BIOGEOCHEMISTRY OF THE CALVERTON PONDS, SUFFOLK COUNTY, NEW YORK

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ABSTRACT

The Calverton Ponds, or Manorville Ponds, are a unique set of coastal plain ponds in the core of the Central Pine Barrens of Eastern Long Island (CPBLI). The objective of this study was to determine the changes in hydrogeochemistry of these ponds as a function of bioactivity. To meet this objective three ponds and a shallow well in the pine-oak forest were intensively monitored from March 27, 1993, through May 9, 1993. Unexpectedly, a significant difference was found in the chemical composition among these ponds. Fox Pond has much higher NO_3, SO_4, Ca, Mg and HCO_3 concentrations than Big Sandy Pond and Grassy Pond. The source for these constituents may be three houses upgradient from the ponds. As the water temperature increases, the dissolved oxygen concentration and nitrate concentrations drop rapidly. In the midst of the growing season, the nitrate concentration in Fox Pond drops to a level below those in the other two ponds and the shallow ground. The results of this study demonstrate that the fresh water wetlands in the CPBLI can be affected by relatively small anthropogenic sources at distances in excess of 1000 feet. Furthermore, the results indicate that the pond communities are capable of removing nitrate from the water column at a rate in excess of the advection rate. As a result, there is relatively little difference in nitrate levels between disturbed and undisturbed ponds during the growing season.

INTRODUCTION

The Calverton Ponds, also known as a the Manorville Ponds, are located within the Peconic River watershed, which forms the core of the Central Pine Barrens of Long Island (see Fig. 1). These ponds support some of the most exquisite Coastal Pond Communities on the North Atlantic Coastal Plain (Reschke, 1990; Zaremba and Lamont, 1993). To protect this ecologically important site, the Calverton Ponds and a buffer zone of pine-oak forest are part of the Suffolk County Park lands.

