Contribution by Leaves to Nutrient Levels in Lake Wingra: Phosphorous Leaching from Sugar Maple (*Acer saccharum*) and White Oak (*Quercus alba*) Leaves in Standing Water

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Abstract

In order to determine how nutrient levels, and therefore excessive plant growth, in Lake Wingra are affected by phosphorus contained in leaves, we measured the rate of phosphorus leaching from tree leaves immersed in water. We tested the phosphorus (using the Hach PhosVer®3 method) that leached from leaves of two tree species, Sugar Maple (*Acer saccharum*) and White Oak (*Quercus alba*), at six time intervals: 5 hours, and 1, 3, 7, 14, and 21 days. We hypothesized that the amount of phosphorus leached from the leaves immersed in water would be low at first, then increase with time until they reached a plateau. We found that phosphorus levels in the water increased dramatically between 5 hours and 3 days. After this time, the White Oak phosphorus levels decreased then leveled off, while the Sugar Maple's levels decreased initially then increased after 15 days. These results suggested that phosphorus leached from decomposing leaves was quickly taken up by growing bacterial populations, thus reducing phosphorus concentrations in the water. To test this hypothesis, we boiled the immersed leaves to release phosphorus contained in any microorganisms present. Subsequent phosphorus testing supported the idea that much of the phosphorus originally contained in leaves had been taken up by bacteria. We discuss the implications of our results for watershed management and for protection of lake water quality.

Introduction

Phosphorous is a necessary nutrient for lakes to have in order for the plants and animals within them to grow[1]. However, when this amount gets too large, the extra amount of phosphorous in the lake can lead to more lake weeds and algae, which can be detrimental to the lake's health[2]. Too much phosphorous in lakes can lead to green scum which causes lake water to be unsafe for consumption and recreation as well as preventing sunlight from reaching deep water plants.[3] Another problem with increased phosphorous levels in the lake is that when the algae dies, "masses of bacteria break them down, using up all the oxygen in the water," which leaves less oxygen for the fish and other aquatic animals, and may cause them to die. We conducted an experiment to test how much phosphorus was in leaves and how it could be harmful to lakes and other bodies of water. Our purpose was to find out how much phosphorous is released from two different types of leaves commonly found in the Wingra Watershed area, namely White Oak and Sugar Maple leaves. We then used this information as a model to demonstrate the effect that wet leaves within the watershed have on the phosphorous levels in Lake Wingra. After observing the amount of leaves in streets, yards, areas surrounding the lake, as well as in the lake itself, we hypothesized that these leaves may be contributing to the phosphorus levels in Lake Wingra. More specifically, we hypothesized that the amount of phosphorus leached from the leaves immersed in water would be low at first, then

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[1] Watershed Resources Youth Stewardship Project, *Phosphorus and the Green Scum*, 1; [article online] available from http://cgee.hamline.edu/watershed/action/background/Phosphorus.pdf; Internet; Accessed on November 2, 2005.

[2] Friends of Lake Wingra PowerPoint on Leaves in the Watershed; [power-point online]; available from http://edgecms.edgewood.edu/courses/1/NATS-104-105-106-107-F5-2005-2006/groups/_727_1/_67152_1/Leaves_presentation.pdf; Internet. Accessed on November 2, 2005.

[3] Watershed Resources Youth Stewardship Project, *Phosphorus and the Green Scum*, 1; [article online] available from http://cgee.hamline.edu/watershed/action/background/Phosphorus.pdf; Internet; Accessed on November 2, 2005.

increase with time until they reached a plateau. The long term goals of this experiment are to determine how often the city of Madison should be removing leaves from the streets and how often residents of the watershed should be properly disposing of the leaves on their own property. Hopefully, this would result in a reduction in the amount of phosphorus that could enter Lake Wingra from these leaves.

