Investigating Dangerous Levels of Lead and Relationship to pH in Local Soil

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29 March 2017

Investigating Dangerous Levels of Lead in Local Soil

Research Questions

The Environmental Protection Agency conducted lead soil tests in December 1986. The EPA performed this project to determine whether reduction of lead in soil could reduce the lead level in the blood of children located in the inner city (EPA, 1996). This project is similar to that of the EPA, however this experiment is testing the lead levels in the soil of Gettysburg and Biglerville.

Lead is a naturally bright metal, but once it is exposed to the oxygen in air, it developes a dull, bluish-gray covering. Lead is a soft, heavy metal because it has a high atomic number (how many protons the element contains in the nucleus), and each of the atoms are relatively heavy (Watt, 1958). Like most metals, lead does not usually occur naturally in pure form. Instead, it is found in compounds combined with other elements, and these compounds do not occur in a pure form either. The most important lead ore (rocks that contain useful amounts of metals and other minerals) is a rock called galena (Symes, 1988).

About the Experiment

The purpose of this project was to identify if there were high levels of lead in local soil, and the relationship between the lead levels and the pH of the soil. The hypothesis states that if three locations; school, house, and foundry, are tested, then the foundry location is going to have the highest lead level because the industry most likely contaminated the soil, due to the materials used while in operation and level of pH. The independent variable is the location of the testing. These locations include a residence housing children, a school, and the site of a former foundry. The dependent variables are the lead levels, measured in ppm and pH, obtained following

GLOBE protocols. The controlled variables are the amount of soil tested and the testing procedure.

Introduction

Once lead is extracted from Earth, it goes through processes to remove other elements and impurities. First, it is burned with a blast of air, changing the lead sulfide to lead oxide and sulfur dioxide. Then it is converted to lead metal by heating with carbon in a blast furnace. Next, it has tiny traces of other metals labeled as impurities (Congress, 1990). To remove the other metals and impurities from the lead metal a process, called refining, removes the unnecessary metals. Zinc is then added to remove remaining precious metals. Depending on what the use of lead is going to be will determine which impurities will be added to it (Storage, 1889*).*

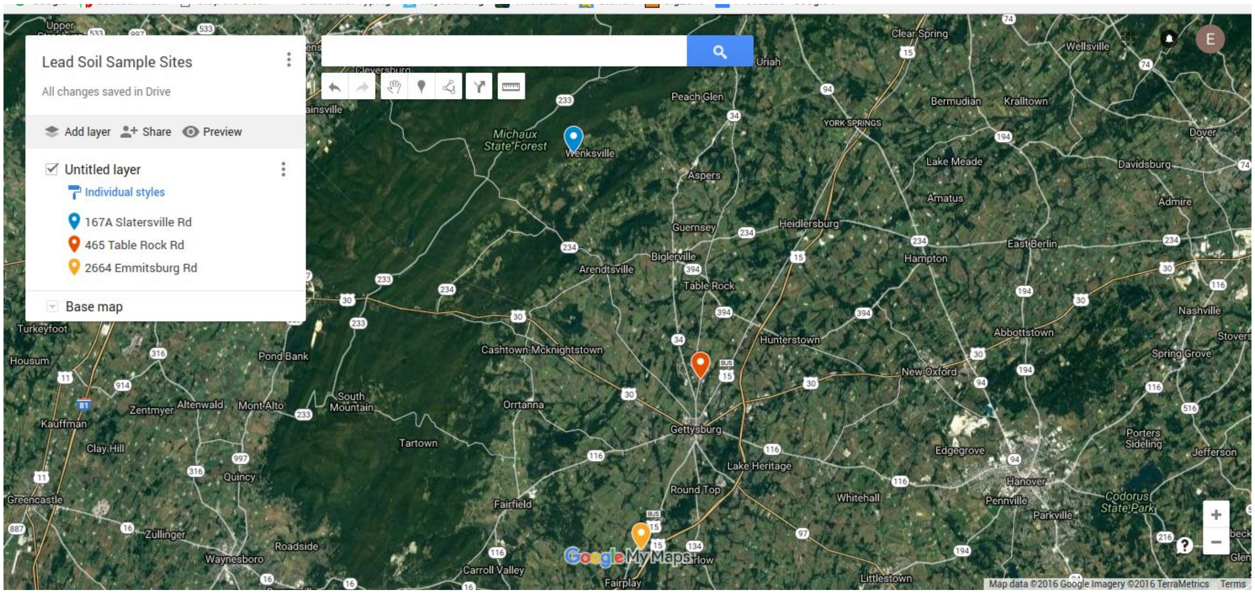
Long ago, lead was used as a protective sheet for ships' hulls and roofs. Plumbing and water supply systems contained lead piping. During this time period, lead was also used in ornaments, drinking cups, and other everyday objects. Although lead is not found in these objects anymore, lead can be found in the environment due to vehicle and industry emissions and lead-based paint that chipped from buildings. Some industries' emissions contaminate the air and soil. The majority of industries, especially industrial practices that deal with metals, can release lead into the air. Lead that is emitted into the air can be inhaled, or can be ingested ("How Does Lead"). Lead is naturally existent in the environment and can be found in air, soil, and water ("Lead in History").

