# CHARACTERIZATION OF DRINKING WATER SLUDGES FOR BENEFICIAL REUSE AND DISPOSAL

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# Characterization of Drinking Water Sludges for Beneficial Reuse and Disposal


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## LIST OF ABBREVIATIONS, ACRONYMS, AND UNITS OF MEASUREMENT

| | |
|---|---|
| BDL | Below Detection Limit |
| FGGC | Florida Groundwater Guidance Concentration |
| SCTLs | Soil Cleanup Target Levels |
| SPLP | Synthetic Precipitation Leaching Procedure |
| SVOC | Semi-Volatile Organic Compounds |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TDS | Total Dissolved Solids |
| US EPA | United States Environmental Protection Agency |
| VOC | Volatile Organic Compounds |
| mg/kg | milligram per kilogram |
| mg/L | milligrams per liter |
| μg/L | microgram per liter |

KEYWORDS

Drinking Water Sludge

Leaching

Water Treatment Facility

Synthetic Precipitation Leaching Procedure (SPLP)

Soil Cleanup Target Levels (SCTLs)

Metals

Organics

# ABSTRACT

Most water treatment facilities produce large quantities of sludge resulting from drinking water treatment processes such as flocculation and filtration.  Sludge disposal in lagoons or drying beds for economical short-term management represents a common practice, while the most acceptable long-term disposal method is landfilling.  As disposal of the sludges is becoming expensive and difficult because of limited available land for disposal as well as high landfill tipping fee, beneficial use options have been proposed for the materials. For applications where the sludge are placed direct contact with the environment, concern has been raised by regulators in regard to the chemical characteristics of the sludge and the potential risk to human and environment. To address this concern, drinking water sludge must be properly characterized for chemical composition.

A research project was conducted to examine the chemical characteristics of drinking water sludge from water treatment facilities in Florida.  A total of 28 drinking water sludge samples were collected from 26 drinking water treatment facilities in Florida. The samples were analyzed for a number of chemical parameters: volatile organic compounds, semi-volatile organic compounds, pesticides, and heavy metals. Both the total and leachable concentrations were measured. Metals were measured in all 28 drinking water sludge samples, while a total of 9 sludge samples were analyzed for organic constituents.

The results of total heavy metal concentrations indicated that there is great variation of concentration of different metals in different sludge type. All of alum and ferric sludge had total arsenic concentration much above the industrial direct exposure limits. For one third of lime sludge samples, arsenic concentration was between the residential (0.8 mg/kg) and the industrial (3.7 mg/kg) direct exposure limits.  Heavy metal leaching was evaluated using the synthetic precipitation leaching procedure.  Though some of alum sludge and ferric sludge samples leached managanese more than Florida groundwater guidance concentration, heavy metals concentrations in SPLP leachate were well below Florida groundwater guidance concentrations. As expected, alum and ferric sludge SPLP leachate had aluminum and iron concentrations, respectively, greater than Florida groundwater guidance concentrations.  For the most part, the total concentrations of organic compounds were not a major concern regarding human direct exposure of Florida soil cleanup target levels. Only two organic compounds, acetone and methylene chloride, were found in some of total and leaching samples. The concentrations did not exceed the limits of the target levels.  Inorganic ions such as chloride and sulfate were found in some of the SPLP leaching samples, but the concentrations of the ions were below the limits of Florida groundwater guidance concentrations.

# EXECUTIVE SUMMARY

## Introduction

A water treatment plant produces large quantities of sludge as a result of treatment processes of raw water such as flocculation, filtration and coagulation. Sludge is usually disposed of in a lagoon system located at and around the plant in a short-term period. Ultimately, sludge is dumped into a landfill. As disposal of sludge produced from water treatment plants is expensive and difficult, beneficial use options have been proposed for the materials. Questions have been raised in regard to the potential environmental impacts of the sludge when used. In order to evaluate the potential risks posed by land application of drinking water sludge, the University of Florida’s Department of Environmental Engineering Sciences was contracted by the Florida Center for Solid and Hazardous Waste Management to perform a characterization of drinking water sludge from water treatment plants in Florida. This report presents the results of chemical and physical analyses conducted on drinking water sludge collected throughout the state.

## Methodology

Over a period of four months (May 2001- August 2001), sampling trips were made to water treatment facilities throughout the state. Drinking water sludge samples were collected from drying beds or stockpiles from 26 water treatment facilities. A number of analyses were performed to characterize the material.

Total content analyses for metals and organics were conducted for chemical characterization. Where applicable, the results of total analysis are compared the Florida Soil Cleanup Target Levels (SCTLs). It should be noted that these goals are not regulatory standards, but rather a set of goals used in the assessment of waste site clean up. Further, the goals can be used voluntarily by those who want to land apply solid waste in lieu of a risk assessment. A synthetic precipitation leaching procedure (SPLP) test was also performed to determine leachability of pollutants: heavy metals (aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, sodium, zinc), organics (volatile organics, semi-volatile organics, and pesticides), and inorganic ions (fluoride, chloride, sulfate, and total dissolved solids). The concentrations of chemicals detected in the SPLP extracts were compared to the Florida Groundwater Guidance Concentrations (FGCC) to assess potential leaching risks.

## Results

Results for both total and leaching analyses of drinking water sludge are summarized below. Metals in all 28 drinking water sludge samples were measured during the total and leaching analyses, while a total of the nine samples were analyzed for organic compounds including volatile organics, semi-volatile organics, and pesticides.

1. For the total metal analysis of sludge samples, most metal concentrations were either below detection limit or detectable, but not exceeding the appropriate soil cleanup target level. However, all of alum and ferric sludge samples were above the industrial limit of soil

cleanup target level for arsenic. Of the 7 lime sludge samples that exceeded the limit, 1 sample was above the industrial limit of soil cleanup target level for arsenic. Another metal that was on occasion above the soil cleanup target level was barium. 1 out of 5 alum sludge sample and 3 out of 20 lime sludge samples exceeded the residential cleanup goal (based on direct exposure). Copper was also detected above the residential (SCTL) in 1 of the ferric sludge samples analyzed.

As expected, all the alum sludge samples had aluminum concentration above the residential cleanup goal (based on direct exposure) and all the ferric sludge samples had iron concentration above the residential cleanup goal (based on direct exposure).

2. For the total volatile organic compound (VOC) analysis of 9 drinking water sludge samples collected, only two target VOC compounds out of 74 VOC compounds (acetone and methylene chloride) were consistently detected in the samples. None of the concentrations of the compounds exceeded the limits of Florida soil cleanup target levels. These analytes were commonly used for laboratory glassware cleaning and organic extractions in the laboratory. The probable source of the analytes is laboratory glassware cleaning and extraction.

3. For the total semi-volatile organic compound (SVOC) analysis of drinking water sludge samples collected, none of the SVOC compounds were detected in the samples. Pesticides (nitrogen-phosphorous pesticides and organochlorine pesticides) were not detected above the detection limit in any of total samples.

4. The SPLP leaching test was performed to determine leachability of heavy metals (aluminum, arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, mercury, molybdenum, nickel, sodium, selenium, silver and zinc) from all the sludge samples collected. The data were compared to Florida Groundwater Guidance Concentrations (FGGC). As far as lime sludge samples are concerned no heavy metal leached above FGGC, but 3 sample (1 alum and 2 ferric samples) leached manganese above FGGC.

   Most of the alum sludge samples and 2 ferric sludge samples leached aluminum above FGGC and all the ferric sludge samples leached iron concentration above FGGC.

5. Using the SPLP VOC leaching test with a Zero Headspace Extraction (ZHE), only two VOC compounds were detected in the leaching samples. Acetone was consistently found in all SPLP leaching samples, while methylene chloride was detected only once in one sample. The concentration of the sample exceeded the limit of groundwater guidance concentration. However, the source of these compounds is most likely laboratory contamination.

6. None of the SVOC compounds were detected in SPLP leaching samples. Pesticides (nitrogen-phosphorous pesticides and organochlorine pesticides) were not found in any of the samples during a SPLP leaching test.

7. Inorganic ions such as chloride and sulfate were found in some of the SPLP leaching samples, but the concentrations of the ions were below the limits of Florida groundwater guidance concentrations. The TDS concentrations of all 28 SPLP extracts did not exceed the groundwater guidance concentration for TDS (500 mg/L) with the exception of one sample. No fluoride was found in any of the SPLP extracts.

# 1 INTRODUCTION

The Department of Environmental Protection Agency and water treatment facility operators are wrestling with the issue of drinking water sludge reuse. Several different types of drinking water sludge are produced, including alum, lime, and ferric chloride. The preferred management option is beneficial reuse through land application. The question has been raised as to whether this is protective of the environment. Research has initiated to characterize drinking water sludge from water treatment facilities in Florida. The reuse of drinking water sludge must be balanced with the need to protect human health and the environment. In order to satisfy the need, the University of Florida's Department of Environmental Engineering Sciences was contracted by the Florida Center for Solid and Hazardous Waste Management to perform the characterization of drinking water sludge collected from Florida water treatment facilities. This report presents the results of chemical and physical analyses conducted on drinking water sludge collected from throughout the state.

The overview of sampling trips conducted throughout the state during the research, drinking water sludge sampling methodology, and a number of chemical analyses performed are outlined in Chapter 2. Chapter 3 presents the results of the chemical analyses. All the results of total concentrations of drinking water sludge are provided for metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and pesticides. Where applicable, the resulting chemical characteristics are compared to existing regulations or guidelines for the land application of drinking water sludge. The primary guidelines used for comparison are those presented in the Florida Soil Cleanup Target Levels. It should be noted that these goals are not regulatory standards, but rather a set of goals used in the assessment of waste site clean up. Further, the goals can be used voluntarily by those who want to land apply solid waste in lieu of a risk assessment. Chapter 3 also presents the results of a leaching analysis on drinking water sludge. Drinking water sludge samples were subjected to a leaching analysis using the synthetic precipitation leaching procedure (SPLP) (US EPA SW 846 Method 1312). The concentrations of chemicals detected in the leachate were also compared to the Florida Soil Cleanup Target Levels for leachability to assess potential leaching risks. Chapter 4 presents conclusions drawn from the results. The appendices include raw data and quality assurance data during the laboratory analyses.

# 2 METHODOLOGY

## 2.1 Sample Locations

A total of 28 drinking water sludge samples were collected from a total of 26 water treatment plants throughout the state of Florida (see Table 2.1). The facilities selected for this study were recommended by FDEP. Among the sampling sites, two different types of sludge samples per site from two different locations were collected to characterize the sludge.

## 2.2 Sample collection

A total of 28 samples were collected from a total of 26 water treatment plants throughout the state according to quality assurance project plan (Contract # WM 806- DEP contract using drinking water program funds). The sampling plan was approved by FDEP for laboratory operations and sample collection activities. Composite samples were collected from dried drinking water sludge piles at the water treatment plants. Each pile was sectioned into quarters, and the first 3-inch. surface of the sludge was removed. Samples from sludge disposal areas were collected using stainless steel scoops and mixed in stainless steel bowls. In some cases, samples were taken directly from sludge storage tanks. Approximately 5 g of drinking water sludge sample for volatile organic compounds was collected first from the mixed sludge sample in the stainless steel bowl into 40-ml VOC vials (I-Chem. Corp.) equipped with Teflon lined septa. 10-ml deionized water was initially added to the vials before sampling. Samples for other organics and metals were collected in 2-liter glass jars with Teflon lined lids. A total of 9 total and leaching samples (*5 lime sludge, 2 alum sludge, and 2 ferrric sludge*) were analyzed for organic analyses, while metals were measured in all 28 samples during total and leaching analyses (*20 lime sludge, 5 alum sludge, and 3 ferrric sludge*). The samples were stored below 4°C in an iced container and transported to a cold room (below 4°C) located at the University of Florida Solid and Hazardous Waste Laboratory prior to analysis.

To implement quality assurance (QA) practices in the field and laboratory analyses, trip blanks, field blanks, equipment blanks, and duplicate samples were carried or collected during sampling trips. The QA samples were analyzed during laboratory work to determine whether any contamination occurred in field or along the trips.

## 2.3 Laboratory procedures

### 2.3.1 Sample Handling

A drinking water sludge sample in a glass jar collected from the water treatment facilities was mixed again in the laboratory with a stainless steel scoop to get a representative sample for a number of chemical analyses.

**Table 2-1 Samples Locations and Site Description**

| ***County*** | ***Treatment Facility*** | ***Sample ID*** | ***Sludge Type*** | | |
|---|---|---|---|---|---|
| | | | ***L*** | ***A*** | ***F*** |
| Alachua | Murphree Water Treatment Plant (Gainesville) | GAI | X | | |
| Bay | Bay County Water Treatment Facility | BAY | | | X |
| Brevard | City of Cocoa | COC A (lime), COC B (Ferric) | X | | X |
| Brevard | North Brevard County/Mims | MIM | X | | |
| Broward | Lauderdale Lakes BCOES 1A | LAU B | X | | |
| Broward | Pompano Beach BCOES 2A | PAM | X | | |
| Broward | City of North Lauderdale | LAU A | X | | |
| **Charlotte** | **Charlotte County Utilities** | **CHA** | X | | |
| Charlotte | City of Punta Gorda | PON | | X | |
| **Charlotte** | **City of Englewood** | **ENG** | X | | |
| Collier | Florida Water Services - Marco Island | MAR | X | | |
| DeSoto | Peace River | PRW | | X | |
| DeSoto | Arcadia Water Department | ARC | X | | |
| Flagler | Flagler Beach WTP | FLA | X | | |
| Lee | Bonita Springs Water System | BON | X | | |
| Manatee | Manatee County Public Works | MAN A (lime), MAN B (alum) | X | X | |
| Manatee | City of Bradenton | BRT | | | X |
| **Marion** | **City of Ocala WTF** | **OCA** | X | | |
| Okeechobee | Okeechobee WTP | OKE | | X | |
| Palm Beach | City of Pahokee | POH | X | | |
| Polk County | City of Lakeland | LAK | X | | |
| Saint Johns | St. Johns County (CR-214) | STJ | X | | |
| Saint Lucie | Fort Pierce Utilities | PTF | X | | |
| Saint Lucie | Port Saint Lucie Utilities | STL | X | | |
| Sarasota | North Port Utilities | NWP | | X | |
| **Suwannee** | **Live Oak WTP** | **OAK** | X | | |

Note: * L = Lime, A = Alum, F = Ferric
* It should be noted that samples from some of the facilities on original list were not obtained because no stockpile exists at the sites.

* Researchers added Bolded facilities.

### 2.3.2 Overview of drinking water sludge analysis

A number of different analytical procedures were performed on the drinking water sludge samples collected from water treatment facilities in Florida. The following analytical procedures included:

*Total Analysis*

- Total heavy metals concentrations (Al, Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Na, Ni, Pb, Se, Zn): **28 samples**
- Total volatile organic compound (VOC) concentrations: **9 samples**
- Total semi-volatile organic compound (SVOC) concentrations: **9 samples**
- pH and volatile solids: **28 samples**

*Leaching Analysis*

- Leachable heavy metals concentrations (Al, Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Na, Ni, Pb, Se, Zn): **28 samples**
- Leachable VOC concentrations: **9 samples**
- Leachable SVOC concentrations: **9 samples**
- Leachable ion concentrations ($Cl^-$, $SO_4$, $F^-$) and total dissolved solids concentrations: **28 samples**

Table 2.2 presents a list of drinking water sludge samples analyzed for total and leaching analyses of metals and organics. The following sections detail the analyses performed on drinking water sludge samples.

