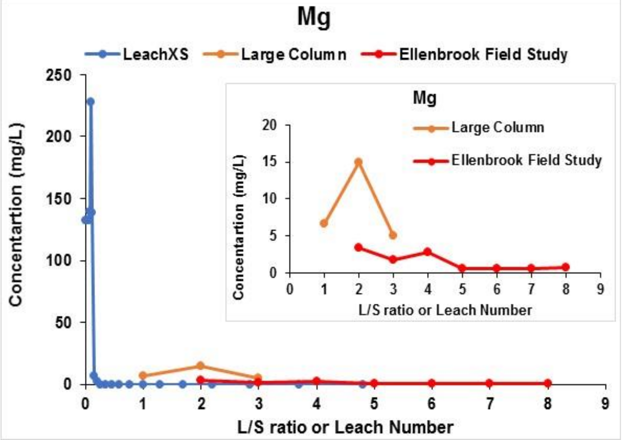


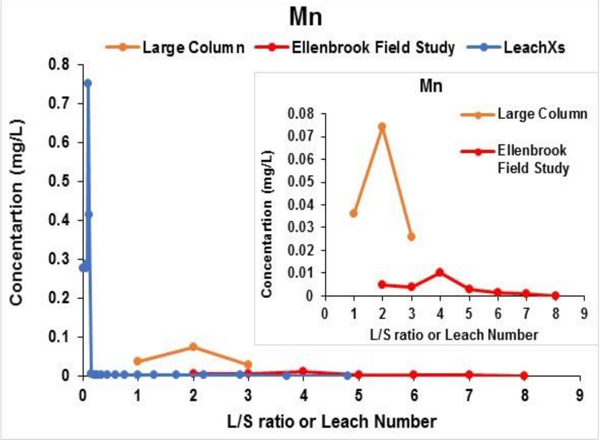

Cr
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 2 4 6 8 10 12 14
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9
Cr
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.000 0.005 0.010 0.015 0.020 0.025 0.030
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9

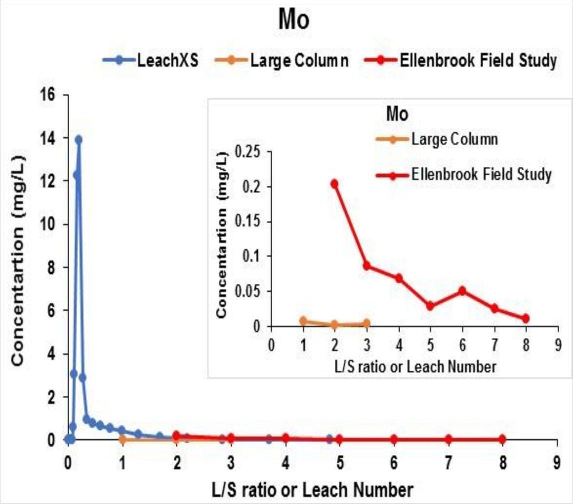

Cu
Large Column
Ellenbrook Field Study
LeachXs
Concentartion (mg/L)
0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9
Cu
LeachXs
Concentartion (mg/L)
0.000 0.001 0.002 0.003 0.004 0.005 0.006 0.007
L/S ratio or Leach Number
0 1 2 3 4 5 6

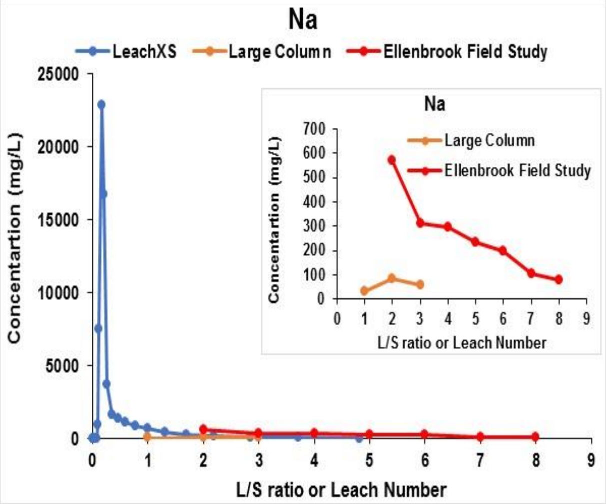

Fe
Large Column
Ellenbrook Field Study
LeachXs
Concentartion (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9
Fe
LeachXs
Concentartion (mg/L)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
L/S ratio or Leach Number
0 1 2 3 4 5 6

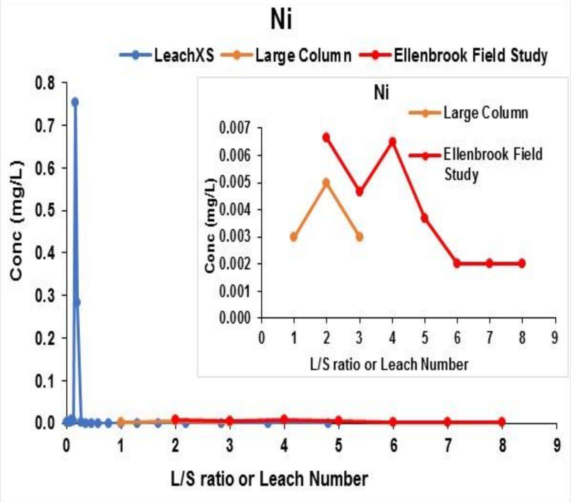

K
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 10000 20000 30000 40000 50000 60000
L/S ratio or Leach Number
0 2 4 6 8 10
K
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 5 10 15 20 25
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9

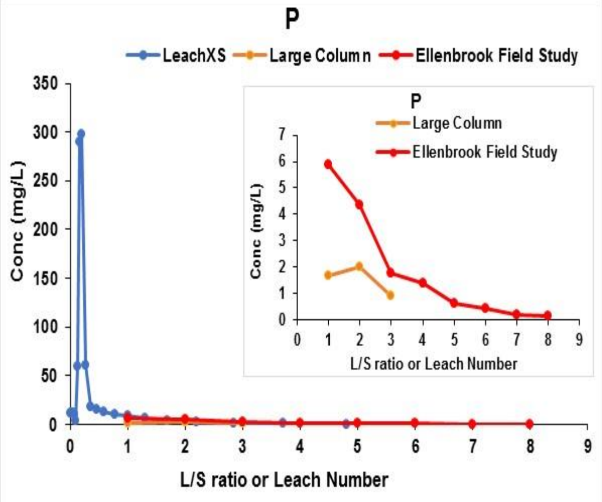

Mg
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 50 100 150 200 250
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9
Mg
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 5 10 15 20
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9

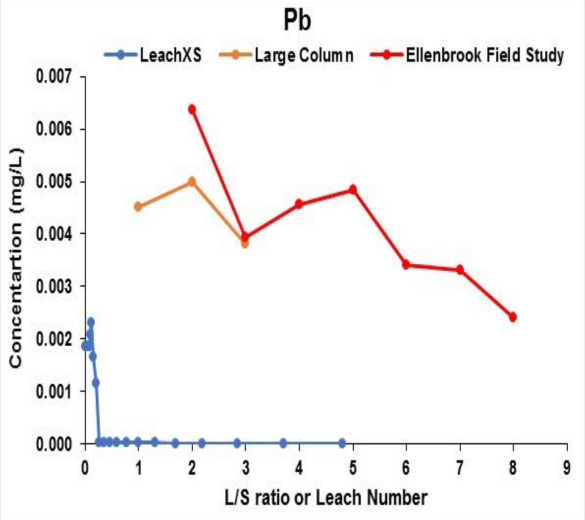

Mn
Large Column
Ellenbrook Field Study
LeachXs
Concentartion (mg/L)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9
Mn
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
L/S ratio or Leach Number
0 1 2 3 4 5 6 7 8 9

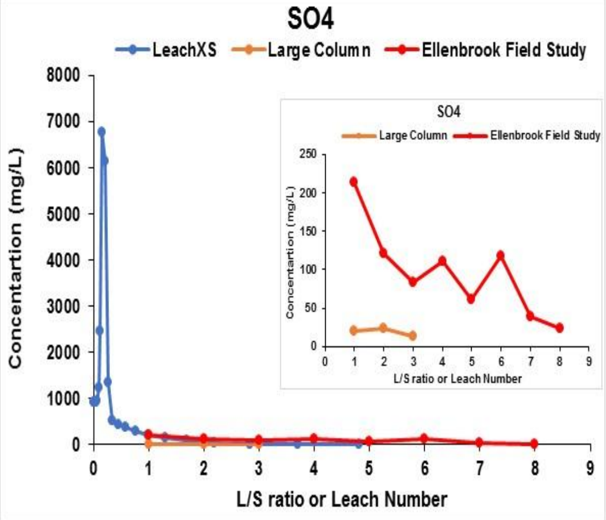

Mo
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
2
4
6
8
10
12
14
16
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9
Mo
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
0.05
0.1
0.15
0.2
0.25
L/S ratio or Leach Number