This metal is a hazard to human health ("Lead in the"). Once lead enters the body, it can be stored in the bones and teeth in place of calcium. Lead is not harmful in these places, but after some time, lead leaches out causing damage in the blood and in soft tissues, such as the spleen and liver. Lead prevents enzymes and other essential molecules from functioning properly, especially hemoglobins. This can cause anemia (a disease when hemoglobins do not carry enough oxygen to supply the body). Lead also affects the nerves and brain cells, and once it has reached the brain, it is extremely difficult to remove. Children are more at risk for lead poisoning than adults, due to a faster absorption rate (Harris, 2001).

Research Methods

Materials

- Sensafe Soil Chec-480311
  - 5 test vials
  - 5 test strip pads
  - Reagent A (contains distilled white vinegar)
- Notebook
- Newspaper
- Target brand 473.176 mL plastic cups
- Shovel
- Vernier pH sensor
- Vernier LabQuest
- 3 jars with lids
- Chosen locations
  - 39.763921, -77.271388 (Foundry)
  - 39.858838, -77.224738 (School)
  - 39.990000,-77.323740 (House)



Map 1: This map shows the locations of testing. Each site is within a temperate climate, has short grass, and trees within 30 meters.

Procedure

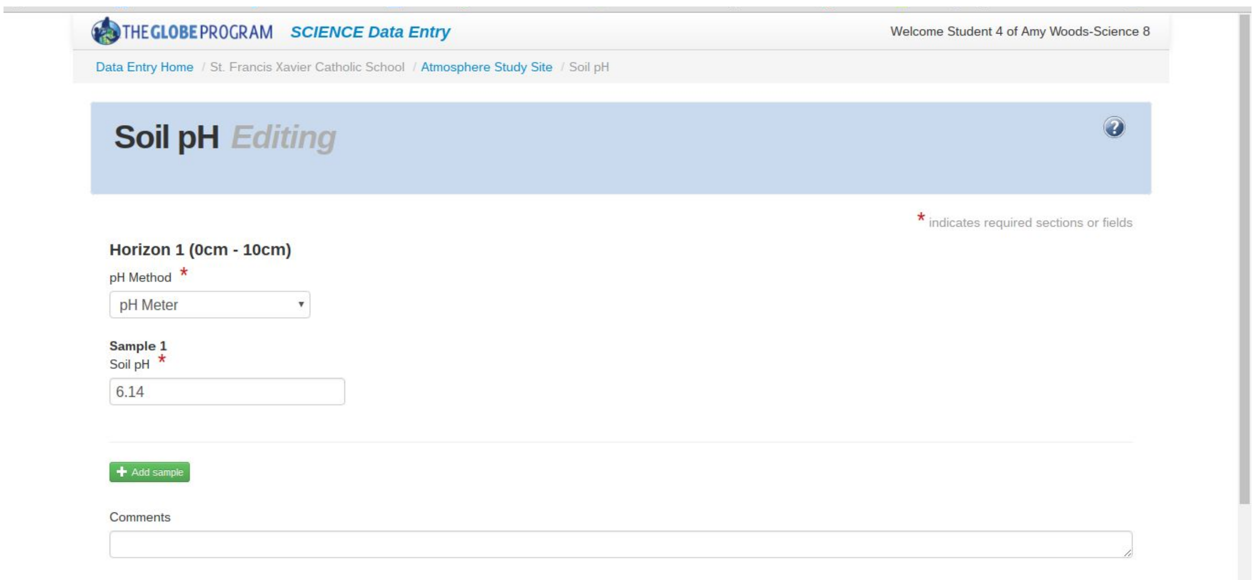
1. Determine sampling location (School, House, Foundry).
2. Gather a cup of soil using a shovel.
3. Put down newspaper and spread the soil across it.
4. Remove any stones or debris from the soil.
5. Break up any clumps of soil.
6. Leave the soil to dry for two days, then return the soil to the cup.
7. Prepare the “strip wash solution” by dispensing about 100mL of tap water into a container.
8. Fill half the test vial with soil.
9. Add the entire contents of one bottle of Reagent A to the soil.

10. Place the cap on the vial.
11. Shake vigorously for 30 seconds.
12. Remove one strip from one “ Heavy Metal Test” packet.
13. Use the strip within 10 minutes once the packet has been opened.
14. Dip the aperture (oval window) end of the test strip into the soil for 5 seconds.
15. After 5 seconds, remove the strip and place it in a safe location.
16. Make sure the oval window of the test pad is facing up, because it will be covered with soil.
17. Wait 1,2,5, or 10 minutes depending upon the detection level (for this test, trials 1-4 at the school were completed waiting 10 minutes. Trial 5 was completed using 1 minute since all of the results were the same in order to try to get a more accurate result).
18. After these minutes are up, rinse the test strip aperture in the strip wash solution for 5 seconds.
19. Remove the strip from the solution and immediately match the test strip color that appears through the aperture against the color chart on the Display Card.
20. Record data in logbook.
21. Repeat steps 1-20, four more times for a total of 5 trials for the Foundry and House locations.
22. Analyze the results.

