Searching for Lead in Our Environment, a Qualitative Test of Water and Soil Samples

by William W. Felinski III, Edison-Fareira High School, Science Department, Philadelphia, PA

Foundation

Lead is a common contaminant in the environment, especially in older, urban environments. The sources of this contamination are numerous. Children begin their exposure *in utero* in the course of their development because their mothers are exposed to lead, albeit it in very small quantities, through water, soil, and even the dust they breathe on a daily basis. Students may not be aware that this exposure exists or the effects that lead exposure might present to them and their future generations, so while I originally developed this exercise for my general chemistry classes, The subject matter is easily approached in an Environmental Science or Anatomy and Physiology class; and can be used in a cross-curricular research topic in either an Language Arts or Social Science class.

The qualitative basis for this project is the net ionic equation:

$$Pb^{+3}{}_{(aq)} \; + \; I^{-1}{}_{(aq)} \rightarrow PbI_3 \text{ (bright yellow ppt)}$$

Many of you might recognize this from your general chemistry class as a demonstration of a double-replacement reaction. I recall seeing my high school chemistry teacher mixing the clear solutions of Lead nitrate with Potassium iodide and seeing the bright yellow cloud forming almost instantly and watching it slowly drift to the bottom of the large glass beaker. That image has stuck with me for a very long time and it may even be the one of the anchor points of why I have continued my career in science.

Using this reaction as a starting point, I decided to look at adapting it as a qualitative tool and applying it to the detection of Lead, first in drinking water, and then in soil or as my students call it, dirt.

Introduction

To provide students with some kind of background in the problems associated with Lead in the environment, I used to begin with a trip to the library and an exercise in the use of search engines. However, I was fortunate in one of my recent web searches to come across a wonderful lesson plan on the Yale-New Haven Teachers Institute site. The plan by Ms. Carolyn Kinder, is titled, "*Lead Contamination in Our Environment*" and it provides students, and teachers, with a well-documented basis for understanding the issues and effects, as well as some of the background and sources of this insidious contaminant.

The complete lesson plan can be found at the following URL:
http://www.yale.edu/ynhti/curriculum/units/1997/7/97.07.05.x.html

Chemical Procedure

Water Sample Test:

1. Sample protocols will be discussed in a later section.
2. A 15 mL sample of water is pipetted into a clean Pyrex glass test tube.
3. Carefully add 2.5 mL of concentrated Nitric Acid (HNO_3) to the test tube and *gently* mix.
4. The test tube is then allowed to cool in an ice bath for several minutes.
5. 5 mL of a saturated solution of Potassium iodide (KI_{sat}) is added to the acidified water sample test tube.
6. The tube is gently mixed
7. Record Observations
8. *Optional* - the sample can be placed into a chemically inert centrifuge tube before the KI addition, the tube can then be spun down to force any precipitant to the bottom for ease of observation.

Soil or Dirt Sample Test:

1. Sample protocol will be discussed in a later section.
2. Place approximately 5 mL of a finely ground soil sample in a small beaker.
3. Add 5 mL of deionized (DI) water to the beaker, stir slowly with a glass rod.
4. *Carefully* add 5 mL of concentrated Nitric Acid (HNO_3), and mix using a glass rod.
5. *Carefully* filter the mixture into a Pyrex glass test tube.
6. Cool the test tube in an ice bath for several minutes.
7. 5 mL of a saturated solution of Potassium iodide (KI_{sat}) is added to the acidified water sample test tube.
8. The tube is gently mixed
9. Record Observations
10. *Optional* - the sample can be placed into a chemically inert centrifuge tube before the KI addition, the tube can then be spun down to force any precipitant to the bottom for ease of observation.

Water and Soil (Dirt) Sample Protocols

1. Only sterile, plastic, chemically inert containers or jars should be used to collect samples.

2. Students should use a fresh pair of disposable gloves every time they collect a sample of household water, ground water, soil, or dirt. To limit exposure to breathing either dust or dirt particles, you may want to consider having your students wear dust-masks while they collect these samples in addition to the disposable gloves.

3. It is best to collect household water sample either first thing in the morning, before the system has been flushed by users within the home, or if the home is unoccupied during the day, samples can be collected before household members begin their normal water use routines.

4. If water sample are being collected from household faucets, use only the cold-water faucet and take the first 25 to 50 mL to come from the faucet. Open the faucet very slowly; you want to catch the very first drops out of the cold-water line. You are only collecting a small (one or two fluid ounce sample.) DO NOT use water taken from the hot-water faucet; these samples will contain contaminants from the cathodes used to protect the hot-water heater tank.

5. Ground water samples, i.e. those taken from a local stream, river, pond, drainage ditch, or urban street puddle, can be collected for purposes of this study.

6. Soil, or as our students often refer to it, dirt samples can be collected from indoor or outdoor locations. Inside locations, such as unfinished basements, laundry rooms, or garages can often supply a large enough sample. Surface soil samples can be collected from any number of locations throughout the geographic area of your study. Soil from around the outside of houses, schools, playgrounds, parks, driveways, parking lots, curb-sides, and even window-box planters or medial strips can all yield large enough soil samples. However, you can suggest that students concentrate on any areas where children play should be sampled.