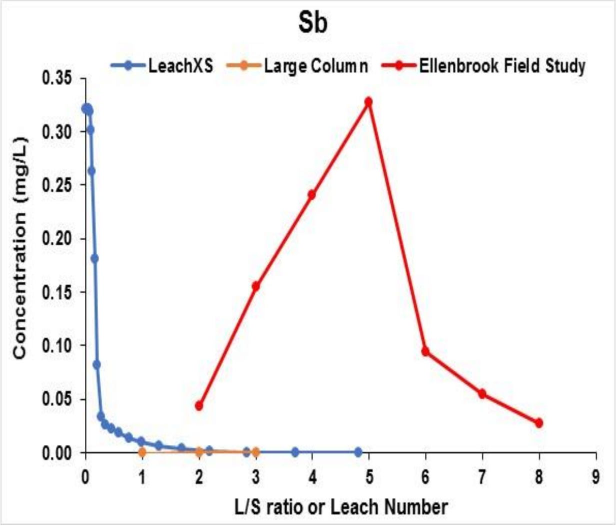

Na
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
5000
10000
15000
20000
25000
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9
Na
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
100
200
300
400
500
600
700
L/S ratio or Leach Number

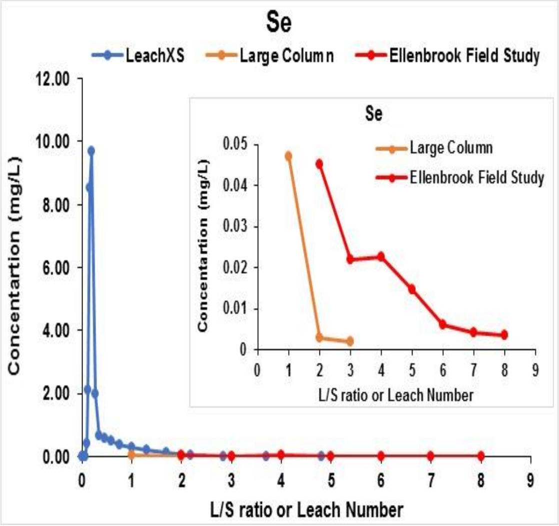

Ni
LeachXS
Large Column
Ellenbrook Field Study
Conc (mg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9
Ni
Large Column
Ellenbrook Field Study
Conc (mg/L)
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
L/S ratio or Leach Number

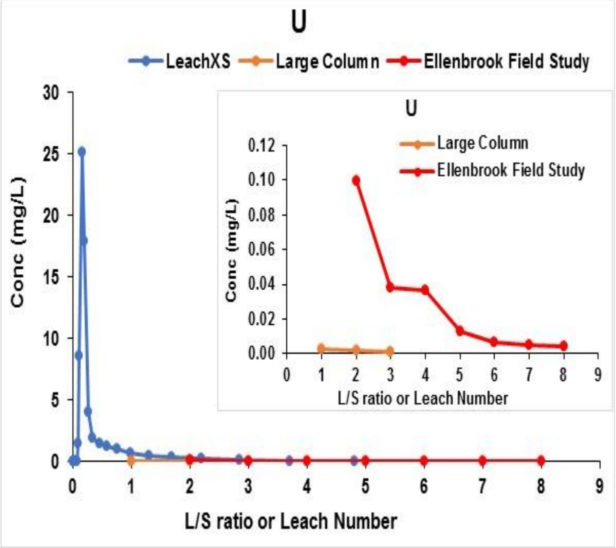

P
LeachXS
Large Column
Ellenbrook Field Study
Conc (mg/L)
0
50
100
150
200
250
300
350
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9
P
Large Column
Ellenbrook Field Study
Conc (mg/L)
0
1
2
3
4
5
6
7
L/S ratio or Leach Number

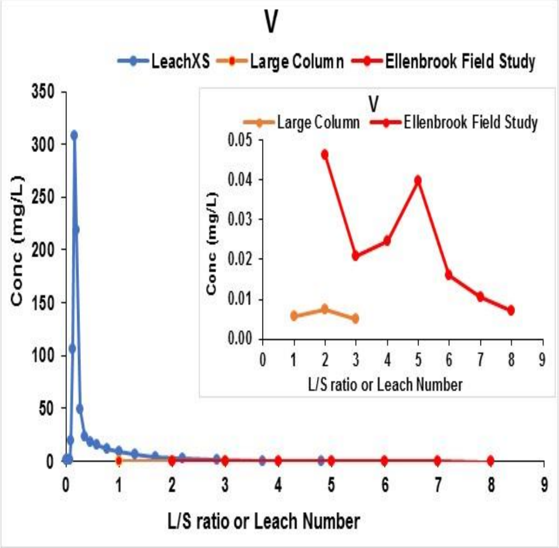

Pb
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9

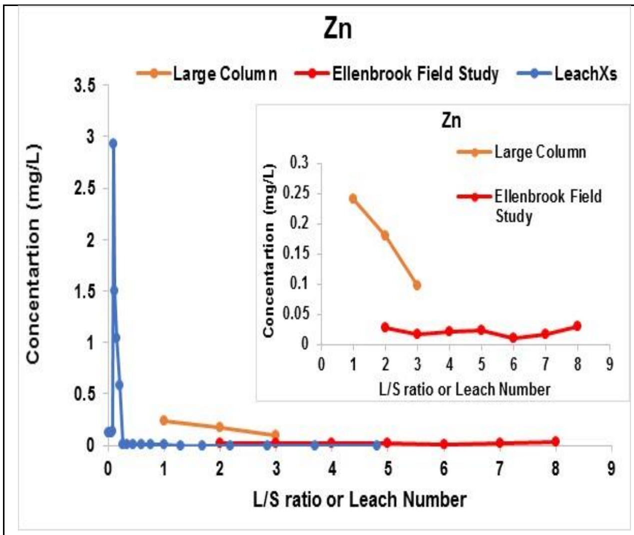

SO4
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
1000
2000
3000
4000
5000
6000
7000
8000
L/S ratio or Leach Number
0
1
2
3
4
5
6
7
8
9
SO4
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0
50
100
150
200
250
L/S ratio or Leach Number

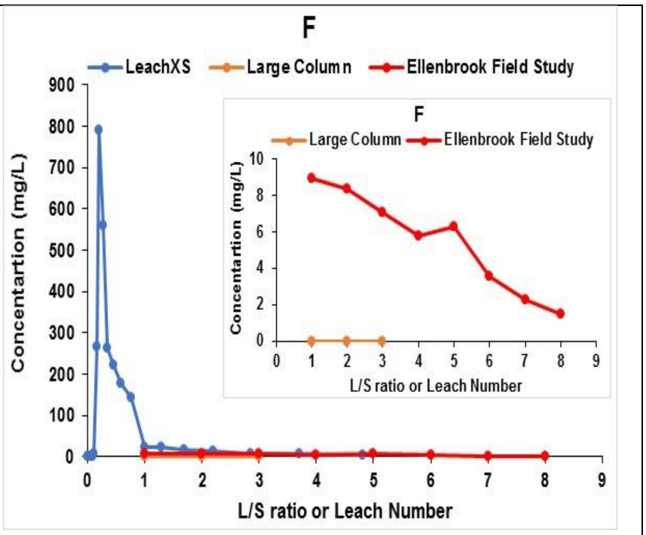

Sb
LeachXS
Large Column
Ellenbrook Field Study
Concentration (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

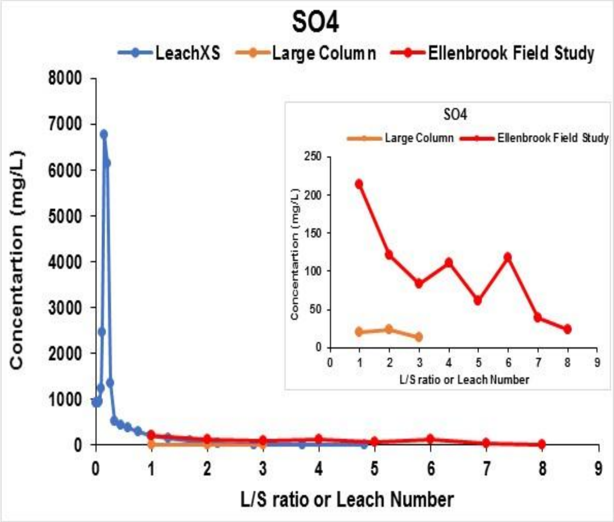

Se
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
Se
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.05
0.04
0.03
0.02
0.01
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

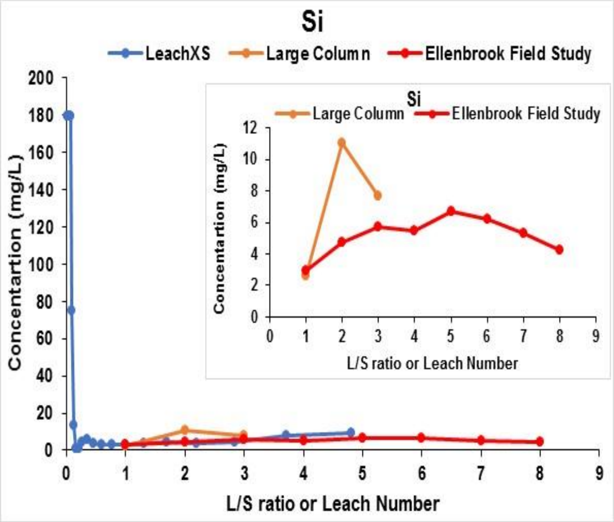

U
LeachXS
Large Column
Ellenbrook Field Study
Conc (mg/L)
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
U
Large Column
Ellenbrook Field Study
Conc (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number


