the Hypolimnion of a Lake and Its Effects on Eutrophication

Paul Boudreaux

Introduction

Lakes can be classified at different levels of trophic status in many ways. One way is to measure the amount of nitrogen and phosphorous present in the water. (Schindler, 1974). Mortimer (1941) found that chemical exchanges occur at the mud-water interface in a hypolimnion (the deepest level) of a eutrophic lake.

Aerobic Condition

When the water is aerobic, an oxidized microlayer is formed that prevents some of the chemical exchanges. (Mortimer, 1941). This is due to oxygen changing the redox potential of the chemicals in the sediment (Schindler, 1971). The oxidized microlayer is formed when $Fe(OH)_3$ attaches to phosphorous and becomes insoluble. The chemicals in the mud beneath the oxidized microlayer are then unable to reach the water column. (Mortimer, 1971).

Anaerobic Conditions

Organic material from plants and animals in the upper water layers deposit into the hypolimnion during the period of stratification (Mortimer, 1941). This is due to less wind mixing of the water because of its isolation (Gorham, 1958). The hypolimnion is therefore naturally highly anaerobic in stratified periods due to the decomposition of organic matter that occurs there (Mortimer, 1941). Because the water is anaerobic, the compounds in the oxidized microzone are reduced causing the release of the phosphorous in the microzone. Because the microzone disappears, compounds in the sediment below are also able to diffuse into the water column. As a result, phosphorous mobilization will increase PO_4^{---} in the water column when oxygen levels are low enough. Also, nitrogen levels (nitrate) should decrease in the anaerobic environment since there is no oxygen to oxidize ammonium and denitrification occurs. (Mortimer, 1942). This information means that anaerobic conditions should promote increased amounts of two of the chemicals measured to determine higher Eutrophic status.

Materials and Methods

Sediment samples were collected from Cougar Lake (Tower Lake) near the heating plant dock and put into two microcosms filled to the top with tap water. One of these microcosms was labeled "aerobic microcosm" because of an air bubbler placed inside it. The other was labeled "anaerobic microcosm" because it had been sealed off with very little exposure to oxygen from the atmosphere. These microcosms helped to imitate the conditions of a hypolimnion in aerobic and anaerobic conditions in a eutrophic lake. We took samples of water from each microcosm every Tuesday and Thursday starting on January 26, 2006 until March 10,2006.

The Biol 465 class helped with phosphorus and nitrogen analyses. We used approximately 50 ml of each sample for phosphorous analysis and approximately 100 ml of each sample for nitrogen analysis. We used a YSI 95 dissolved oxygen probe to record the oxygen levels and temperatures of these samples the days that we collect them. I also measured pH, Alkalinity, Bicarbonate Alkalinity, and free CO_2 in the water for a more complete analysis of the chemical changes that occurred in the microcosms over time. I graphed the Oxygen levels (figure 1), Phosphorus levels (figure 2), Nitrate levels (figure 3), and I did a statistical analysis (table 1) of all of our data using a paired sample t test to determine if the differences in the microcosms were statistically significant.

Hypothesis: Increased chemical exchanges caused by anaerobic conditions in the hypolimnion induce Eutrophication in lakes.

Results

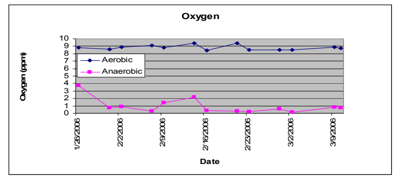

Figure 1: Oxygen levels in aerobic and anaerobic microcosms over a 44 day period.

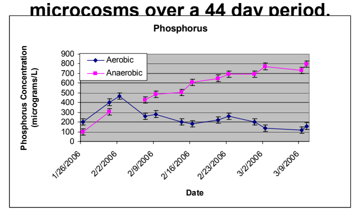

Figure 2: Phosphorus levels in aerobic and anaerobic microcosms over a 44 day period.

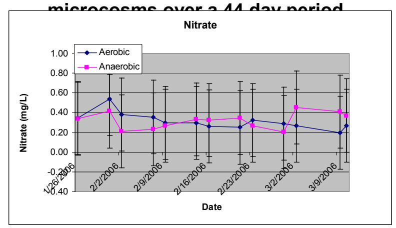

Figure 3: Nitrate levels in aerobic and anaerobic Microcosms over a 44 day period.

Table 1: A statistical analysis of significance using a paired sample t test.

Variable	N	Mean	Std Dev	t Value	Pr > |t|
O2	12	7.8308333	1.0151709	26.72	<.0001
TP	12	-345.3033333	259.3263186	-4.61	0.0007
N	12	-0.02	0.1141769	-0.61	0.5563
pH	6	1.1683333	0.1749762	16.36	<.0001
Temp	12	-0.4	0.4	-3.46	0.0053
Alk	6	-4.6666667	12.8121921	-0.89	0.4132
CO2	6	-0.0716667	0.1400595	-1.25	0.2655

Results

Figure 1 shows that oxygen levels in the anaerobic microcosm dropped less than one part per million. Oxygen levels in the aerobic microcosm stayed around nine parts per million.The differences in O_2 are significant (Table 1). Therefore the anaerobic microcosm simulates the hypolimnion of a eutrophic lake during stratification. Figure 2 shows that phosphorus concentrations increased in the anaerobic microcosm and decreased in the aerobic microcosm. This suggests that the oxidized microlayer in the anaerobic microcosm was broken down and phosphorus continued to move into the water column from the sediment while the oxygen levels stayed low. Figure 3 shows nitrate concentration variations throughout the experiment. The graph shows very little changes in either the aerobic or anaerobic microcosms. Even if there were a good trend, table 1 shows that the probability of the difference in the two being significant is very bad. My results support Mortimer's findings that chemical exchanges occur at the mud-water interface in anaerobic conditions. It however does not support the hypothesis that nitrate would undergo dinitrification because there was no good trend in nitrate concentration changes. We did get significant differences in pH and temperature in the microcosms throughout the experiment as well shown significant by table 1.

My results suggest that one of the chemicals shown to increase trophic status (phosphorus) is rising as oxygen levels stay low. This would suggest that eutrophication is possible under those conditions. Because nitrogen readings were unsuccessful, a better test will have to be done to see if they are increasing as well and further pushing the trophic status of the lake to the eutrophic side of the spectrum. pH was significantly higher in the aerobic microcosm suggesting the possibility of different chemical reactions occurring than in the anaerobic microcosm. Temperature was also significantly higher in the anaerobic conditions. This could possibly be due to the bubbler in the aerobic microcosm cooling the water. Further testing is necessary to determine if these have any significant effects on the results. Table 1 shows high probability of chance in differences in Alkalinity and free CO_2. Overall, my results do correspond with my hypothesis, but further testing is needed to show more significant support for increased trophic status.

References

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