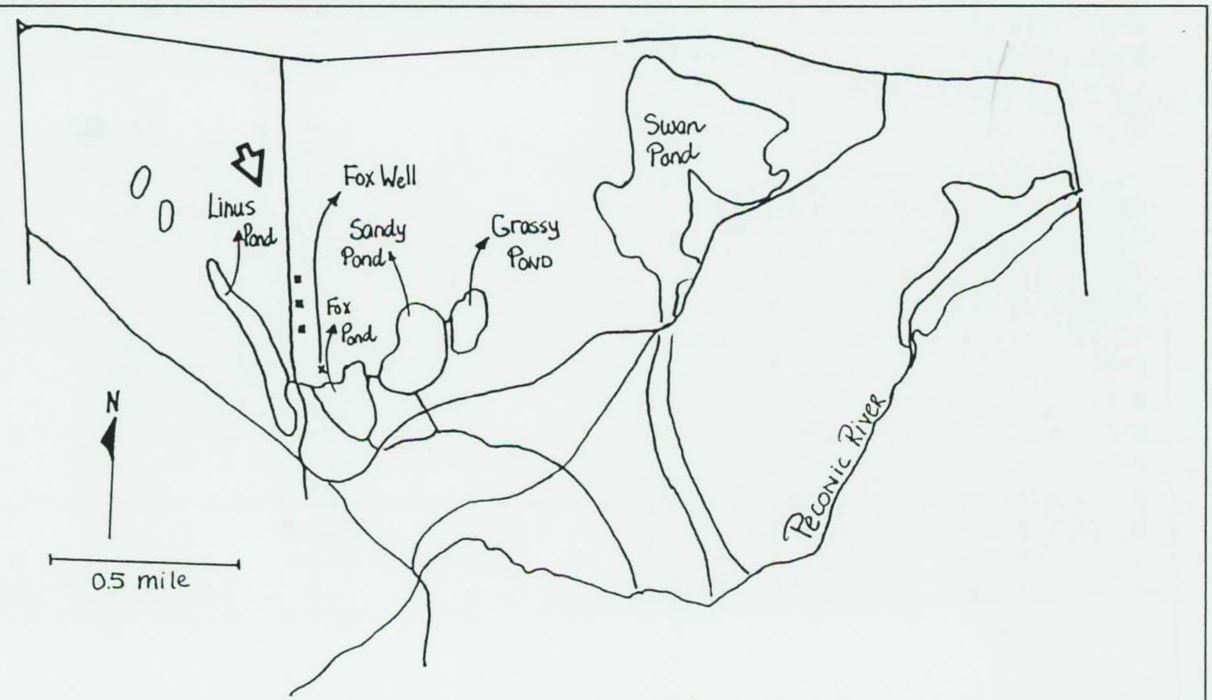

Figure 1. Location map of Calverton Ponds, Eastern Long Island, New York. The three small blank boxes north of Fox Pond are houses. The bold open arrow is the approximate direction of ground water flow in this area.

The objective of this study was to determine the changes in the water chemistry of these ponds as a function of bioactivity in pristine pine barrens water. In our earlier work, we documented a significant seasonal variation in nitrate as a function of bioactivity for the entire Peconic River watershed (Brown and Schoonen, 1993). However, in that study it was not clear how much of the nitrate in the watershed was from non-atmospheric sources. Hence, to minimize the effects of fertilizers and septic tank effluent, we choose to study the Calverton Ponds which are some of the most remote wetlands within the CPBLI. The study covered the period from March 27, 1993 through July 9., 1993. However, most samples were taken between the end of March and the second week of May because during that time interval the temperature, and presumably the bioactivity, increased rapidly.

The Calverton Ponds form a series of interconnected, groundwater-fed ponds. In addition to precipitation, water enters the ponds through ground water seepage and through small streams interconnecting the ponds. Hence, Fox Pond receives some water form Linus Pond and some Fox Pond water flows into Big Sandy Pond. However, Grassy Pond is essentially isolated from Big Sandy Pond. Big Sandy Pond drains into the Peconic River through a small stream. It is not clear how important the inter-pond flow is with respect to ground water seepage. In addition, it should be emphasized that much of the pond discharge may be as groundwater. The direction of regional ground water flow is from north to south. Therefore, ground water may seep in at the north shore of the ponds and leave the pond at the south shore. A thorough hydrological study is clearly warranted.

METHODS

At weekly or biweekly intervals water samples were collected from Big Sandy Pond, Grassy Pond, and Fox Pond. In addition, samples were withdrawn from a shallow monitoring well (depth <3 ft) located within the pine-oak forest near Fox Pond. The well, a 2.5" slotted PVC pipe, was installed six months in advance of our study. Samples were collected using a Teflon bailer, stored in polyethylene bottles, and transported in a cooler. Dissolved oxygen (DO), pH, conductivity, and temperature were determined on site. Within an hour after sampling, the samples were filtered over a 0.45 μm membrane filter. One 150-mL subsample was acidified for Fe analysis (not reported here), a 25-mL subsample was acidified for cation analysis, and a 25-ml untreated subsample was stored for anion analysis. In addition, the pH was measured again upon return from the field and if necessary 20 mL unfiltered sample was used for an alkalinity titration. However, many of the samples did not require an alkalinity titration because their pH was lower than 4.2.

Great difficulty was experienced in measuring the pH in the field. Particularly the shallow ground water was very acidic and charged with CO_2. Due to CO_2-degassing of the water, the pH never stabilized if an open container was used. To minimize CO_2-degassing, subsequent measurements were made by inserting the pH electrode through the cap of a so-called electrode saver bottle. Because the waters are very dilute, low ionic strength pH buffers were used throughout the study. For the analysis of cation and anions the same techniques were used as described in Choynowski and Schoonen (1994).

RESULTS

The results of this study show a significant difference in chemical composition among the three ponds and the shallow ground water. The water in Fox Pond is more concentrated than all other waters. Most notable is the high Ca concentration throughout the study and the high nitrate concentration until May, see Fig. 2. Because evaporation accounts for some of the rise in the Ca concentrations in Fig. 2, all major constituents are presented as molar X/Cl ratios in Fig. 3. Chloride is chosen as a divisor because it is very soluble, not taken up by plants and does not sorb onto mineral surfaces. Hence, the molar X/Cl ratio is insensitive to the effects of evaporation, evapotranspiration and the occasional dilution by rain. It is clear from Fig. 3, that the relative Ca, Mg, and K concentrations rise in Fox Pond while no such trend is seen in the other waters. Unfortunately, there were no samples collected between May 9, 1993, and July 9, 1993. Therefore, it is not known how the Ca, Mg, and K changed in the early summer. However, by early July the relative concentrations of Ca, Mg, and K are lower than at May 9, 1993. This could be due to uptake of some of these constituents by plants or it could be that Ca, Mg, and K were flushed from the system.

