Decomposition rates of a common litter between stream and pond environments in a Maple-Basswood ecosystem

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Decomposition rates of sugar maple (*Acer saccharum*) leaves in a stream and pond environment within a Maple-Basswood ecosystem in southern Minnesota were recorded over a period of 35 days. Six decomposition bags at each site were left to be collected, two at a time, from their locations at approximately 12 day intervals. It was found that the leaves in the stream bags decomposed at a greater rate than the pond bags. The final mean percent oven dried mass lost of leaves in the stream was 55.5% and for the pond it was 34.25%. These data all provided statistically significant values except for the second extraction date. Temperature, dissolved oxygen, pH and conductivity were all measured at each location as well. The only significant difference found between sites was in the conductivity levels, with the stream having a much higher conductivity. However, the dissolved oxygen levels showed a trend towards being significant; and as with conductivity, the stream values were greater. If it can be assumed that these trends stay static, it would be expected that as time goes on the stream litter would be fully decomposed quicker than the pond litter.

Introduction

Organic litter is a large part of the natural life-cycle. Every year 2.3 to 4.0 metric tons/ha of leaf litter falls in temperate deciduous forests (Thomas, 1970). Some of this litter ends up in aquatic, freshwater ecosystems such as streams and ponds. In temperate forest zones (such as the test locations in Minnesota) the usual aquatic ecosystems consist of freshwater streams and ponds. Aquatic ecosystems play a large part in nutrient recycling. When litter falls in a pond or stream it is subsequently broken down over time by decomposing organisms. The decomposition of organic litter is very important to the natural world. It helps to provide an abundance of food for many organisms, such as: fish, amphibians, microorganisms and even some terrestrial organisms that extract nutrients from litter after it has been broken down (Mann, 1988). All life depends on decomposition; without it the basic life-cycle could not function.

While it is known that freshwater ecosystems play a vital role in decomposition and the life-cycle, the rate at which freshwater ecosystems decompose the litter is not fully understood. One suggestion is that moving bodies of water, such as streams and rivers, may have faster decomposition rates than bodies of water that do not flow (i.e. ponds and non-fed lakes) due to constant abrasion from flowing particles (Thomas, 1970). Pond decomposition can also be limited by the availability of oxygen in the system. If there is a shortage of oxygen (usually through respiration during previous decomposition) then the decomposing microorganisms will be unable to metabolize the remaining litter (Dineen, 1953). Along with dissolved oxygen being a possible limiting factor, other studies have found a correlation between higher nitrogen levels in freshwater systems and faster decomposition rates of leaf litter (Carpenter & Adams, 1979). However, phosphorus levels have not been linked to being beneficial or hindering in aquatic decomposition (Carpenter & Adams, 1979). Stepping away from chemical aspects, through the act of immersion into water and leaching, up to 25% of the initial dry weight of litter can be lost in the first 24 hours (Webster & Benfield, 1986). Along with the rapid decay in the initial 24 hours it has been shown that half to three-fourths of the organic material decomposition is completed within the following three weeks of submersion. This means that within three weeks of submersion 50 to 75% of all organic litter should be decomposed as long as there are no limiting factors (Carpenter & Adams, 1979).

In the research I conducted, I examined the difference in rates of decomposition of common forest litter in a pond ecosystem (Skoglund Pond) and a stream ecosystem (Heath Creek). The hypotheses that I specifically planned to test were:

1.) There is no difference in initial decomposition rates between pond and stream environments.

2.) There is no difference in final decomposition levels between pond and stream environments.

My plan was, through data collection and analysis, to determine whether or not it is necessary to reject these null hypotheses due to differences in decomposition.

Methods and Materials

This decomposition study was conducted over a span of five weeks. There were two sites used for the study: Skoglund pond on the northwest end of the St. Olaf College campus and Heath Creek on the southeast end of the St. Olaf College property. Both of theses sites are considered to be within a Maple-Basswood ecosystem. I collected sugar maple (*Acer saccharum*) leaves from the St. Olaf College campus to study the rates of decomposition in these freshwater ecosystems. I chose sugar maples due to their extreme abundance in the area and because they are a species that naturally exist in and around both ecosystems.