### 2.3.3 Total Analysis

#### 2.3.3.1 Metals

Total metal concentration, except for mercury, was estimated by using a hot plate digestion following the U.S. EPA Method SW-846 3050B (US EPA, 1994). Samples of drinking water sludge (2 g) were weighed into Erlenmeyer flasks to which 10 ml of 1: 1 nitric acid was added. The flasks were covered with watch glasses, and then heated on a hot plate without boiling. After 15 minutes, they were removed from the hop plate, 5 ml of concentrated nitric acid was added, and then placed back onto the plate for 30 minutes. This procedure was repeated until no brown fume was produced. After being removed from the hot plate, 2 ml of deionized water and 3 ml of 30% hydrogen peroxide were added to the flasks. Samples were then filtered through prerinsed Whatman 45 filter paper (pore size 1.0 μm) and diluted to 100 ml. After digestion, the extracts were analyzed by either ICP-AES or a Perkin-Elmer Model 5100 atomic absorption spectrophotometer, depending on the type of metals. Figure 1 shows a schematic diagram of the sample analysis on drinking water sludge samples. Samples with high concentrations of metal were diluted to fit within the linear region of the calibration curve. Total mercury concentrations in drinking water sludge were measured using a cold-vapor atomic absorption technique (US EPA SW 846 Method 7471). This method is based on the absorption of radiation at the 253-nm wavelength by mercury vapor.

**Table 2-2 Overview of Sample Analysis**

| *Sample* | *Total Analysis* | | | | *Leaching Analysis* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Metals* | *VOC* | *SVOC* | *Pesticides (NP, C)* | *Metals* | *VOC* | *SVOC* | *Pesticides (NP, C)* |
| GAI | X | X | X | X | X | X | X | X |
| BAY | X | X | X | X | X | X | X | X |
| COC A (lime) | X | | | | X | | | |
| COC B (ferric) | X | | | | X | | | |
| MIM | X | | | | X | | | |
| LAU B | X | | | | X | | | |
| PAM | X | | | | X | | | |
| LAU A | X | | | | X | | | |
| CHA | X | | | | X | | | |
| PON | X | | | | X | | | |
| ENG | X | | | | X | | | |
| MAR | X | | | | X | | | |
| PRW | X | X | X | X | X | X | X | X |
| ARC | X | X | X | X | X | X | X | X |
| FLA | X | | | | X | | | |
| BON | X | X | X | X | X | X | X | X |
| MAN A (lime) | X | | | | X | | | |
| MAN B (alum) | X | | | | X | | | |
| BRT | X | X | X | X | X | X | X | X |
| OCA | X | X | X | X | X | X | X | X |
| OKE | X | X | X | X | X | X | X | X |
| POH | X | X | X | X | X | X | X | X |
| LAK | X | | | | X | | | |
| STJ | X | | | | X | | | |
| PTF | X | | | | X | | | |
| STL | X | | | | X | | | |
| NWP | X | | | | X | | | |
| OAK | X | | | | X | | | |

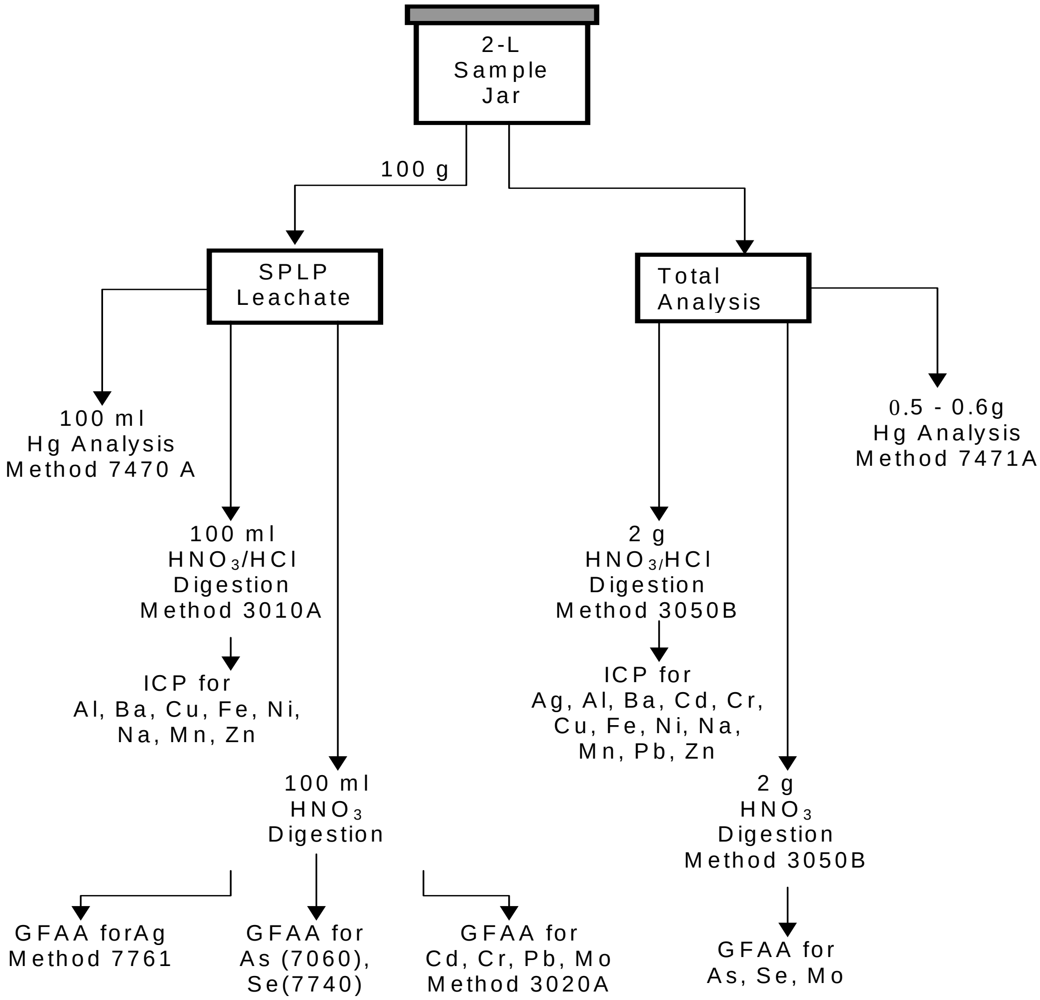


**Figure 2-1 A schematic diagram of drinking water sludge samples for metal analysis**

### 2.3.3.2 VOCs

Volatile organic compound (VOC) total analysis was carried out using a purge-and trap concentrator attached to a gas chromatography mass spectrometer (US EPA SW-846 Method 8260A). Table 2.3 presents the volatile organic compounds analyzed. VOC samples collected from drinking water sludge sites were purged with an inert gas (helium) to transfer the volatile components from the aqueous phase to the vapor phase, where they were swept through an adsorbent trap. After purging (10 min.), the sorbent trap was heated and back flushed with the inert gas to desorbs trapped sample components. The desorbed analytes were cryofocussed onto the capillary column. The analytes were detected with a mass spectrometer interfaced to the gas chromatography**.**

**Table 2-3 Target VOC Compounds**

| | | | |
|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 1,4-Dichlorobenzene | Chloroethane | n-Butylbenzene |
| 1,1,1-Trichloroethane | 2,2-Dichloropropane | Chloroform | o-Xylene |
| 1,1,2,2-Tetrachloroethane | 2-Butanone (MEK) | Chloromethane | Pentachloroethane |
| 1,1,2-Trichloroethane | 2-Chlorotoluene | cis-1,2-Dichloroethene | p-Isopropyltoluene |
| 1,1-Dichloroethane | 2-Hexanone | cis-1,3-Dichloropropene | Propionitrile |
| 1,1-Dichloroethene | 4-Chlorotoluene | cis-1,4-Dichloro-2-butene | Propylbenzene |
| 1,1-Dichloropropene | 4-Methyl-2-pentanone (MIBK) | Dibromochloromethane | sec-Butylbenzene |
| 1,2,3-Trichlorobenzene | Acetone | Dibromomethane | Styrene |
| 1,2,3-Trichloropropane | Acetonitrile | Dichlorodiflurομethane | tert-Butylbenzene |
| 1,2,4-Trichlorobenzene | Acrylonitrile (2-Propeneni | Ethyl Methacrlate | Tetrachloroethene |
| 1,2,4-Trimethylbenzene | Alkyl Chloride (3-Chloro-1 | Ethyl benzene | Toluene |
| 1,2-Dibromo-3-chloropropane | Benzene | Hexachlorobutadiene | trans-1,2-Dichloroethene |
| 1,2-Dibromoethane | Bromobenzene | Iodomethane | trans-1,3-Dichloropropene |
| 1,2-Dichlorobenzene | Bromodichloromethane | Isopropylbenzene (Cumene) | trans-1,4-Dichloro-2-butene |
| 1,2-Dichloroethane | Bromoform | m,p-Xylenes | Trichloroethene |
| 1,2-Dichloropropane | Bromomethane | Methacrylonitrile | Trichlorofluoromethane |
| 1,3,5-Trimethylbenzene | Carbon Disulfide | Methyl Methacrylate | Vinyl Chloride |
| 1,3-Dichlorobenzene | Carbon Tetrachloride | Methylene Chloride | |
| 1,3-Dichloropropane | Chlorobenzene | Naphthalene | |

### 2.3.3.3 SVOCs and Pesticides

An ultrasonic extraction technique (Sonicator™ Model W-375, Heat Systems-Ultrasonics, Inc.) was used for extracting semi-volatile organic compounds (SVOCs) and pesticides from drinking water sludge samples (US EPA SW-846 Method 3550A). The ultrasonic process ensures intimate contact of the sample matrix with an extraction solvent of 1:1 acetone/hexane (by vol.) A 2-g sludge sample was weighed into a 400-ml Erlenmeyer flask with 25 ml of the solvent. The semi-volatile components and pesticides were extracted ultrasonically for 3 minutes. The sonication process was repeated two more times. The extract was then filtered through sodium sulfate to remove water in the extract. After filtration, a solvent evaporation apparatus (Turbovap® II, Zimark Inc.) was then used to reduce the solvent volume to approximately 1.0 ml using a gentle stream of clean, dry nitrogen gas. An extracted sample was analyzed for semi-volatile organic compounds using gas chromatography/mass spectrometry (GC/MS) (US EPA SW 846 Method 8270B). An analysis for pesticides was done with Gas Chromatography. Table 2.4 and Table 2.5 present semi-VOCs and pesticides targeted, respectively.

## Table 2-4 Target SVOC Compounds

| | | | |
|---|---|---|---|
| 1,2,4,5-Tetrachlorobenzene | 4-Aminobiphenyl | Chlorobenzilate | Methyl_Parathion |
| 1,2,4-Trichlorobenzene | 4-Bromophenyl_phenyl_ether | Chrysene | Napthalene |
| 1,2-Dichlorobenzene | 4-Chloro-3-methylphenol | Diallate | Nitrobenzene |
| 1,3,5-Trinitrobenzene | 4-Chloroaniline | Dibenz(a,h)anthracene | N-Nitrosodiethylamine |
| 1,3-Dichlorobenzene | 4-Chlorophenyl_pheyl_ether | Dibenz(a,j)acridine | N-Nitrosodi-n-butylamine |
| 1,4-Dichlorobenzene | 4-Methylphenol | Dibenzofuran | N-Nitrosodi-n-propylamine |
| 1,4-Naphthoquinone | 4-Nitroaniline | Diethyl_phthalte | N-Nitrosomorpholine |
| 1-Napthylamine | 4-Nitrophenol | Dimethoate | N-Nitrosopyrrolidine |
| 1-Nitrosopiperidine | 4-Nitroquinoline-1-oxide | Dimethyl_phthalate | O,O,O-Triethyl_Phosphorothioate |
| 2,3,4,6-Tetrachlorophenol | 5-Nitro-o-toluidine | Di-n-butyl_phthalate | o-Toluidine |
| 2,4,5-Trichlorophenol | 7,12-Dimethylbenz(a)anthracene | Di-n-octyl_phthalate | Parathion |
| 2,4,6-Trichlorophenol | Acenaphthylene | Dinoseb | p-Dimethylaminoazobenzene |
| 2,4-Dichlorophenol | Acenapthene | Diphenylamine | Pentachlorobenzene |
| 2,4-Dimethylphenol | Acetophenone | Disulfoton | Pentachloronitrobenzene |
| 2,4-Dinitrophenol | Aniline | Ethyl_Methanesulfonate | Pentachlorophenol |
| 2,4-Dinitrotoluene | Anthracene | Famphur | Phenacetin |
| 2,6-Dinitrotoluene | Aramite | Fluoranthene | Phenanthrene |
| 2-Acetylaminofluorene | Benzidine | Fluorene | Phenol |
| 2-Chloronapthalene | Benzo(a)anthracene | Hexachlorobenzene | Phorate |
| 2-Chlorophenol | Benzo(a)pyrene | Hexachlorobutadiene | p-Phenylenediamine |
| 2-Methylnapthalene | Benzo(b)fluoranthene | Hexachlorocyclopentadiene | Pronamide |
| 2-Methylphenol | Benzo(g,h,i)perylene | Hexachloroethane | Pyrene |
| 2-Napthylamine | Benzo(k)fluoranthene | Hexachloropropene | Safrole |
| 2-Nitroaniline | Benzoic_Acid | Indeno(1,2,3-cd)pyrene | Silvex |
| 2-Nitrophenol | Benzyl_Alcohol | Isodrin | Sulfotepp |
| 3,3'-Dichlorobenzidine | Bis(2-chloroethoxy)methane | Isophorone | Thionazin |
| 3,3'-Dimethylbenzidine | Bis(2-chloroethyl)ether | Isosafrole | |
| 3-Methylcholanthrene | Bis(2-chloroisopropyl)ether | Kepone | |
| 3-Nitroaniline | Bis(2-ethylhexyl)_phthalate | m-Dinitrobenzene | |
| 4,6-Dinitro-2-methylphenol | Butyl_benzy_phthalate | Methapyrilene | |

**Table 2-5 Target Chlorinated Pesticides and Nitrogen/Phosphorus Pesticides**

| ***Chlorinated Pesticides*** | | ***Nitrogen/Phosphorus Pesticides*** | |
|---|---|---|---|
| 1,2-Dibromo-3-chloropropane | Endrin | Aspon | Fensulfothion |
| 4,4'-DDD | Endrin Aldehyde | Azinphos ethyl | Fenthion |
| 4,4'-DDE | Endrin Ketone | Azinphos methyl (guthion) | Fonofos |
| 4,4'-DDT | Etridiazole (terrazole) | Bolstar | Leptophos |
| Alachor | gamma-BHC (Lindane) | Carbophenothion | Malathion |
| Aldrin | gamma-Chlordane | Chlorfenvinphos | Merphos |
| alpha-BHC | Heptachlor | Chlorpyrifos | Methyl parathion |
| alpha-Chlordane | Heptachlor Epoxide | Chlorpyriphos methyl | Mevinphos |
| beta-BHC | Hexachlorobenzene | Coumaphos | Monocrotophos |
| Captafol | Hexachlorocyclopentadiene | Crotoxyphos | Naled |
| Chlorobenzilate | Isodrin | Demeton | Parathion |
| Chloroneb | Methoxychlor | Diazinon | Phorate |
| Chloropropylate | Mirex | Dichlofention | Phosmet |
| Chlorothalonil | Nitrofen | Dichlorvos | Phosphamidon |
| DCPA (dacthal) | Pentachloronitrobenzene (PCNB) | Dicrotophos | Ronnel |
| delta-BHC | Permetrins | Dimethoate | Stirofos |
| Diallate | Perthane | Dioxathion | Sulfotepp |
| Dichlone | Propachlor | Disulfoton | TEPP |
| Dicofol (keltane) | trans-Nonachlor | EPN | Terbuphos |
| Dieldrin | Trifluralin | Ethion | Thionazin |
| Endosulfan I | | Ethoprop | Tokuthion |
| Endosulfan II | | Famphur | Trichlorfon |
| Endosulfan Sulfate | | Fenitrothion | Trichloronate |

#### 2.3.3.4 pH and Percent Solids

The pH and percent solids were measured in drinking water sludge samples in parallel with the total analysis. Samples of the drinking water sludge (approximate 20 g) were weighed and dried at 105 °C for overnight, and percent solids were calculated by subtracting moisture content from total weight. The pH was determined in a suspension of 20 g of drinking water sludge in 10 ml of deionized water (EPA SW 846-9045C). Table 2.6 presents the pH and percent solids of the drinking water sludge. The pH of the drinking water sludge samples depends upon the type of sludge. The pH of the lime drinking water sludge was above pH 8, while alum and ferric sludge showed either neutral pH or slightly acidic pH values. Percent solids of the sludge samples vary widely, ranging from 9.1 % to 87%.

