THE EFFECTS OF SOIL ON THE RATE OF BIODEGRADATION

BY:

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Abstract

Humans do not know what to do with trash. One of the ways we take care of trash is burying it in a landfill. Scientists found a 50-year-old newspaper in a recently dug up landfill. Since paper is supposed to decay in one week, we know that landfills do not help. Another way we try to get rid of trash is incineration. This also is not good because it releases pollution into the air. We want to know the best way to decompose our trash. Our group did this experiment so that we could see if different soils would affect the rate of decay on different substances. Our hypothesis was that the forest area samples would show the most decay, and that the clay area samples would show the least decay. Four groups separately buried five different samples at three sites with contrasting soil types. Each group had several samples starting with squares of aluminum, squares of Styrofoam, squares of paper, squares of plastic, and squares of cardboard. We tested the temperature, nutrients, porosity, organisms, texture, moisture and pH at each site. Two weeks later, we dug the samples up and used an acetate grid that was made of 10 x 10 centimeter squares to calculate the percentage of decay. We averaged the percentages together and calculated the standard deviation for the three different sites. After that, we calculated the t-test at a 90% confidence level with a p-value of .1. All of our values were above .1, so our data was not statistically different. We accepted the null hypothesis, which was a significant difference in the rate of decay of the samples in the different soil types. We believe that with more experiments, humans can find better ways to decompose their trash than burying them in landfills or incinerating trash.

INTRODUCTION

Have you ever thought of what happens to your trash after you throw it away? Most Americans produce tons of waste yearly and have no idea of where it ends up or what happens to it. Garbage handlers simply place the waste into a landfill. A landfill is a disposal site, a synthetic valley dug into a piece of land. In a landfill, the trash is compacted and sealed into small quarters with little or no air in order to prevent contact with organisms and rainwater. While this may be a good way to contain trash, landfills take up a lot of space, and the trash only sits there. This practice has worries scientists who continue to look for more favorable disposal methods.

One environmentally friendly way to dispose of garbage is recycling. Many things can be recycled, such as glass, metal, paper, and plastic. Recycling is the reprocessing of used materials that would otherwise become waste. As a result of the recycling process, the used materials become renewed, usable materials. Recycling prevents the disposal of these wastes in landfills or incinerators and reduces the consumption of new raw materials (Wikipedia, 2006).

Another way to dispose of trash is composting. Composting is the process of decomposing organic materials under controlled conditions. At composts, organic wastes are recycled into resources that can be used to enrich soil and support plant growth (Trautmann, 2003). Composting utilizes biodegradation, taking natural wastes and making them into healthy fertilizers.

Biodegradation is the process of decay that is carried out by various invertebrates, and some types of micro and macro-organisms. Some organisms that help with the process of decay include earthworms, maggots, and mites. In order to live and grow, all living things need a source of energy, carbon, and nutrients (Trautmann, 2003). Microbes use respiration to break down matter into carbon dioxide, water and energy; and to release the chemical energy stored in the sugars, starches and other organic compounds. This energy is released to the environment in the form of heat (Trautmann, 2003).

The biodegradation process involves three categories of organisms: producers, consumers and decomposers. These different types of organisms help to continue the nutrient cycle because they depend on each other to get their food. The producers, such as plants and trees, make their own energy from the sun. Consumers, such as animals, eat other organisms to get energy. Decomposers are the organisms that get nutrients by eating waste products, such as microbes, fungi, and bacteria. Microbes are organisms that are too small to see without a microscope. Decomposers need certain conditions to grow and to help decompose products efficiently.

Some conditions that could affect the rate of biodegradation are the pH, aeration, moisture, temperature, nutrients and texture of the soil. The pH is the measure of acidity or alkalinity of a substance or solution, with zero representing the most acidic, seven representing neutral and fourteen represents the most basic. Temperature is an affect of biodegradation because microbes can work most efficient in warm soil. Microbes thrive best in soil with a pH close to neutral. Aeration is the amount of air between the particles of soil; the compaction of soil is a good indicator if that soil has good aeration. Aeration is the measure of the porosity, or percentage of pores that the soil contains. The more aeration or porosity that a soil has, the less moisture it can hold. This is because the pores between the soil grains permit water and nutrients to be contained for microbes, therefore assisting in the decay of waste products. The moisture and nutrients are important because microbes grow faster in more moisture and nutrients. Two of the soil conditions that have a correlation are moisture and aeration. Soil texture can also affect the rate of decomposition.