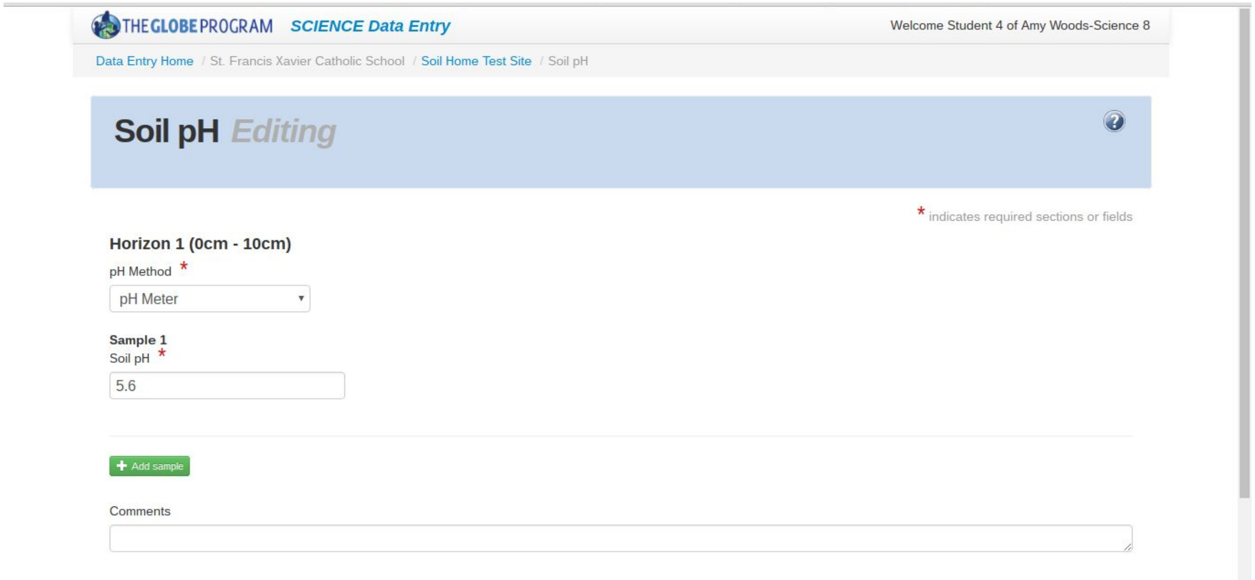
Soil pH (Procedure taken directly from GLOBE protocols)

1. In a cup or beaker, mix 40 g of dried and sieved soil with 40 mL of distilled water (or other amount in a 1:1 soil to water ratio) using a spoon or other utensil to transfer the soil.

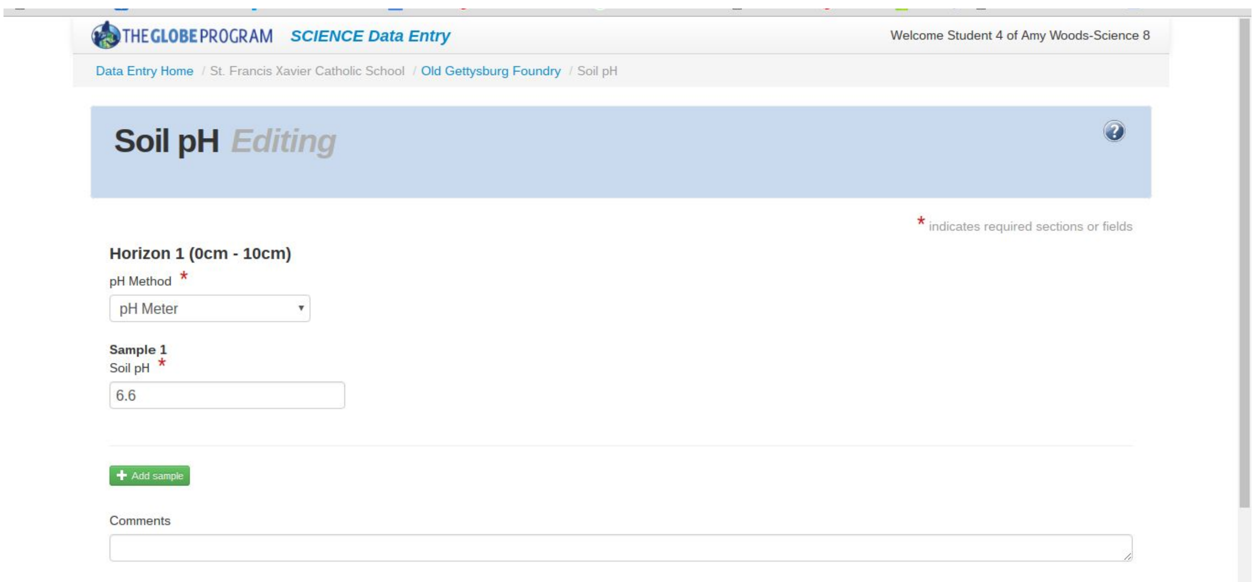
2. Stir the soil/water mixture with a spoon or other stirrer until it is thoroughly mixed. Stir the soil/water mixture for 30 seconds and then wait for three minutes for a total of five stirring/waiting cycles. Then, allow the mixture to settle until a supernatant (clearer liquid above the settled soil) forms (about 5 minutes).
3. Measure the pH of the supernatant using the pH meter. Dip the pH calibrated pH meter in the supernatant. Record the pH value on the Soil pH Data Sheet. If pH meter requires calibration, gloves should be worn.
4. Repeat steps 1-3 for two more samples from the same location.