I gathered the leaves and oven dried them at 65C for twenty-four hours to obtain a 'dry' weight. While the leaves were drying I created plastic mesh decomposition bags by cutting rectangular pieces of mesh and sealing three sides with a heat sealer. I then weighed the bags to obtain an empty bag weight. When the leaves were done drying I placed them into the bags and weighed the bags and leaves together, subtracting the bag weight to gather a leaf-in-bag weight. I then took coiled wire and cut it into approximately 1m sections. I then wrapped the six sections around six bricks and attached two bags to each brick.

When I went to the sites to collect my samples I also took location characteristic data. I recorded the water temperature, dissolved oxygen levels, conductivity, water depth, pH and flow rate. I used three pieces of electronic equipment to obtain most of my data. Dissolved oxygen level was acquired with one instrument, conductivity and temperature with another and pH with the final piece. To measure depth and flow rate I used a standard wooden meter stick.

After I gathered the bag sets, I brought them back into the lab and removed all the contents. I needed to wash the leaves under running water in a sieve to remove all non-leaf matter. After removing the non-leaf matter I oven dried the leaves again at 65C for twenty-four hours. When the leaves dried I re-weighed them to look for the amount of mass lost in that time period. I then compared the percent mass of original remaining to see a difference (if any) in decomposition rates.

To see if there was a statistical difference in decomposition rates I used Stata 9.1 to run statistical analysis, including ANOVA and regression tests. I also used Microsoft Excel 2003 to create graphs of the results that were significant or that showed trends.

Results

I gathered data on environmental characteristics from both locations each time I visited. I found that there was a significant difference between two of the characteristics at the two locations. I found a significant difference in the mean conductivity levels, 517.1 Siemens/m in the stream and 269.5 Siemens/m in the pond (p-value = 0.0004) (Figure 1). In addition to the difference in conductivity, I found a significant difference in flow rate. On one hand there was the pond, which had no flow and no measurable circulation. On the other hand there was the stream, with an average velocity of 0.78 m/s (p-value = .035). Also, while there were not any more significant differences, some of my results point toward a trend. The mean dissolved oxygen level at the stream was 14.43 mg/L and at the pond it was 12.10 mg/L (p-value = 0.061) (Figure 2).

When running data analysis on the actual leaf samples, I examined the mean original percent mass remaining and I found many statistically significant items. The first collection results showed that there was a significant difference between mean original percent mass remaining between the pond (93.25%) and the stream (67.55%). Running an ANOVA analysis gave a p-value of 0.02. The third collection also showed a significant difference in original mean original percent mass remaining between the pond

(65.75%) and the stream (44.5%). Conducting an ANOVA test here resulted in a p-value of 0.0068. The total mean original percent mass remain also gave significant results, the pond retained an average of 80.03% and the stream retained an average of 58.63% (p-value = 0.0152).

In addition to only testing the specific data sets against themselves, I used the data I gathered from the samples and the locations to see if there were any significant findings. When running regression tests I found two more non-significant trends that showed a possibility for decomposition differences. I compared conductivity to the percent mass of leaves remaining I found a p-value of 0.056 and an r^2 value of 0.67 (Figure 3). I also found that as dissolved oxygen levels increase, percent mass remaining amounts decrease (p-value = 0.061, r^2 = 0.62) (Figure 4).

Discussion

Goals-

My goals were to see how quickly each freshwater ecosystem begins to decompose organic litter and what the levels of decomposition are after approximately a month's time. I controlled as many variables as I could while still allowing for a 'natural' setting. After completing the study I found significant differences between the initial decomposition rates and the end decomposition levels of my leaf litter in a pond and a stream environment. Therefore I must reject my null hypotheses.