**Table 2-6 pH and Percent Solids of Drinking Water Sludge**

| Sample Name | Solid pH | Percent Solids | Sample Name | Solid pH | Percent Solids |
|---|---|---|---|---|---|
| ARC | 10.61 | 64.8 | MAN B | 5.58 | 74.1 |
| BAY | 6.44 | 30.4 | MAR | 9.55 | 59.7 |
| BON | 12.33 | 61.8 | MIM | 10.87 | 59.8 |
| BRT | 5.41 | 64.4 | NWP | 6.73 | 53.8 |
| CHA | 10.02 | 34.4 | OAK | 10.94 | 64.9 |
| COC | 5.60 | 38.2 | OCA | 10.70 | 87.1 |
| COC | 9.21 | 63.0 | OKE | 7.30 | 9.1 |
| ENG | 8.78 | 64.2 | PAM | 10.15 | 71.0 |
| FLA | 9.36 | 67.8 | POH | 8.64 | 39.2 |
| GAI | 9.91 | 67.3 | PON | 7.19 | 25.6 |
| LAK | 9.14 | 63.1 | PRW | 5.90 | 56.2 |
| LAU A | 10.06 | 54.0 | PTF | 11.33 | 64.6 |
| LAU B | 9.35 | 79.4 | STJ | 8.88 | 71.0 |
| MAN A | 12.25 | 66.0 | STL | 9.72 | 18.7 |

### 2.3.4 Leaching Test and Analysis

Drinking water sludge sample leaching tests have been performed using the Synthetic Precipitation Leaching Procedure (SPLP; EPA SW-846 Method 1312, USEPA 1995). The SPLP test mimics leaching of contaminants resulting from land-disposed wastes under conditions of slightly acidic rainfall. The leaching test procedures described in US EPA SW-846 Method 1312 depend upon the type of analytes or element, specifically whether volatile organics are involved or not.

#### 2.3.4.1 Metal

A 100-gram sludge sample was placed in a 2-liter Teflon-coated glass container. A SPLP leaching solution of pH 4.20 (± 0.05) was prepared to simulate acidic rainwater by adding the 60/40 weight percent mixture of sulfuric and nitric acids. Two liters of the SPLP solution were then added to the container. The container was placed in a rotary extraction vessel and leached for 18 ± 2 hours at 30 rpm. After tumbling, the mixture was filtered using a pressurized filtration apparatus with a 0.45-μm membrane filter. An extracted sample from the test was digested using either US EPA SW846 Method 3010 for ICP-AES or US EPA SW846 Method 3020 for graphite furnace analysis, as described previously in total analysis.

#### 2.3.4.2 VOC

When the mobility of volatile organic is evaluated, the zero headspace extraction (ZHE) device should be used during the SPLP test. In this study, a leaching test for volatile organics from drinking water sludge has been conducted using a zero headspace extraction vessel (ZHE) (Analytical Testing Corporation). Approximately 25 g of drinking water sludge was placed in the ZHE. In order to prevent the loss of volatile compounds, sample loading was performed in a refrigerated room below 4°C. A 500-ml of nano-pure water was then added to the ZHE. The

ZHE unit was placed in a rotary extractor and rotated for 18 ± 2 hours at 30 rpm at room temperature. After tumbling, the filtered leachate was collected into a glass syringe (Hamilton Gastight™ Syringe). The sample was then analyzed following the same VOC analytical method for total content described above.

#### 2.3.4.3 SVOC and Pesticides

Semi-volatile organic and pesticides leachability test was the same procedures as metal described in section 2.3.4.1. The filtered leachate was extracted following liquid-liquid extraction (US EPA SW846 Method 3510B, 1995). After extraction, the semi-VOC sample was analyzed by GC-MS, while gas chromatography was used for analyzing nitrogen-phoshrous pesticides and organochlorine pesticides in samples.

#### 2.3.4.4 Inorganic Ion Analysis

Inorganic ions such as fluoride, chloride, sulfate, and total dissolved solids, were also measured in the SPLP extracts. Total dissolved solids of the SPLP extracts were measured using Standard Method 2540C (APHA, 1995). A Dionex DX 500 Ion Chromatograph was used for measuring the concentration of inorganic ions in the extracts (EPA SW-846 Method 9056, USEPA 1995).

# 3 RESULTS AND DISCUSSIONS

## 3.1 RESULTS OF TOTAL ANALYS

### 3.1.1 Metals

Twenty eight drinking water sludge samples (5 alum, 3 ferric, and 20 lime) were analyzed for total concentration for metals: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, sodium, selenium, silver and zinc. The samples for total content of the metals consist of 5 alum sludge, 3 ferric sludge, and 20 lime sludge. The result of each metal in the drinking water sludge during total analysis is presented and discussed by the type of sludge in the following section.

#### 3.1.1.1 Aluminum

**Alum Sludge**

As shown in Table 3.1, the highest aluminum concentration was detected with alum sludge samples. Aluminum was detected in all the samples with an average of 142,000 mg/kg, a minimum of 104,500 mg/kg and a maximum of 176,700 mg/kg. All samples analyzed contained aluminum at concentrations higher than the residential SCTL (72,000 mg/kg).

**Ferric Sludge**

Ferric sludge samples contained aluminum at an average concentration of 4,400 mg/kg, a minimum of 2,800 mg/kg and a maximum of 5,900 mg/kg, as presented in Table 3.1. Aluminum concentration is well below the residential SCTL (72,000 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As presented in table 3.1, lime sludge samples had an average aluminum concentration of 1,800 mg/kg, a minimum of 367 mg/kg and a maximum of 14,500 mg/kg. All lime sludge samples were well below the residential SCTL (72,000 mg/kg).

**Table 3-1 Total Aluminum Concentration (mg/kg)**

**(Residential SCTL = 72,000 mg/kg)**

| Sludge Type | Sample Name | Aluminum Concentration (mg/kg) | Sludge Type | Sample Name | Aluminum Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 104,478 | Lime | FLA | 565 |
| | NWP | 136,883 | | GAI | 658 |
| | OKE | 141,134 | | LAK | 494 |
| | PON | 150,908 | | LAU A | 422 |
| | PRW | 176,700 | | LAU B | 367 |
| | **Average** | **142,020** | | MAN A | 3,752 |
| | **Std. Deviation** | **26,068** | | MAR | 2,257 |
| | **Minimum** | **104,478** | | MIM | 1,619 |
| | **Maximum** | **176,700** | | OAK | 555 |
| Ferric | BAY | 5,884 | | OCA | 386 |
| | BRT | 4,467 | | PAM | 475 |
| | COC A | 2,802 | | POH | 14,498 |
| | **Average** | **4,384** | | PTF | 592 |
| | **Std. Deviation** | **1,543** | | STJ | 1,621 |
| | **Minimum** | **2,802** | | STL | 1,514 |
| | **Maximum** | **5,884** | | **Average** | **1,778** |
| Lime | ARC | 846 | | **Std. Deviation** | **3,110** |
| | BON | 604 | | **Minimum** | **367** |
| | CHA | 1,602 | | **Maximum** | **14,498** |
| | COC B | 1,805 | | | |
| | ENG | 933 | | | |

Note: Detection Limit 3.5 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.2 Arsenic

**Alum Sludge**

As shown in Table 3.2, the highest arsenic concentration was detected with alum sludge samples. Arsenic was detected in all the samples with an average of 11.32 mg/kg, a minimum of 8.53 mg/kg and a maximum of 16.89 mg/kg. All samples analyzed contained arsenic at concentrations higher than both the residential and industrial SCTLs (0.8 mg/kg and 3.7 mg/kg).

**Ferric Sludge**

Ferric sludge samples contained arsenic at an average concentration of 7.04 mg/kg, a minimum of 1.92 mg/kg and a maximum of 9.68 mg/kg, as presented in Table 3.2. Arsenic concentration is well above the residential SCTL (0.08 mg/kg) in all ferric sludge samples analyzed. However, two of the samples contained arsenic at levels higher than the industrial SCTL (3.7 mg/kg).

**Lime Sludge**

As presented in Table 3.2, lime sludge samples had an average arsenic concentration of 1.15 mg/kg, a minimum of 0.18 mg/kg and a maximum of 4.93 mg/kg. The average arsenic concentration found in lime sludge samples was well below the arsenic industrial SCTL (3.7 mg/kg) but above the residential SCTL (0.8 mg/kg). Of the 20 lime sludge samples analyzed 9 contained levels above or equal to the residential SCTL. Of these samples only one contained arsenic above the industrial SCTL.

**Table 3-2 Total Arsenic Concentration (mg/kg)**

**(Residential SCTL = 0.8 mg/kg, Industrial SCTL = 3.7 mg/kg)**

| Sludge Type | Sample Name | Arsenic Concentration (mg/kg) | Sludge Type | Sample Name | Arsenic Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 8.53 | Lime | FLA | 0.43 |
| | NWP | 9.77 | | GAI | 0.80 |
| | OKE | 12.67 | | LAK | 0.82 |
| | PON | 8.71 | | LAU A | 0.95 |
| | PRW | 16.89 | | LAU B | 0.20 |
| | **Average** | **11.32** | | MAN A | 4.93 |
| | **Std. Deviation** | **3.53** | | MAR | 0.69 |
| | **Minimum** | **8.53** | | MIM | 2.44 |
| | **Maximum** | **16.89** | | OAK | 2.04 |
| Ferric | BAY | 9.51 | | OCA | 0.80 |
| | BRT | 9.68 | | PAM | 0.47 |
| | COC A | 1.92 | | POH | 3.69 |
| | **Average** | **7.04** | | PTF | 0.37 |
| | **Std. Deviation** | **4.43** | | STJ | 0.18 |
| | **Minimum** | **1.92** | | STL | 0.73 |
| | **Maximum** | **9.68** | | **Average** | **1.15** |
| Lime | ARC | 0.39 | | **Std. Deviation** | **1.28** |
| | BON | 0.20 | | **Minimum** | **0.18** |
| | CHA | 2.13 | | **Maximum** | **4.93** |
| | COC B | 0.31 | | | |
| | ENG | 0.40 | | | |

Note: Detection Limit 0.25 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.3 Barium

**Alum Sludge**
As shown in Table 3.3, the highest barium concentration as detected with alum sludge samples. Barium was detected in all the samples with an average of 84.92 mg/kg, a minimum of 15.47 mg/kg and a maximum of 316.21 mg/kg. The average barium content of the alum sludge samples was below both the residential and the industrial SCTLs (110 mg/kg and 87,000 mg/kg). However, one sample contained 310 mg/kg barium almost three times the residential limit.

**Ferric Sludge**
Ferric sludge samples contained barium at an average concentration of 35.69 mg/kg, a minimum of 16.05 mg/kg and a maximum of 58.15 mg/kg, as presented in Table 3.3. Barium concentration was well below the residential and industrial SCTLs (110 mg/kg and 87,000 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**
As presented in Table 3.3, lime sludge samples had an average barium concentration of 58.80 mg/kg, a minimum of 18.33 mg/kg and a maximum of 210.49 mg/kg. The average barium concentration found in lime sludge samples was well below barium's residential and industrial SCTLs (110 mg/kg and 87,000 mg/kg). Of the 20 lime sludge samples analyzed, 3 contained levels above or equal to the residential SCTL . None of those samples contained barium above the industrial SCTL.

**Table 3-3 Total Barium Concentration (mg/kg)**

**(Residential SCTL = 110 mg/kg, Industrial SCTL = 87,000 mg/kg)**

| Sludge Type | Sample Name | Barium Concentration (mg/kg) | Sludge Type | Sample Name | Barium Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 15.47 | Lime | FLA | 65.25 |
| | NWP | 316.21 | | GAI | 51.96 |
| | OKE | 34.29 | | LAK | 24.13 |
| | PON | 20.00 | | LAU A | 34.83 |
| | PRW | 38.64 | | LAU B | 40.56 |
| | **Average** | **84.92** | | MAN A | 210.49 |
| | **Std. Deviation** | **129.65** | | MAR | 43.60 |
| | **Minimum** | **15.47** | | MIM | 26.20 |
| | **Maximum** | **316.21** | | OAK | 30.45 |
| Ferric | BAY | 16.05 | | OCA | 18.33 |
| | BRT | 32.88 | | PAM | 31.52 |
| | COC A | 58.15 | | POH | 117.14 |
| | **Average** | **35.69** | | PTF | 81.61 |
| | **Std. Deviation** | **21.19** | | STJ | 33.62 |
| | **Minimum** | **16.05** | | STL | 54.60 |
| | **Maximum** | **58.15** | | **Average** | **58.80** |
| Lime | ARC | 59.31 | | **Std. Deviation** | **45.58** |
| | BON | 40.70 | | **Minimum** | **18.33** |
| | CHA | 124.85 | | **Maximum** | **210.49** |
| | COC B | 47.81 | | | |
| | ENG | 38.99 | | | |

Note: Detection Limit 0.5 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.4 Cadmium

**Alum Sludge**

As shown in Table 3.4, cadmium was not detected in any sample above detection limit. The average cadmium content of the alum sludge samples was well below both the residential and the industrial SCTLs (75 mg/kg and 1,300 mg/kg). None of the samples exceeded either of the SCTLs for cadmium.

**Ferric Sludge**

As shown in Table 3.4, cadmium was not detected in any sample above detection limit. Cadmium concentration was well below the residential and industrial SCTLs (75 mg/kg and 1,300 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As shown in Table 3.4, cadmium was not detected in any sample above detection limit. The average cadmium concentration found in lime sludge samples was well below cadmium's residential and industrial SCTLs (75 mg/kg and 1,300 mg/kg). None of the 20 samples contained cadmium above the residential or industrial SCTL.

**Table 3-4 Total Cadmium Concentration (mg/kg)**

**(Residential SCTL = 75 mg/kg, Industrial SCTL = 1,300 mg/kg)**

| Sludge Type | Sample Name | Cadmium Concentration (mg/kg) | Sludge Type | Sample Name | Cadmium Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.37 | Lime | FLA | < 0.40 |
| | NWP | < 0.50 | | GAI | < 0.41 |
| | OKE | < 2.99 | | LAK | < 0.42 |
| | PON | < 1.10 | | LAU A | < 0.49 |
| | PRW | < 0.49 | | LAU B | < 0.33 |
| | **Average** | **-** | | MAN A | < 0.41 |
| | **Std. Deviation** | **-** | | MAR | < 0.46 |
| | **Minimum** | **0.37** | | MIM | < 0.45 |
| | **Maximum** | **2.99** | | OAK | < 0.41 |
| Ferric | BAY | < 4.49 | | OCA | < 0.30 |
| | BRT | < 1.83 | | PAM | < 0.38 |
| | COC A | < 5.78 | | POH | < 0.68 |
| | **Average** | **-** | | PTF | < 0.42 |
| | **Std. Deviation** | **-** | | STJ | < 0.39 |
| | **Minimum** | **1.83** | | STL | < 0.47 |
| | **Maximum** | **5.78** | | **Average** | **-** |
| Lime | ARC | < 0.75 | | **Std. Deviation** | **-** |
| | BON | < 0.45 | | **Minimum** | **0.30** |
| | CHA | < 0.80 | | **Maximum** | **0.80** |
| | COC B | < 0.43 | | | |
| | ENG | < 0.42 | | | |

Note: Detection Limit 0.275 (mg/kg) based on 2.0 g dry sample weight. But since 2.0 g of wet samples were digested and samples had variable moisture content, when the concentration is expressed in mg/kg each sample will have a different detection limit.