Screenshot 1: This shows the data entry into GLOBE for the soil pH of the school site.



Screenshot 2: This shows the data entry into GLOBE for the soil pH of the home site.



Screenshot 3: This shows the data entry into GLOBE for the soil pH of the foundry site.

Results

	School Lead Levels (PPM)
Trial 1	400
Trial 2	400
Trial 3	400
Trial 4	400
Trial 5	400
	House Lead Levels (PPM)
Trial 1	400
Trial 2	400
Trial 3	400
Trial 4	400
Trial 5	400
	Foundry Lead Levels (PPM)
Trial 1	400
Trial 2	400
Trial 3	400
Trial 4	400
Trial 5	n/a

Figure 1: This shows the levels of lead for all of the locations.

Figure 2: This shows the levels of lead for the school location.

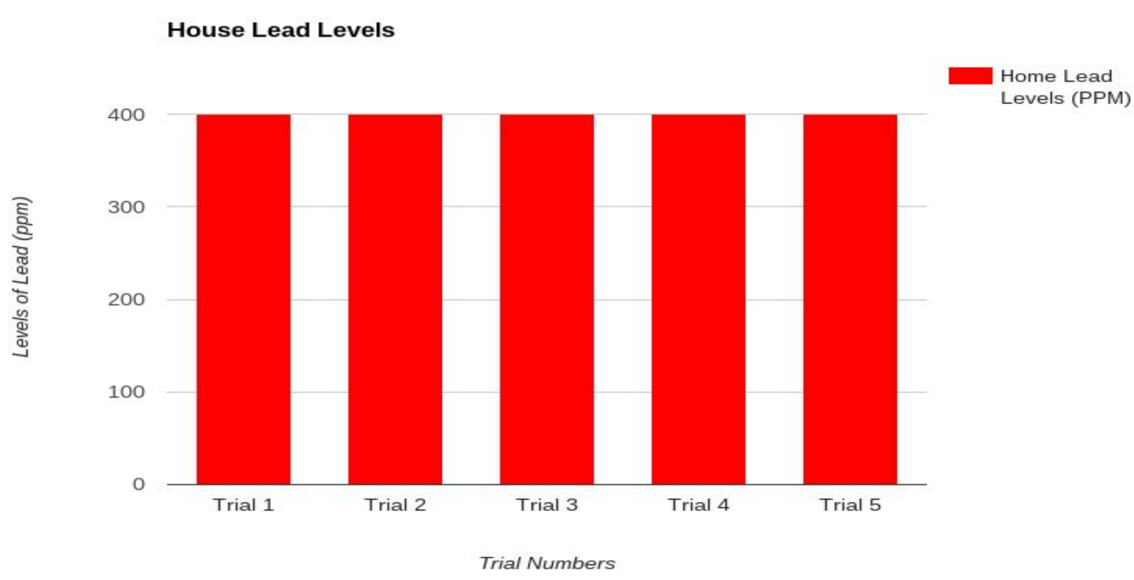


Figure 3: This shows the levels of lead for the house location.

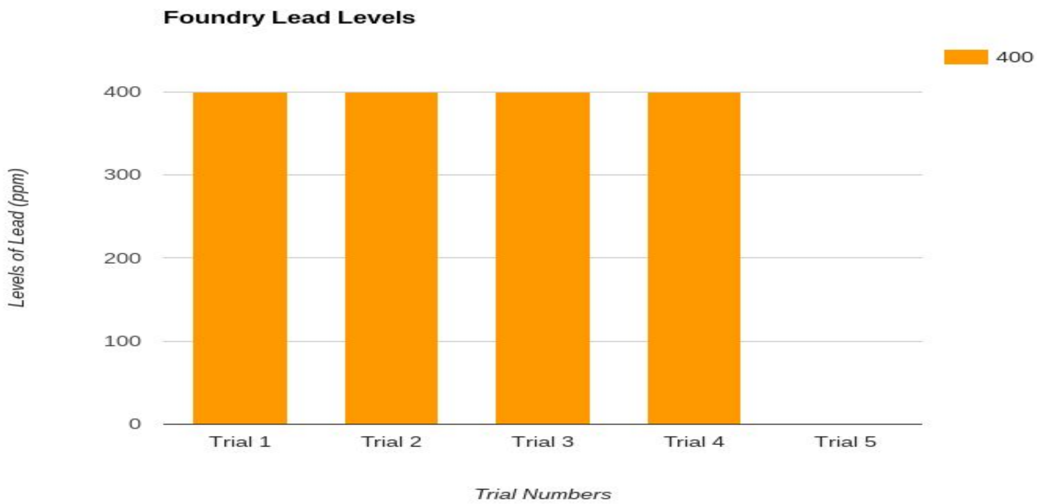


Figure 4: This shows the levels of lead for the foundry location.