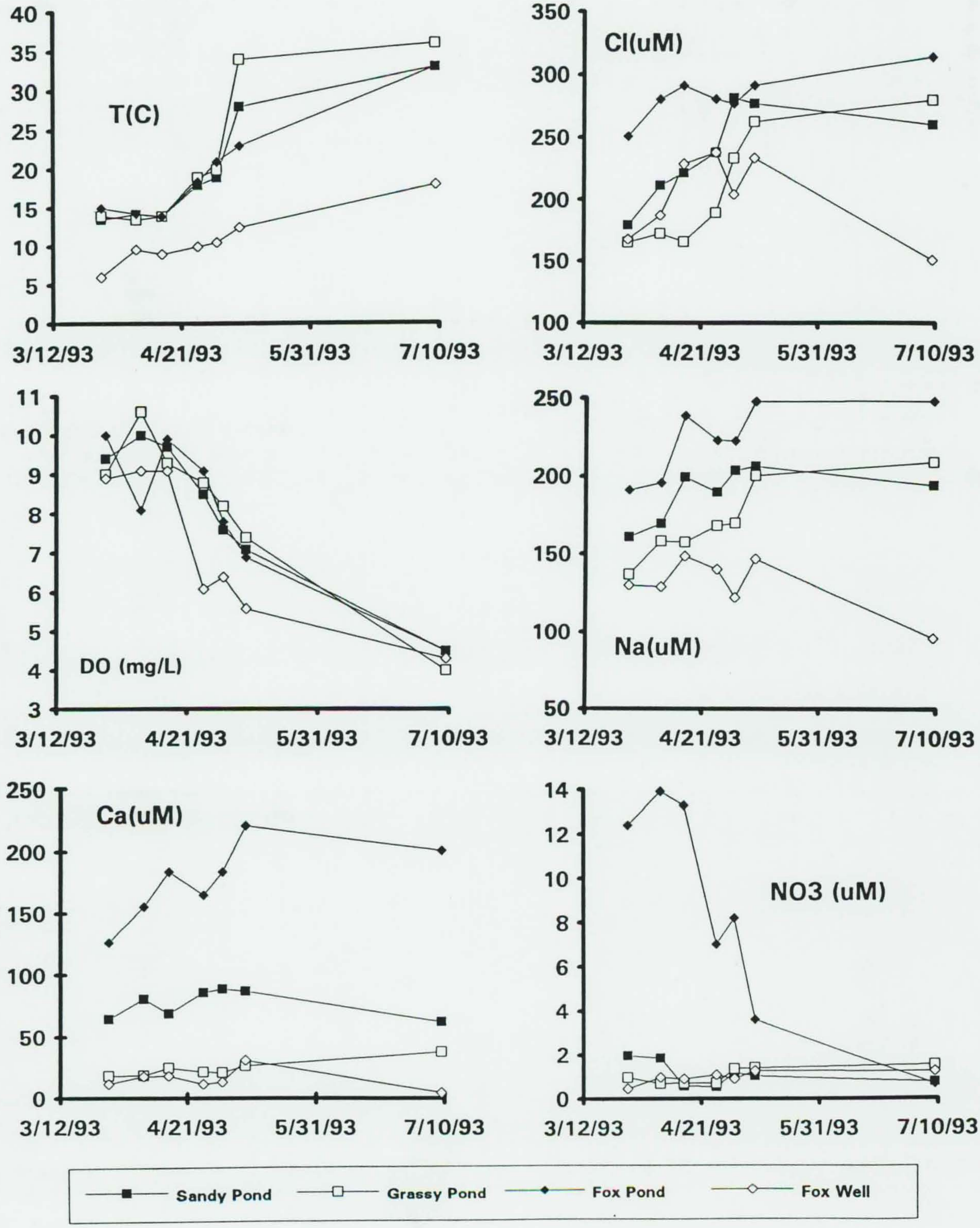

Figure 2. Changes in the chemistry of the Calverton Ponds with the change from dormant season to growing season.