V
LeachXS
Large Column
Ellenbrook Field Study
Conc (mg/L)
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
V
Large Column
Ellenbrook Field Study
Conc (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

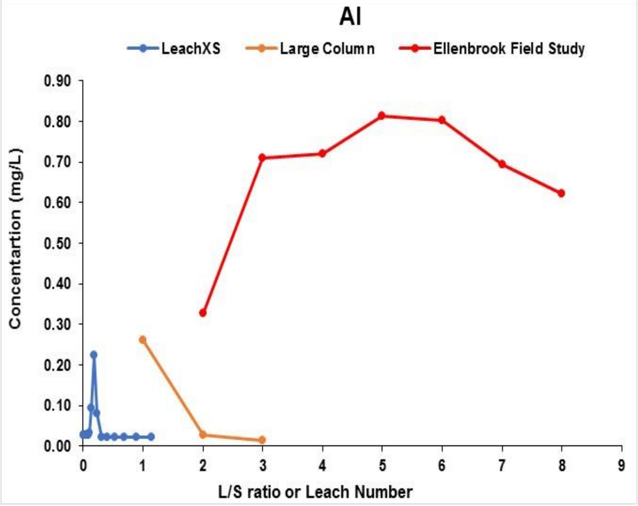

Zn
Large Column
Ellenbrook Field Study
LeachXs
Concentartion (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
Zn
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

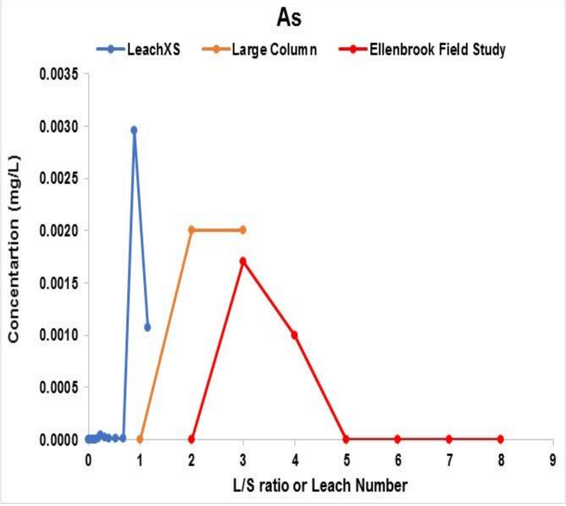

F
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
900
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
F
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

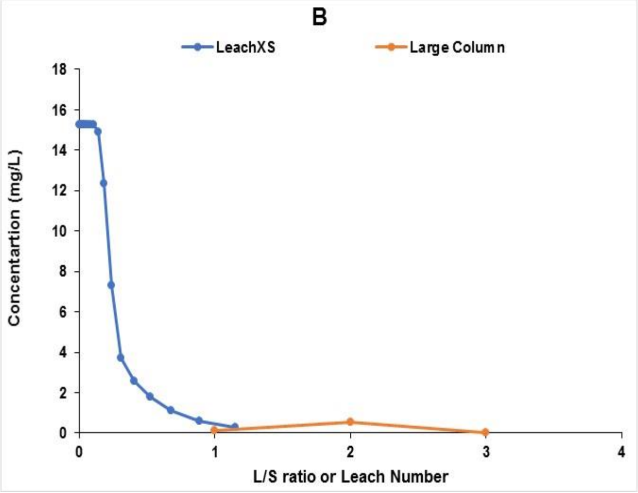

SO4
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
SO4
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

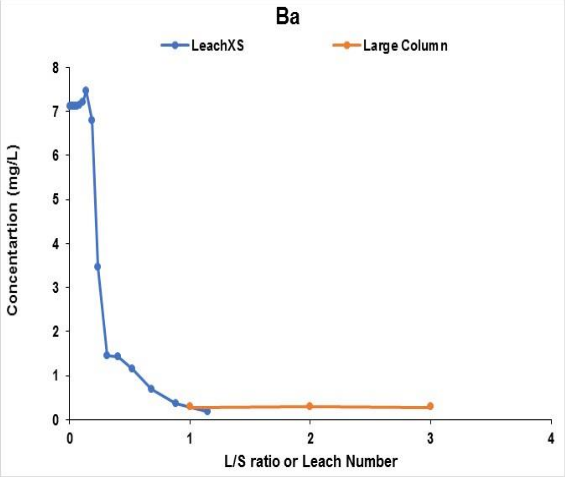

Si
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
Si
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
12
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

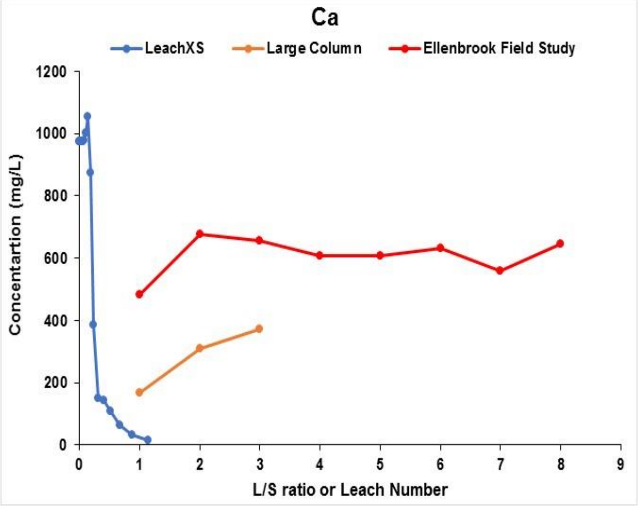
Appendix A19: Comparison between LeachXS model data (20 Cell Model), field study and Large Column Study for Ironman Gypsum (IMG).