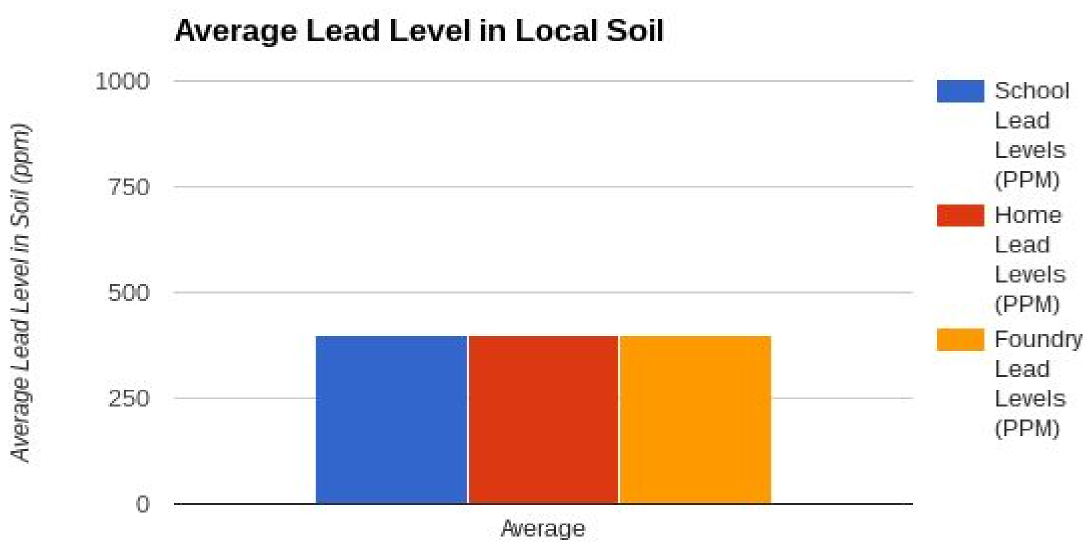


Figure 5: This shows the averages and the standard deviation of 0 for all three locations.

	School pH levels
Trial 1	5.94
Trial 2	6.06
Trial 3	6.15
Trial 4	6.25
Trial 5	6.29
Average pH level	6.14

Figure 6: This shows the trial levels and average of pH for the school location.

	House pH levels
Trial 1	5.89
Trial 2	5.58
Trial 3	5.53
Trial 4	5.49
Trial 5	5.53
Average pH level	5.6

Figure 7: This shows the trial levels and average of pH for the house location.

	Foundry pH levels
Trial 1	6.5
Trial 2	6.59
Trial 3	6.59
Trial 4	6.63
Trial 5	6.69
Average pH level	6.6

Figure 8: This shows the trial levels and average of pH for the foundry location.

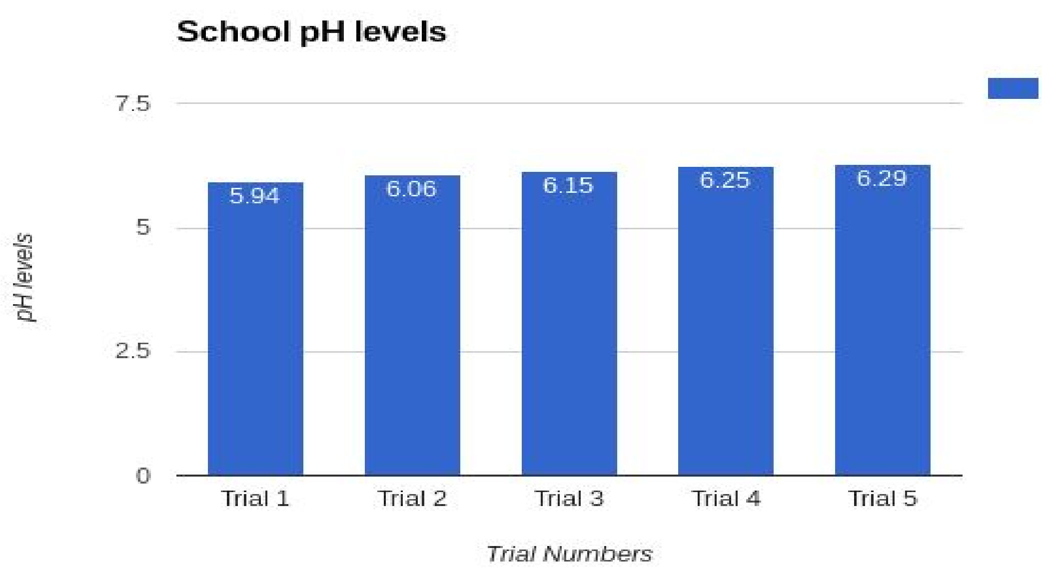


Figure 9: This shows the levels of pH for the school location.

