ADSORPTION AND SEDIMENTATION OF PHOSPHORUS BY CLAY SOILS IN LAKE LANIER

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INTRODUCTION

Total phosphorus (TP) has traditionally been the nutrient of choice for assessing the trophic status of lakes and has been used successfully throughout Canada and the upper United States. However, in Lake Lanier and in many other southeastern lakes phosphorus has not been a good determinant of trophic state. In these lakes high phosphorus loading in tributaries has not resulted in high productivity (Rast and Lee, 1978; Mayhew and Mayhew, 1992). Reckhow (1988) proposed that productivity is low in these lakes because clay is removing phosphorus and organics from the water column. The organics cause hypolimnetic oxygen deficits characteristic of eutrophy although the trophic state index for TP is oligotrophic or mesotrophic. Lake Lanier has the characteristic oxygen deficit and contradictory low TP of this type of lake (Mayhew and Mayhew,1991). The purpose of this study is to determine whether clays in the watershed adsorb and remove P from the water column of Lake Lanier. If this is the case, the high concentrations of P supplied by the rivers do not reach the euphotic zone and cannot contribute to lake productivity. However, organics also precipitated by the clay deplete dissolved oxygen in the hypolimnion.

METHODS

Soil with a high clay content, hereafter referred to as clay, was obtained from the top 10 cm of the soil profile in the watershed of Lake Lanier. The clay was dried, ground, weighed and mixed with a standard 0.5 mg/l phosphorus (P) solution. The solution was shaken for 24 hours, then filtered through a glass fiber filter. The filtrate was tested to determine if TP had decreased and therefore been adsorbed to clay. The filter loaded with clay was then placed in distilled water and shaken for 24 hours to allow desorption of P from the clay. The distilled water/clay solution was then filtered and the filtrate tested to determine how much P desorbed from the clay into the water.

Clear acrylic sediment traps(30 cm tall, 4.4 cm I. D.). were suspended from docks at three stations in Flat Creek, a tributary of Lake Lanier. The location of the stations are shown in Figure 1. The first station, FC1, is 50m above FC2, which is near the mouth of the creek and 400 m above FC3, which is across the embayment. The traps were placed 1 m above the bottom and replaced every two days for a six day period. Water bottle grab samples were collected and transparency was measured each time the sediment traps were changed. The grab samples and sediment trap samples were returned to the lab and tested for TP, abioseston (suspended inorganic particulates), and bio-seston (suspended organic particulates). TP was determined by persulfate digestion and the stannous chloride method (APHA, 1985). Abioseston and bioseston were determined according to Standard Methods (APHA, 1985) with some modification.

RESULTS

The adsorption of P to clay in a 0.5 mg P/l solution is shown in Figure 2. Adsorption ranged from 9.5 to 49.6 ug P/g clay and the average was 23.4 ug P/g clay. Desorption of P from clay to distilled water ranged from 0.3 to 1.6 mg P/g clay; the average was 1.0 mg P/g clay. The average

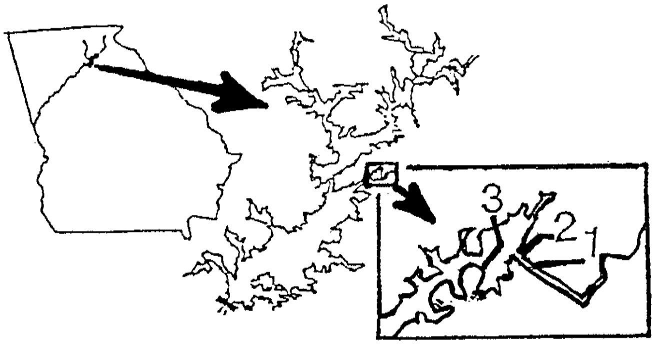

Figure 1. Area map showing location of Lake Lanier and stations on Flat Creek, a tributary of Lake Lanier.

Table 1. Average Transparency and Average Abioseston, Bioseston, and TP in Sediment Traps (ST) and Grab Samples (GR) Over a 6-Day Period at Three Stations in Flat Creek.

Station	Trans-parency m	Abioseston ST mg/m²	Abioseston GR mg/l	Bioseston ST mg/m²	Bioseston GR mg/l	TP ST mg/m²	TP GR mg/l
FC1	0.9	22181	5	8050	9	163	189
FC2	1.0	19500	3	7689	6	101	121
FC3	1.9	12639	1	2825	3	35	52

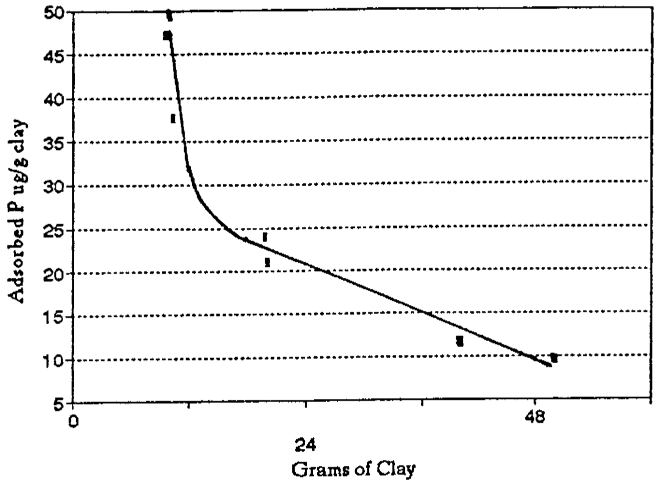

Figure 2. **Uptake of phosphorus by clay from a 0.5 mg/l solution over a 24 hour period.**