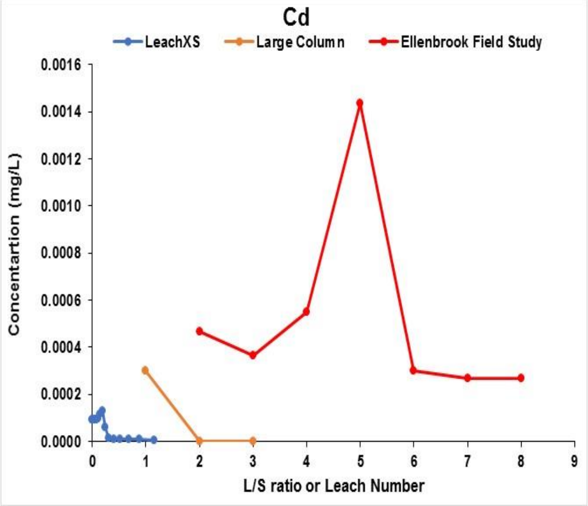


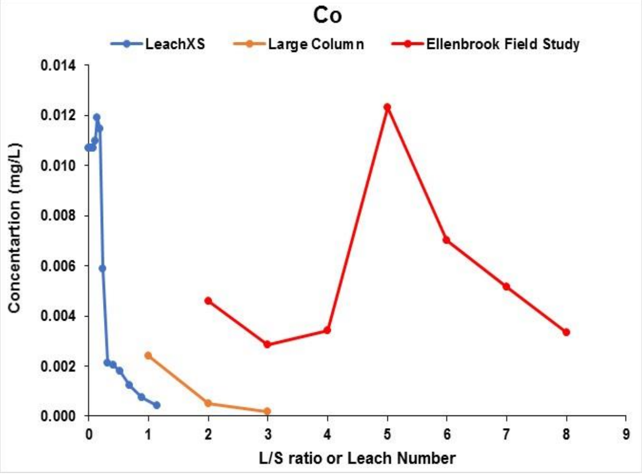


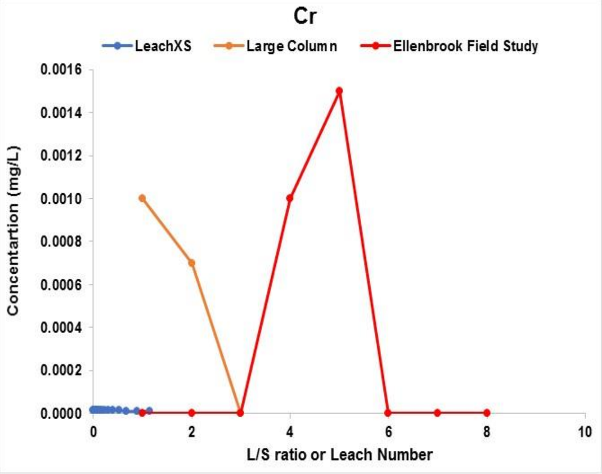


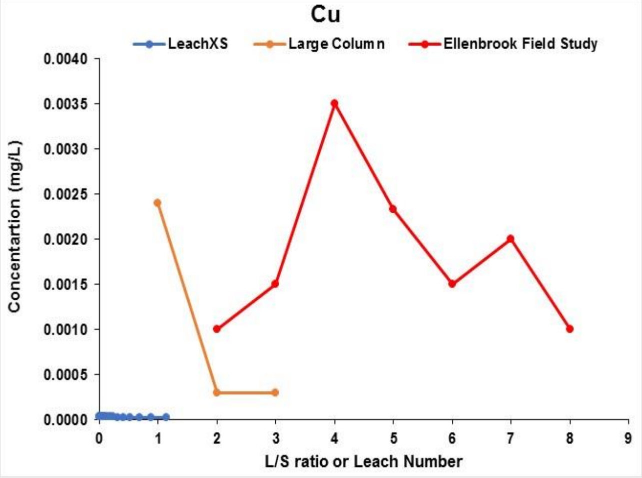


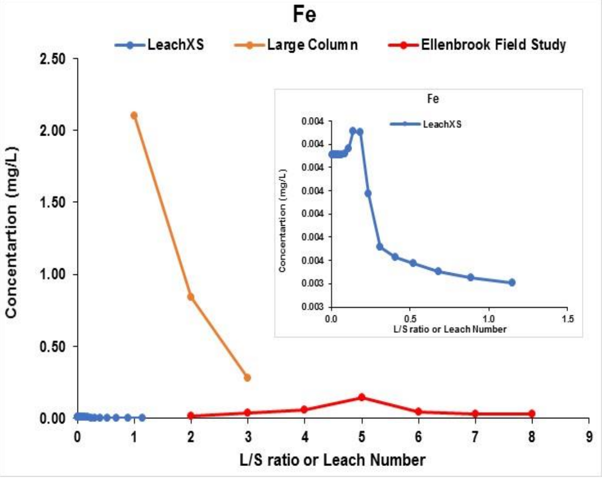


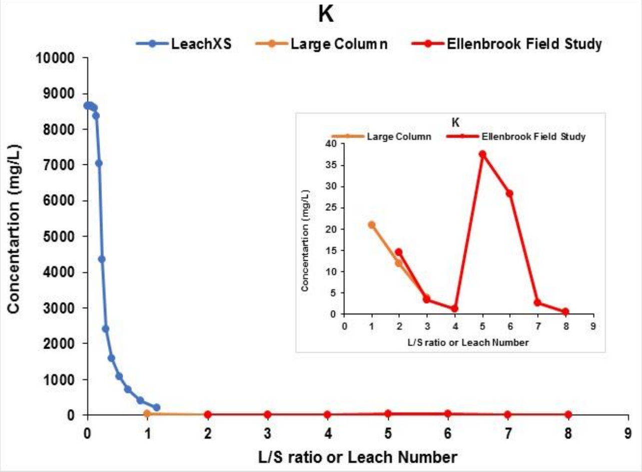


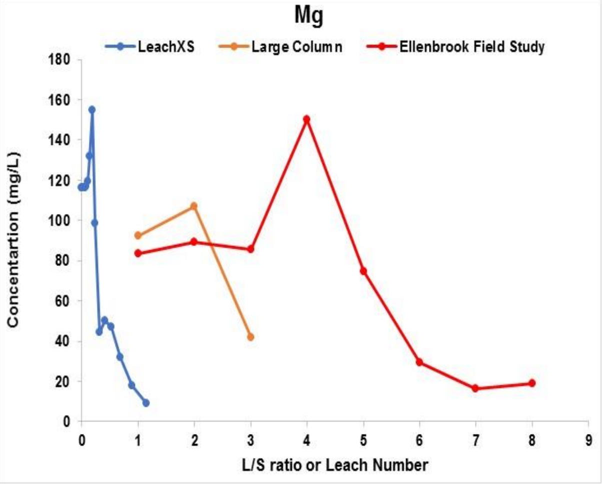

Co
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number

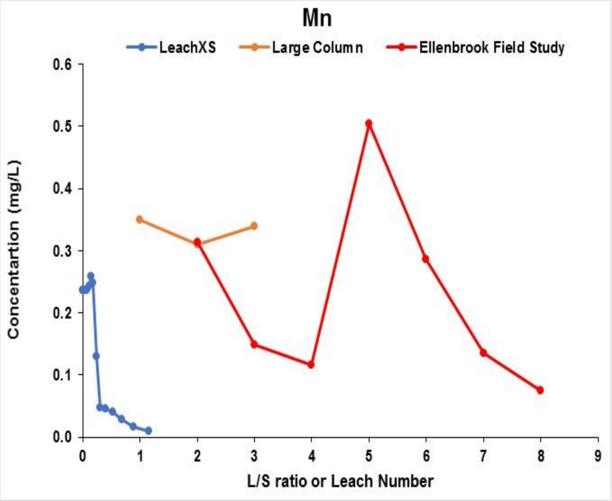

Cr
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0
2
4
6
8
10
L/S ratio or Leach Number

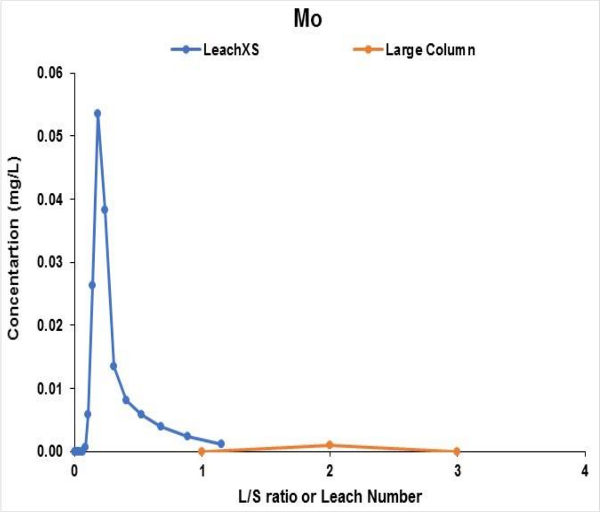

Cu
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number

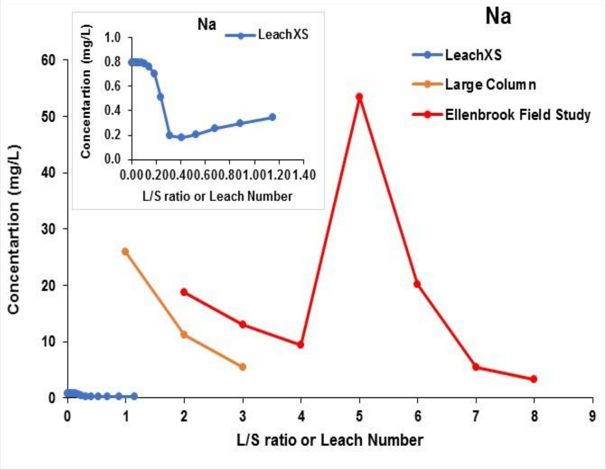

Fe
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
2.50
2.00
1.50
1.00
0.50
0.00
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number
Fe
LeachXS
Concentartion (mg/L)
0.004
0.004
0.004
0.004
0.004
0.004
0.004
0.003
0.003
0.0
0.5
1.0
1.5
L/S ratio or Leach Number

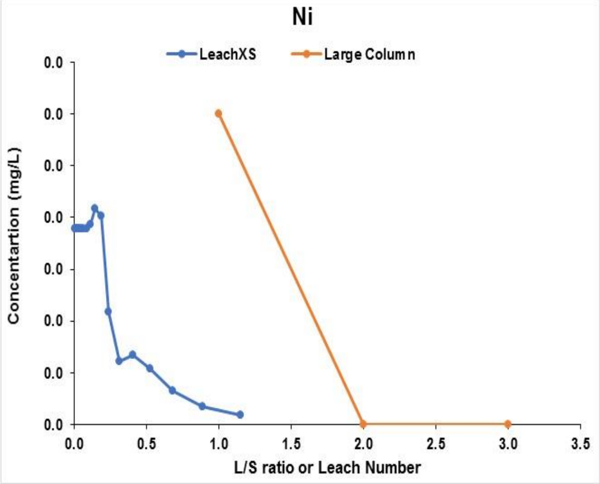

K
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number
K
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number

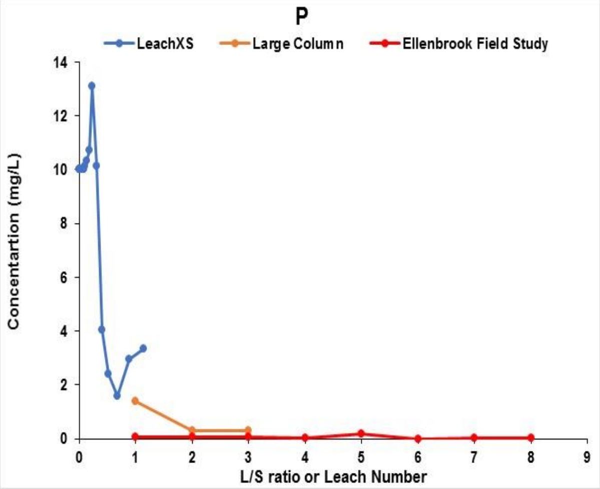

Mg
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
L/S ratio or Leach Number