7. The exact location of where the sample was collected is needed for mapping purposes. Needed information should include: house number and apartment number, if applicable, street name, closest cross street, city, state, zip code with + 4 (if this is know) AND where in the household the sample was taken, i.e. Third floor bathroom sink, rear of the house. This information can be recorded on a permanent label fixed to the sample container, or the sealed container can be placed within a new, sandwich sized, plastic bag with the label fixed to the outside of the bag. All label information should be in permanent ink. Depending on the level of sophistication available to your classes, sample information can then be recorded into a product such as Google Earth to generate a sample location map that students could use to illustrate the geography of their study area.

8. Samples, once collected, can be stored, in the sealed containers, at room temperature before testing. However, it is imperative that all samples be treated as though they are contaminated with Lead, and standard laboratory safety protocol should be observed.

Interpreting Test Results and Clean-up

1. **What does it mean if nothing happens?**

   Answer: Because this is a relatively simple qualitative test, a negative test could mean one of two things. First possible reason is that there is no Lead in the sample. This is sometimes referred to as a true negative result. The second possibility is that Lead is present in the sample, but it is below the detectable limits of the test. This would be a false negative result.

2. **What can we do to limit or prevent False Negative Results?**

   Answer: While a cursory review of the literature will tell us that Lead iodide is insoluble in water, that is not quantatively true, however, we further limit the solubility of the product by cooling the sample in an ice bath for several minutes, which brings the temperature down between O^{o} C and 4^{o}C, where the solubility of Lead iodide is less than 5 ppm. In addition, if one uses a centrifuge to help concentrate any precipitant that may form, especially if the centrifuge tube is examined using a hand-held, magnifying lens.

3. **A precipitant formed, but it isn't bright yellow, what happened?**

   Answer: If a precipitant formed, but it isn't bright yellow, the sample might not contain Lead. I have found, that Iron ions will form a Red or Red-Orange colored precipitant. This would be a false positive result.

4. **What can be done to limit false positive results?**

   Answer: If you suspect that Iron and Lead may be in the soil or dirt samples, use a small Neodymium Permanent magnet to stir the sample before the addition of the deionized water and the concentrated nitric acid. These high gauss magnets can play havoc with credit cards or the signal from a cathode ray tube, in fact, they can actually "pull" at the ink on U.S. paper currency, so it is an excellent way to remove magnetic particles from soil samples.

5. **What do I do with "leftover" samples after testing?**

   Answer: Leftovers will fall into two broad classes those that tested positive for Lead, and those that did not. All samples need to be catalogued and mapped, after that, it is a matter of common sense.

   <u>If the sample show a negative result</u>, then they can be discarded. Water sample can be poured into a sink or toilet and flushed with fresh water. Negative soil samples and the filtrate can be disposed of in the trash. The negative solution from either water or soil tests should be carefully neutralized using household baking soda to a pH of approximately 7, and can then be poured into a sink or toilet and flushed with fresh water.

<u>If the sample shows a positive result</u>, this is another matter, but as with negative results, <u>all samples</u> need to be catalogued and mapped. The unused portion of the sample <u>must be considered contaminated</u> if the processed sample provided a positive result. These samples must be preserved in the original sample container, and serious thought should be given in sending those samples out to an independent laboratory for a quantitative assay to determine the level of Lead contamination. As liquid fraction, the acidified liquid should be neutralized using household baking soda, and since it is unlikely that the remaining liquid contains any appreciable levels of Lead, these can probably be flushed down or sink drain, But you need to check with your school or district's safety officer or local Environmental Protection group first. The problem comes with the filtrate and the solid precipitant. These, like the original Samples, contain Lead, these should be collected into a single plastic, chemically inert, plastic bag, sealed, and double wrapped again, and disposed of in a manner consistent with local school, district, or Environmental Protection Authority Requirements.

<u>DO NOT</u> simply throw these positive test items in the trash can, rubbish bin, or neighborhood dumpster.

<u>Publish Your Results</u>

Regardless of what you find, you should make the results known, even if it is only a short human-interest article in the local or school newspaper. Your students could use their background research and test results for a community service project or public service campaign.

Don't be afraid to ask for help. Many local Community Colleges, Universities, or Colleges may be willing to help your students with everything from lab space for sample preparation and chemical analysis. Likewise, local environmental action groups or the community farm bureau might be willing to help with material or funds, or both.

I have begun to collect information for a broader community project where we are going to make use of a WIKISPACE, which is an internet tool that allows the students to upload and share data beyond their local neighborhoods, cities, or states.

The only limits are those found in one's imagination!

Thank you for your time and consideration.

Respectfully submitted by:

William (Bill) W. Felinski III
Science Department
Edison-Fareira High School
151 West Luzerne Street
Philadelphia, PA 19140
School District Email: wfelinski@philasd.org
or
Graduate School Email: wwf61953@temple.edu
or
Private Email: wwfelinski1@verizon.net