There are four general types of soil: sand, silt, clay, and loam. Sand is a soil texture with small particles that lead to copious aeration but its loose structure prevents it from holding much water and nutrients. (answers.com 2006) Silt is a soil with medium sized particles that can hold much water, but its particles do not allow much aeration to the microbes in the soil. Clay soil has the smallest particles and can hold the most water and nutrients of all the soils described, but have poor aeration for microbes. Loam is a balance of all the soil types above, and is therefore, the best for biodegradation. Loam can hold an adequate amount of water while allowing microbes to receive satisfying amounts of oxygen. (compost.org/healthysoilPR.html, 2006)

Our study was conducted to find the largest percentage of decay of trash in different types of soil. The hypothesis is that there would be a statistically significant difference in the rate of decay among the various soils, that will occur fastest in the wooded soil (silt loam) and slowest in the clay area.

METHODS

To prepare for the experiment, four lab groups cut three 10x10 cm squares of each of our samples: paper, plastic, styrofoam, cardboard and aluminum foil.

We chose three sites, a Barton, Maryland clearing, the Frostburg State University meadow and the Frostburg State University forest, which are located in the Frostburg State Arboretum. We chose the three sites because we thought that each area would have different soil types. We arrived on Monday, June 26, 2006 at around 10:35 a.m. at the Barton site. It was raining lightly during our experiment, and we spent only about a half an hour at the site. The following day, we arrived at the FSU Arboretum, where it was raining hard, at about 9:30 a.m.

At each site, we gathered a soil sample to determine the pH of the soil and took the initial temperature using a ground thermometer. After the pre-soil tests were completed at the sites, each group dug a 30x30 cm hole that was 10 centimeters in depth. Each of the four groups then placed the five samples into the hole and replaced the topsoil. The soil was compacted, to the best of our ability, to its natural condition. We placed a flag on the site to mark it. We followed the same procedure at all three sites. We spent a little over a half of an hour at each of the sites.

After one week, our groups returned to the sites to perform several halfway tests. The groups collected soil samples to test for moisture, porosity, microbes, nutrients and temperature.

We conducted a soil moisture test with the soil collected from the sites.. We weighed the soil on a triple beam balance scale, and then placed it in a drying oven for twenty-four hours. After twenty-four hours, we removed the soil and measured its dry weight. We then entered this data into a formula below, to get percent moisture.

$$\%Moisture = \frac{WetWeight - DryWeight}{WetWeight}$$

We calculated porosity by measuring 10 grams of soil from each area and recorded its volume by placing it in a graduated cylinder. Then we added 10 mL of water, let it settle and then recorded the combined volume (V_{s+w}) of the water and soil after it settled. After collecting this data, we entered it into a formula of volume of air (V_a) divided by the volume of soil (V_s). We calculated the volume by entering data into the formula below:

$$V_a = (V_s + V_w) - V_{s+w}$$

We observed soil organisms in two ways, using a dissecting microscope to view microbes and by using the Berlese funnel to view small invertebrates. To use the Berlese funnel, the funnel was placed on a ring stand. A beaker that contained 100 ml of water was placed under the funnel. Then, a 25 watt light bulb was placed over the funnel. The soil sample was placed in the funnel, and the microbes fell in the water and floated. The water sample was placed under the dissecting microscope to view the microbes. We also measured the nutrients to determine the levels of nitrogen, phosphorus and potassium using a nutrient test kit.