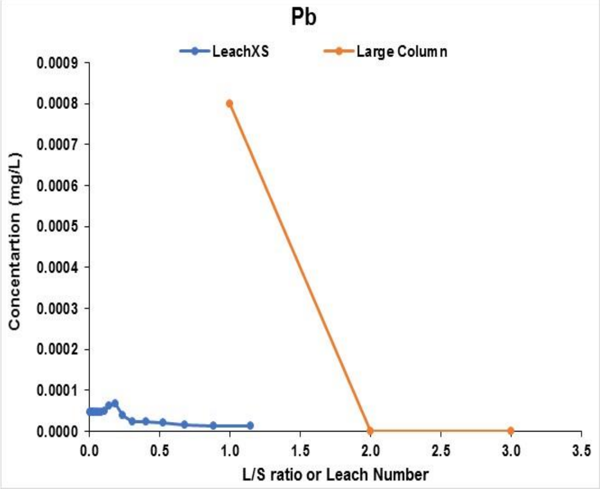

Mn
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

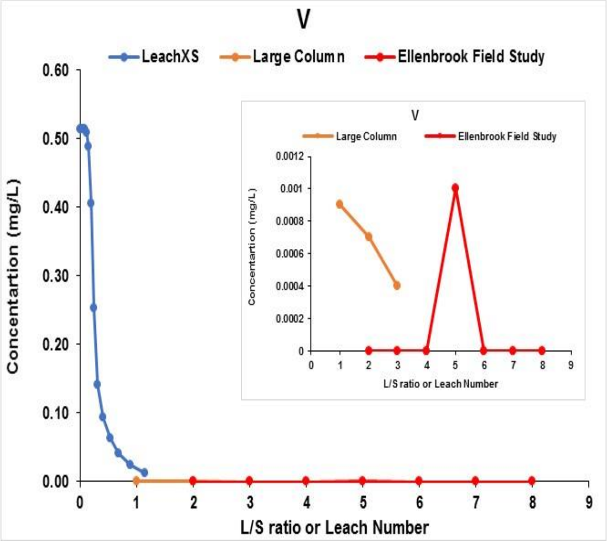

Mo
LeachXS
Large Column
Concentartion (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0 1 2 3 4
L/S ratio or Leach Number

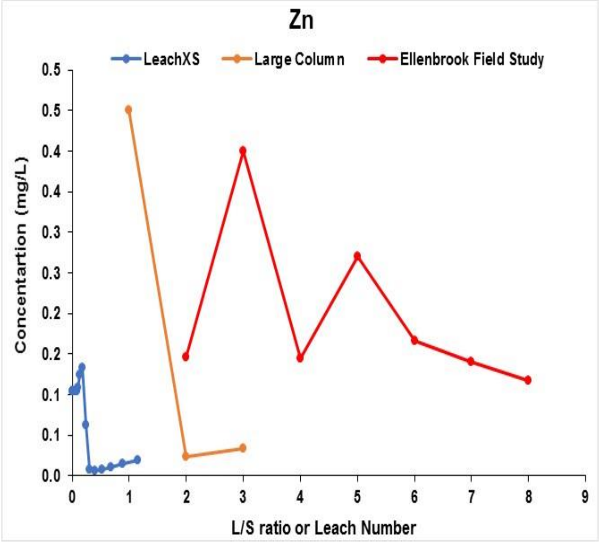

Na
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
Na
LeachXS
Concentartion (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0.00 0.20 0.40 0.60 0.80 1.00 1.20 1.40
L/S ratio or Leach Number

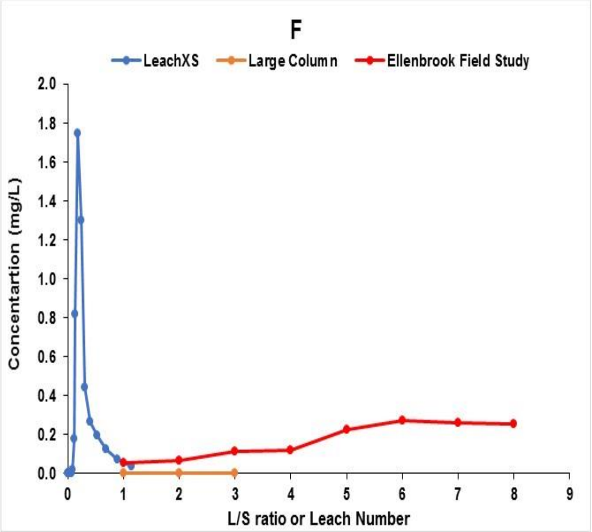

Ni
LeachXS
Large Column
Concentartion (mg/L)
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
L/S ratio or Leach Number

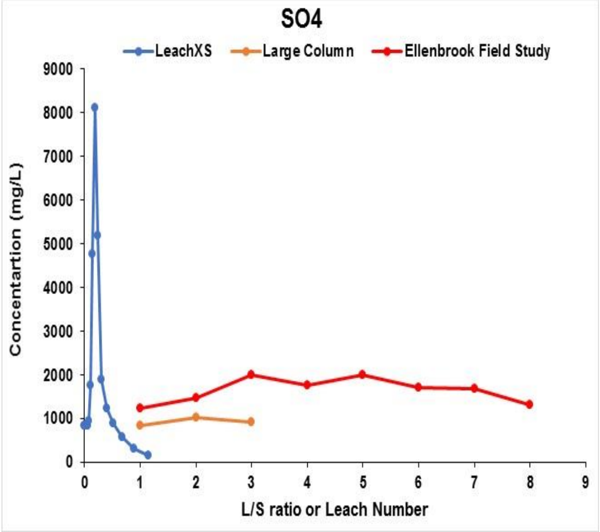

P
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
14
12
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number


Pb
LeachXS
Large Column
Concentartion (mg/L)
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
L/S ratio or Leach Number

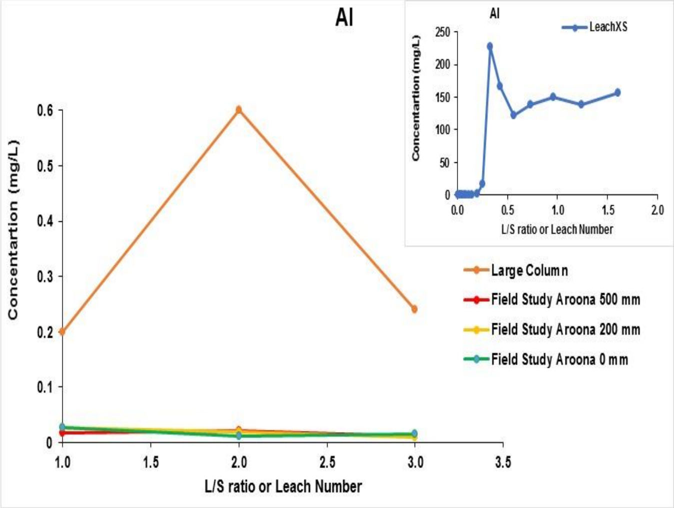

V
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number
V
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

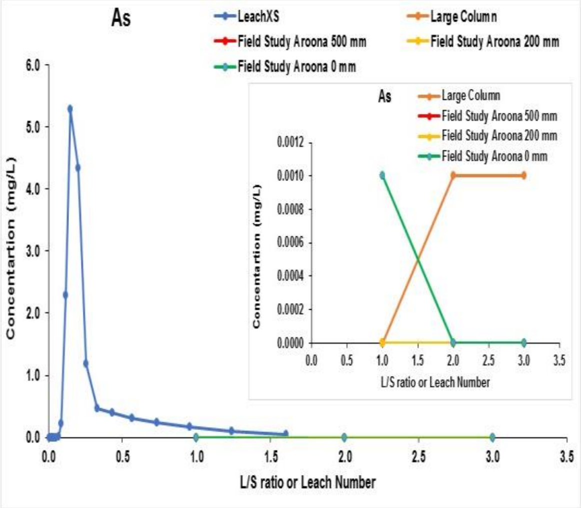

Zn
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
0.5
0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