#### 3.1.1.5 Chromium

**Alum Sludge**

As shown in Table 3.5, chromium was detected in all the samples with an average of 120.77 mg/kg, a minimum of 54.82 mg/kg and a maximum of 173.74 mg/kg. The average chromium content of the alum sludge samples was well below both the residential and the industrial SCTLs (210 mg/kg and 420 mg/kg). None of the samples exceeded either of the SCTLs for chromium.

**Ferric Sludge**

Ferric sludge samples contained chromium at an average concentration of 34.39 mg/kg, a minimum of 17.39 mg/kg and a maximum of 52.07 mg/kg, as presented in Table 3.5. Chromium concentration was well below the residential and industrial SCTLs (210 mg/kg and 420 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As presented in Table 3.5, lime sludge samples had an average chromium concentration of 3.2[1] mg/kg, a minimum of 0.93 mg/kg and a maximum of 12.62 mg/kg. The average chromium concentration found in lime sludge samples was well below chromium's residential and industrial SCTLs (210 mg/kg and 420 mg/kg). None of the 20 samples contained chromium above the residential or industrial SCTL**.**

[1] Aitchison's adjusted mean

**Table 3-5 Total Chromium Concentration (mg/kg)**

**(Residential SCTL = 210 mg/kg, Industrial SCTL = 420 mg/kg)**

| Sludge Type | Sample Name | Chromium Concentration (mg/kg) | Sludge Type | Sample Name | Chromium Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 54.82 | Lime | FLA | < 1.24 |
| | NWP | 151.36 | | GAI | < 1.26 |
| | OKE | 109.67 | | LAK | 1.31 |
| | PON | 114.28 | | LAU A | 5.80 |
| | PRW | 173.74 | | LAU B | 1.28 |
| | **Average** | **120.77** | | MAN A | < 1.25 |
| | **Std. Deviation** | **45.43** | | MAR | 5.12 |
| | **Minimum** | **54.82** | | MIM | 2.61 |
| | **Maximum** | **173.74** | | OAK | 4.33 |
| Ferric | BAY | 52.07 | | OCA | < 0.93 |
| | BRT | 17.39 | | PAM | 2.07 |
| | COC A | 33.69 | | POH | 12.62 |
| | **Average** | **34.39** | | PTF | 3.48 |
| | **Std. Deviation** | **17.35** | | STJ | 2.69 |
| | **Minimum** | **17.39** | | STL | < 1.44 |
| | **Maximum** | **52.07** | | **Average** | **3.2**[1] |
| Lime | ARC | 4.14 | | **Std. Deviation** | **3.3**[2] |
| | BON | 3.12 | | **Minimum** | **0.93** |
| | CHA | 4.55 | | **Maximum** | **12.62** |
| | COC B | 9.46 | | | |
| | ENG | 1.92 | | | |

Note: Detection Limit 0.85 (mg/kg) based on 2.0 g dry sample weight.

[1] Aitchison's adjusted mean
[2] Aitchison's adjusted standard deviation

#### 3.1.1.6 Copper

**Alum Sludge**

As shown in Table 3.6, copper was detected in all the samples with an average of 31.91 mg/kg, a minimum of 14.92 mg/kg and a maximum of 63.67 mg/kg. The average copper content of the alum sludge samples was well below both the residential and the industrial SCTLs (110 mg/kg and 76,000 mg/kg). None of the samples exceeded either of the SCTLs for copper.

**Ferric Sludge**

Ferric sludge samples contained copper at an average concentration of 154.75 mg/kg, a minimum of 24.29 mg/kg and a maximum of 413.47 mg/kg, as presented in Table 3.6. Copper concentration for 2 out of 3 samples was well below the residential and industrial SCTLs (110 mg/kg and 76,000mg/kg) but one exceeded the residential SCTL.

**Lime Sludge**

As presented in Table 3.6, lime sludge samples had an average copper concentration of 6.36 mg/kg, a minimum of 1.42 mg/kg and a maximum of 38.58 mg/kg. The average copper concentration found in lime sludge samples was well below copper's residential and industrial SCTLs (110 mg/kg and 76,000 mg/kg). None of the 20 samples contained copper above the residential or industrial SCTL.

**Table 3-6 Total Copper Concentration (mg/kg)**

**(Residential SCTL = 110 mg/kg, Industrial SCTL = 76,000 mg/kg)**

| Sludge Type | Sample Name | Copper Concentration (mg/kg) | Sludge Type | Sample Name | Copper Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 63.67 | Lime | FLA | 3.27 |
| | NWP | 14.92 | | GAI | 3.72 |
| | OKE | 17.20 | | LAK | 4.96 |
| | PON | 20.72 | | LAU A | 8.32 |
| | PRW | 43.03 | | LAU B | 1.42 |
| | **Average** | **31.91** | | MAN A | 2.38 |
| | **Std. Deviation** | **20.99** | | MAR | 3.18 |
| | **Minimum** | **14.92** | | MIM | 38.58 |
| | **Maximum** | **63.67** | | OAK | 7.39 |
| Ferric | BAY | 24.29 | | OCA | 1.50 |
| | BRT | 413.47 | | PAM | 1.72 |
| | COC A | 26.48 | | POH | 14.55 |
| | **Average** | **154.75** | | PTF | 2.29 |
| | **Std. Deviation** | **224.06** | | STJ | 2.15 |
| | **Minimum** | **24.29** | | STL | 4.31 |
| | **Maximum** | **413.47** | | **Average** | **6.36** |
| Lime | ARC | 6.55 | | **Std. Deviation** | **8.27** |
| | BON | 4.33 | | **Minimum** | **1.42** |
| | CHA | 10.12 | | **Maximum** | **38.58** |
| | COC B | 3.74 | | | |
| | ENG | 2.75 | | | |

Note: Detection Limit 0.7 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.7 Iron

**Alum Sludge**

As shown in Table 3.7, iron was detected in all the samples with an average of 10,584 mg/kg, a minimum of 5,686 mg/kg and a maximum of 16,603 mg/kg. The average iron content of the alum sludge samples was well below both the residential and the industrial SCTLs (23,000 mg/kg and 480,000 mg/kg). None of the samples exceeded either of the SCTLs for iron.

**Ferric Sludge**

Ferric sludge samples contained highest levels of iron at an average concentration of 365,238 mg/kg, a minimum of 161,291 mg/kg and a maximum of 482,589 mg/kg, as presented in Table 3.7. Iron concentration was well above the residential SCTL (23,000 mg/kg ) in all ferric sludge samples analyzed. One sample had iron concentration higher than industrial SCTL (480,000 mg/g).

**Lime Sludge**

As presented in Table 3.7, lime sludge samples had an average iron concentration of 2,957 mg/kg, a minimum of 254 mg/kg and a maximum of 12,734 mg/kg. The average iron concentration found in lime sludge samples was well below iron's residential and industrial SCTLs (23,000 mg/kg and 480,000). None of the 20 samples contained iron above the residential or industrial SCTL.

**Table 3-7 Total Iron Concentration (mg/kg)**

**(Residential SCTL = 23,000 mg/kg, Industrial SCTL = 480,000 mg/kg)**

| Sludge Type | Sample Name | Iron Concentration (mg/kg) | Sludge Type | Sample Name | Iron Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 6,410 | Lime | FLA | 803 |
| | NWP | 16,603 | | GAI | 391 |
| | OKE | 15,572 | | LAK | 497 |
| | PON | 8,648 | | LAU A | 11,209 |
| | PRW | 5,686 | | LAU B | 1,084 |
| | **Average** | **10,584** | | MAN A | 2,617 |
| | **Std. Deviation** | **5,154** | | MAR | 470 |
| | **Minimum** | **5,686** | | MIM | 4,635 |
| | **Maximum** | **16,603** | | OAK | 5,341 |
| Ferric | BAY | 482,589 | | OCA | 254 |
| | BRT | 161,291 | | PAM | 1,155 |
| | COC A | 451,833 | | POH | 7,116 |
| | **Average** | **365,238** | | PTF | 1,171 |
| | **Std. Deviation** | **177,291** | | STJ | 1,087 |
| | **Minimum** | **161,291** | | STL | 12,734 |
| | **Maximum** | **482,589** | | **Average** | **2,957** |
| Lime | ARC | 813 | | **Std. Deviation** | **3,625** |
| | BON | 255 | | **Minimum** | **254** |
| | CHA | 3,182 | | **Maximum** | **12,734** |
| | COC B | 3,309 | | | |
| | ENG | 1,006 | | | |

Note: Detection Limit 2.25 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.8 Lead

**Alum Sludge**

As shown in Table 3.8, lead was detected in all the samples with an average of 5.71 mg/kg, a minimum of 2.65 mg/kg and a maximum of 11.72 mg/kg. The average lead content of the alum sludge samples was well below both the residential and the industrial SCTLs (400 mg/kg and 920 mg/kg). None of the samples exceeded either of the SCTLs for lead.

**Ferric Sludge**

Ferric sludge samples contained lead at an average concentration of 3.11 mg/kg, a minimum of 1.36 mg/kg and a maximum of 4.8 mg/kg, as presented in Table 3.8. Lead concentration was well below the residential and industrial SCTLs (400 mg/kg and 920 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As presented in Table 3.8, lead was not detected in 13 out of 20 lime sludge samples. These samples had a minimum of 0.32 mg/kg and a maximum of 1.77 mg/kg. None of the samples contained lead above the residential or industrial SCTL.

**Table 3-8 Total Lead Concentration (mg/kg)**

**(Residential SCTL = 400 mg/kg, Industrial SCTL = 920 mg/kg)**

| Sludge Type | Sample Name | Lead Concentration (mg/kg) | Sludge Type | Sample Name | Lead Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 2.65 | Lime | FLA | < 0.37 |
| | NWP | 7.52 | | GAI | < 0.37 |
| | OKE | 11.72 | | LAK | 0.56 |
| | PON | 3.63 | | LAU A | < 0.46 |
| | PRW | 3.03 | | LAU B | < 0.32 |
| | **Average** | **5.71** | | MAN A | < 0.38 |
| | **Std. Deviation** | **3.88** | | MAR | < 0.42 |
| | **Minimum** | **2.65** | | MIM | 0.49 |
| | **Maximum** | **11.72** | | OAK | 0.40 |
| Ferric | BAY | 4.80 | | OCA | 0.33 |
| | BRT | 1.36 | | PAM | < 0.35 |
| | COC A | 3.16 | | POH | 1.77 |
| | **Average** | **3.11** | | PTF | < 0.38 |
| | **Std. Deviation** | **1.72** | | STJ | 0.47 |
| | **Minimum** | **1.36** | | STL | < 0.42 |
| | **Maximum** | **4.80** | | **Average** | **-** |
| Lime | ARC | < 0.71 | | **Std. Deviation** | **-** |
| | BON | < 0.40 | | **Minimum** | **0.32** |
| | CHA | < 0.73 | | **Maximum** | **1.77** |
| | COC B | 0.92 | | | |
| | ENG | < 0.39 | | | |

Note: Detection Limit 0.25 (mg/kg) based on 2.0 g dry sample weight. But since 2.0 g of wet samples were digested and samples had variable moisture content, when the concentration is expressed in mg/kg each sample will have a different detection limit.

#### 3.1.1.9 Manganese

**Alum Sludge**

As shown in Table 3.9, manganese was detected in all the samples with an average of 83.31 mg/kg, a minimum of 28.28 mg/kg and a maximum of 134.66 mg/kg. The average manganese content of the alum sludge samples was well below the residential and the industrial SCTLs (1,600 mg/kg and 22,000 mg/kg).

**Ferric Sludge**

Ferric sludge samples contained manganese at an average concentration of 228.77 mg/kg, a minimum of 42.04 mg/kg and a maximum of 595.42 mg/kg, as presented in Table 3.9. Manganese concentration was well above below the residential and industrial SCTLs (1,600 mg/kg and 22,000 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As presented in Table 3.9, lime sludge samples had an average manganese concentration of 47.33 mg/kg, a minimum of 10.7 mg/kg and a maximum of 131.5 mg/kg. The average manganese concentration found in lime sludge samples was well below manganese's residential and industrial SCTLs (1,600 mg/kg and 22,000 mg/kg). None of the samples contained manganese above the residential or industrial SCTL.

**Table 3-9 Total Manganese Concentration (mg/kg)**

**(Residential SCTL = 1,600 mg/kg, Industrial SCTL = 22,000 mg/kg)**

| Sludge Type | Sample Name | Manganese Concentration (mg/kg) | Sludge Type | Sample Name | Manganese Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 42.98 | Lime | FLA | 33.18 |
| | NWP | 102.64 | | GAI | 15.14 |
| | OKE | 134.66 | | LAK | 86.88 |
| | PON | 107.99 | | LAU A | 65.35 |
| | PRW | 28.28 | | LAU B | 20.27 |
| | **Average** | **83.31** | | MAN A | 29.95 |
| | **Std. Deviation** | **45.48** | | MAR | 18.96 |
| | **Minimum** | **28.28** | | MIM | 39.39 |
| | **Maximum** | **134.66** | | OAK | 41.50 |
| Ferric | BAY | 48.84 | | OCA | 10.70 |
| | BRT | 42.04 | | PAM | 25.47 |
| | COC A | 595.42 | | POH | 80.59 |
| | **Average** | **228.77** | | PTF | 12.66 |
| | **Std. Deviation** | **317.55** | | STJ | 117.75 |
| | **Minimum** | **42.04** | | STL | 98.37 |
| | **Maximum** | **595.42** | | **Average** | **47.33** |
| Lime | ARC | 17.23 | | **Std. Deviation** | **37.44** |
| | BON | 12.11 | | **Minimum** | **10.70** |
| | CHA | 62.74 | | **Maximum** | **131.51** |
| | COC B | 131.51 | | | |
| | ENG | 26.96 | | | |

Note: Detection Limit 0.55 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.10 Mercury

As shown in Table 3.10, mercury was not detected in any sample above the detection limit of 20 ug/kg.  None of the samples exceeded either of the SCTLs (Residential: 3.4 mg/kg, Industrial : 2.6 mg/kg) for mercury.

**Table 3-10 Total Mercury Concentration (mg/kg)**

**(Residential SCTL = 3.4 mg/kg, Industrial SCTL = 2.6 mg/kg)**

| Sludge Type | Sample Name | Manganese Concentration (ug/kg) | Sludge Type | Sample Name | Manganese Concentration (ug/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | BDL | Lime | FLA | BDL |
| | NWP | BDL | | GAI | BDL |
| | OKE | BDL | | LAK | BDL |
| | PON | BDL | | LAU A | BDL |
| | PRW | BDL | | LAU B | BDL |
| | **Average** | **-** | | MAN A | BDL |
| | **Std. Deviation** | **NA** | | MAR | BDL |
| | **Minimum** | **-** | | MIM | BDL |
| | **Maximum** | **-** | | OAK | BDL |
| Ferric | BAY | BDL | | OCA | BDL |
| | BRT | BDL | | PAM | BDL |
| | COC A | BDL | | POH | BDL |
| | **Average** | **-** | | PTF | BDL |
| | **Std. Deviation** | **NA** | | STJ | BDL |
| | **Minimum** | **-** | | STL | BDL |
| | **Maximum** | **-** | | **Average** | **-** |
| Lime | ARC | BDL | | **Std. Deviation** | **NA** |
| | BON | BDL | | **Minimum** | **-** |
| | CHA | BDL | | **Maximum** | **-** |
| | COC B | BDL | | | |
| | ENG | BDL | | | |

Note: Detection Limit 20 (ug/kg) based on 0.5 g dry sample weight.