Two weeks after burying our samples we returned to the sites: the clearing in Barton, MD on July 10, 2006 and the FSU Arboretum, where our meadow and forest sites are located, on July 11, 2006. On these dates, we dug up our samples and placed a clear plastic acetate grid with 1x1 cm squares on each of the samples. Each group then colored the grids where we saw any form of breaking down or changing, following a criteria that consisted of discoloration, rips and tears, thinning, and missing pieces that were not man-made. Then we counted the colored squares and determined the percent decay.

$$\%Decay = \frac{\#ofcoloredsquares}{total\#ofsquares} \bullet 100$$

Finally, we did a one-tailed Student t-test to compare the rate of biodegradation of the samples in the different soil types. The groups combined their averages of percent biodegradation for each sample to do the student t-test. We calculated the standard deviations and p-values. We used a confidence level of 90% (.1) to determine if the hypothesis was accepted or rejected.

RESULTS

On day 1, the temperature of the sandy clay loam soil at the Barton clearing site was 64ºF; on day 8 the temperature was 61ºF and on day 14 the temperature was 60ºF. The average temperature of the Barton clearing was 61.7ºF. The temperature on day 1 of the FSU meadow site loam soil was 62ºF; on day 8 the temperature was 61.5ºF and on day 14 the temperature was 58.75ºF. The average temperature of the soil at the FSU meadow site was 60.1ºF. On day 1, the temperature of the silt loam soil at the FSU forest site was 58ºF; on day 8 the temperature was 58ºF and on day 14 the temperature was 60ºF. The FSU forest area had an average of 58.7ºF. Figure 1 below shows the temperatures of day1, day 8, and day 14 of the soil at each site.

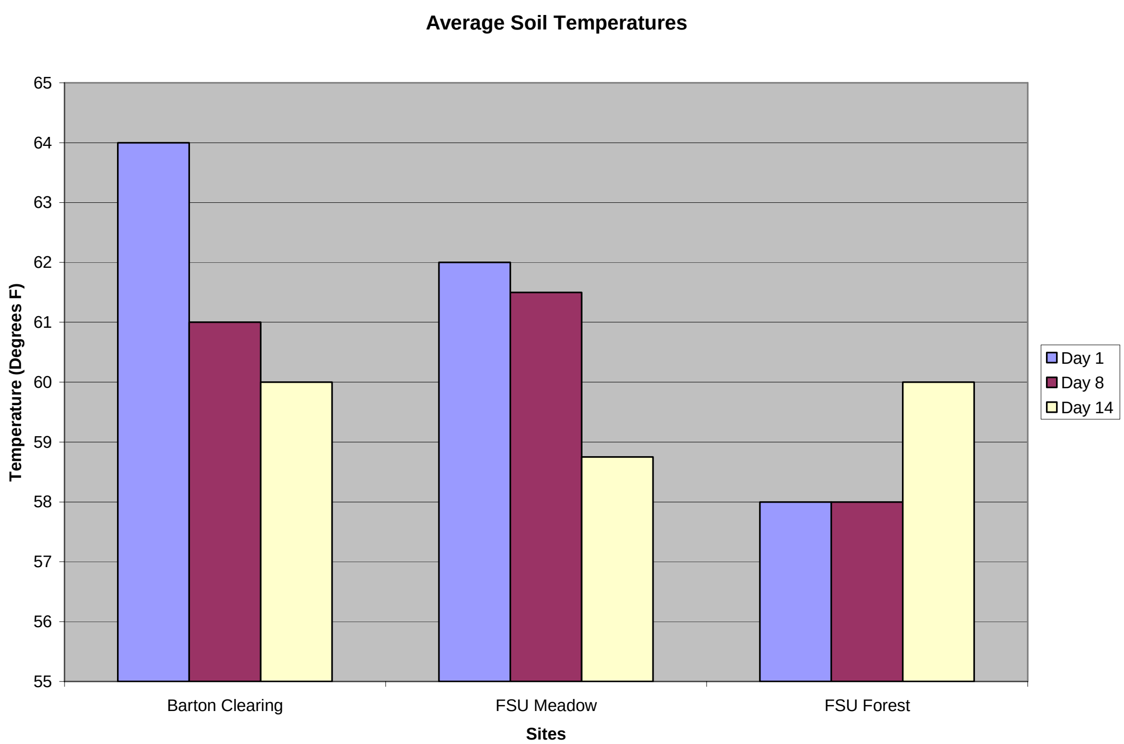

Fig. 1. – This figure shows the average temperature at each soil site over a time of two weeks.