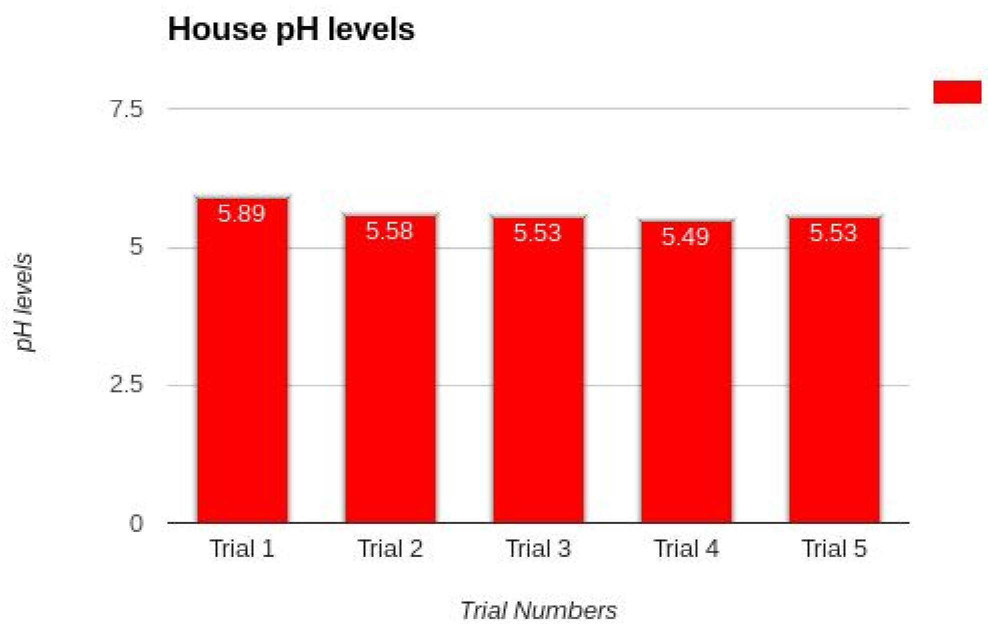


Figure 10: This shows the levels of pH for the house location.

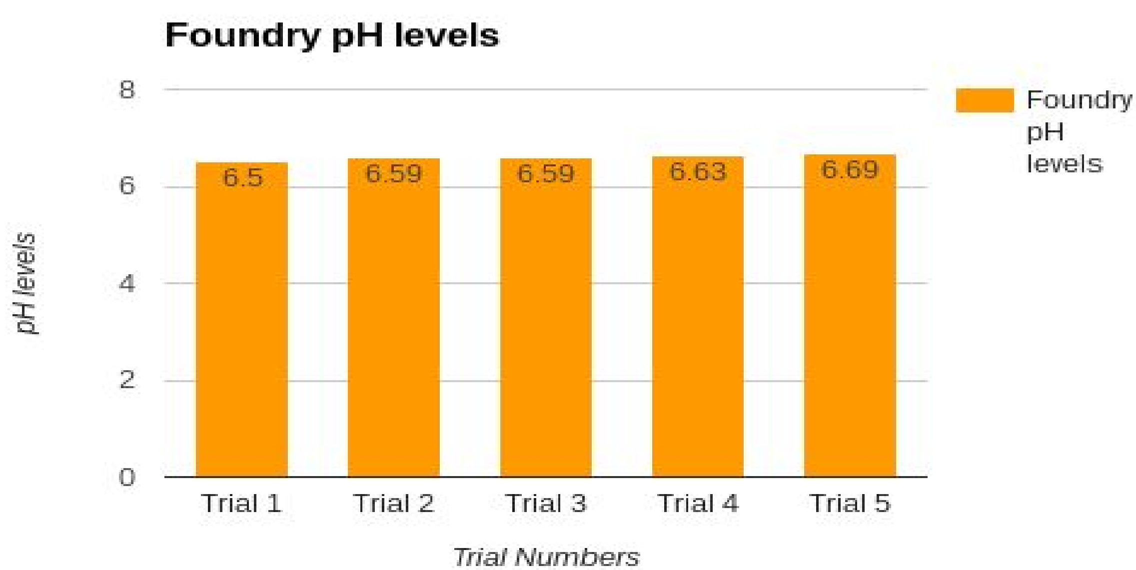


Figure 11: This shows the levels of pH for the foundry location.