#### 3.1.1.11 Molybdenum

**Alum Sludge**

As shown in Table 3.11, molybdenum was not detected in any of the samples above detection limit. Due high moisture content of OKE, when concentration is expressed in mg/kg it is exceeding the residential SCTLs (390 mg/kg). Except OKE none of the samples exceeded either of the SCTLs for molybdenum.

**Ferric Sludge**

As shown in Table 3.11, molybdenum was not detected in any of the samples above detection limit. Molybdenum concentration was well below the residential and industrial SCTLs (390 mg/kg and 9700 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As shown in Table 3.11, molybdenum was not detected in any of the samples above detection limit. None of the samples contained molybdenum above the residential or industrial SCTL.

**Due to high matrix interferences on ICP and GFAA molybdenum was analyzed by Flame atomic absorbance technique.**

**Table 3-11 Total Molybdenum Concentration (mg/kg)**

**(Residential SCTL = 390 mg/kg, Industrial SCTL = 9,700 mg/kg)**

| Sludge Type | Sample Name | Molybdenum Concentration (mg/kg) | Sludge Type | Sample Name | Molybdenum Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | < 67.83 | Lime | FLA | < 73.02 |
| | NWP | < 91.98 | | GAI | < 74.84 |
| | OKE | < 536.61 | | LAK | < 78.96 |
| | PON | < 193.83 | | LAU A | < 92.67 |
| | PRW | < 88.49 | | LAU B | < 63.20 |
| | **Average** | **-** | | MAN A | < 75.43 |
| | **Std. Deviation** | | | MAR | < 83.85 |
| | **Minimum** | **< 67.83** | | MIM | < 82.44 |
| | **Maximum** | **< 536.61** | | OAK | < 76.59 |
| Ferric | BAY | < 166.98 | | OCA | < 56.50 |
| | BRT | < 77.81 | | PAM | < 69.43 |
| | COC A | < 129.55 | | POH | < 121.83 |
| | **Average** | **-** | | PTF | < 76.49 |
| | **Std. Deviation** | | | STJ | < 70.14 |
| | **Minimum** | **< 77.81** | | STL | < 83.81 |
| | **Maximum** | **< 166.98** | | **Average** | **-** |
| Lime | ARC | < 142.57 | | **Std. Deviation** | |
| | BON | < 80.14 | | **Minimum** | **< 56.50** |
| | CHA | < 146.28 | | **Maximum** | **< 146.28** |
| | COC B | < 80.77 | | | |
| | ENG | < 78.43 | | | |

Note: Detection Limit 50 (mg/kg) based on 2.0 g dry sample weight. But since 2.0 g of wet samples were digested and samples had variable moisture content, when the concentration is expressed in mg/kg each sample will have a different detection limit.

#### 3.1.1.12 Nickel

**Alum Sludge**
As shown in Table 3.12, nickel was detected in all the samples with an average of 8.3 mg/kg, a minimum of 4.99 mg/kg and a maximum of 13.28 mg/kg. The nickel content of all the alum sludge samples was well below both the residential and the industrial SCTLs (110 mg/kg and 28,000 mg/kg). None of the samples exceeded either of the SCTLs for nickel.

**Ferric Sludge**
Ferric sludge samples contained nickel at an average concentration of 26.01 mg/kg, a minimum of 7.66 mg/kg and a maximum of 55.53 mg/kg as presented in Table 3.12. Nickel concentration was well below the residential and industrial SCTLs (110 mg/kg and 28,000 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**
As presented in Table 3.12, nickel was not detected in 8 out of 20 lime sludge samples above the detection limit of 0.75 mg/kg. Lime sludge samples had an average nickel concentration of 1.7[3] mg/kg and a maximum of 9.54 mg/kg. The average nickel concentration found in lime sludge samples was well below nickel's residential and industrial SCTLs (110 mg/kg and 28,000 mg/kg). None of the 20 samples contained nickel above the residential or industrial SCTL.

[3] Aitchinson, adjusted mean

**Table 3-12 Total Nickel Concentration (mg/kg)**

**(Residential SCTL = 110 mg/kg, Industrial SCTL = 28,000 mg/kg)**

| Sludge Type | Sample Name | Nickel Concentration (mg/kg) | Sludge Type | Sample Name | Nickel Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 6.70 | Lime | FLA | < 1.09 |
| | NWP | 10.56 | | GAI | 1.13 |
| | OKE | 13.28 | | LAK | < 1.15 |
| | PON | 4.99 | | LAU A | 1.38 |
| | PRW | 5.99 | | LAU B | < 0.91 |
| | **Average** | **8.30** | | MAN A | 9.54 |
| | **Std. Deviation** | **3.49** | | MAR | 2.92 |
| | **Minimum** | **4.99** | | MIM | 1.26 |
| | **Maximum** | **13.28** | | OAK | 2.38 |
| Ferric | BAY | 14.85 | | OCA | < 0.82 |
| | BRT | 7.66 | | PAM | < 1.03 |
| | COC A | 55.53 | | POH | 5.89 |
| | **Average** | **26.01** | | PTF | 2.19 |
| | **Std. Deviation** | **25.81** | | STJ | 1.98 |
| | **Minimum** | **7.66** | | STL | < 1.27 |
| | **Maximum** | **55.53** | | **Average** | **1.7**[3] |
| Lime | ARC | < 2.06 | | **Std. Deviation** | **2.4**[4] |
| | BON | 2.18 | | **Minimum** | **<0.82** |
| | CHA | < 2.17 | | **Maximum** | **9.54** |
| | COC B | 1.53 | | | |
| | ENG | 1.41 | | | |

Note: Detection Limit 0.75 (mg/kg) based on 2.0 g dry sample weight.

[3] Aitchison's adjusted mean
[4] Aitchison's adjusted standard deviation

#### 3.1.1.13 Sodium

**Alum Sludge**

As shown in Table 3.13, sodium was detected in all the samples with an average of 649.57 mg/kg, a minimum of 34.64 mg/kg and a maximum of 1089.48 mg/kg.

**Ferric Sludge**

Ferric sludge samples contained sodium at an average concentration of 172.36 mg/kg, a minimum of 71.26 mg/kg and a maximum of 264.54 mg/kg, as presented in Table 3.13.

**Lime Sludge**

As presented in Table 3.13, lime sludge samples had an average sodium concentration of 609.43 mg/kg, a minimum of 66.54 mg/kg and a maximum of 4,176.21 mg/kg.

**Table 3-13 Total Sodium Concentration (mg/kg)**

| Sludge Type | Sample Name | Sodium Concentration (mg/kg) | Sludge Type | Sample Name | Sodium Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 34.64 | Lime | FLA | 403.15 |
| | NWP | 660.28 | | GAI | 228.34 |
| | OKE | 1,083.68 | | LAK | 102.76 |
| | PON | 1,089.48 | | LAU A | 403.74 |
| | PRW | 379.76 | | LAU B | 423.33 |
| | **Average** | **649.57** | | MAN A | 66.54 |
| | **Std. Deviation** | **456.35** | | MAR | 574.46 |
| | **Minimum** | **34.64** | | MIM | 616.37 |
| | **Maximum** | **1,089.48** | | OAK | 67.88 |
| Ferric | BAY | 264.54 | | OCA | 324.83 |
| | BRT | 71.26 | | PAM | 470.69 |
| | COC A | 181.29 | | POH | 4,176.21 |
| | **Average** | **172.36** | | PTF | 431.65 |
| | **Std. Deviation** | **96.95** | | STJ | 524.25 |
| | **Minimum** | **71.26** | | STL | 485.29 |
| | **Maximum** | **264.54** | | **Average** | **609.43** |
| Lime | ARC | 475.50 | | **Std. Deviation** | **859.60** |
| | BON | 656.33 | | **Minimum** | **66.54** |
| | CHA | 716.54 | | **Maximum** | **4,176.21** |
| | COC B | 568.54 | | | |
| | ENG | 472.26 | | | |

Note: Detection Limit 7.5 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.14 Selenium

As shown in Table 3.14, selenium was not detected in any sample above the detection limit of 1.5 mg/kg. None of the samples exceeded either of the SCTLs (Residential: 390 mg/kg, Industrial : 10,000 mg/kg) for selenium.

**Table 3-14 Total Selenium Concentration (mg/kg)**

**(Residential SCTL = 390 mg/kg, Industrial SCTL = 10,000 mg/kg)**

| Sludge Type | Sample Name | Selenium Concentration (mg/kg) | Sludge Type | Sample Name | Selenium Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | BDL | Lime | FLA | BDL |
| | NWP | BDL | | GAI | BDL |
| | OKE | BDL | | LAK | BDL |
| | PON | BDL | | LAU A | BDL |
| | PRW | BDL | | LAU B | BDL |
| | **Average** | **-** | | MAN A | BDL |
| | **Std. Deviation** | **NA** | | MAR | BDL |
| | **Minimum** | **-** | | MIM | BDL |
| | **Maximum** | **-** | | OAK | BDL |
| Ferric | BAY | BDL | | OCA | BDL |
| | BRT | BDL | | PAM | BDL |
| | COC A | BDL | | POH | BDL |
| | **Average** | **-** | | PTF | BDL |
| | **Std. Deviation** | **NA** | | STJ | BDL |
| | **Minimum** | **-** | | STL | BDL |
| | **Maximum** | **-** | | **Average** | **-** |
| Lime | ARC | BDL | | **Std. Deviation** | **NA** |
| | BON | BDL | | **Minimum** | **-** |
| | CHA | BDL | | **Maximum** | **-** |
| | COC B | BDL | | | |
| | ENG | BDL | | | |

Note: Detection Limit 10 (mg/kg) based on 2.0 g dry sample weight.

#### 3.1.1.15 Silver

As shown in Table 3.15, silver was not detected in any sample above the detection limit of 1.5 mg/kg. None of the samples exceeded either of the SCTLs (Residential: 390 mg/kg, Industrial : 9,100 mg/kg) for silver.

**Table 3-15 Total Silver Concentration (mg/kg)**

**(Residential SCTL = 390 mg/kg, Industrial SCTL = 9,100 mg/kg)**

| Sludge Type | Sample Name | Manganese Concentration (mg/kg) | Sludge Type | Sample Name | Manganese Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | BDL | Lime | FLA | BDL |
| | NWP | BDL | | GAI | BDL |
| | OKE | BDL | | LAK | BDL |
| | PON | BDL | | LAU A | BDL |
| | PRW | BDL | | LAU B | BDL |
| | **Average** | **-** | | MAN A | BDL |
| | **Std. Deviation** | **NA** | | MAR | BDL |
| | **Minimum** | **-** | | MIM | BDL |
| | **Maximum** | **-** | | OAK | BDL |
| Ferric | BAY | BDL | | OCA | BDL |
| | BRT | BDL | | PAM | BDL |
| | COC A | BDL | | POH | BDL |
| | **Average** | **-** | | PTF | BDL |
| | **Std. Deviation** | **NA** | | STJ | BDL |
| | **Minimum** | **-** | | STL | BDL |
| | **Maximum** | **-** | | **Average** | **-** |
| Lime | ARC | BDL | | **Std. Deviation** | **NA** |
| | BON | BDL | | **Minimum** | **-** |
| | CHA | BDL | | **Maximum** | **-** |
| | COC B | BDL | | | |
| | ENG | BDL | | | |

Note: Detection Limit 1.5 (mg/kg) based on 2 g dry sample weight.
But since 2.0 g of wet samples were digested and samples had variable moisture content, when the concentration is expressed in mg/kg each sample will have a different detection limit.

#### 3.1.1.16 Zinc

**Alum Sludge**

As shown in Table 3.16, zinc was detected in all the samples with an average of 19.36 mg/kg, a minimum of 14.19 mg/kg and a maximum of 26.94 mg/kg. The average zinc content of the alum sludge samples was much below the SCTLs (23,000 mg/kg and 560,000 mg/kg). None of the samples exceeded either of the SCTLs for zinc.

**Ferric Sludge**

Ferric sludge samples contained zinc at an average concentration of 18.6 mg/kg, a minimum of 8.31 mg/kg and a maximum of 33.55 mg/kg, as presented in Table 3.16. Zinc concentration was well above below the residential and industrial SCTLs (23,000 mg/kg and 560,000 mg/kg) in all ferric sludge samples analyzed.

**Lime Sludge**

As presented in Table 3.16, lime sludge samples had an average zinc concentration of 7.85 mg/kg, a minimum of 3.88 mg/kg and a maximum of 23.81 mg/kg. The average zinc concentration found in lime sludge samples was well below zinc's residential and industrial SCTLs (23,000 mg/kg and 560,000 mg/kg). None of the samples contained zinc above the residential or industrial SCTL.

**Table 3-16 Total Zinc Concentration (mg/kg)**

**(Residential SCTL = 23,000 mg/kg, Industrial SCTL = 560,000 mg/kg)**

| Sludge Type | Sample Name | Zinc Concentration (mg/kg) | Sludge Type | Sample Name | Zinc Concentration (mg/kg) |
|---|---|---|---|---|---|
| Alum | MAN B | 17.63 | Lime | FLA | 6.34 |
| | NWP | 14.19 | | GAI | 5.05 |
| | OKE | 26.94 | | LAK | 6.29 |
| | PON | 20.84 | | LAU A | 5.80 |
| | PRW | 17.21 | | LAU B | 4.19 |
| | **Average** | **19.36** | | MAN A | 7.08 |
| | **Std. Deviation** | **4.85** | | MAR | 6.03 |
| | **Minimum** | **14.19** | | MIM | 9.67 |
| | **Maximum** | **26.94** | | OAK | 4.46 |
| Ferric | BAY | 13.93 | | OCA | 4.43 |
| | BRT | 8.31 | | PAM | 5.40 |
| | COC A | 33.55 | | POH | 23.81 |
| | **Average** | **18.60** | | PTF | 5.42 |
| | **Std. Deviation** | **13.25** | | STJ | 5.05 |
| | **Minimum** | **8.31** | | STL | 15.85 |
| | **Maximum** | **33.55** | | **Average** | **7.85** |
| Lime | ARC | 8.80 | | **Std. Deviation** | **4.77** |
| | BON | 3.88 | | **Minimum** | **3.88** |
| | CHA | 11.42 | | **Maximum** | **23.81** |
| | COC B | 9.42 | | | |
| | ENG | 8.59 | | | |

Note: Detection Limit 1.25 (mg/kg) based on 2.0 g dry sample weight.

### 3.1.2 VOC

The compounds that were detected are presented in Table 3.17. Only two volatile organic compounds, acetone and methylene chloride, were consistently detected in total samples. The concentrations of all the detected analytes did not exceed the soil cleanup target levels of residential and industrial limits. These chemicals are commonly used as solvents for laboratory cleaning and organic extraction, respectively. Laboratory blanks also contained the chemicals at above detection levels (5 μg/kg). The source of the chemicals is most likely laboratory contamination.

