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Determination of Lead in Soil and Phytoremediation Trials

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Sources of Lead

Lead exposure comes from many sources in history. The two main sources of lead in the environment are lead based paint and leaded gasoline. Leaded gasoline contained tetraethyl and tetramethyl lead compounds and lead based paint contained lead pigments such as white lead (lead carbonate), red lead (lead oxide), and yellow lead (lead chromate). Although these are the major sources, there are many other sources of lead the persists in the environment. Along with lead fishing weights and lead bullet, lead acid batteries still remain in use today as car batteries and contain lead oxides. In the past, lead arsenate was used as a pesticide for apple orchards and lead acetate, also known as the “sugar of lead”, was historically used as a sweetener in remedies and medicines. Finally, lead oxides were used in ceramic glazes and glass along with the same pigments used in lead based paint to create stained glass.

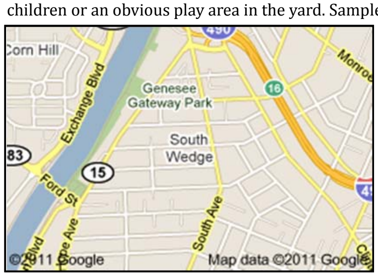
Health Problems Caused by Lead Exposure

Lead enters the body and is absorbed into the blood stream. The lead then makes its way to the bones, teeth, nerves, kidneys, brain, heart, and muscles. The biggest problem with lead is that it cannot be metabolized in the body and is mistaken for calcium and zinc in bodily processes. Lead is so easily mistaken for calcium and zinc because it has a similar size and the same +2 charge. Once lead is in the body it accumulates and causes lead poisoning, also known as, plumbism. Lead poisoning is defined as a toxic condition caused by the inhalation or ingestion of the metallic element lead. An adult is considered to have lead poisoning when the achieve blood lead levels (BLL) of greater than or equal to 25µg/dL. A child is considered to have lead poisoning with BLL’s greater than or equal to 10µg/dL. Children are most greatly affected by lead exposure. Over 310,000 children from ages one to five have are reported with lead poisoning in the United States each year. Low levels of lead ingestion can cause brain damage, diminished motor skills, hyperactivity, and poor learning ability, slowed growth, hearing problems, and digestive complications in children. Lead can have a serious affect on adults after prolonged exposure. Anemia, colic, severe brain damage, reproductive complications, muscle weakness and death in adults can be attributed to great amounts of lead exposure in an adult’s lifetime.

Knowing the detrimental health effects that lead can cause, the EPA set standards for lead contaminated soil. Lead contaminated soil is defined as: uncovered soil on a residential property that contains a minimum of 400ppm for play areas and a minimum of 1200ppm for all other locations. Other regulations against the use of lead in production have also be implemented.

Sample Collection

Soil samples from Rochester areas were collected and tested. Soil samples were collected by the CHEM316, instrumental chemistry class in April 2010 from 7 houses and 5 open plots that will be used for community gardens in the South Wedge area. From each home, samples were collected from 4 areas of the surrounding lawn. The soil was from uncovered areas that were accessible to children or an obvious play area in the yard. Samples were collected from the front yard near the home as well as closer to the street and from the backyard close to the back of the home as well as closer to the back of the property (as in previous research). From the large open plots, the plots were divided up into grids and samples were taken from each spot on the grid.



To collect the samples, small metal shovels were covered with nitrile gloves; small samples were taken and placed in plastic bags labeled with the address, location on the property, and date of the sample collection. Distilled water was brought along to rinse off the few small plastic shovels that were used for sample collection in order to eliminate cross contamination. The samples were returned to the lab and stored for future analysis.

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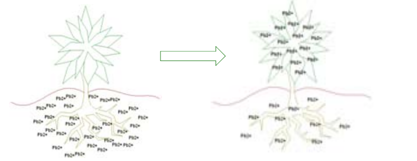
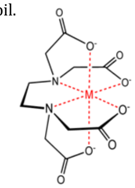
Phytoextraction

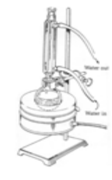


Phytoextraction involves the use of plants to extract an element from the soil which is then stored in the roots, stem, leaves, and/or fruit of the plant. The use of chelating agents such as EDTA can be used to enhance the extraction of the given element.
The above figure shows how heavy metals, such as lead, are collected through the roots and stored in the stem and leaves, permanently removing the unwanted metal from the soil.