Causes-

There are many variables within each environment that could have lead to these results. Decomposition does not occur due to one factor alone. However, not everything in a system contributes to decomposition at the same level, and some things do not interact with the decomposition process at all. Some research suggests that the differences in stream and pond decomposition are due to factors such as flow rate, dissolved oxygen and microbial abundance (Webster, 1986). I also found these factors to be important in decomposition. In addition, I found that temperature, pH and depth were not dissimilar enough to contribute to the differences in decomposition rates and levels.

Flow rate of a body of water is one aspect of an aquatic environment that can boost decomposition by creating more surface area for microbes to attach (Webster, 1986). In the locations I studied there was a significant difference in the flow rates. I used a riffle location in the stream, which most likely increased the flow rate difference more than if I had used a pool location (Webster, 1986). However, through all of this, the stream flow rate steadily dropped between collection dates, yet the leaf litter kept decomposing. This suggests that there is more causing decomposition than just the flow of water.

Dissolved oxygen level is the amount of oxygen that the body of water can hold, measured in mg/L. The difference in my study's findings between dissolved oxygen levels showed a trend that, with some more data points, the level of dissolved oxygen in the stream could be significantly greater than the level in the pond. Other research states that this thought would hold true because flowing water sources usually have a significantly higher dissolved oxygen level (Webster, 1986). Also, when comparing mean original percent mass remaining, a trend appeared that showed that as the dissolved oxygen level increased, the percent mass remaining decreased. This coincides with results that have been presented in earlier research, reduced dissolved oxygen levels result in slower decomposition rates than areas of high dissolved oxygen. (Reed, 1979 as cited by Webster, 1986).

Microbial levels in the stream and pond were not recorded. However, the locations of the environments were dramatically different. Heath Creek, the stream, borders farm land and then flowed to where the samples were located. Skoglund pond is surrounded by prairie of on three sides and a parking lot on the fourth. While speculative, it can be estimated that the nitrogen levels in Heath Creek would be higher, due to farm fertilizer run-off. Nitrogen has been shown to be a limiting factor in microbial growth (Dent, 1999). If nitrogen concentrations are indeed higher in the stream than in the pond, then that could account for some of the decomposition disparity between the two sites. Nutrient levels in the water are factors that should definitely be examined if this study is ever duplicated.

Conductivity levels and decomposition are not frequently researched. I could not find research that linked decomposition rates and conductivity. However, my research shows that there may be a link. The disparity in conductivity levels between locations is extensive and there is an intriguing trend that seems to have formed between conductivity and original mean percent mass remaining. With more data points taken on this subject, it could show that conductivity somehow plays a role in decomposition.

Future Considerations-

This study, like many others, does have flaws. Some of the most obvious seem to be the small sample size, no microbe data, no nutrient data and short time span. If this experiment were to be repeated it should be noted that larger sample sizes collected over a longer time span would be crucial to amass more conclusive results. Also, knowing microbe and nutrient levels of the water would help further identify the causes of decomposition differences. These suggestions for future researchers would add to the study, making it more complete.

Why Study?-

Finding new paths for research is beneficial because it uncovers new possibilities which help us to understand the world and its natural interactions. When studying a subject that is not extensive in literature, every new discovery adds to the collective knowledge of the subject. It is beneficial to determine the properties of an ecosystem allow for more rapid decomposition. For instance, new techniques in human waste management could be developed from these types of findings. Discerning which ecosystems facilitate nutrient cycling more rapidly can lead to findings about which organisms could flourish better in specific settings. Dealing with organic pollution is also an everyday occurrence in nature and figuring out which systems are more adept at solving pollution problems can lead to better waste management. These reasons, along with innumerable others, are why I investigated these questions.

Summary & Conclusions-

Through data collection and analysis I have discovered that stream environments decompose litter faster than pond environments in similar ecosystems. These decomposition findings agree with other research that has been previously conducted on the matter. The explanations for these findings also seemed to match up. Dissolved oxygen and flow rate play a large role in the decomposition of organic materials in aquatic systems. Microbial levels, although they were not recorded, also have been shown to contribute to decomposition. Moreover, this study hints at the possibility of conductivity levels playing a role in decomposition. Temperature, depth and pH levels were the same between the two locations and therefore do not seem to have contributed to the overall decomposition differences.