Materials and Methods

We collected approximately three gallons of two types of leaves – White Oak and Sugar Maple, trees that are commonly found in the Lake Wingra Watershed. These leaves were collected on October 27 directly from tree branches on the Edgewood College campus. The leaves were then placed in Ziploc™ bags in a refrigerator for approximately three months. Upon removing the leaves from the refrigerator, we weighed out 442 g of the Sugar Maple leaves and 443 g of the White Oak leaves, placed them in two separate, labeled, gallon jars, and added 3000 mL of de-ionized water. We also filled a third gallon jar with de-ionized water to serve as a control for each test. After a soaking period of four hours, we took three sample vials of water from each jar to test for the levels of phosphorous using the Hach Phosphorus Test[4] (Test #1). (We also tested a vial of the plain de-ionized water to serve as a control.) We repeated this test at the following increments: 1 day (Test #2), 3 days (Test #3), 1 week (Test #4), 2 weeks (Test #5), and 3 weeks (Test #6).

After viewing the data from the first three weeks, we noted an unexpected decrease in the phosphorus levels. We hypothesized that this decrease was being caused by bacteria which were consuming the phosphorus from the water. Thus, we decided at the three week point to add two additional tests and sets of data. We took the leaves out of the jar, squeezed as much water out of them as possible, and put the water into two, separate, clean beakers labeled White Oak and Sugar Maple. We took one sample from each beaker of leaf water and tested it with the Hach Phosphorus Test[5] (Test #7). Next, we weighed the wet leaves that were taken from the jar. We then weighed out a portion of 100 grams of each kind of leaf and boiled them separately with 750 mL of de-ionized water. With this process, we hoped to kill the remaining bacteria present, release all the phosphorous left in the leaves and get a more accurate reading of the amount of total phosphorous that was in the jars. We placed the rest of the leaves in an oven (103° C) to be dried and weighed at a later date. After the leaves had been boiled for approximately two hours, we took them off the heat and allowed them to cool for two days. At that time, we performed the 8th Hach Phosphorous Test[6]. In this test, we included one sample each from the beakers of leaf water only, as we had done for Test #7. When testing the water from the leaves and water that had been boiled, we diluted the solution, as we expected high values of phosphorous that would exceed the maximum range of the test (3.5 mg/L). We created two dilutions for each type of leave/water combination. The first dilution was a 10:1 ratio; the second dilution was 100:1. We then tested one sample vial from each of the following solutions: the 10:1 White Oak solution, the 100:1 White Oak solution, the 10:1 Sugar Maple solution, and the 100:1 Sugar Maple solution.

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[4] Hach PhosVer®3 with Acid Persulfate Digestion Method; 0.06-3.50 mg/L PO_4^{3-}; Method 8190.
[5] Hach PhosVer®3 with Acid Persulfate Digestion Method; 0.06-3.50 mg/L PO_4^{3-}; Method 8190.
[6] lbid

Results

Phosphorus levels in the water increased dramatically between 5 hours and 3 days. Subsequently, the White Oak phosphorus levels decreased then leveled off, while the Sugar Maple's levels decreased initially then increased after 15 days (Figures 1 & 2).