**Table 3-17 Results of VOCs in Drinking Water Sludge**

| ***Detected Compounds*** | ***Sample*** | ***Concentration (μg/kg)*** | ***Soil Cleanup Target Levels*** | | |
|---|---|---|---|---|---|
| | | | ***Residential SCTL (μg/kg)*** | ***Industrial SCTL (μg/kg)*** | ***Leaching SCTL (μg/kg)*** |
| Acetone | ARC | 2,210 | 780,000 | 5,500,000 | 2,800 |
| | BAY | 28.0 | 780,000 | 5,500,000 | 2,800 |
| | BON | 280 | 780,000 | 5,500,000 | 2,800 |
| | BRT | 7.9 | 780,000 | 5,500,000 | 2,800 |
| | GAI | 32.5 | 780,000 | 5,500,000 | 2,800 |
| | OCA | 51.2 | 780,000 | 5,500,000 | 2,800 |
| | OKE | 181 | 780,000 | 5,500,000 | 2,800 |
| | POH | 190 | 780,000 | 5,500,000 | 2,800 |
| Methylene chloride | ARC | 99.0 | 16,000 | 23,000 | 20 |
| | BAY | 43.4 | 16,000 | 23,000 | 20 |
| | BON | 2,720 | 16,000 | 23,000 | 20 |
| | BRT | 29.2 | 16,000 | 23,000 | 20 |
| | GAI | 980 | 16,000 | 23,000 | 20 |
| | OCA | 1,200 | 16,000 | 23,000 | 20 |
| | OKE | 71.4 | 16,000 | 23,000 | 20 |
| | POH | 3,420 | 16,000 | 23,000 | 20 |
| | PRW | 154 | 16,000 | 23,000 | 20 |

### 3.1.3 SVOC

Of a total of 9 drinking water sludge samples from 9 water treatment facilities, no acid and base/neutral extractable compounds were detected above the detection limit of 5 mg/kg.

### 3.1.4 Pesticides

Pesticides in drinking water sludge have been analyzed by two major groups: nitrogen-phosphorous pesticides and organochlorine pesticides. No nitrogen-phosphorous pesticides and organochlorine pesticides were detected above the detection limits of 0.25 mg/kg and 0.025 mg/kg, respectively, in any of the total drinking water sludge samples.

## 3.2 Results of Leaching Analysis

### 3.2.1 Metals

Twenty eight drinking water sludge samples (5 alum, 3 ferric, and 20 lime) were analyzed for leaching concentration for metals: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, sodium, selenium, silver and zinc. The results of the leaching metals in the drinking water sludge are presented and discussed in the following section.

#### 3.2.1.1 Aluminum

**Alum Sludge**

As shown in Table 3.18, the highest aluminum concentration was detected with alum sludge samples. Aluminum was detected in all the samples with an average of 1.14 mg/L, a minimum of 0.07 mg/L and a maximum of 4.12 mg/L. Three out of 5 samples analyzed contained aluminum at concentrations higher than the FGGC (0.2 mg/L).

**Ferric Sludge**

Ferric sludge samples contained aluminum at an average concentration of 0.46 mg/L, a minimum of 0.12 mg/L and a maximum of 0.68 mg/L, as presented in Table 3.18. Aluminum concentration is above the FGGC (0.2 mg/L) in 2 out of 3 ferric sludge samples analyzed.

**Lime Sludge**

As presented in table 3.18, lime sludge samples had an average aluminum concentration of 0.08 mg/L, a minimum of 0.07 mg/L and a maximum of 0.17 mg/L. All lime sludge samples were well below the residential FGGC (0.2 mg/L)

**Table 3-18 Leaching Aluminum Concentration (mg/L)**

**(FGGC = 0.2 mg/L)**

| **Sludge Type** | **Sample Name** | **Aluminum Concentration (mg/L)** | **Sludge Type** | **Sample Name** | **Aluminum Concentration (mg/L)** |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.07 | Lime | FLA | 0.13 |
| | NWP | 0.89 | | GAI | < 0.07 |
| | OKE | 0.55 | | LAK | < 0.07 |
| | PON | 4.12 | | LAU A | < 0.07 |
| | PRW | < 0.07 | | LAU B | < 0.07 |
| | **Average** | **1.14** | | MAN A | 0.12 |
| | **Std. Deviation** | **1.70** | | MAR | < 0.07 |
| | **Minimum** | **0.07** | | MIM | < 0.07 |
| | **Maximum** | **4.12** | | OAK | < 0.07 |
| Ferric | BAY | 0.12 | | OCA | < 0.07 |
| | BRT | 0.60 | | PAM | < 0.07 |
| | COC A | 0.68 | | POH | < 0.07 |
| | **Average** | **0.46** | | PTF | < 0.07 |
| | **Std. Deviation** | **0.30** | | STJ | < 0.07 |
| | **Minimum** | **0.12** | | STL | < 0.07 |
| | **Maximum** | **0.68** | | **Average** | **0.08** |
| Lime | ARC | < 0.07 | | **Std. Deviation** | **0.03** |
| | BON | < 0.07 | | **Minimum** | **0.07** |
| | CHA | < 0.07 | | **Maximum** | **0.17** |
| | COC B | 0.17 | | | |
| | ENG | < 0.07 | | | |

Note: Detection Limit 0.07 mg/L.

### 3.2.1.2 Arsenic

**Alum Sludge**
As shown in Table 3.19, arsenic was not detected in any sample. All samples analyzed contained arsenic at concentrations lower than FGGC (0.05 mg/L).
**Ferric Sludge**
As shown in Table 3.19, arsenic was not detected in any sample. All samples analyzed contained arsenic at concentrations lower than FGGC (0.05 mg/L).
**Lime Sludge**
As presented in Table 3.19, arsenic was detected in only 1 out of 20 lime sludge samples and it was well below the FGGC (0.05 mg/L).

**Table 3-19 Leaching Arsenic Concentration (ug/L)**
**(FGGC = 50 ug/L)**

| Sludge Type | Sample Name | Arsenic Concentration (ug/L) | Sludge Type | Sample Name | Arsenic Concentration (ug/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 2.5 | Lime | FLA | < 2.5 |
| | NWP | < 2.5 | | GAI | < 2.5 |
| | OKE | < 2.5 | | LAK | < 2.5 |
| | PON | < 2.5 | | LAU A | < 2.5 |
| | PRW | < 2.5 | | LAU B | < 2.5 |
| | **Average** | 2.50 | | MAN A | < 2.5 |
| | **Std. Deviation** | | | MAR | < 2.5 |
| | **Minimum** | 2.50 | | MIM | < 2.5 |
| | **Maximum** | 2.50 | | OAK | < 2.5 |
| Ferric | BAY | < 2.5 | | OCA | < 2.5 |
| | BRT | < 2.5 | | PAM | < 2.5 |
| | COC A | < 2.5 | | POH | < 2.5 |
| | **Average** | 2.50 | | PTF | < 2.5 |
| | **Std. Deviation** | | | STJ | < 2.5 |
| | **Minimum** | 2.50 | | STL | 2.84 |
| | **Maximum** | 2.50 | | **Average** | 2.52 |
| Lime | ARC | < 2.5 | | **Std. Deviation** | 0.07 |
| | BON | < 2.5 | | **Minimum** | 2.50 |
| | CHA | < 2.5 | | **Maximum** | 2.84 |
| | COC B | < 2.5 | | | |
| | ENG | < 2.5 | | | |

Note: Detection Limit 2.5 ug/L.

#### 3.2.1.3 Barium

**Alum Sludge**
As shown in Table 3.20, barium was detected in 4 out of 5 alum sludge samples. Barium was detected with an average of 0.01 mg/L, a minimum of 0.01 mg/L and a maximum of 0.02 mg/L. None of the sample exceeded the FGGC.

**Ferric Sludge**
As shown in Table 3.20, barium was detected in 2 out of 3 ferric sludge samples. Barium was detected with an average of 0.03 mg/L, a minimum of 0.01 mg/L and a maximum of 0.07 mg/L. None of the sample exceeded the FGGC.

**Lime Sludge**
As presented in Table 3.20, barium was detected in only 6 out of 20 lime sludge samples. Barium was detected with an average of 0.09 mg/L, a minimum of 0.01 mg/L and a maximum of 1.43 mg/L. None of the sample exceeded the FGGC.

**Table 3-20 Leaching Barium Concentration (mg/L)**
**(FGGC = 2 mg/L)**

| Sludge Type | Sample Name | Barium Concentration (mg/L) | Sludge Type | Sample Name | Barium Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.01 | Lime | FLA | 0.03 |
| | NWP | 0.02 | | GAI | 0.04 |
| | OKE | 0.01 | | LAK | < 0.01 |
| | PON | 0.01 | | LAU A | < 0.01 |
| | PRW | 0.01 | | LAU B | < 0.01 |
| | **Average** | **0.01** | | MAN A | 1.43 |
| | **Std. Deviation** | **0.00** | | MAR | < 0.01 |
| | **Minimum** | **0.01** | | MIM | < 0.01 |
| | **Maximum** | **0.02** | | OAK | < 0.01 |
| Ferric | BAY | < 0.01 | | OCA | < 0.01 |
| | BRT | 0.07 | | PAM | < 0.01 |
| | COC A | 0.01 | | POH | < 0.01 |
| | **Average** | **0.03** | | PTF | 0.09 |
| | **Std. Deviation** | **0.03** | | STJ | < 0.01 |
| | **Minimum** | **0.01** | | STL | < 0.01 |
| | **Maximum** | **0.07** | | **Average** | **0.09** |
| Lime | ARC | < 0.01 | | **Std. Deviation** | **0.32** |
| | BON | 0.01 | | **Minimum** | **0.01** |
| | CHA | 0.02 | | **Maximum** | **1.43** |
| | COC B | < 0.01 | | | |
| | ENG | < 0.01 | | | |

Note: Detection Limit 0.01 mg/L.

### 3.2.1.4 Cadmium

As shown in Table 3.21, cadmium was not detected in any sample above detection limit of 0.5 ug/L. The average cadmium content of the all sludge samples was well below FGGCs (0.005 mg/L). None of the samples exceeded FGGC for cadmium.

**Table 3-21 Leaching Cadmium Concentration (ug/L)**

**(FGGC = 5 ug/L)**

| Sludge Type | Sample Name | Cadmium Concentration (ug/L) | Sludge Type | Sample Name | Cadmium Concentration (ug/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.5 | Lime | FLA | < 0.5 |
| | NWP | < 0.5 | | GAI | < 0.5 |
| | OKE | < 0.5 | | LAK | < 0.5 |
| | PON | < 0.5 | | LAU A | < 0.5 |
| | PRW | < 0.5 | | LAU B | < 0.5 |
| | **Average** | **0.5** | | MAN A | < 0.5 |
| | **Std. Deviation** | | | MAR | < 0.5 |
| | **Minimum** | **0.5** | | MIM | < 0.5 |
| | **Maximum** | **0.5** | | OAK | < 0.5 |
| Ferric | BAY | < 0.5 | | OCA | < 0.5 |
| | BRT | < 0.5 | | PAM | < 0.5 |
| | COC A | < 0.5 | | POH | < 0.5 |
| | **Average** | **0.5** | | PTF | < 0.5 |
| | **Std. Deviation** | | | STJ | < 0.5 |
| | **Minimum** | **0.5** | | STL | < 0.5 |
| | **Maximum** | **0.5** | | **Average** | **0.5** |
| Lime | ARC | < 0.5 | | **Std. Deviation** | |
| | BON | < 0.5 | | **Minimum** | **0.5** |
| | CHA | < 0.5 | | **Maximum** | **0.5** |
| | COC B | < 0.5 | | | |
| | ENG | < 0.5 | | | |

Note: Detection Limit 0.5 ug/L.

#### 3.2.1.5 Chromium

**Alum Sludge**

As shown in Table 3.22, chromium was detected in 3 out of 5 samples with an average of 0.019 mg/L, a minimum of 0.017 mg/L and a maximum of 0.024 mg/L. The average chromium content of the alum sludge samples was well below FGGC (0.1 mg/L). None of the samples exceeded the FGGCs for chromium.

**Ferric Sludge**

As shown in Table 3.22, chromium was not detected in any sample. All samples analyzed contained chromium at concentrations lower than FGGC (0.1 mg/L).

**Lime Sludge**

As presented in Table 3.22, chromium was detected in only 6 out of 20 samples with an average of 0.022 mg/L, a minimum of 0.017 mg/L and a maximum of 0.088 mg/L. The average chromium content of the lime sludge samples was well below FGGC (0.1 mg/L). None of the samples exceeded the FGGCs for chromium.

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**Table 3-22 Leaching Chromium Concentration (mg/L)**
**(FGGC = 0.1 mg/L)**

| Sludge Type | Sample Name | Chromium Concentration (mg/L) | Sludge Type | Sample Name | Chromium Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.017 | Lime | FLA | < 0.017 |
| | NWP | 0.024 | | GAI | < 0.017 |
| | OKE | 0.019 | | LAK | 0.018 |
| | PON | 0.019 | | LAU A | < 0.017 |
| | PRW | < 0.017 | | LAU B | < 0.017 |
| | **Average** | **0.019** | | MAN A | 0.088 |
| | **Std. Deviation** | **0.003** | | MAR | < 0.017 |
| | **Minimum** | **0.017** | | MIM | < 0.017 |
| | **Maximum** | **0.024** | | OAK | < 0.017 |
| Ferric | BAY | < 0.017 | | OCA | < 0.017 |
| | BRT | < 0.017 | | PAM | < 0.017 |
| | COC A | < 0.017 | | POH | < 0.017 |
| | **Average** | **0.017** | | PTF | 0.033 |
| | **Std. Deviation** | **0.000** | | STJ | 0.027 |
| | **Minimum** | **0.017** | | STL | < 0.017 |
| | **Maximum** | **0.017** | | **Average** | **0.022** |
| Lime | ARC | < 0.017 | | **Std. Deviation** | **0.016** |
| | BON | 0.017 | | **Minimum** | **0.017** |
| | CHA | < 0.017 | | **Maximum** | **0.088** |
| | COC B | < 0.017 | | | |
| | ENG | 0.019 | | | |

Note: Detection Limit 0.0175 mg/L.

#### 3.2.1.6 Copper

**Alum Sludge**

As shown in Table 3.23, copper was detected in only 1 out of 5 samples. The average copper content of the alum sludge samples was well below FGGC (1 mg/L). None of the samples exceeded the FGGC for copper.

**Ferric Sludge**

As shown in Table 3.23, copper was detected in 1 out of 3 samples. All samples analyzed contained copper at concentrations lower than FGGC (1 mg/L).

**Lime Sludge**

As presented in Table 3.23, copper was detected in only 4 out of 20 samples with an average of 0.02 mg/L, a minimum of 0.014 mg/L and a maximum of 0.112 mg/L. The average copper content of the alum sludge samples was well below FGGC (1 mg/L). None of the samples exceeded the FGGCs for copper.

**Table 3-23 Leaching Copper Concentration (mg/L) (FGGC=1 mg/L)**

| Sludge Type | Sample Name | Copper Concentration (mg/L) | Sludge Type | Sample Name | Copper Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.014 | Lime | FLA | < 0.014 |
| | NWP | 0.020 | | GAI | < 0.014 |
| | OKE | < 0.014 | | LAK | 0.025 |
| | PON | < 0.014 | | LAU A | < 0.014 |
| | PRW | < 0.014 | | LAU B | < 0.014 |
| | **Average** | **0.015** | | MAN A | < 0.014 |
| | **Std. Deviation** | **0.003** | | MAR | 0.112 |
| | **Minimum** | **0.014** | | MIM | 0.034 |
| | **Maximum** | **0.020** | | OAK | < 0.014 |
| Ferric | BAY | < 0.014 | | OCA | 0.014 |
| | BRT | 0.115 | | PAM | < 0.014 |
| | COC A | < 0.014 | | POH | < 0.014 |
| | **Average** | **0.048** | | PTF | < 0.014 |
| | **Std. Deviation** | **0.058** | | STJ | < 0.014 |
| | **Minimum** | **0.014** | | STL | < 0.014 |
| | **Maximum** | **0.115** | | **Average** | **0.020** |
| Lime | ARC | < 0.014 | | **Std. Deviation** | **0.022** |
| | BON | < 0.014 | | **Minimum** | **0.014** |
| | CHA | < 0.014 | | **Maximum** | **0.112** |
| | COC B | < 0.014 | | | |
| | ENG | < 0.014 | | | |

Note: Detection Limit 0.014 mg/L.