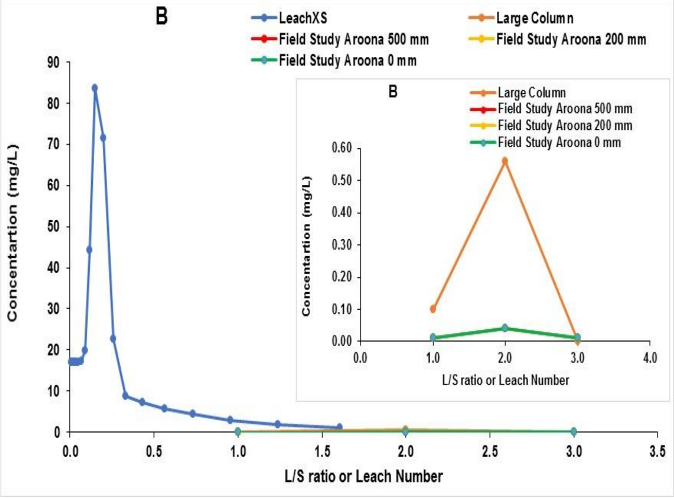

F
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

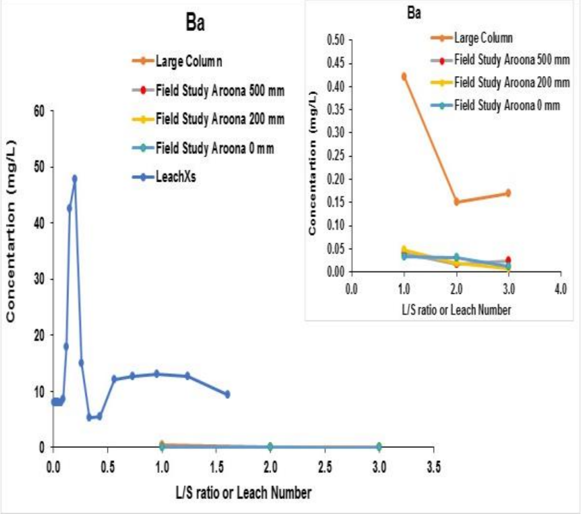

SO4
LeachXS
Large Column
Ellenbrook Field Study
Concentartion (mg/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9
L/S ratio or Leach Number

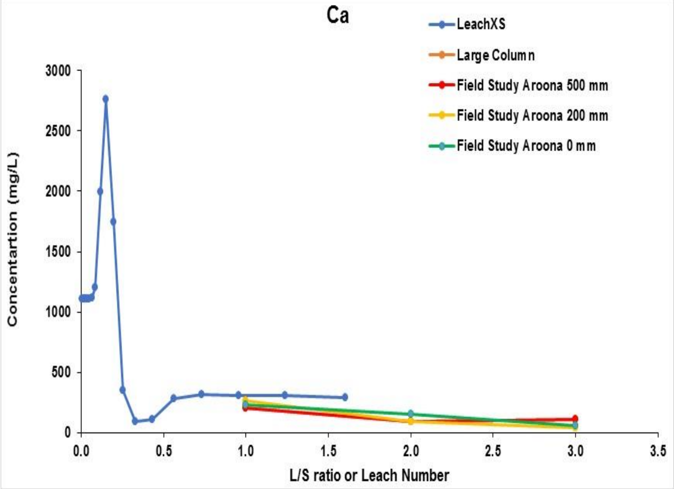
Appendix A20: Comparison between LeachXS model data (20 Cell Model), field study and Large Column Study for Jandakot.

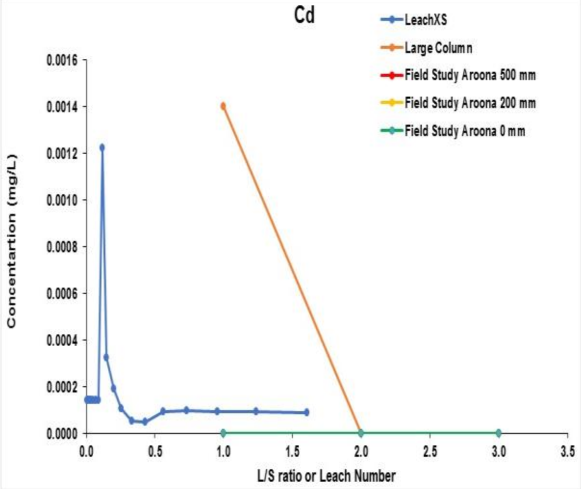


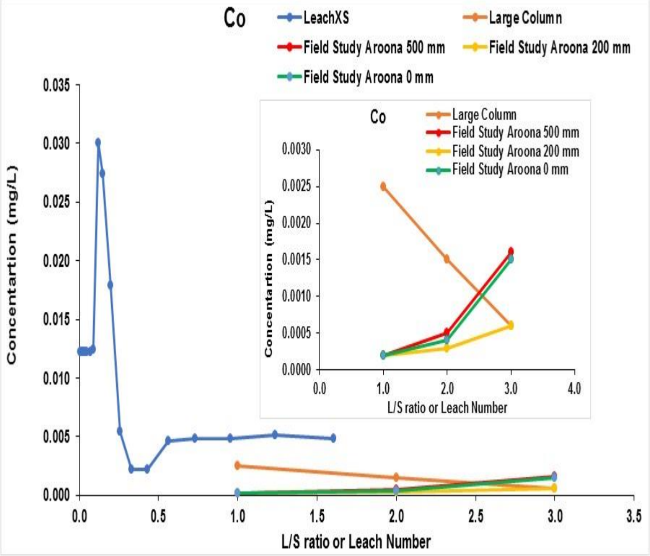


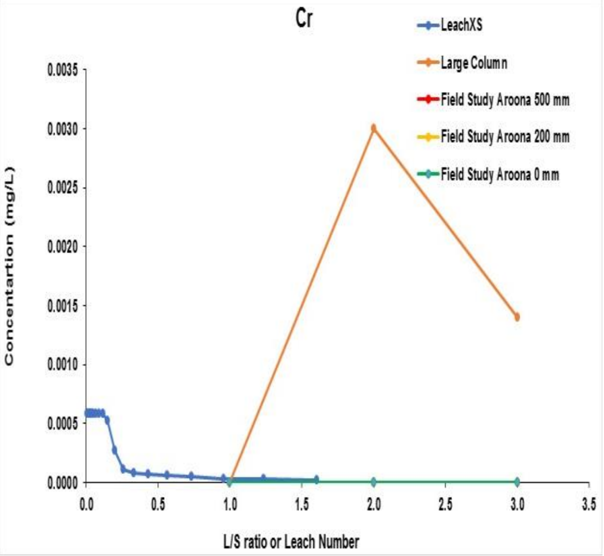


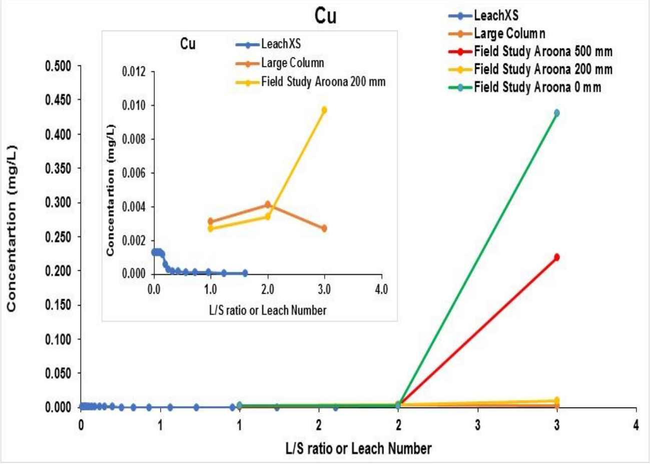


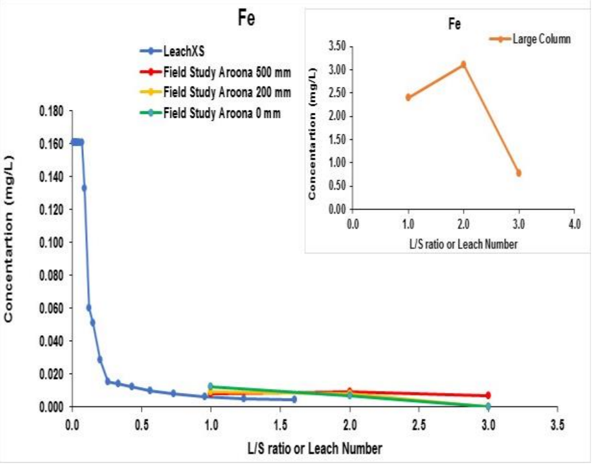


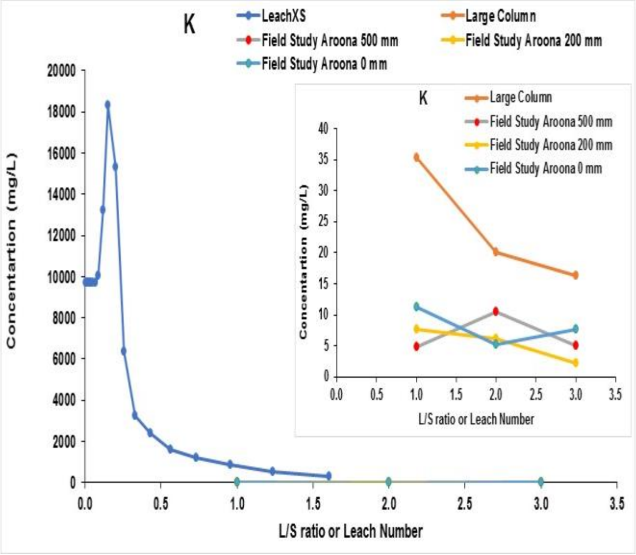


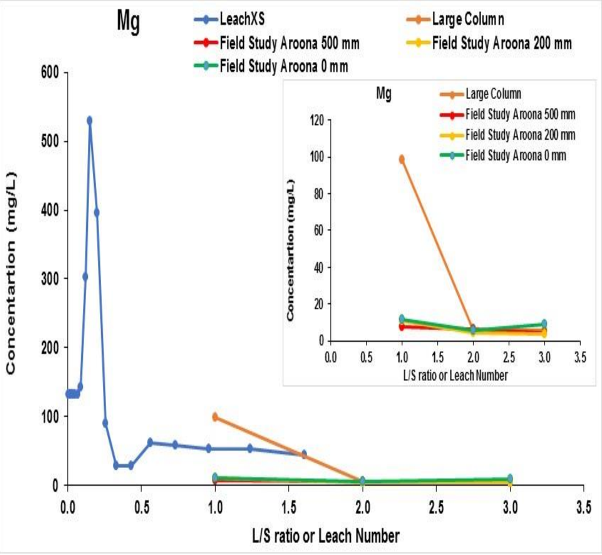

Co
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Co
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number