The porosity of the soil was 64% at the Barton clearing site, 55.23% at the meadow site and 55% at the forest site. The pH at both the Barton clearing and meadow sites was 5, while the pH for the forest site was 6. We found the texture of the soil to be sandy clay loam at the Barton clearing site, loam at the meadow and silt loam at the forest. The average moisture of the soil was 29% at the Barton clearing site 21.58% at the meadow site and 35% at the forest site.

Table 1- This table shows the class average of the porosity, pH, and moisture from all of the sites.

	Barton Clearing	**FSU Meadow**	**FSU Forest**
Porosity	64%	55.23%	55%
pH	5	5	6
Moisture	29%	21.58%	35%

The results from the nutrient tests were that there was an adequate amount of phosphorus, a surplus of potassium, and a depleted amount of nitrogen for all of the sites. The invertebrates that aid in biodegradation found at the forest site were worms, centipedes, and beetles. We also observed microbes such as mites. The meadow site had many invertebrates including worms, pill bugs, ants, beetles, and maggots. We also observed mites at this site. At the Barton clearing site we observed worms, ants, and grasshoppers.

There were signs of biodegradation in the samples at all the sites. At the Barton clearing site the paper degraded 26%, the plastic degraded 3%, the styrofoam degraded 11%, the cardboard degraded 18% and the aluminum degraded 8%. At the FSU meadow site, the paper degraded 22%, the plastic degraded 2.75%, the styrofoam degraded 5%, the cardboard degraded 6.75% and the aluminum degraded 11%. At the FSU forest site, the paper degraded 35%, the plastic degraded 1%, the styrofoam degraded 4%, the cardboard degraded 18% and the aluminum degraded 5%. This data is illustrated below in Figure 2.