#### 3.2.1.7 Iron

**Alum Sludge**
As shown in Table 3.24, iron was detected in only 3 out of 5 samples. The average iron content of the alum sludge samples was well below FGGC (0.3 mg/L). None of the samples exceeded the FGGC for iron.

**Ferric Sludge**
As shown in Table 3.24, iron was detected in all ferric sludge samples with an average of 47.7 mg/L, a minimum of 4.36 mg/L and a maximum of 114.8 mg/L. All samples analyzed contained iron at concentrations greater than FGGC (0.3 mg/L).

**Lime Sludge**
As presented in Table 3.24, iron was detected in only 8 out of 20 samples with an average of 0.071 mg/L, a minimum of 0.045 mg/L and a maximum of 0.278 mg/L. The average iron content of the alum sludge samples was well below FGGC (0.3 mg/L). None of the samples exceeded the FGGCs for iron.

**Table 3-24 Leaching Iron Concentration (mg/L)**

**(FGGC = 0.3 mg/L)**

| Sludge Type | Sample Name | Iron Concentration (mg/L) | Sludge Type | Sample Name | Iron Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.045 | Lime | FLA | 0.102 |
| | NWP | 0.252 | | GAI | < 0.045 |
| | OKE | 0.125 | | LAK | < 0.045 |
| | PON | 0.218 | | LAU A | < 0.045 |
| | PRW | < 0.045 | | LAU B | < 0.045 |
| | **Average** | **0.137** | | MAN A | 0.121 |
| | **Std. Deviation** | **0.096** | | MAR | < 0.045 |
| | **Minimum** | **0.045** | | MIM | < 0.045 |
| | **Maximum** | **0.252** | | OAK | < 0.045 |
| Ferric | BAY | 23.94 | | OCA | 0.086 |
| | BRT | 4.36 | | PAM | < 0.045 |
| | COC A | 114.8 | | POH | < 0.045 |
| | **Average** | **47.7** | | PTF | 0.047 |
| | **Std. Deviation** | **58.929** | | STJ | 0.048 |
| | **Minimum** | **4.36** | | STL | 0.278 |
| | **Maximum** | **114.8** | | **Average** | **0.071** |
| Lime | ARC | < 0.045 | | **Std. Deviation** | **0.055** |
| | BON | < 0.045 | | **Minimum** | **< 0.045** |
| | CHA | < 0.045 | | **Maximum** | **0.278** |
| | COC B | 0.101 | | | |
| | ENG | 0.094 | | | |

Note: Detection Limit 0.045 mg/L.

### 3.2.1.8 Lead

**Alum Sludge**

As shown in Table 3.25, lead was detected in 1 out of 5 sample. One sample contained lead at concentrations higher than FGGC (0.015 mg/L).

**Ferric Sludge**

As shown in Table 3.25, lead was not detected in any of ferric sludge samples. All samples analyzed contained lead at concentrations lower than FGGC (0.015 mg/L).

**Lime Sludge**

As presented in Table 3.25, lead was detected in only 1 out of 20 lime sludge samples. Except 1, all samples analyzed contained lead at concentrations lower than FGGC (0.015 mg/L).

**Table 3-25 Leaching Lead Concentration (ug/L)**

**(FGGC = 0.015 mg/L)**

| Sludge Type | Sample Name | Lead Concentration (ug/L) | Sludge Type | Sample Name | Lead Concentration (ug/L) |
|---|---|---|---|---|---|
| | MAN B | 39.11 | | FLA | < 5 |
| | NWP | < 5 | | GAI | < 5 |
| | OKE | < 5 | | LAK | < 5 |
| | PON | < 5 | | LAU A | 30.30 |
| Alum | PRW | < 5 | | LAU B | < 5 |
| | **Average** | 11.82 | | MAN A | < 5 |
| | **Std. Deviation** | 15.25 | | MAR | < 5 |
| | **Minimum** | 5.00 | | MIM | < 5 |
| | **Maximum** | 39.11 | | OAK | < 5 |
| | BAY | < 5 | Lime | OCA | < 5 |
| | BRT | < 5 | | PAM | < 5 |
| | COC A | < 5 | | POH | < 5 |
| Ferric | **Average** | 5.33 | | PTF | < 5 |
| | **Std. Deviation** | 0.58 | | STJ | < 5 |
| | **Minimum** | 5.00 | | STL | < 5 |
| | **Maximum** | 6.00 | | **Average** | 6.37 |
| | ARC | < 5 | | **Std. Deviation** | 5.65 |
| | BON | < 5 | | **Minimum** | 5.00 |
| Lime | CHA | < 5 | | **Maximum** | 30.30 |
| | COC B | < 5 | | | |
| | ENG | < 5 | | | |

Note: Detection Limit 0.005 mg/L.

#### 3.2.1.9 Manganese

**Alum Sludge**

As shown in Table 3.26, manganese was detected in only 3 out of 5 samples. The average manganese content of the alum sludge samples was well below FGGC (0.05 mg/L). One of the samples exceeded the FGGC for manganese.

**Ferric Sludge**

As shown in Table 3.26, manganese was detected in all ferric sludge samples with an average of 0.1325 mg/L, a minimum of 0.0406 mg/L and a maximum of 0.1982 mg/L. Two out of 3 samples analyzed contained manganese at concentrations greater than FGGC (0.05 mg/L).

**Lime Sludge**

As presented in Table 3.26, manganese was detected in only 1 out of 20 samples. The average manganese content of the lime sludge samples was well below FGGC (0.05 mg/L). None of the samples exceeded the FGGCs for manganese.

**Table 3-26 Leaching Manganese Concentration (mg/L)**

**(FGGC = 0.05 mg/L)**

| Sludge Type | Sample Name | Manganese Concentration (mg/L) | Sludge Type | Sample Name | Manganese Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | 0.1197 | Lime | FLA | 0.0111 |
| | NWP | < 0.011 | | GAI | < 0.011 |
| | OKE | < 0.011 | | LAK | < 0.011 |
| | PON | 0.0176 | | LAU A | < 0.011 |
| | PRW | 0.0141 | | LAU B | < 0.011 |
| | **Average** | **0.0347** | | MAN A | < 0.011 |
| | **Std. Deviation** | **0.0476** | | MAR | < 0.011 |
| | **Minimum** | **0.0110** | | MIM | < 0.011 |
| | **Maximum** | **0.1197** | | OAK | < 0.011 |
| Ferric | BAY | 0.0406 | | OCA | < 0.011 |
| | BRT | 0.1586 | | PAM | < 0.011 |
| | COC A | 0.1982 | | POH | < 0.011 |
| | **Average** | **0.1325** | | PTF | < 0.011 |
| | **Std. Deviation** | **0.0820** | | STJ | < 0.011 |
| | **Minimum** | **0.0406** | | STL | < 0.011 |
| | **Maximum** | **0.1982** | | **Average** | **0.0110** |
| Lime | ARC | < 0.011 | | **Std. Deviation** | **0.0000** |
| | BON | < 0.011 | | **Minimum** | **0.0110** |
| | CHA | < 0.011 | | **Maximum** | **0.0111** |
| | COC B | < 0.011 | | | |
| | ENG | < 0.011 | | | |

Note: Detection Limit 0.011 mg/L.

### 3.2.1.10 Mercury

As shown in Table 3.27, mercury was not detected in any sample above the detection limit of 0.25 ug/L. None of the samples exceeded the FGGCs (2 ug/L) for mercury.

**Table 3-27 Leaching Mercury Concentration (ug/L)**

**(FGGC = 0.002 mg/L= 2 ug/L)**

| Sludge Type | Sample Name | Mercury Concentration (ug/L) | Sludge Type | Sample Name | Mercury Concentration (ug/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.25 | Lime | FLA | < 0.25 |
| | NWP | < 0.25 | | GAI | < 0.25 |
| | OKE | < 0.25 | | LAK | < 0.25 |
| | PON | < 0.25 | | LAU A | < 0.25 |
| | PRW | < 0.25 | | LAU B | < 0.25 |
| | **Average** | **< 0.25** | | MAN A | < 0.25 |
| | **Std. Deviation** | | | MAR | < 0.25 |
| | **Minimum** | **< 0.25** | | MIM | < 0.25 |
| | **Maximum** | **< 0.25** | | OAK | < 0.25 |
| Ferric | BAY | < 0.25 | | OCA | < 0.25 |
| | BRT | < 0.25 | | PAM | < 0.25 |
| | COC A | < 0.25 | | POH | < 0.25 |
| | **Average** | **< 0.25** | | PTF | < 0.25 |
| | **Std. Deviation** | | | STJ | < 0.25 |
| | **Minimum** | **< 0.25** | | STL | < 0.25 |
| | **Maximum** | **< 0.25** | | **Average** | **< 0.25** |
| Lime | ARC | < 0.25 | | **Std. Deviation** | |
| | BON | < 0.25 | | **Minimum** | **< 0.25** |
| | CHA | < 0.25 | | **Maximum** | **< 0.25** |
| | COC B | < 0.25 | | | |
| | ENG | < 0.25 | | | |

Note: Detection Limit 0.25 ug/L.

#### 3.2.1.11 Molydbenum

**Alum Sludge**

As shown in Table 3.28, molybdenum was not detected in any of the samples. All samples analyzed contained molybdenum at concentrations lower than FGGCs (0.035 mg/L).

**Ferric Sludge**

As shown in Table 3.28, molybdenum was not detected in any sample. All samples analyzed contained molybdenum at concentrations lower than FGGC (0.035 mg/L).

**Lime Sludge**

As presented in Table 3.28, Molybdenum was not detected in 18 out of 20 sample above the detection limit of 0.0025 mg/L. The average molybdenum concentration in lime sludge was 0.00299 mg/L. None of the sample contained molydbenum above FGGC.

**Table 3-28 Leaching Molybdenum Concentration (ug/L)**

**(FGGC = 0.035 mg/L)**

| Sludge Type | Sample Name | Molybdenum Concentration (ug/L) | Sludge Type | Sample Name | Molybdenum Concentration (ug/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 2.5 | Lime | FLA | < 2.5 |
| | NWP | < 2.5 | | GAI | < 2.5 |
| | OKE | < 2.5 | | LAK | 6.68 |
| | PON | < 2.5 | | LAU A | < 2.5 |
| | PRW | < 2.5 | | LAU B | < 2.5 |
| | **Average** | 2.50 | | MAN A | 5.37 |
| | **Std. Deviation** | | | MAR | < 2.5 |
| | **Minimum** | 2.50 | | MIM | < 2.5 |
| | **Maximum** | 2.50 | | OAK | < 2.5 |
| Ferric | BAY | < 2.5 | | OCA | < 2.5 |
| | BRT | < 2.5 | | PAM | < 2.5 |
| | COC A | < 2.5 | | POH | < 2.5 |
| | **Average** | 2.50 | | PTF | < 2.5 |
| | **Std. Deviation** | | | STJ | < 2.5 |
| | **Minimum** | 2.50 | | STL | < 2.5 |
| | **Maximum** | 2.50 | | **Average** | **2.99** |
| Lime | ARC | < 2.5 | | **Std. Deviation** | **1.23** |
| | BON | < 2.5 | | **Minimum** | **2.50** |
| | CHA | < 2.5 | | **Maximum** | **6.68** |
| | COC B | < 2.5 | | | |
| | ENG | < 2.5 | | | |

Note: Detection Limit 0.0025 mg/L.

#### 3.2.1.12 Nickel

**Alum Sludge**
As shown in Table 3.29, nickel was detected in 2 out of 5 samples with an average of 0.0153 mg/L, a minimum of 0.015 mg/L and a maximum of 0.018 mg/L. The average nickel content of the alum sludge samples was well below FGGC (0.1 mg/L).

**Ferric Sludge**
As shown in Table 3.29, nickel was not detected in any sample. All samples analyzed contained nickel at concentrations lower than FGGC (0.1 mg/L).

**Lime Sludge**
As presented in Table 3.29, nickel was detected in only 5 out of 20 samples with an average of 0.017 mg/L, a minimum of 0.015 mg/L and a maximum of 0.035 mg/L. The average nickel content of the alum sludge samples was well below FGGC (0.1 mg/L).

Table 3-29 Leaching Nickel Concentration (mg/L)

(FGGC = 0.1 mg/L)

| Sludge Type | Sample Name | Nickel Concentration (mg/L) | Sludge Type | Sample Name | Nickel Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.015 | Lime | FLA | < 0.015 |
| | NWP | 0.018 | | GAI | 0.0206 |
| | OKE | < 0.015 | | LAK | < 0.015 |
| | PON | < 0.015 | | LAU A | < 0.015 |
| | PRW | < 0.015 | | LAU B | < 0.015 |
| | **Average** | **0.0153** | | MAN A | 0.0154 |
| | **Std. Deviation** | **0.0017** | | MAR | 0.0351 |
| | **Minimum** | **0.015** | | MIM | < 0.015 |
| | **Maximum** | **0.0180** | | OAK | < 0.015 |
| Ferric | BAY | < 0.015 | | OCA | 0.0259 |
| | BRT | < 0.015 | | PAM | < 0.015 |
| | COC A | < 0.015 | | POH | < 0.015 |
| | **Average** | **0.015** | | PTF | < 0.015 |
| | **Std. Deviation** | | | STJ | < 0.015 |
| | **Minimum** | **0.015** | | STL | < 0.015 |
| | **Maximum** | **0.015** | | **Average** | **0.0171** |
| Lime | ARC | < 0.015 | | **Std. Deviation** | **0.0051** |
| | BON | < 0.015 | | **Minimum** | **0.0150** |
| | CHA | < 0.015 | | **Maximum** | **0.0351** |
| | COC B | < 0.015 | | | |
| | ENG | 0.0206 | | | |

Note: Detection Limit 0.015 mg/L.

#### 3.2.1.13 Sodium

**Alum Sludge**
As shown in Table 3.30, sodium was detected in all the samples with an average of 10.08 mg/L, a minimum of 0.97 mg/L and a maximum of 15.99 mg/L. All the samples leached sodium much below FGGC (160 mg/L).

**Ferric Sludge**
Ferric sludge samples contained sodium at an average concentration of 14.69 mg/L, a minimum of 11.34 mg/L and a maximum of 19.06 mg/L, as presented in Table 3.30. All the samples leached sodium much below FGGC (160 mg/L).

**Lime Sludge**
As presented in Table 3.30, lime sludge samples had an average sodium concentration of 4.86 mg/L, a minimum of 0.17 mg/L and a maximum of 67.21 mg/L. All the samples leached sodium much below FGGC (160 mg/L).

**Table 3-30 Leaching Sodium Concentration (mg/L)**

**(FGGC = 160 mg/L)**

| Sludge Type | Sample Name | Sodium Concentration (mg/L) | Sludge Type | Sample Name | Sodium Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | 0.97 | Lime | FLA | 3.29 |
| | NWP | 8.52 | | GAI | 0.56 |
| | OKE | 15.99 | | LAK | 0.17 |
| | PON | 14.47 | | LAU A | 1.64 |
| | PRW | 10.45 | | LAU B | 0.61 |
| | **Average** | **10.08** | | MAN A | 3.20 |
| | **Std. Deviation** | **5.91** | | MAR | 2.28 |
| | **Minimum** | **0.97** | | MIM | 0.76 |
| | **Maximum** | **15.99** | | OAK | 0.42 |
| Ferric | BAY | 13.68 | | OCA | 1.81 |
| | BRT | 19.06 | | PAM | 0.54 |
| | COC A | 11.34 | | POH | 67.21 |
| | **Average** | **14.69** | | PTF | 1.01 |
| | **Std. Deviation** | **3.96** | | STJ | 1.14 |
| | **Minimum** | **11.34** | | STL | 2.10 |
| | **Maximum** | **19.06** | | **Average** | **4.86** |
| Lime | ARC | 1.41 | | **Std. Deviation** | **14.72** |
| | BON | 1.93 | | **Minimum** | **0.17** |
| | CHA | 4.50 | | **Maximum** | **67.21** |
| | COC B | 1.80 | | | |
| | ENG | 0.80 | | | |

Note: Detection Limit 0.15 mg/L.