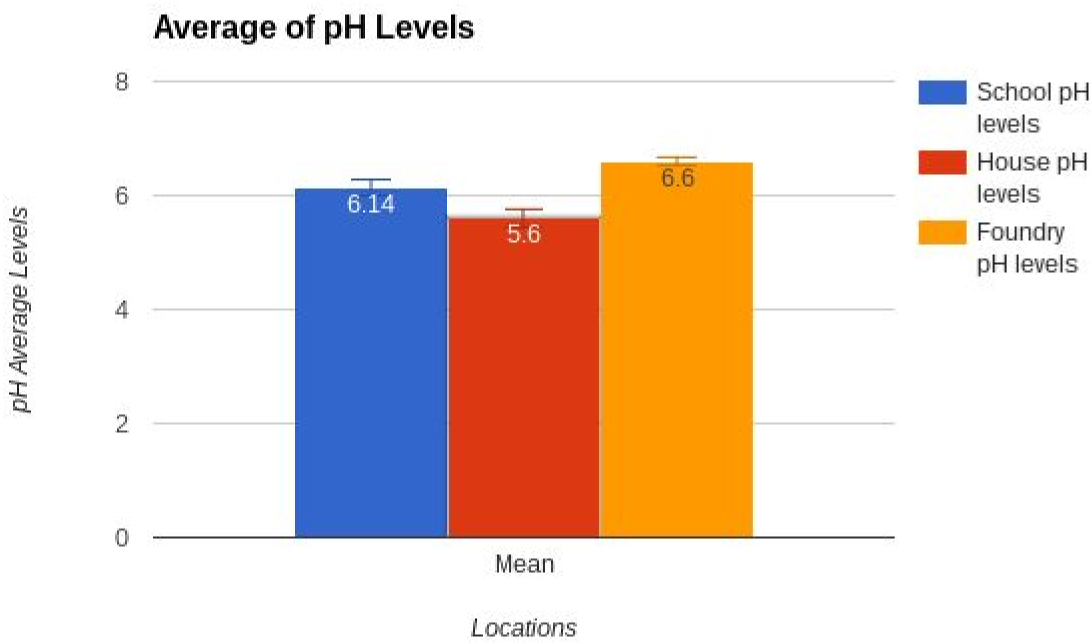
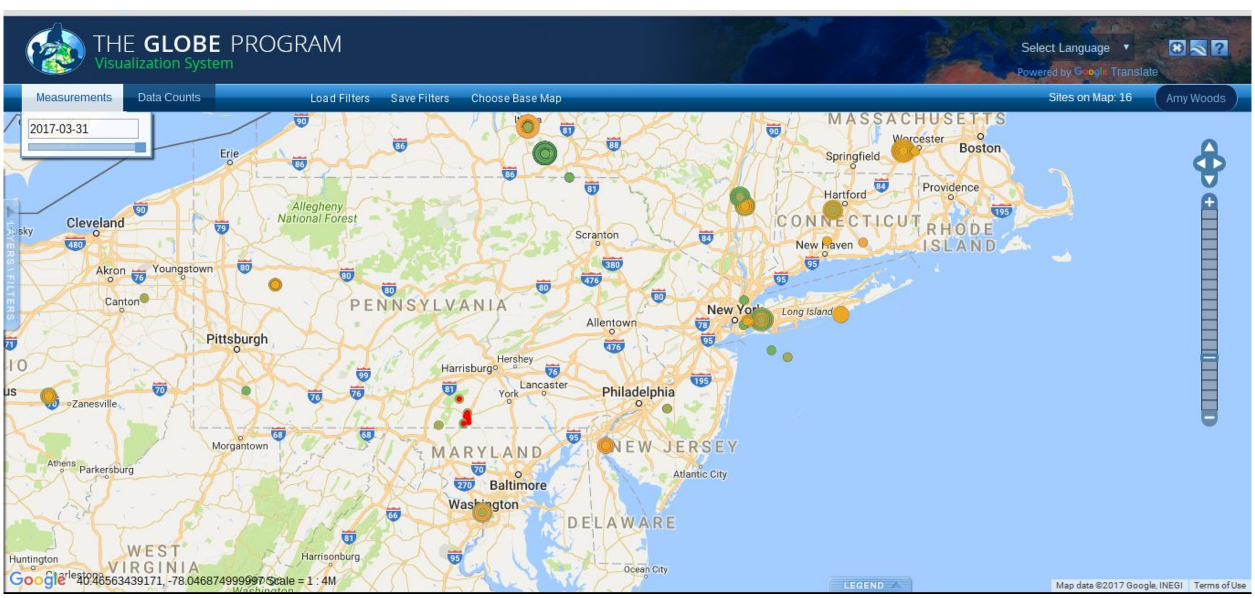


Figure 12: This shows the averages and the standard deviation of 0.14 for the school, 0.16 for the house, and 0.07 for the foundry.



Screenshot 4: This shows the data entry into GLOBE for the soil pH of the school, home, and foundry sites.

Discussion

The results show that the first four trials for school originally sat for ten minutes before having the colors read. The ten minute time frame showed lead levels of 100 ppm or higher. Since all four trials indicated levels of 100 or higher it was decided to see if the trials showed 400 or higher. Trial 5 sat for a minute to see if lead levels showed 400 or higher to get the proper level of lead. The rest of the trials sat for one minute, all showing 400 or higher lead levels. The standard deviation was 0 for all locations.