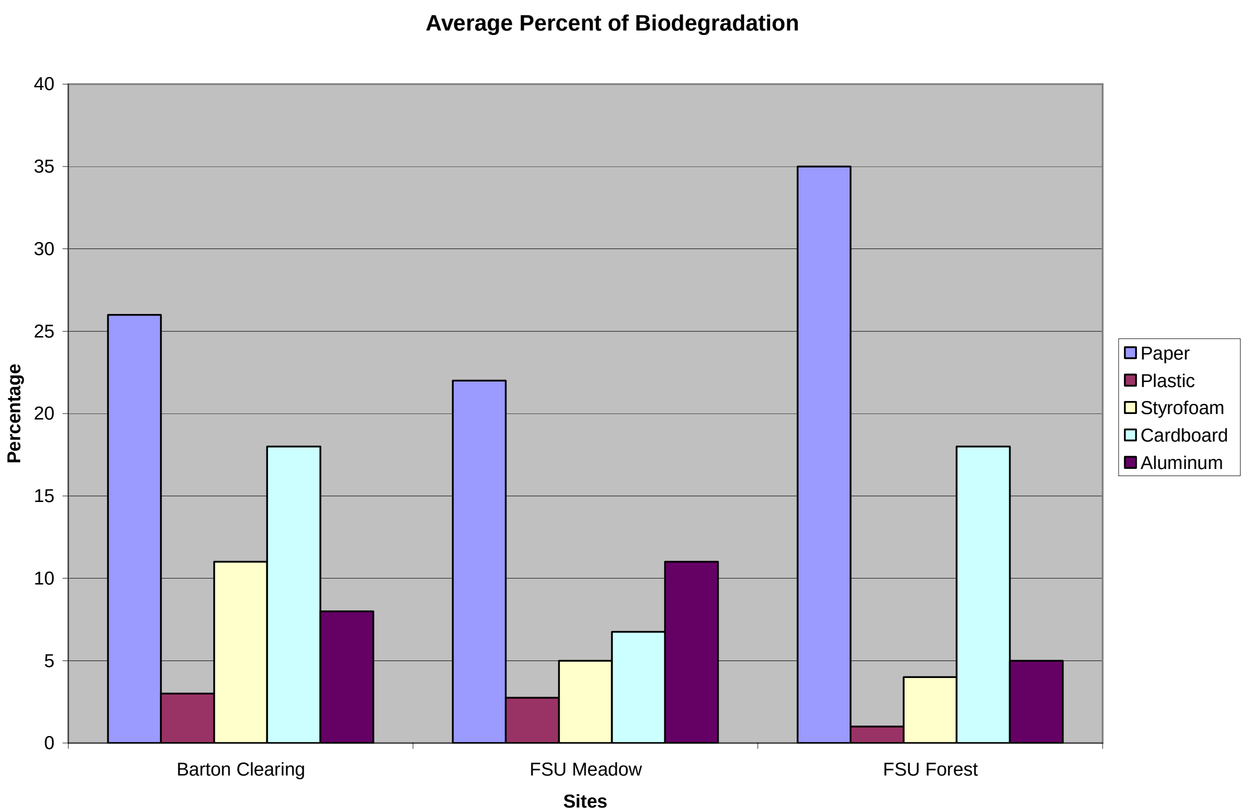

Fig. 2. – This graph illustrates the average percentage of biodegradation for each sample at each soil site

The graph below (Fig. 3.) illustrates the total average percent of biodegradation of the combined samples from the three different sites. The average biodegradation for the Barton clearing was 13.2%, for the FSU Meadow it was 9.5%, and for the FSU Forest, it was 12.6%. We used this data to perform a student t-test to determine. If there was a statistically significant difference in the percent of biodegradation, this t-test had a 90% confidence level, which means the p-value for comparison was .1. The results of our t-test were that the p-value comparing the Barton clearing to the FSU Forest site was .251, the meadow site to forest site was .339, and forest site to Barton clearing site was .469. There was no statistical difference according to this data.

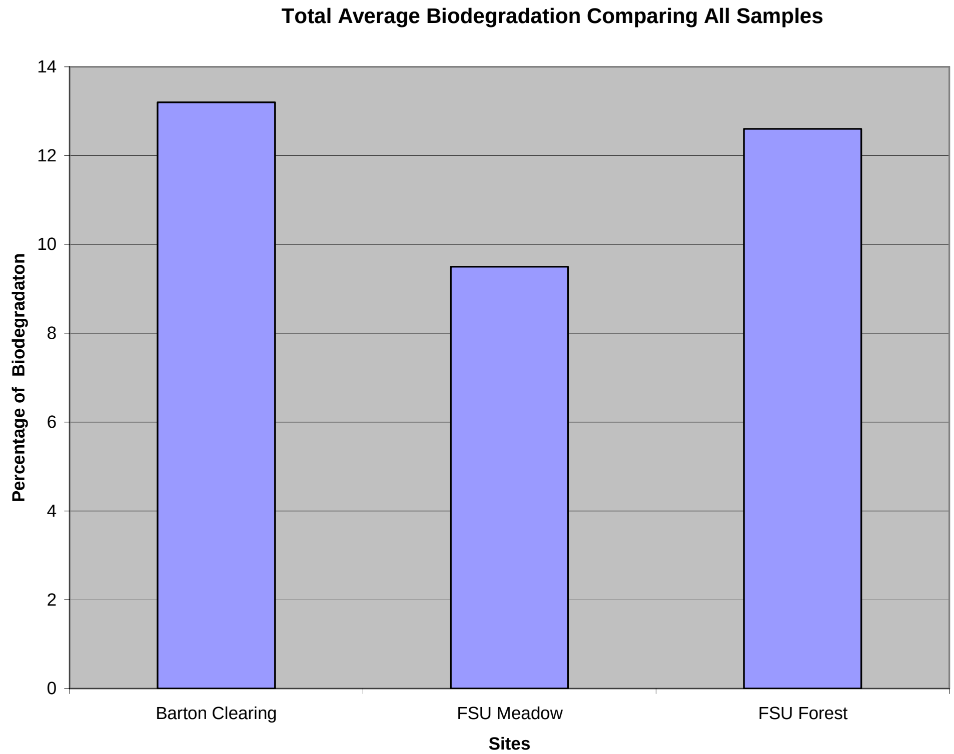

Fig. 3- This graphs illustrates the total average of biodegradation of all the samples from all of the sites.