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Figures

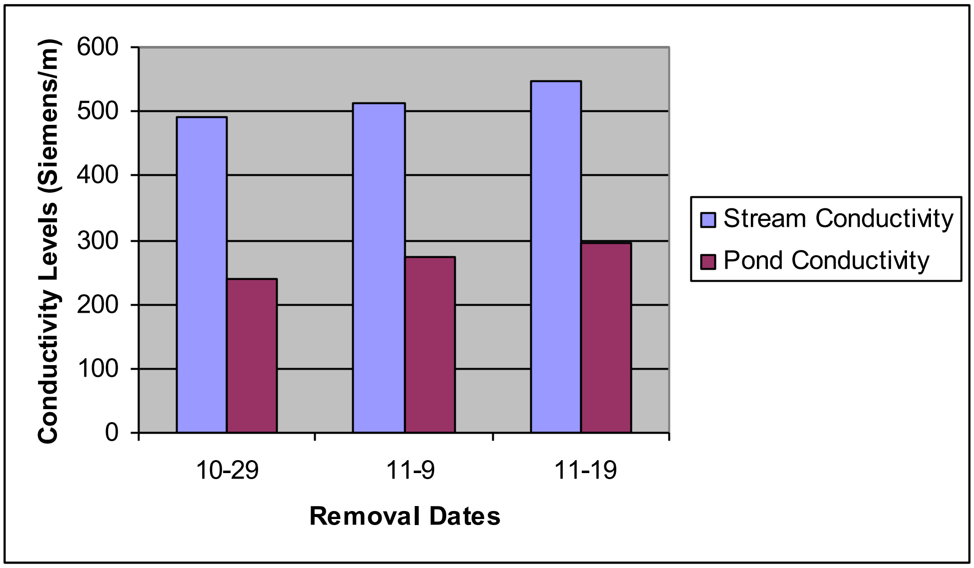

Figure 1. Conductivity levels in a pond and a stream environment on three collection dates, over a 35 day period, in southern Minnesota.

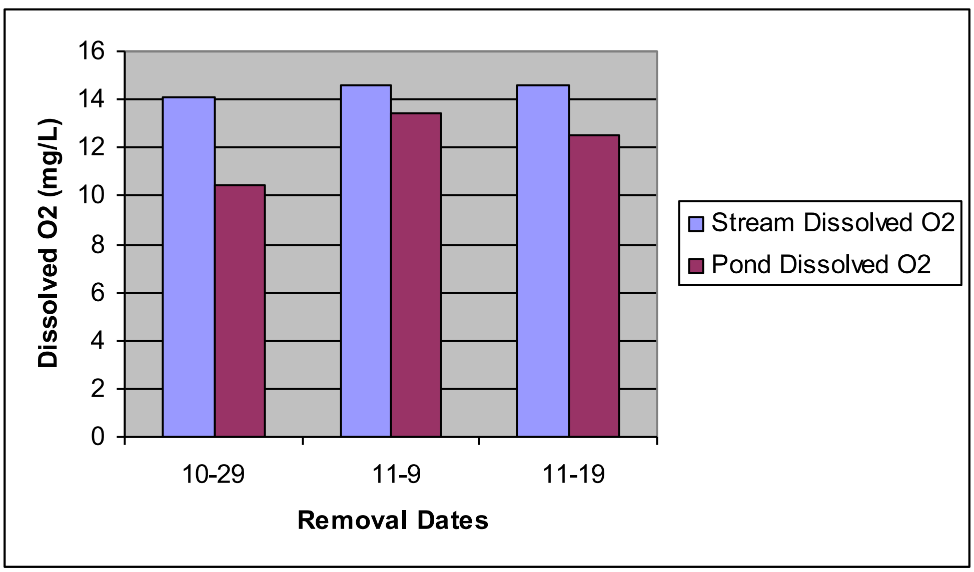

Figure 2. Dissolved oxygen levels in pond and stream environments on three collection dates, over a 35 day period, in southern Minnesota.