The average pH level for the location of school pH was 6.14. The standard deviation for the school was also 6.14. The average of the house location was 5.6. The standard deviation for the house location was also 5.6 The average for the foundry location was 6.6. The standard deviation for the foundry location was also 6.6. The data from the lead and pH tests was graphed and analyzed using Google Sheets.

During the testing, there could have been some sources of error. The kit could possibly have had expired chemicals, the pH sensor could have been inaccurate, and there is always the possibility of human error, although based on the standard deviation, there did not appear to be much error and there was a lot of consistency.

People are now encouraged to perform lead testing in their own areas, especially if children are going to be present or food is to be grown (Attanayake, 2014). There have been many studies to help guide people on how to deal with lead in their soil (Rosen, 2016 and Attanayake, 2014).

Conclusion

This experiment focused on investigating the levels of lead in local soil. The hypothesis states that if three locations; school, home, and foundry are tested, then the foundry location is going to have the highest lead level because the industry most likely contaminated the soil, due to the materials used while in operation. The data showed that the chosen areas have high lead levels of 400 ppm or higher. This data does not entirely support the hypothesis, because after the trials were finished, the data showed that all of the locations' soil had high lead levels. It was thought that the soil near industries would have the highest lead levels, because the waste that the industry may dump can possibly be liquid, solid, or sludge and contain chemicals, heavy metals, radiation, dangerous pathogens, or other toxins (National Geographic). As the experiment was performed, the data continued to show high lead levels for all three locations. Due to these results, the revised hypothesis states that if three locations; school, home, and foundry are tested, then all locations are going to have high lead levels because of industry pollution, car emissions, and previous use of soil which could have possibly been contaminated with lead.

The results for the pH testing showed all five trials for each location had a level of pH lower than 7. Each location's soil is considered acidic, because the results were lower than a 7. Most plants grow best in soil with a pH around 6.5, but some plants thrive in a more severe soil pH. Although all the results were lower than 7, most plants thrive with a pH level of 6.5. To reduce the amount of lead in the soil, spread all organic matters, like compost. Compost will weaken overall lead concentration in the soil. The substances in compost, phosphates and iron oxides, also help reduce lead concentrations in plants. pH is the measure of how acidic or alkaline soil is, and it can affect how much lead is held by the soil. Many people use lime to make soil more alkaline. Adding sulfur or peat (decomposed vegetable matter) will make soil more acidic. Neutral or slightly alkaline soils hold more lead ("Lead Contamination," 2017).

Lead may occur where old buildings are, because the paint contained lead. When the paint chips from the building, it mixes with the soil. Vehicles and industries are also common sources of lead pollution. Some industries dump toxic wastes into the ground which causes it to be a dead zone, because nothing grows there. Since lead accumulates, an area with lead is going to deal with consequences of lead contamination for along time. Lead stays in the soil for along time because it does not biodegrade, meaning when a substance does not decompose by bacteria or other living organisms ("Learn about Lead," 2016).

Uncontaminated soil contains lead concentrations less than 50 ppm, but lead levels in soil in many urban areas exceed 200 ppm. The EPA's standard for lead in bare soil in play areas is 400 ppm by weight and 1200 ppm for non-play areas. If high lead levels are detected in soil, then make sure to wash hands after playing outside, regularly clean floors and window sills, and often have young ones tested for lead ("Learn about Lead," 2016).

The company that created the kit was contacted to get their views on the result of this experiment. However, their response has not come through yet. If this experiment were to be repeated, two different lead level kits may be used to compare results. If future experiments were to be conducted, then a more sensitive lead level detection kit would be needed to obtain a more accurate result. More locations in the area would also be tested.

Lead and the pH of the soils possibly containing lead can have a long-lasting, potentially very harmful connection to many communities, local and around the globe. Before the mid-1970s leaded paints and leaded gasoline was used and contaminated many urban soils have much greater than normal background levels. Even if soils are high in lead, knowing the pH of the soil and working to make it more acidic will greatly help, especially those who live in areas where there is no money or ability to bring in new soil or make drastic changes to their area. People working for the EPA have definitely performed exercises and experiments measuring the levels of lead and pH in the soil, and try to figure out a solution to reduce the amounts of lead in the soil ("Learn about Lead," 2016)

The connection to STEM professionals was incredibly important to this research. Mrs. Bird, a scientist and educator from Gettysburg College and Advancing Science and GLOBE trainer, provided equipment to test the pH levels of the soil and gave guidance on GLOBE protocols. She has been trained by Mr. Toth from NASA Goddard on GLOBE protocols. A high school teacher recommended that the Penn State extension be contacted to perform official lead testing to compare these results to new ones, and possibly contact the local government to see what options are available to reduce the amount of lead, especially at the school.

Acknowledgements

I would like to thank all my teachers and mentors who helped me make this project possible. I would also like to thank my parents who bought all my supplies.

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