### 3.2.1.14 Selenium

All the sludge samples leached selenium below detection limit (2.5 ug/L). None of the samples exceeded FGGC (5 ug/L)

**Table 3-31 Leaching Selenium Concentration (ug/L)**
**(FGGC = 0.005 mg/L)**

| Sludge Type | Sample Name | Arsenic Concentration (ug/L) | Sludge Type | Sample Name | Arsenic Concentration (ug/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 2.5 | Lime | FLA | < 2.5 |
| | NWP | < 2.5 | | GAI | < 2.5 |
| | OKE | < 2.5 | | LAK | < 2.5 |
| | PON | < 2.5 | | LAU A | < 2.5 |
| | PRW | < 2.5 | | LAU B | < 2.5 |
| | **Average** | 2.50 | | MAN A | < 2.5 |
| | **Std. Deviation** | | | MAR | < 2.5 |
| | **Minimum** | 2.50 | | MIM | < 2.5 |
| | **Maximum** | 2.50 | | OAK | < 2.5 |
| Ferric | BAY | < 2.5 | | OCA | < 2.5 |
| | BRT | < 2.5 | | PAM | < 2.5 |
| | COC A | < 2.5 | | POH | < 2.5 |
| | **Average** | 2.50 | | PTF | < 2.5 |
| | **Std. Deviation** | | | STJ | < 2.5 |
| | **Minimum** | 2.50 | | STL | < 2.5 |
| | **Maximum** | 2.50 | | **Average** | 2.5 |
| Lime | ARC | < 2.5 | | **Std. Deviation** | |
| | BON | < 2.5 | | **Minimum** | 2.5 |
| | CHA | < 2.5 | | **Maximum** | 2.5 |
| | COC B | < 2.5 | | | |
| | ENG | < 2.5 | | | |

**Note: Detection Limit 2.5 ug/L.**

#### 3.2.1.15 Silver

As shown in Table 3.32, silver was not detected in any sample above the detection limit of 0.03 mg/L. None of the samples exceeded the FGGC (0.1 mg/L) for silver.

**Table 3-32 Leaching Silver Concentration (mg/L)**

**(FGGC = 0.1 mg/L)**

| Sludge Type | Sample Name | Silver Concentration (mg/L) | Sludge Type | Sample Name | Silver Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.03 | Lime | FLA | < 0.03 |
| | NWP | < 0.03 | | GAI | < 0.03 |
| | OKE | < 0.03 | | LAK | < 0.03 |
| | PON | < 0.03 | | LAU A | < 0.03 |
| | PRW | < 0.03 | | LAU B | < 0.03 |
| | **Average** | **< 0.03** | | MAN A | < 0.03 |
| | **Std. Deviation** | | | MAR | < 0.03 |
| | **Minimum** | **< 0.03** | | MIM | < 0.03 |
| | **Maximum** | **< 0.03** | | OAK | < 0.03 |
| Ferric | BAY | < 0.03 | | OCA | < 0.03 |
| | BRT | < 0.03 | | PAM | < 0.03 |
| | COC A | < 0.03 | | POH | < 0.03 |
| | **Average** | **< 0.03** | | PTF | < 0.03 |
| | **Std. Deviation** | | | STJ | < 0.03 |
| | **Minimum** | **< 0.03** | | STL | < 0.03 |
| | **Maximum** | **< 0.03** | | **Average** | **< 0.03** |
| Lime | ARC | < 0.03 | | **Std. Deviation** | |
| | BON | < 0.03 | | **Minimum** | **< 0.03** |
| | CHA | < 0.03 | | **Maximum** | **< 0.03** |
| | COC B | < 0.03 | | | |
| | ENG | < 0.03 | | | |

Note: Detection Limit 0.03 mg/L.

#### 3.2.1.16 Zinc

**Alum Sludge**

As shown in Table 3.33, zinc was detected in only 2 out of 5 samples. The average zinc content of the alum sludge samples was well below FGGC (5 mg/L). None of the samples exceeded the FGGC for zinc.

**Ferric Sludge**

As shown in Table 3.33, zinc was detected in all ferric sludge samples with an average of 0.0422 mg/L, a minimum of 0.0319 mg/L and a maximum of 0.0475 mg/L. All samples analyzed contained zinc at concentrations less than FGGC (5 mg/L).

**Lime Sludge**

As presented in Table 3.33, zinc was detected in 11 out of 20 samples. The average zinc content of the lime sludge samples was well below FGGC (0.05 mg/L). None of the samples exceeded the FGGC for zinc.

**Table 3-33 Leaching Zinc Concentration (mg/L)**

**(FGGC = 5 mg/L)**

| Sludge Type | Sample Name | Zinc Concentration (mg/L) | Sludge Type | Sample Name | Zinc Concentration (mg/L) |
|---|---|---|---|---|---|
| Alum | MAN B | < 0.025 | Lime | FLA | 0.0278 |
| | NWP | 0.0557 | | GAI | < 0.025 |
| | OKE | 0.0396 | | LAK | 0.0572 |
| | PON | < 0.025 | | LAU A | < 0.025 |
| | PRW | < 0.025 | | LAU B | < 0.025 |
| | **Average** | **0.0341** | | MAN A | 0.0472 |
| | **Std. Deviation** | **0.0136** | | MAR | 0.6858 |
| | **Minimum** | **< 0.0250** | | MIM | 0.1844 |
| | **Maximum** | **0.0557** | | OAK | < 0.025 |
| Ferric | BAY | 0.0319 | | OCA | 0.0748 |
| | BRT | 0.0475 | | PAM | 0.0617 |
| | COC A | 0.0471 | | POH | < 0.025 |
| | **Average** | **0.0422** | | PTF | < 0.025 |
| | **Std. Deviation** | **0.0089** | | STJ | < 0.025 |
| | **Minimum** | **0.0319** | | STL | < 0.025 |
| | **Maximum** | **0.0475** | | **Average** | **0.0760** |
| Lime | ARC | 0.0258 | | **Std. Deviation** | **0.1481** |
| | BON | 0.0332 | | **Minimum** | **0.0250** |
| | CHA | < 0.025 | | **Maximum** | **0.6858** |
| | COC B | 0.0555 | | | |
| | ENG | 0.0421 | | | |

Note: Detection Limit 0.025 mg/L.

### 3.2.2 VOC

Table 3.34 presents the results of VOC leaching analysis of the drinking water sludge samples. Acetone was consistently detected in the leaching samples, while methylene chloride was found in one leaching sample. The methylene chloride concentration of the sample exceeded the groundwater guidance concentration of 2.7 μg/L. The probable source of these two analytes is believed to be laboratory chemicals commonly used for either glassware cleaning or laboratory extraction.

**Table 3-34 Results of Leaching VOCs in Drinking Water Sludge**

| ***Detected Compounds*** | ***Sample*** | ***Concentration (μg/L)*** | ***Groundwater Guidance Concentration (μg/L)*** |
|---|---|---|---|
| Acetone | ARC | 28.5 | -- |
| | BAY | 18.4 | -- |
| | BON | 46.2 | -- |
| | BRT | 9.4 | -- |
| | GAI | 13.5 | -- |
| | OCA | 9.8 | -- |
| | OKE | 6.3 | -- |
| | POH | 5.1 | -- |
| | PRW | 14,400 | -- |
| Methylene chloride | PRW | 5.3 | 2.7 |

#### 3.2.2.1 SVOC

No acid and base/neutral extractable compounds were detected above the detection limit of 10 μg/L in any of the SVOC leaching samples.

#### 3.2.2.2 Pesticides

No nitrogen-phosphorous pesticides and organochlorine pesticides were detected above the detection limits of 0.5 μg/L and 0.05 μg/L, respectively, in any of the drinking water sludge leaching samples.

#### 3.2.2.3 Inorganic Ions

Table 3-35 presents the results of total dissolved solids and inorganic ions (fluoride, chloride, and sulfate) in SPLP leaching samples. In most cases, the pH of the SPLP extracts was out of the range (6.5 – 8.5) listed in Florida ground water guidance concentration (FGGC) criteria. The concentrations of TDS, fluoride, chloride, and sulfate in the SPLP extracts did not exceed the levels of FGGC, with an exception of one sample for TDS. The TDS concentration of the sample was five times higher than the limit. No fluoride was detected in any of the SPLP extracts above the detection limit of 1 mg/L.

**Table 3-35 Results of Inorganic Concentrations and TDS in SPLP Leaching Samples**

| Sample Name | Sludge Type | Final pH | TDS (mg/L) | Fluoride (mg/L) | Chloride (mg/L) | Sulfate (mg/L) |
|---|---|---|---|---|---|---|
| ***FGGC*[a]** | | ***6.5 – 8.5*** | ***500*** | ***2.0*** | ***250*** | ***250*** |
| ARC | Lime | 8.81 | <50 | <1.0 | 4.9 | 9.4 |
| BAY | Ferric | 5.19 | 170 | <1.0 | 3.8 | 20.5 |
| BON | Lime | 11.86 | 193 | <1.0 | 5.4 | 11.5 |
| BRT | Ferric | 5.15 | 370 | <1.0 | 3.4 | 125.3 |
| CHA | Lime | 10.40 | 230 | <1.0 | 10.7 | 10.6 |
| COC B | Ferric | 6.88 | 75 | <1.0 | 4.1 | 54.4 |
| COC A | Lime | 9.48 | 60 | <1.0 | 6.9 | 14.9 |
| ENG | Lime | 9.31 | 190 | <1.0 | 4.3 | 4.3 |
| FLA | Lime | 9.75 | 210 | <1.0 | 6.9 | 40.2 |
| GAI | Lime | 10.37 | 140 | <1.0 | 4.0 | 44.9 |
| LAK | Lime | 9.64 | 200 | <1.0 | 5.1 | 55.2 |
| LAU A | Lime | 10.23 | <50 | <1.0 | 5.0 | 12.0 |
| LAU B | Lime | 9.89 | <50 | <1.0 | 4.3 | 3.8 |
| MAN A | Lime | 12.57 | 2,540 | <1.0 | 24.9 | 13.6 |
| MAN B | Alum | 5.54 | 220 | <1.0 | 5.1 | 31.2 |
| MAR | Lime | 9.99 | <50 | <1.0 | 6.6 | 12.6 |
| MIM | Lime | 10.49 | <50 | <1.0 | 4.8 | 12.1 |
| NWP | Alum | 6.95 | 113 | <1.0 | 7.2 | 99.3 |
| OAK | Lime | 10.59 | 130 | <1.0 | 3.3 | 4.4 |
| OCA | Lime | 9.76 | 70 | <1.0 | 3.2 | 6.6 |
| OKE | Alum | 6.41 | 160 | <1.0 | 5.9 | 40.9 |
| PAM | Lime | 10.53 | <50 | <1.0 | 5.1 | 4.8 |
| POH | Lime | 9.13 | 370 | <1.0 | 94.8 | 43.3 |
| PON | Alum | 7.29 | 440 | <1.0 | 20.6 | 121.0 |
| PRW | Alum | 5.92 | <50 | <1.0 | 8.8 | 70.8 |
| PTF | Lime | 10.89 | 140 | <1.0 | 4.6 | 7.8 |
| STJ | Lime | 9.37 | <50 | <1.0 | 4.7 | 7.0 |
| STL | Lime | 9.81 | 90 | <1.0 | 8.2 | 5.0 |

Note: [a.] Florida groundwater guidance concentrations. All parameters are based on the Secondary Standards.

### 3.2.3 Analysis of Treatment Chemicals

One sample of each treatment chemical type was collected and analyzed to determine if they might represent a source of the As and V observed at relatively high concentrations in some of the WTS samples. The concentrations of As in the alum and ferric coagulants were 13.4 and 15.1 mg/kg, respectively, while the lime sample contained 1.46 mg/kg of As. The concentrations of V in the alum and ferric coagulants were 12 and 180 mg/kg, respectively, while the lime sample tested contained 7.6 mg/kg. While this exercise was conducted on only one sample of each chemical, the results suggest that one source of these elements may have been the treatment chemicals.

# 4 REPORT SUMMARY

## 4.1 Total Metals

For the total metal analysis of sludge samples, most metal concentrations were either below detection limit or detectable, but not exceeding the appropriate soil cleanup target level. However, all of alum and 2 of 3 ferric sludge samples were above the industrial limit of soil cleanup target level for arsenic. Of the 9 lime sludge samples that exceeded the limit, 1 sample was above the industrial limit of soil cleanup target level for arsenic. Another metal that was on occasion above the soil cleanup target level was barium. One out of 5 alum sludge samples and 3 out of 20 lime sludge samples exceeded the residential cleanup goal (based on direct exposure). Copper was also detected above the residential (SCTL) in 1 of the ferric sludge samples analyzed.

As expected, all the alum sludge samples had aluminum concentration above the residential cleanup goal (based on direct exposure) and all the ferric sludge samples had iron concentration above the residential cleanup goal (based on direct exposure).

## 4.2 Total Organics

A total of 74 volatile organic compounds were analyzed for drinking water sludge samples. Two VOCs, acetone and methylene chloride, were consistently found in most samples, probably because of the use of the solvents for glassware cleaning and organic extractions in the laboratory. None of the analytes detected exceeded the residential and industrial limits of Florida soil cleanup target levels.

Target semi-volatile organic compounds for drinking water sludge samples were categorized two major gropus: acid SVOC and base/neutral SVOC. A total of 117 compounds were targeted during semi-VOC analysis. None of the analytes was detected above the detection limit of 5 mg/kg in any of nine SVOC samples during total SVOC analysis.

Two major groups were targeted for pesticide analysis: nitrogen and phosphorous pesticides, and organochlorine pesticides. No pesticides were detected above the detection limts in any of the drinking water sludge samples during total analysis.

## 4.3 Leaching Metal

The SPLP leaching test was performed to determine leachability of heavy metals (aluminum, arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, mercury, molybdenum, nickel, sodium, selenium, silver and zinc) from all the sludge samples collected. The data were compared to Florida Groundwater Guidance Concentrations (FGGC). As far as lime sludge samples are concerned 2 samples leached above FGGC for lead only. Three sample (1 alum and 2 ferric samples) leached manganese above FGGC.

Most of the alum sludge samples and 2 ferric sludge samples leached aluminum above FGGC and all the ferric sludge samples leached iron concentration above FGGC.

## 4.4 Leaching organics

A SPLP test for drinking water sludge samples was carried out to examine leachability of volatile organic compounds. No VOCs were found above the detection limit of 5 μg/L in any of nine VOC leaching samples with the exception of acetone and methylene chloride. Acetone was constitently detected in all leaching samples, while methylene chloride was detected in only one SPLP extract. As mentioned above, the probable source of acetone is laboratory cleaning or organic extractions in the laboratory.

No acid and base/neutral SVOC compounds were detected above the detection limit of 5 μg/L in any of SPLP leaching samples. No nitrogen and phosphorous pesticides and organochlorine pesticides were found in any of the SPLP extracts.

A total of 28 SPLP leaching samples were also analyzed for inorganic ions. The concentrations of TDS, chloride, and sulfate detected in the SPLP extracts were less than the ground water guidance concentration levels with the exception of one sample for TDS. No fluoride was detected in any of the SPLP samples above the detection limit of 1 mg/L.

# 5 REFERENCES

United States Environmental Protection Agency (1995), *Test Methods for Evaluating Solid Waste. U.S. EPA SW-846*, Office of Solid Waste, Washington D.C.