Ethylenediaminetetraacetic acid (EDTA) is a hexadentate ligand with four carboxylate binding sites and 2 amine binding sites. The structure of EDTA gives it the ability to sequester metal cations and can be therefore used as a treatment for lead poisoning in the body. EDTA can also be used in lead uptake studies as a chelator; increasing the ability of the plant to uptake the lead in the soil.



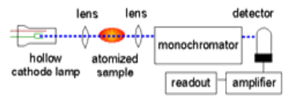
EPA Method 3050B

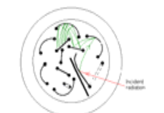


Analysis began with the digestion of the soil samples using EPA Method 3050B: Acid Digestion of Sediments, Sludges, and Soils. Section 7.5 of this method was used because it is known to enhance the solubilities and recovery of Antimony, Barium, Lead, and Silver. Approximately 1 to2 grams of sample are added to a round bottom flask. To the round bottom flask containing the soil is added 2.5mL HNO_3 and 10mL HCl which is then refluxed using a condenser and a heating mantel. After reflux is complete, the digested sample is filtered and the filtrate is collected in a 100mL volumetric flask. The sample, while still in the funnel is washed with 5mL of 95°C HCl followed by 20mL of 95°C distilled water. The filter paper along with any residue are placed back into the round bottom flask and 5mL of 95°C HCl is added. The filter paper is allowed to dissolve and the solution is then filtered into the same volumetric flask. The flask is allowed to cool and it is diluted to volume with distilled water.

Atomic Absorption Spectroscopy

The Flame Atomic Absorption Spectrometer has four main components, as well as the final steps of the amplifier and readout. The source for atomic absorption (AA) must be a line source, meaning it only radiates a small range of wavelengths. The AA at St. John Fisher College has an HCL. An HCL has a small amount of ion of interest in the lamp giving it the ability to only look at only one element at a time. The radiation from the HCL passes through a sample that has been vaporized and converted to its atom state by the atomizer. After radiation from the hollow cathode lamp has passed through the atomized sample, the radiation passes through the monochromator which isolates a narrow band of radiation energy. The detector used for FAAS is a photomultiplier tube (PMT). A PMT has a very high sensitivity, producing 10^7 from the initial photon.





Results

Home Lead Levels

Home	Front back [Pb^{2+}] ppm	Front near [Pb^{2+}] ppm	Back Near [Pb^{2+}] ppm	Back Far [Pb^{2+}] ppm
Caroline	26.67	293.33	426.67	266.67
Bond	---	26.67	1226.67	---
Hamilton	106.67	453.33	266.67	480
Cypress	106.67	Not detected	266.67	Not detected
Mulberry	Not detected	---	---	853.33

Garden	Front	Middle	Back	Bed
South	13.71	52.54	21.42	7.75
Garden	**#4**	**#5**	**#8**	
Hickory	53.33	133.33	80	

After analysis, it was determined that out of 24 sites tested, only 1 site was over the limit for residential areas and only 5 locations had lead levels over the limit for play areas.

Plant Lead Uptake

Soil Pb^{2+} Concentration	Plant Pb^{2+} concentration, ppm
Leaves	
400 ppm w/EDTA **(lettuce)**	Not detected
400 ppm w/EDTA **(lettuce)**	Not detected
Roots	
400 ppm w/ EDTA **(lettuce)**	30.8906
Stems	
400 ppm w/EDTA **(lettuce)**	4.9459
Full plant	
Control no EDTA **(lettuce)**	Not detected
8000 ppm no EDTA **(beans)**	66.20763
8000 ppm EDTA **(beans)**	**563.6316**
16000 ppm w/EDTA **(collards)**	**364.7057**
Fruit	
400 ppm w/ EDTA **(beans)**	7.2517
1000 ppm w/EDTA **(beans)**	19.5215
8000 ppm no EDTA **(beans)**	14.3349

It was determined that only two of the plants analyzed had accumulated a significant amount of lead. The digestion and analysis of the full bean plant at 8000ppm lead concentration with EDTA and the full collard plant at 16000ppm lead concentration with EDTA had accumulated lead. These results are significant in the fact that we know, as preliminary results, that at high concentration with the addition of EDTA to the system, these plants are able to accumulate lead.

EPA lead contaminated soil regulations
Play area ≥400ppm
Residential ≥1200ppm