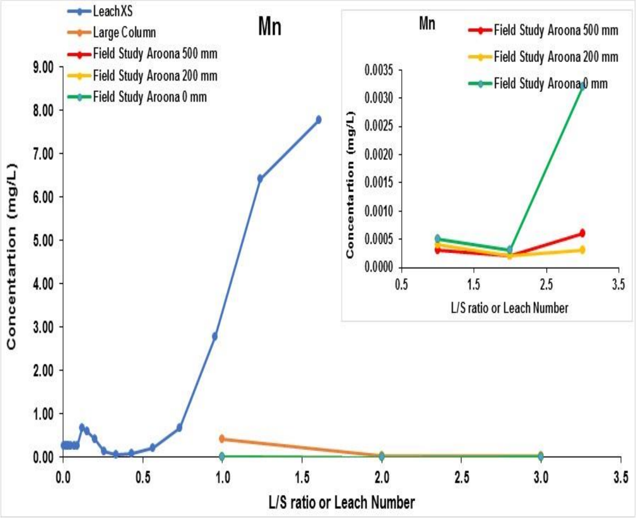

Cr
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

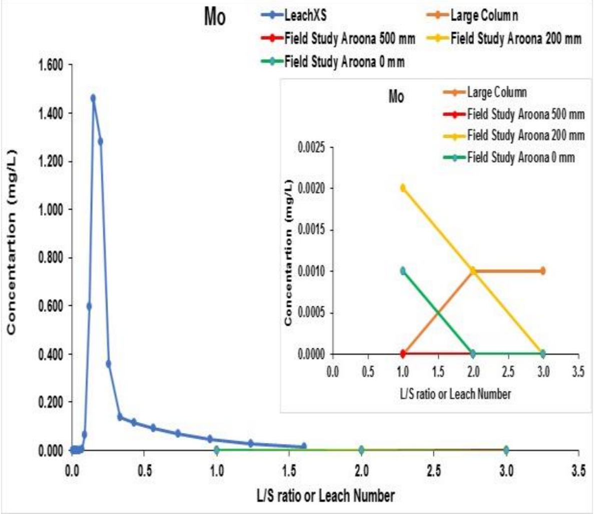

Cu
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0
1
1
2
2
3
3
4
L/S ratio or Leach Number
Cu
LeachXS
Large Column
Field Study Aroona 200 mm
Concentartion (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number

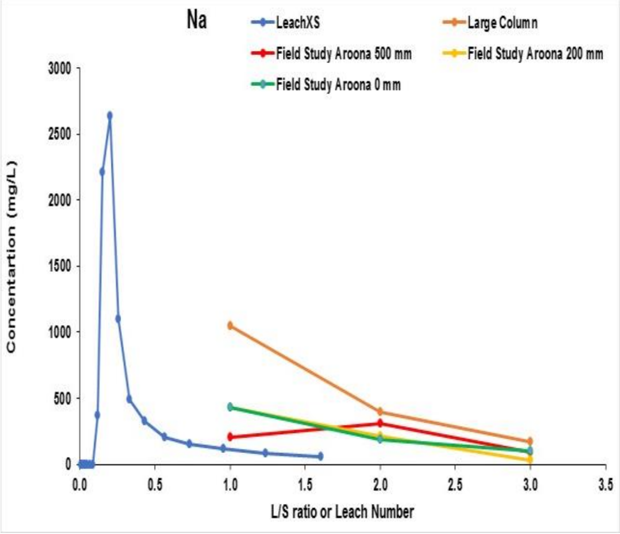

Fe
LeachXS
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Fe
Large Column
Concentartion (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number

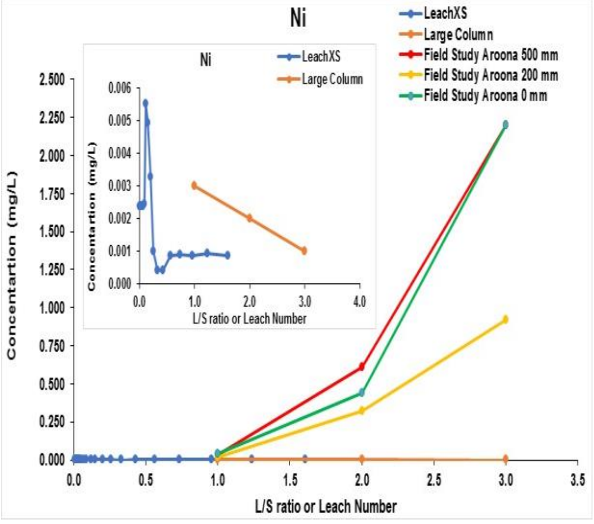

K
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
K
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
40
35
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

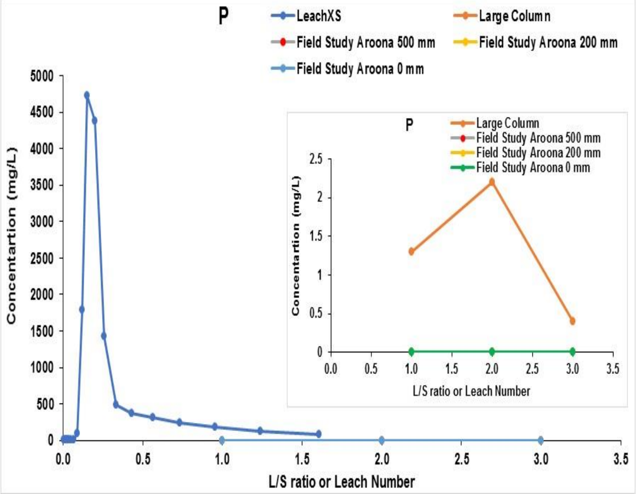

Mg
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
600
500
400
300
200
100
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Mg
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
120
100
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

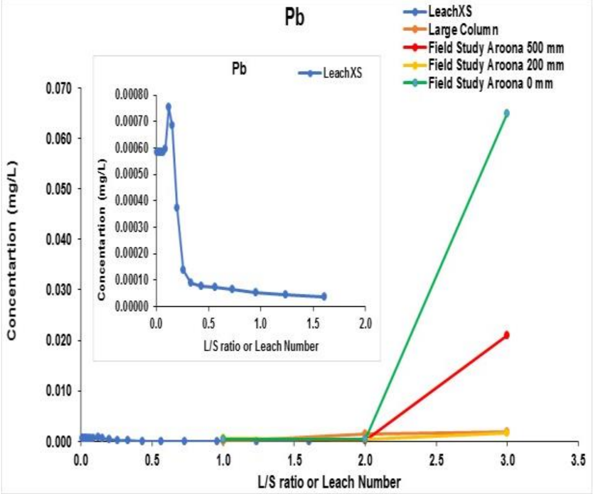

Mn
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Mn
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0.5
1.5
2.5
3.5
L/S ratio or Leach Number

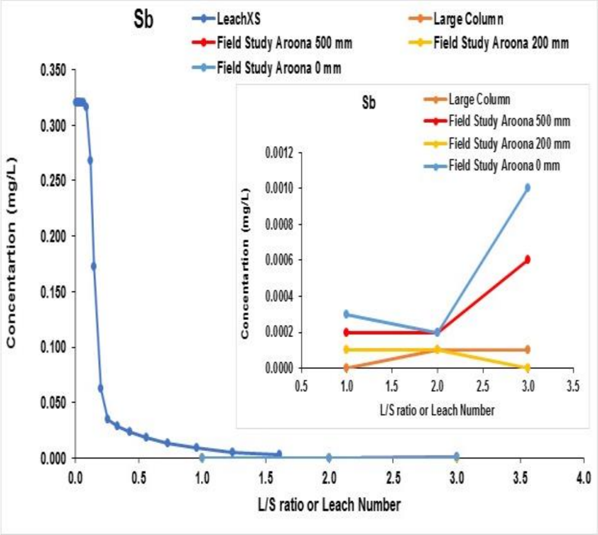

Mo
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Mo
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