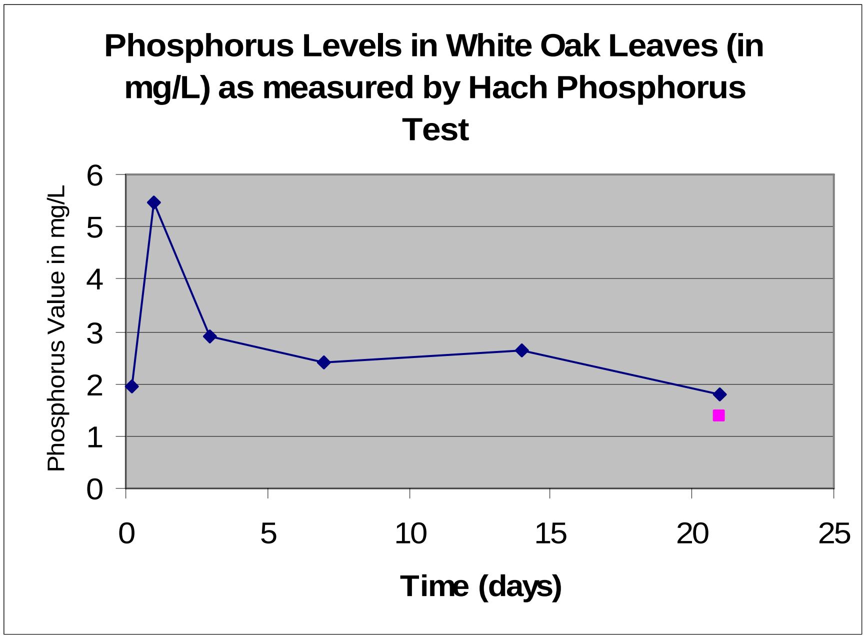


Figure 1 Phosphorus levels in White Oak leaves (in mg/L) The additional data point (pink square) is the result from Test 7.

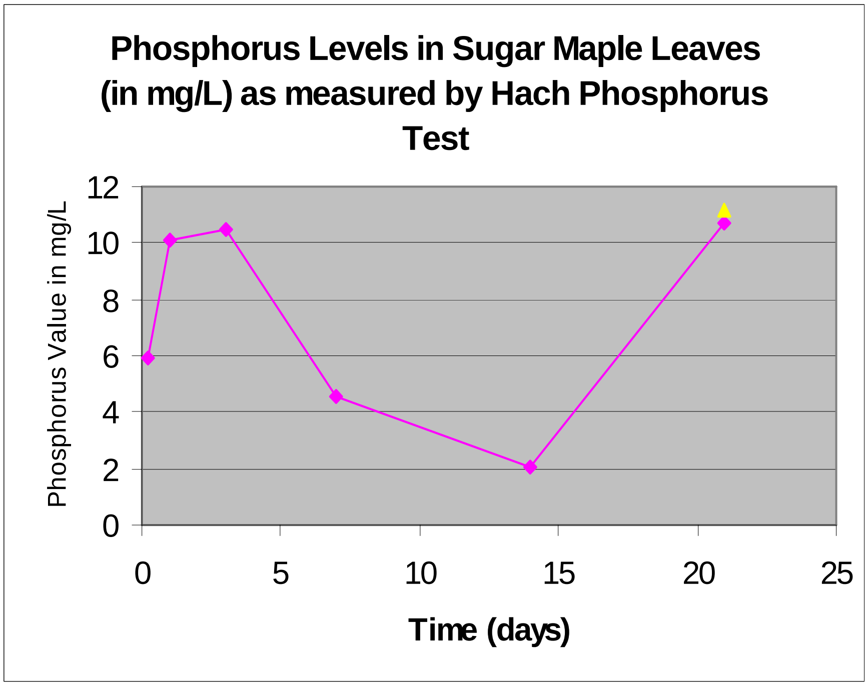


Figure 2 Phosphorus levels in Sugar Maple leaves (in mg/L). The additional data point (yellow triangle) is the result from Test 7.

Overall, the total leached phosphorus levels in the Sugar Maple leaves were higher than those of the White Oak leaves (Figure 3).