Although we saw no significant difference in the overall rates of biodegradation, we did observe a trend between the amount of biodegradation of paper and cardboard at the different sites. So we performed a couple of statistical tests on that data. After performing a t-test on the paper and cardboard data, we saw a statistically significant difference. Table 2 below shows all of our p-values from this new t-test. We determined if a value was significant due to the fact if it had a p-value less than.1.

	Meadow to Forest	Forest to Clay	Clay to Meadow
Paper	0.048	0.092	0.263
Cardboard	0.0028	0.476	0.104

Table 2. – This table illustrates the p-values of our student t-test comparing the average biodegradation of paper to cardboard at all of the different sites.

When we compared the paper samples from the FSU forest and FSU meadow sites the p-value was .048. When comparing the FSU forest and Barton clearing site the p-value was .092. The only significant difference we saw with the cardboard samples was when we compared the FSU meadow and FSU forest, which gave us a p-value of .0028. Figure 4 below illustrates the average percents of biodegradation of the paper and cardboard samples from all of the sites.

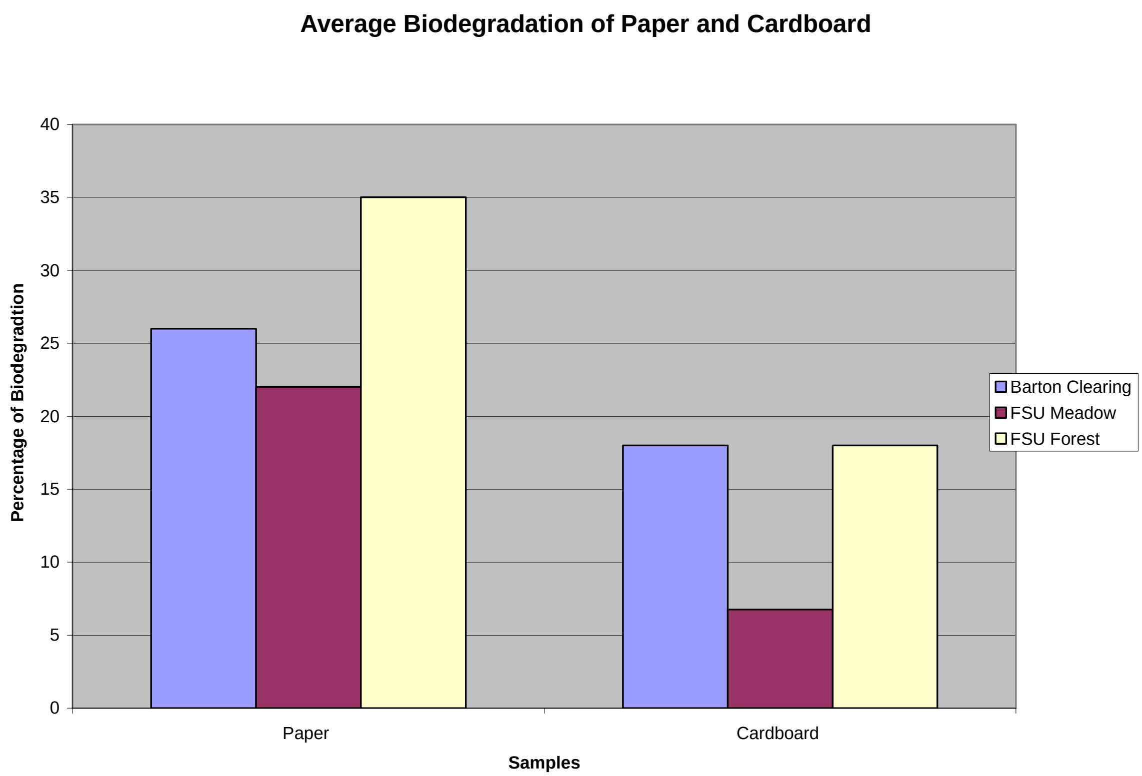

Fig 4. – This graph illustrates the average percent of biodegradation of paper and cardboard at all three sites