The drastic change in nitrate concentration in Fox Pond coincides with the increase in water temperature and a drop in DO. Big Sandy Pond shows the same pattern but the drop in nitrate is far less drastic because the initial concentration in much less than in Fox Pond. The drop in nitrate indicates that the rate of uptake by the ecosystem exceeds the rate of input. The drop in DO is in part due to the fact that the equilibrium DO concentration decreases significantly with increasing temperature. However, the values measured in July are below the equilibrium DO concentration (7 mg/L at 35C) and indicate that the pond at the time of sampling experienced a DO deficit.

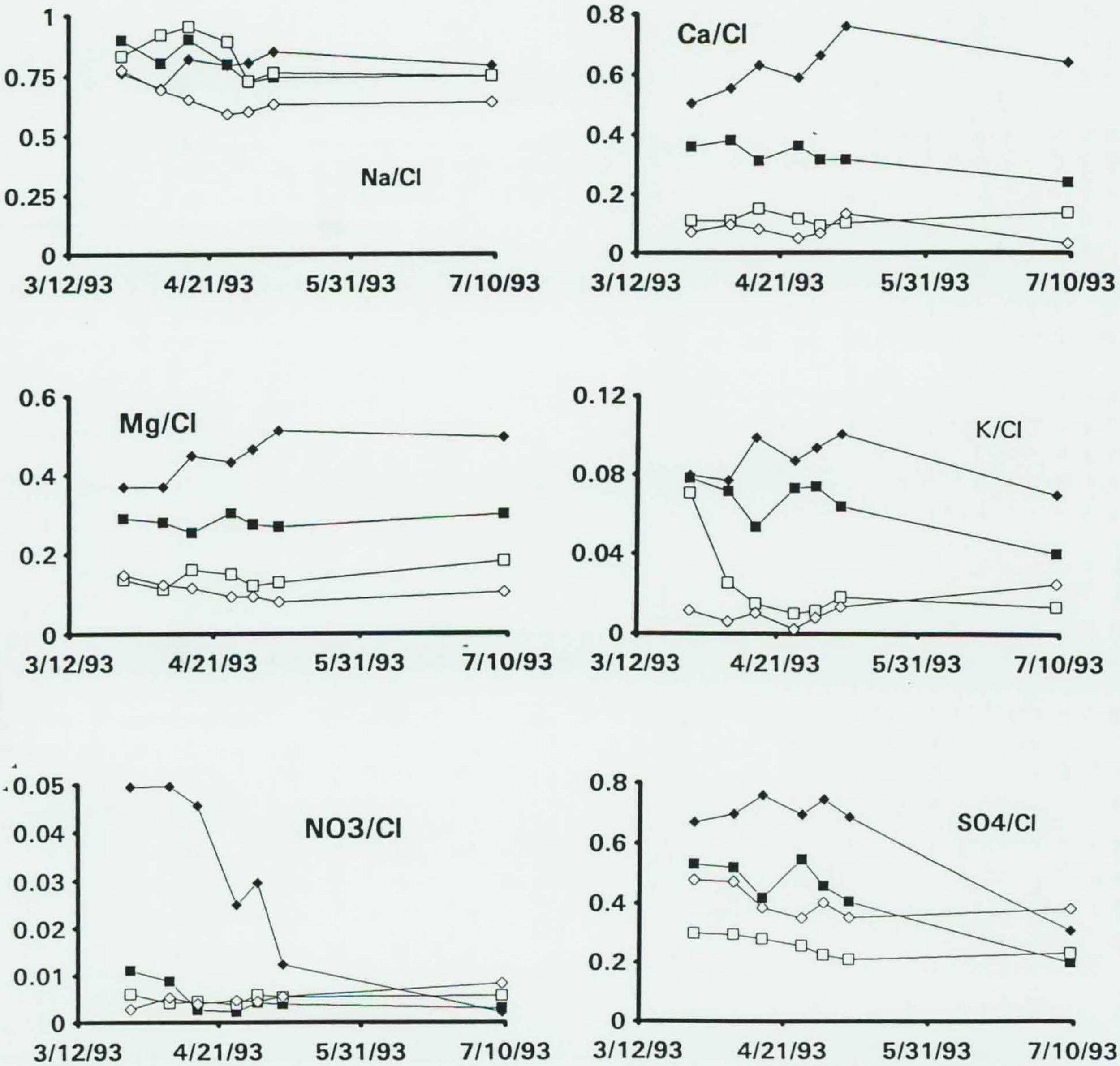

Figure 3. Changes in molar ratios with respect to chloride for the Calverton Ponds.

DISCUSSION

The study affords a comparison between a pristine, a near pristine and a disturbed pine barrens pond. Grassy pond, the most remote of the three appears to be the most pristine of all three ponds. It has the lowest major constituent concentrations and it resembles the composition of the shallow ground water collected in the pine-oak forest. This shallow ground water is very similar in composition to streams in undisturbed watersheds in the New Jersey Pine Barrens (Schoonen and Brown, 1994; and Morgan and Good, 1988). Characteristic for pristine pine barrens water is its very low nitrate concentrations and high acidity (low pH). Interestingly, the nitrate level in Fox Pond (disturbed) and Big Sandy Pond (near pristine) are initially higher than either Grassy Pond or the well but in July their nitrate levels dropped below those in the pristine waters. It is possible that higher phosphate loadings in Big Sandy Pond and Fox Pond allow for a higher primary productivity, which would result in a higher rate of nitrate removal in these ponds than in Grassy Pond. Although speculative, this would be consistent with a phosphor-limited ecosystem. The near pristine conditions in Big Sandy Pond may be due to mixing of Fox Pond water with pristine water. This is possible because some Fox Pond water flows into Big Sandy Pond.