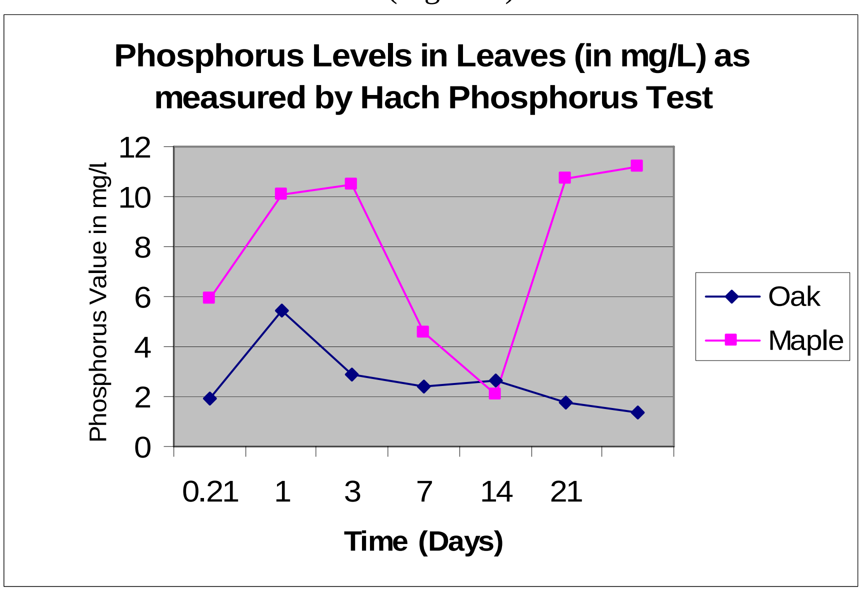
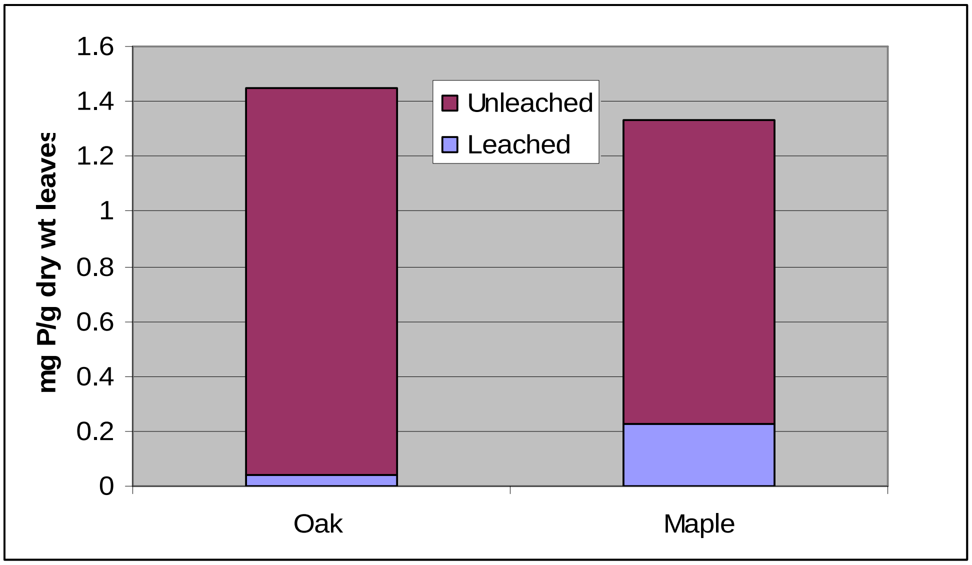


Figure 3 Phosphorus Levels in leaves from both tree species (in mg/L)

We calculated the total amount of phosphorus in each type of leaf by adding the amount leached into the water while the leaves were soaking and the amount released after boiling (Figure 4). This graph shows that while the Maple leaves initially leached more phosphorus, but, in the end, after all the phosphorus was measured (leached and unleached), we found that the Oak leaves actually contained more phosphorus, but were leaching at a slower rate.



(Figure 4) Total amount of phosphorus per gram of leaves

Discussion

Our results disproved our original hypothesis that the amount of phosphorus leached from the leaves immersed in water would be low at first, then increase with time until they reached a plateau. Instead, the phosphorus levels increased dramatically until about day three, after which they declined steadily for the oak leaves. However, the maple leaves, although they too declined after day three, began to rise again around the two week mark. These results lead us to the conclusion that there must be bacteria present in the leaves. This would explain why the phosphorus levels were decreasing (as the bacteria were consuming the phosphorus) until the two week mark. A possible explanation for the increase in phosphorus levels in the maple leaves at the two week mark is that the bacteria died, which re-released phosphorus into the maple leaves. Phosphorus levels in the oak leaves are still steadily decreasing at this time, which means that the bacteria were still alive and consuming the phosphorus.