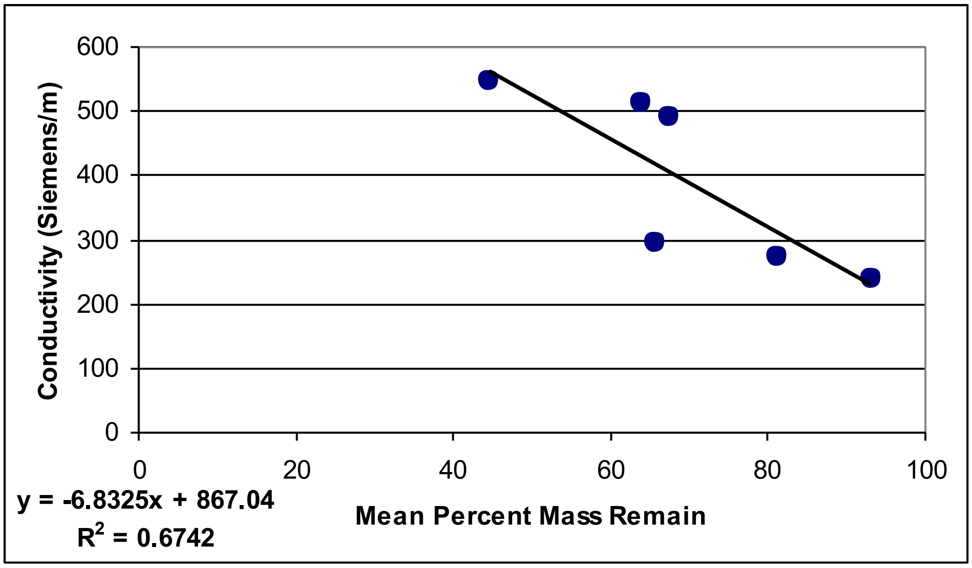

Figure 3. A regression analysis of conductivity levels versus mean percent mass remaining of a pond and a stream environment, over a 35 day collection period, in southern Minnesota.

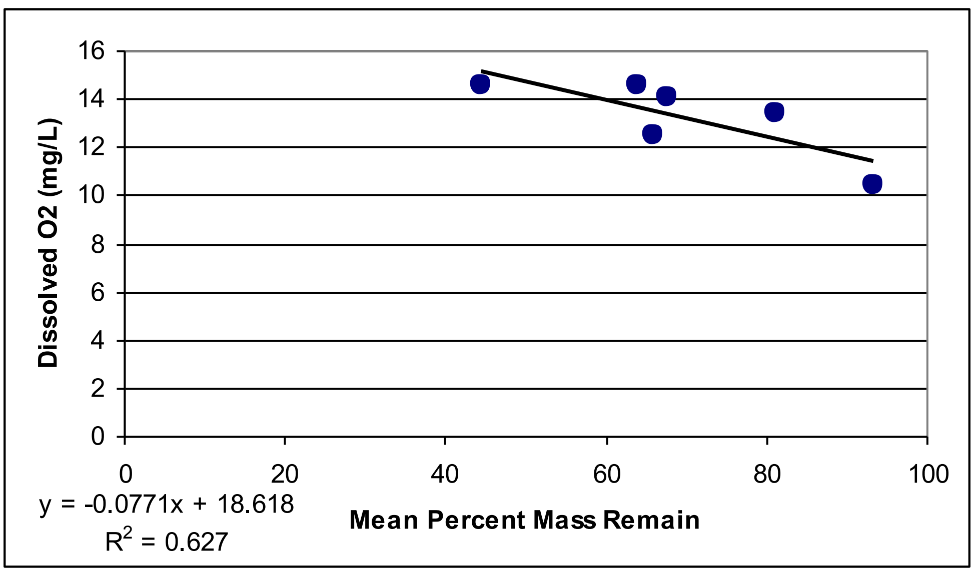

Figure 4. A regression analysis of dissolved oxygen levels versus mean percent mass remaining of a pond and a stream environment, over a 35 day collection period, in southern Minnesota.