The elevated Ca, Mg, and K concentrations in Fox Pond and their increase in April and May is consistent with the use of soil-pH adjusters and fertilizers. There are two possible sources for these constituents. Although the flow between Linus and Fox Pond appears to be very small it is possible that Linus Pond water is disturbed. However, we have no data on Linus Pond to evaluate the relative importance of this source. A second possible source are three houses upgradient from Fox Pond. One of these houses has a large vegetable garden (±2 acres). Pristine pine barrens soils are acidic and nutrient poor. Hence, to improve yields it is necessary to raise the pH through liming (i.e., addition of $CaCO_3$) and apply fertilizers. Fertilizers typically contain soluble potassium salts (including KCl), Mg salts, sulfate, and P and N. However, the P and N components are typically far better retained than Mg, Ca, K, and SO_4. This may be why no P could be detected in Fox Pond.

In addition to fertilizers, septic tank effluent may be an important source of nitrogen in Fox Pond. All three houses upgradient from Fox Pond rely on septic systems. Septic tank effluent contains typically about 3000 μ moles/L nitrate-nitrogen (see e.g., Roberts et al., 1991). Because septic tanks are placed below the rootzone of most plants there is little uptake of this nitrogen before it reaches the water table. With a concentration more than three orders of magnitude higher than pristine pine barrens water, only a contribution of 1 volume % of effluent to the pond would lead to a tenfold increase in nitrogen concentration.

What is particularly important to note is the far reaching effects anthropogenic inputs such as fertilization and septic tank effluent may have. Although it has not been conclusively shown that the houses are an important source of constituent for Fox Pond, it is clear that the pond is disturbed even though it is located more than a thousand feet away from the nearest house. If the houses are a major source, it means that plumes may travel much further than the current setback rule used by towns. This is not unreasonable because the upper glacial aquifer is very permeable and therefore there is little dispersion and pollutants can travel fast (*cf.* Robertson et al., 1991). If Linus Pond is a major source it implies that the streams interconnecting the fresh water wetlands in the CPBLI are important pathways for contaminant transport. It is clear that a study to evaluate the importance of surface versus subsurface flow in this area is of great importance in developing a sound conservation plan.

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