Due to the presence of the bacteria and the effect it was having on the phosphorus level readings, we conducted a final test to determine the true amount of phosphorus in the leaves. We boiled the leaves to release any unleached phosphorus. By adding the amount of leached phosphorus previously calculated (Test 7) to the amount of unleached phosphorus, as well as taking into account the wet and dry weight of the leaves, we concluded that there is 1.45 mg of phosphorus per 1 gram of dry oak leaves, and 1.33 mg of phosphorus per 1 gram of dry maple leaves.

Our findings were consistent with those of the 1986 Dorney Report on phosphorus.[7] The Dorney Report found that on average 9.3% of phosphorus leached out

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[7] Friends of Lake Wingra PowerPoint on Leaves in the Watershed; [power-point online]; available from http://edgecms.edgewood.edu/courses/1/NATS-104-105-106-107-F5-2005-2006/groups/_727_1/_67152_1/Leaves_presentation.pdf; Internet. Accessed on November 2, 2005.

of the leaves (conducted on 13 species of leaves, including maple and oak). Our findings showed that 2.8% of the phosphorus in the oak leaves leached out, and 21% of the phosphorus in the maple leaves leached out. This left us with an average of 12% compared to Dorney's 9.3%. Also in this report, Dorney reported finding that maples had higher leachable phosphorus than oaks, which was also consistent with our results (21% versus 2.8%). These results are also supported by the general idea that maple leaves tend to break down and decompose quicker than oak leaves, which also offers an explanation for why the bacteria in the maple leaves died out and released their consumed phosphorus earlier than the oak leaves.

It is important to note that there were some potential sources of error in our procedure that could be eliminated if the experiment were to be repeated that would help to provide even more accurate results. First of all, in order to begin with an accurate dry weight reading of the leaves, it would have been better to dry all the leaves in an oven before even placing them in the jars of water. Doing this could have an effect on determining the exact amount of phosphorus per gram of dry oak or maple leaves. Secondly, since the Hach Phosphorus Test is only made to test up to phosphorus levels of 3.5 mg/L, we may have been able to get more accurate results if we had diluted all of the tests as we did with the last one. When the readings were over 3.5 mg/L it was difficult to say how accurate they really were since the test was not meant to read levels over that point. Finally, one unresolved issue with our study was the unexpected role that bacteria seemed to play in consuming the phosphorus, and thus altering the levels we were reading with the test. This idea of bacteria consuming the phosphorus is still just a hypothesis, and deserves further research to determine if that is what was really going on.

The results of this study could be very useful in future research regarding the health and management of Lake Wingra. Our results suggest that although some phosphorus is leached out of the leaves when they are in standing water, most of it is not actually released until after about three weeks, perhaps when the bacteria in the leaves begin to die off and release any phosphorus they may have consumed. There are a few conclusions that can be drawn from our research that can be suggested to Wingra Watershed residents as to what they can do to prevent excess amounts of phosphorus in the lake. First of all, it is important to properly dispose of the leaves in their yard, especially within three weeks of them falling (the point at which most of the phosphorus begins to be emitted). Secondly, it is extremely important for residents and city officials to try and keep leaves out of the lake. Once the leaves are in the lake, over time, all of the phosphorus will be emitted, with or without the presence of bacteria, and thus increasing the overall phosphorus levels of the lake, something that can be prevented. For the Edgewood community especially, we are suggesting a type of management for the retention pond which filters into Lake Wingra. If the leaves in the retention pond were removed about once every three weeks, it would greatly reduce the amount of phosphorus filtering into the lake. It is our hope that this research will be utilized by organizations, scientists, naturalists, and the public in an effort to educate people on how phosphorus affects the lake, how much phosphorus is actually in leaves, and what people can do to try and regulate the phosphorus levels and overall health of Lake Wingra.