Household Anthropogenic Pollutants Against Soil Respiration

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ABSTRACT

Macroscopic organisms have been largely studied for carbon dioxide release rate and the effect that human development has had on these rates. However, the majority of biomass on Earth is microbes found on the Earth’s surface, in the waterways and in soil. As for pollution, a single drop of weak acid on the skin is unlikely to kill on a large animal, yet this could be catastrophic to a colony of microbes. This experiment studied the effect of anthropogenic pollution on soil respiration using toxins that could easily infiltrate our soil and water systems. This project specifically examined common household chemicals in conjunction with Putah Creek soil. The tested toxins were Mobil 1 motor oil, Windex window cleaner, Ajax dish soap, and Dawn antibacterial dish soap. Six samples of Putah Creek soil were collected in jars. Four soil samples were exposed to toxins, while the remaining two were the control and glucose replicates. The control included soil damped by water, while the glucose replicate included both water and glucose. The glucose replicate was included because of its known ability to encourage respiration. A 20 mL NaCl base trap was added to each jar before being sealed. The
jars were aerated once a week before titration. The 1.0 N NaCl from each jar of each week was titrated with 0.5 N HCl. The initial prediction for this experiment was that the glucose would raise the respiration levels, and that the control with no glucose would fall. Five weeks of recording the respiration levels confirmed our hypothesis that household toxins are detrimental to the soil microbial community over time. A similar experiment employed heavy metals instead of household toxins. The experiment showed that soil respiration and ATP content were strongly affected by the heavy metal content present in the soil. (P. T. Vanhala, J. H. Ahtiainen, 2006).

This project will raise awareness of the negative effect of improper disposal of seemingly harmless materials. The next step of the project would be to compare the effect of similar toxins on soil respiration in different habitats. This would indicate that soil microbes are more or less acclimated to human-made toxins depending on the exposure or proximity to human development.

**INTRODUCTION**

The effects of anthropogenic pollution in soil respiration were studied over a course of five weeks. Research has shown that CO₂ levels can be up to 50% greater in urban areas than rural areas due to anthropogenic sources. Runoff from the urban settlements has a tendency to enter bodies of water. This keeps the town clean but also delivers pollutants into our water systems. In turn, the creek habitat is exposed to the pollution and soil biomass is damaged. “Human activity has induced a multitude of global changes that are likely to affect the functioning of ecosystems.” (Interactive effects of warming, soil humidity and plant diversity on
A recent study showed observations of drastically decreasing pH levels in beech oak forest soils. The recorded data showed the soil’s pH level falling from 9 to 2. This causes nutrient and mineral deficiency, which will quite possibly end up killing the microscopic life in the soil (Comparison of soil fungal/bacterial ratios in a pH gradient using physiological and PLFA-based techniques). By allowing harmful chemicals to flow in our waterways, we may actually be killing microscopic life. It has been observed that soil microbial activities, population sizes, and community structures are generally greater or most unique in mid-range soils. (Landscape level variation in soil resources and microbial properties in a no-till corn field). This is due to the proper balance of pH, and can be maintained by reducing the amount of toxins we release into our environment. We used soil samples from Putah Creek near the city of Davis to determine whether common household toxins pollute our local ecosystem.

**OBJECTIVE**

The objective of the project was to examine multiple household chemicals and judge the most hazardous toxin to soil-dwelling organisms. We believed the control soil’s respiration rates would decrease, while the soil containing glucose would increase then decrease. Each chemical tested was expected to decrease soil respiration with window cleaner causing the highest magnitude drop in respiration.

**MATERIALS AND METHODS**
We collected soil samples approximately two feet from Putah Creek's edge. We sealed our sample in a plastic bag for safe transport back to the lab. There, we measured out 55 g of soil into each of our six mason jars. Our first jar acted as our control, consisting only of 6 mL DI water. Because of sugar's known ability to raise respiration rates, we decided to include a glucose replicate, forming our second jar, which had 6 mL DI water and .5 g of glucose. Our next four jars were our predetermined household chemicals- Windex window cleaner, Ajax dish soap, Dawn antibacterial dish soap, and Mobile 1 motor oil. We measured 3 mL DI water along with 3 mL Windex in order to dilute the toxin, otherwise it would kill all bacteria within one week, thus preventing the experiment from ______ to its full potential.

