Determining the Human Impact on the Concentration of Copper Ions in Soil Using UV-Vis Spectroscopy

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Introduction

This project was conducted as a part of Robert Thirsk High School's AP Chemistry program alongside the Kananaskis Biogeoscience Institute to conduct research and experiments on a topic of interest. Multiple trips were taken to the Kananaskis area in order to begin our research and collect data in 2018 and tests were conducted afterwards until June.

Figure 1. Location in Kananaskis where sample 7 was collected, directly beside a road near the Barrier Lake Field Station.

Our Project

Soil is an important resource for many organisms in certain ecosystems. It is vital for access to various nutrients that a plant may need, therefore contamination in soil by heavy metals can be a concern when man made interference results in a higher level of the metals that should normally only appear in trace amounts.

Seven similar soil samples were collected from areas of varying amounts of human interference in the Kananaskis area. This was determined by relative proximity to man made structures such as roads, powerlines, and buildings (ex. Sample 7 was collected from the area in figure 1, which is directly beside a road, therefore it is considered to have large amounts of human interference). The samples were collected in order to compare their levels of heavy metals, specifically copper, to identify if there is a clear correlation with the level of human impact in an area and the level of contamination in the soil around it.

Figure 2. Location which the fourth sample was collected. It is near a powerline but fairly isolated otherwise.

UV-Vis Spectroscopy is a technique which determines the absorbance of wavelengths of light in a solution. The absorbance is an indicator for what ions may be present in a solution, and by comparing absorbance with solutions of known concentrations of an ion, the concentration of ions in the unknown solution can be found. For this reason, we chose to specifically look at copper in our samples as it has distinctly high absorbance of certain wavelengths of light.

Experiments and Procedures

Our goal was to wash out heavy metals from our soil samples into solutions in order to measure the absorbance of light and compare them to each other as well as solutions of known copper concentration.

Creating Solutions from the Samples

Each sample of soil was placed in trays and dried in an oven at 61.5 degrees Celsius, and then sieved to a small particle size. An equal mass of each sieved sample was weighed out and had strong nitric acid added to dissolve any metals in the soil. These solutions were diluted with water and filtered into flasks to remove any solid mass. After the samples were filtered out, they were further diluted resulting in 5g per 250mL of solution.

The resulting solutions had no solid mass, but varied in appearance, some having a dark yellow tint while others were nearly clear.

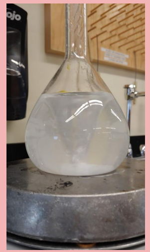

Figure 3. 0.1 M solution of EDTA being stirred with a magnet.

A 0.1 M solution of ethylenediaminetetra--acetic acid (EDTA, a chelating acid which binds to metal ions) was created to be added after the soil was acidified to ensure all the ions were collected, however it did not get used in the end.

Figure 4. Filtration of samples 1-4 to remove solid particles after they were acidified. Filter paper was used inside of funnels to filter the solutions into larger Erlenmeyer flasks.

Measuring Absorbance

Each solution was placed into a cuvette. A spectrophotometer was used to measure absorbance of a range of wavelengths for each sample. Initially, stock solutions of copper (II) sulfate were used to create a calibration curve at 740nm light so the concentrations in the soil solutions could be calculated, however it was more practical to measure a range of wavelengths for each sample and compare them to one another as it is not imperative to exactly know the concentration. A blank cuvette containing distilled water was used to calibrate the spectrophotometer to zero absorbance.

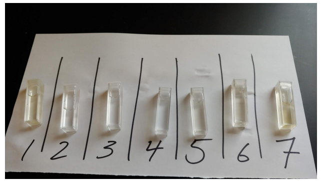

Figure 5. Cuvettes containing the seven acidified and filtered soil solutions.

Observations and Conclusions

The graph in figure 6 shows absorbance data of the seven soil samples we collected. There is significant variation that can be seen around the 400nm wavelength, however there would need to be large amounts of absorbance at around 740nm to show presence of copper, while the soil solutions show nearly none and no variation.

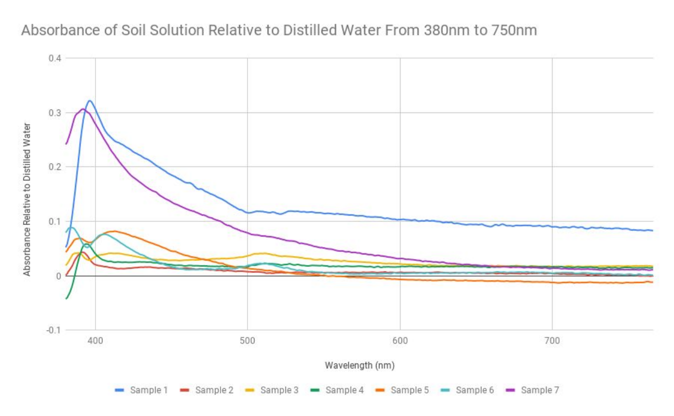

Figure 6. Graph showing the absorbance data for the seven samples in figure 5 for the wavelengths of 380nm to 750nm.

It can be concluded that there is not a significant amount of heavy metals in our samples to be able to determine the significance of the human impact.

Potential Improvements

There are adjustments and improvements which could be made to improve these experiments and potentially yield more conclusive data.

- Samples could be collected from a city area where there is significantly more and consistently more human interference.
- EDTA was not used in the end because it ended up just diluting the solutions because there such a little amount of metals compared to EDTA, but if either a lower volume and concentration of EDTA was used it could be helpful. The samples could also be spiked with copper and then it would more easily allow the EDTA to bind to all of it without having large excess.
- The other wavelengths of light which did turn out to have variance in absorbance could be investigated to identify what substance is causing it, as well as the yellow colour observed in some of the acidified solutions.