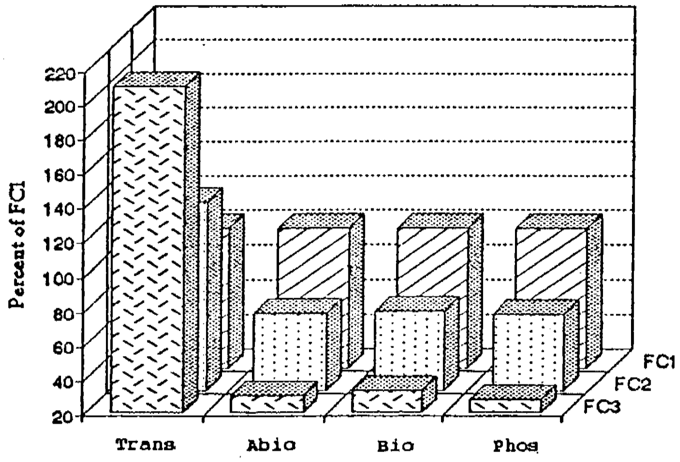

Figure 3. Comparison of % change from FC1 to FC2 and FC3 for transparency, abioseston, bioseston and TP in grab samples.

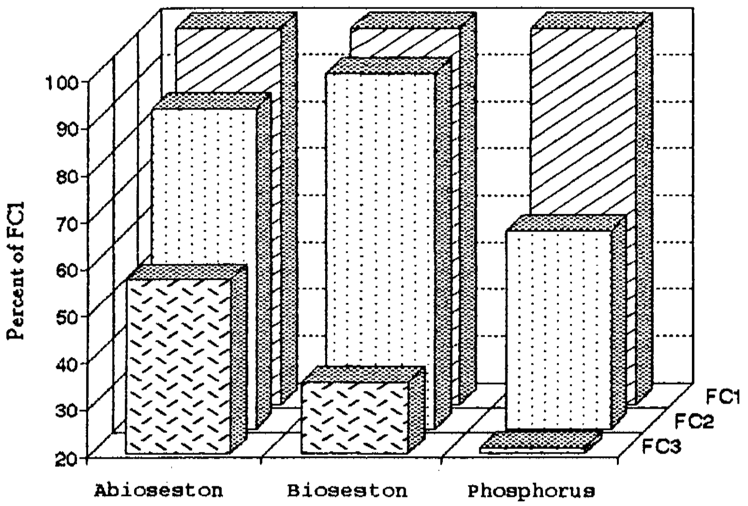

Figure 4. Comparison of % change from FC1 to FC2 and FC3 for abioseston, bioseston, and phosphorus in sediment trap.

transparency and the average abioseston, bioseston, and TP in the sediment traps and in the grab samples at the three stations on Flat Creek are shown in Table 1. The upstream station FC1 was used as a standard and the other two stations compared to it. The percent change in transparency and in abioseston, bioseston and phosphorus in grab samples from FC1 (100%) to FC3 is shown in Figure 3 and the percent change in abioseston, bioseston and TP in sediment trap samples from FC1 (100%) to FC3 is shown in Figure 4.

DISCUSSION

The adsorption of P by clay during a 24 hour period in the lab was moderate and the desorption of P was minimal under the oxic short term conditions. The removal of P and clay from the water column in Flat Creek was obtained by averaging concentrations in sediment traps. The value of 3224 ug P/g clay per day is 138 times higher than the ratio measured in the lab. The percent change in abioseston, bioseston and TP in the grab samples and in the TP in the sediment traps from FC1 to FC3 was similar, dropping to approximately 65% at FC2 and 30% at FC3 (Figures 3 & 4). The abioseston and bioseston in the sediment traps dropped more slowly, to 88% and 57% for abioseston and to 96% and 35% for bioseston (Figure 4). Transparency increased to 129% at FC2 and to 210% at FC3 (Figure 3). The rate of removal of abioseston, bioseston and TP was rapid over the 450 m test interval, supporting the proposal of Reckhow (1988). Other lakes in the piedmont, such as Durant Lake near Raleigh, NC, show a pattern of TP removal by clay (Burkholder, 1992) similar to that in Lake Lanier. It is likely that this type of lake is common in the southeast and management plans for these lakes must take the interaction of TP and clay into account.

Management decisions for these types of lakes fall into three categories: (1) do nothing, (2) control only clay additions, or (3) control clay and phosphorus additions. If the decision is made to do nothing and allow clay to control TP loading in the open lake, the expected results are progressive loss of cold water fisheries due to extensive anoxia in the hypolimnion; a progressive increase in heavy metals in the hypolimnion; a rapid fill-in of bays and river mouths; and continued mineral turbidity. The moderate to good warm water fisheries in these lakes should not change unless metal toxicity occurs. If the decision is made to reduce clay additions through erosion control ordinances but phosphorus is not reduced then the expected result is a shift to a more traditionally eutrophic lake. Mineral turbidity will be relaced by algal turbidity as P becomes available. This should improve warm water fisheries but not change hypolimnetic anoxia and the decline in coldwater fisheries. Heavy metals will be released in anoxic waters as at present.

If both clay and phosphorus additions are reduced then the lake will move toward a more traditional mesotrophic or oligotrophic type. The result shoulb be an overall increase in transparency, little change in available P and produc- tivity, little change in warm water fisheries and an improvement in the hypolimnion. Hypolimnetic waters should have less anoxia, reduced heavy metals, and therefore should support better cold water fisheries.

RECOMMENDATIONS

The best management option of the three discussed above is the last one of controlling both clay and P loading. This option increases longevity of the lake due to reduced fill-in rates and also improves water clarity and enhances cold water fisheries without reducing warm water fisheries.

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