DISCUSSION

There was no statistically significant difference between the percentages of biodegradation between any of the sites. We had to reject our hypothesis that there would be a statistically significant difference in the rates of decay among the various soil types and accept the null hypothesis that there was no statistically significant difference in the total percent of biodegradation.

However, we did find that the decay rate of paper in the forest was statistically different from the other two sites. We also found that there was a statistically significant difference between the decay rates for the cardboard in the forest and the meadow.

Derek Rodricks (1997) did a similar study to see if temperature and moisture affected the percentage of decay in diesel. He found that moisture and temperature did significantly affect the decay of diesel. We also looked at the moisture and temperature of the soil to see how they affected the biodegradation of the samples we buried.

Cardboard and paper decayed more in the high moisture content areas and aluminum seemed to decay more in the lower moisture content area. We found that the forest had the highest soil moisture and the highest decay rate for paper. The rate of decay of cardboard was higher in the forest than in the meadow. This is consistent with Rodricks' discovery.

We did not find that an increase in temperature affects the rate of decay in paper. We did, however, find that the only site that showed an increase in temperature was the forest. This was where we observed the most invertebrates and microorganisms, which may be why the paper's biodegradation rate was so high. High temperature indicates microbes growing and respiring.

The high moisture content probably affected the discoloration of most of the paper-based samples. High moisture can leak the coloring from the soil straight into the sample. Microbe excrement can also discolor the samples.

Furthermore, the soil areas did not have much difference in their pH level averages. Nearly all of them had a pH average of 5, which did not seem to have an effect on biodegradation.

When you have a high porosity and a high moisture content like in the clay soil there will be less microorganisms because they cannot survive in an environment with too much water and not enough oxygen. We found that there was the least amount of microorganisms in the clay environment which is consistent with what we would expect. We would expect to find the most microorganisms in a soil with a balance between porosity and moisture like in a silt loam soil. We found that the forest, which had a silt loam soil, did have the most microorganisms.

There were depleted nitrogen levels at all three sites and this would have affected the microbes in the soil because they need nitrogen to survive.

We found several limitations throughout our experiment. The small amount of organisms may have affected our results because not many organisms were biodegrading the samples that were buried. One of them was that our number of samples was rather small. Another is time, because two weeks might not have been a long enough time for biodegradation to begin, and we could do nothing about the weather within those two weeks, whereas if we had longer, maybe we could have gone when the weather was not too rainy or sunny because it could have affected the moisture, microbes, and the temperature tests. Animals were a limitation because they tore our samples and ate some of them; this also hindered our data. Another limitation was that when we did the porosity test we might not have gotten the correct porosity of the soil because after drying it in the drying oven and placing it in the graduated cylinder, it is not at the same compaction as we might have found it in nature.

After finishing our experiment, we came up with new questions for further studies. If we conducted the experiment at a different time of the year, would it have made a major difference in our results? If we had access to soil that was pure, such as pure sand or pure clay soils, or if we had a longer period of time to conduct the experiment, how much would it affect our results? Finally, if we had more samples, would we have seen more of a difference in the percent of decomposition?

There are some considerations we would take for further studies. One of these is to allow the samples to stay buried for a longer period, about six weeks, instead of just two weeks. We also might want to measure the amount of carbon dioxide at the sites, because microbes produce carbon dioxide when they are biodegrading materials. Therefore, if there is a low measurement of carbon dioxide, then we might be able to conclude that there is not a lot of activity going on. Next time we should try to run more than one porosity test to make our results more accurate. This concludes our paper on the effects of biodegradation.

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