For our third jar we added 2 mL of Ajax dish soap and 4 mL DI water. The fourth jar had 2 mL Dawn antibacterial dish soap and 4 mL DI water. Our last jar contained 4 mL of Mobile 1 motor oil and 2 mL DI water. After adding our chosen chemicals, we installed a 20 mL 1.0 N NaOH base trap in each jar. This was to capture all the soil's released carbon dioxide within the jar. Each jar was incubated for one week, with soil aeration per three days. Once a week we replaced the base trap with fresh 20 mL 1.0 NaOH, and used the titration method to analyze the amount of respiration occurring in each jar per week. This involved adding BaCl2 to the base trap until precipitate formation ceased, then adding a phenolphthalein indicator. We then titrated with 0.5 N HCl until the equilibrium point was reached. At this point our once pink solution now was white. For more accurate results, we back-titrated using 1.0 N NaOH, which brought the solution back to a light pink. We then recorded the amount of HCl that was used and repeated for all remaining jars.
five weeks we recorded data and were able to come to a conclusion about our experiment.

RESULTS

Soil respiration for various chemicals showed signs of converging to 35 mL of titrant. Prior to the convergence of data, the glucose appeared to require the least amount of titrant to be neutralized and the control group required the most titrant. The chemicals requiring the most and least titrant were Windex and dish soap, respectively. With the addition of household chemicals, the base traps required more acid to be neutralized through subsequent titrations. In figure 1, all of the trend lines end up at approximately the same place, 35 mL HCl. This essentially means that the bacteria are close to dead, and the amount of respiration occurring is minimal. Because it took such great amounts of HCl to reach equilibrium, we can determine from this experiment that seemingly harmless chemicals are lethal to the bacteria of soil. Because chemicals such as Windex and dish soap are specifically created for killing bacteria, it would only make sense that the soil’s bacteria would die.

DISCUSSION
Despite having a complex chemical explanation for all of the reagents, the general mechanism of the project is that carbon dioxide is captured into solution, forming carbonate ions which reacts with base. During the project, the question of whether or not more chemicals should be tested arose. Ultimately the decision was to stop the experiment at 4 extra chemicals besides the control and glucose.

Throughout the duration of this experiment, we noticed a common trend occurring in all the jars. As shown in figure 1, all of the trend lines converge at approximately 35 mL HCl. This means that less carbon dioxide was released into the air of the jar, therefore more base was needed to reach equilibrium. In healthy and thriving conditions, the amount of HCl needed to reach equilibrium would be much lower, because more carbon dioxide would be released into the air. Our glucose replicate originally had an ideal amount of CO2 production, but ended up decreasing like the others. Our observations have shown that we are damaging our environment, most often times without even realizing it. I constantly reviewed the broad implication of this study, which is to realize and promote the impact of anthropogenic ignorance to polluting waterways.

**SUMMARY**

The more titrant that was delivered, the more acid evolved in the trap. This meant that little carbon dioxide reacted with water to form a carbonate ion that would precipitate once exposed to BaCl2. Glucose originally caused a spike in CO2 production but as with all but the control, CO2 production decreased with time. The control may have increased in CO2 production because the soil was not yet at its full
capacity for respiring organisms. Our research has shown that not only are we affecting microorganisms with our pollution, but our entire environment. If the tiniest unit of life ceases to exist, our ecosystems will no longer function. All other life forms will soon struggle to survive with our rapidly changing environment. This is happening in other places on a much bigger scale, for we studied only one small sample from a nearby creek. The logical next step in seeking to advance one's knowledge of this subject would be to analyze the respiration rates of other habitats, for instance a rural one. Putah Creek is next to the modern, urban town of Davis, but the results of a rural area may be different from the results of this one. I not only learned the impact we humans have on our environment, but also how to titrate in a lab. Being only a sophomore in high school, I had not yet learned the advanced technique of titrating, but became very comfortable doing so by the end of this experiment. I enjoyed learning about the respiration rates of soil, for I knew very little about this topic when we started. I understand why the respiration rates decreased and now know what I can do to help the environment.

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Figure 1