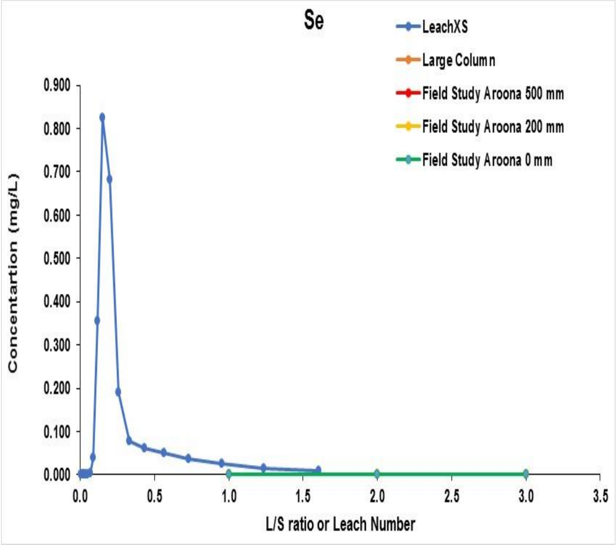

Na
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
3000
2500
2000
1500
1000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

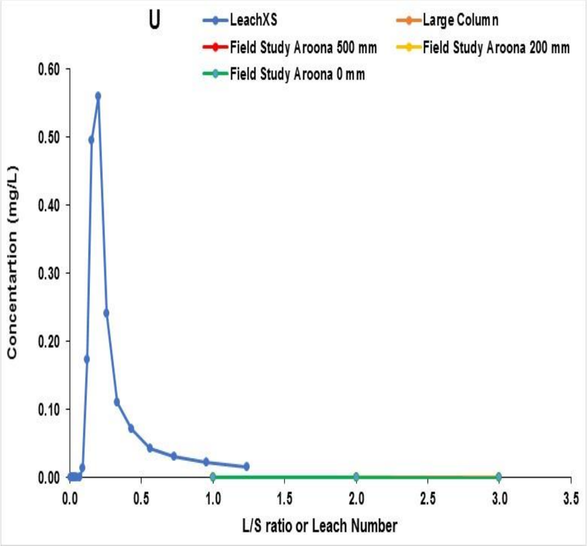

Ni
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
2.500
2.250
2.000
1.750
1.500
1.250
1.000
0.750
0.500
0.250
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Ni
LeachXS
Large Column
Concentartion (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number

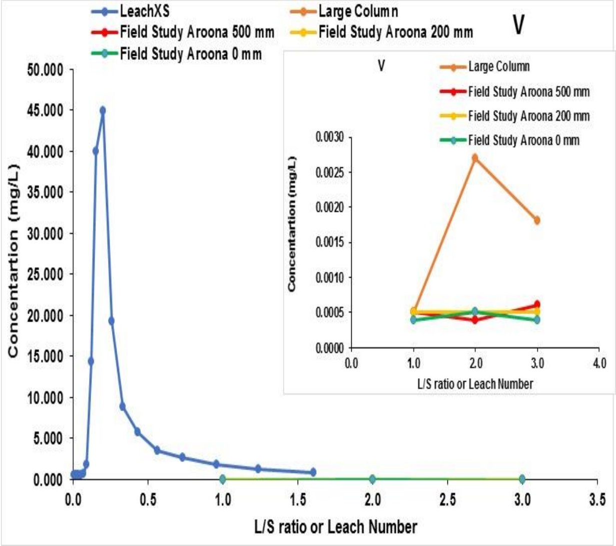

P
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
P
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
2.5
2
1.5
1
0.5
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

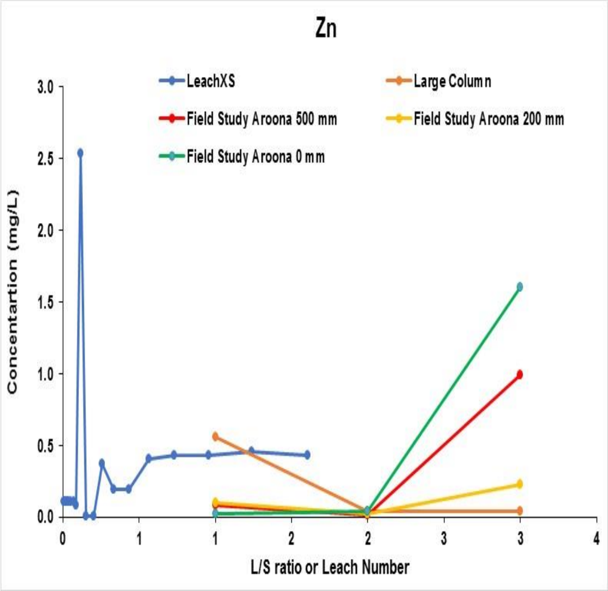

Pb
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
Pb
LeachXS
Concentartion (mg/L)
0.00080
0.00070
0.00060
0.00050
0.00040
0.00030
0.00020
0.00010
0.00000
0.0
0.5
1.0
1.5
2.0
L/S ratio or Leach Number

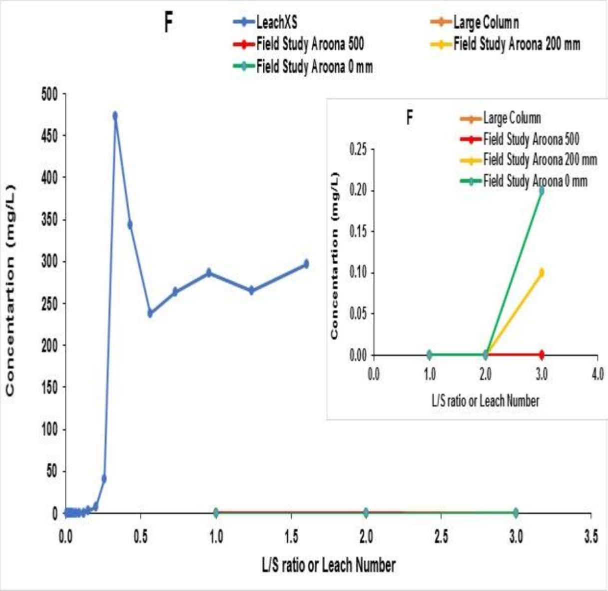

Sb
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
L/S ratio or Leach Number
Sb
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

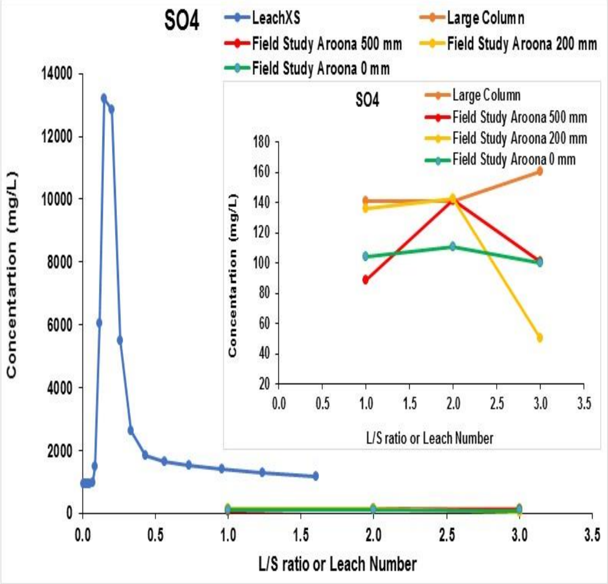

Se
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number

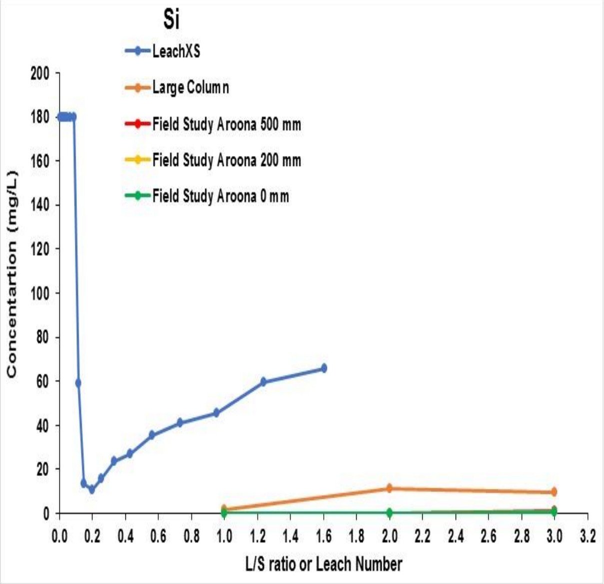

U
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number


V
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
V
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number


Zn
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
1
2
3
4
L/S ratio or Leach Number


F
LeachXS
Large Column
Field Study Aroona 500
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0
50
100
150
200
250
300
350
400
450
500
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
F
Large Column
Field Study Aroona 500
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.0
1.0
2.0
3.0
4.0
L/S ratio or Leach Number


SO4
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0
2000
4000
6000
8000
10000
12000
14000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number
SO4
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
20
40
60
80
100
120
140
160
180
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
L/S ratio or Leach Number


Si
LeachXS
Large Column
Field Study Aroona 500 mm
Field Study Aroona 200 mm
Field Study Aroona 0 mm
Concentartion (mg/L)
0
20
40
60
80
100
120
140
160
180
200
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
L/S ratio or Leach Number