A Comparison of the Chemistry of Soil Surrounding Natural and Anthropogenic Ponds at Brookhaven National Laboratory

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ABSTRACT

Brookhaven National Laboratory (BNL) is located in the Long Island Pine Barrens, an area formed through decomposition and reworking of glacial materials. BNL has many wetland structures including costal plain ponds, vernal ponds, recharge basins, and streams. Some of these serve as breeding grounds for tiger salamanders (*Ambystoma tigrinum*), a species listed as endangered by the New York Natural Heritage Program. Anthropogenic habitats need to possess suitable characteristics with respect to soil and water chemistry in order to serve as successful breeding habitats for tiger salamanders. Soil is an important factor in controlling vegetation and water chemistry. In this study five ponds were selected for a study of soil chemistry: two natural (BP9, BP6) and three anthropogenic (BP7, BP13, MM). Nine soil samples were collected from each pond, eight around the perimeter and one from the pond bottom. Global Positioning System (GPS) was used to locate the sample points and ArcGIS was used to map the ponds and sample points. Soil samples were tested for pH, nitrate nitrogen, phosphorus, potassium, aluminum, ferric iron, magnesium, sulfate, calcium, and chloride using LaMotte Combination Soil and LaMotte Soil Micronutrient Kits. Soil moisture content was also determined. Soil color, texture, structure, consistency, and mottling were also observed and recorded. Five of the nine soil samples from each pond were digested using EPA method 3050B for Acid Digestion of sediment, sludge, and soil and then tested for copper, iron, molybdenum, magnesium, cadmium, aluminum, chromium, manganese, potassium and lead using an Inductively Coupled Plasma – Atomic Emission Spectroscope (ICP-AES). The natural ponds were more acidic then the anthropogenic ponds. The soil temperature is higher around the anthropogenic ponds (BP7, BP13, MM) than the natural ponds (BP9, BP6). Nutrient levels were low and consistent across pond types. Though these differences exist, both types of ponds accomplish the goal of providing suitable breeding sites for tiger salamanders (*Ambystoma tigrinum*). This information will serve as baseline data for BNL's natural resource manager and enable BNL to optimize the management of amphibian and reptile habitats.)

Introduction

The soils of the Long Island Pine Barrens (LIPB) were developed by deposition and reworking following several advances of Pleistocene glacial ice [1]. The soil is made-up of 80-96% sand and is very well-drained, nutrient poor, and acidic [2]. The vegetation types that characterize the LIPB are influenced by its soil's profile [3]. Only vegetation that is able to withstand the harsh conditions of droughty soil, low nutrient levels, and acidity is able to persist. Many of the plants present produce waxes, resins, or volatile oils that reduce both water loss and insect herbivory. This adaptation, which enables vegetation to exist in pine barren soil, also increases the potential for fires [4]. Pitch pine (*Pinus rigida*) is the dominate canopy tree of the LIPB; one or more oak species (*Quercus coccinea*, *Q. alba*, *Q. velutina*) are also normally present. The shrub layer is dominated by ericaceous plants such as huckleberry (*Gaylussacia baccata*) and blueberries (*Vaccinium* spp.) [2].

Land clearing, development, and fire suppression have destroyed much of the LIPB [1]. Brookhaven National Laboratory (BNL), an advocate for preserving the natural beauty of the LIPB, is located in the Central Pine Barrens of Long Island. BNL has many wetland structures including coastal plain ponds, vernal ponds, recharge basins, and streams. Coastal plain ponds are circular depressions that are nutrient- poor, acidic, and ground water fed. They are typified by seasonally fluctuating water levels; ponds which regularly dry out completely are called vernal ponds [4]. Some of these serve as breeding grounds for tiger salamanders (*Ambystoma tigrinum*)(fig.6.), listed as a state endangered species by the New York Natural Heritage Program. Tiger salamanders have been known to breed at sixty-one sites within the Long Island Pine Barrens. Vernal ponds and coastal plain ponds, because of their seasonally fluctuating water levels, are fish free habitat, eliminating the main source of predation of the salamander's eggs and larvae [4].

To enhance the population of tiger salamanders in the Central Pine Barrens anthropogenic habitats are being introduced. The main goal of introducing anthropogenic habitats is to reduce the loss of ecological function by providing habitats that are functionally equivalent to natural habitats [5]. To categorize an anthropogenic habitat as flourishing its ecological functions (hydrologic [e.g., soil], biochemical [e.g., water chemistry] and habitat [e.g., vegetation]) must be compared to the ecological functions of a successful natural habitat [5, 6]. Comparing the soil chemistry of natural and anthropogenic ponds on BNL will allow us to assess the suitability of the latter as alternative breeding sites for tiger salamanders. This research will provide baseline data for BNL's natural resource manager and enable BNL to optimize the management of amphibian and reptile habitats.

Fig.1. Natural Pond (BP9)

Fig. 2. Anthropogenic Pond (BP7)

MATERIALS AND METHODS

Five ponds within Brookhaven National Laboratory were selected for study: two natural (BP6, BP9) and three anthropogenic (BP7, BP13a, MM). Nine soil samples were collected from each pond, one from the center of the pond and eight from around the pond two meters from the shoreline. The center of the pond was found using Global Positioning System (GPS). The other eight samples were collected at each cardinal point (N, S, E, W) and the midpoint between each of them (NE, NW, SE, SW). Soil temperature, texture, structure, consistency, and litter depth was recorded at each sample location. At each of the eight terrestrial sampling points a circular plot representing 0.588 sq.m. was set out and five randomly selected points within the plot were marked. At each of the five points approximately 20 grams of soil was collected; these were mixed to create an approximately 100 gram sample from each plot.

To determine soil moisture content 10g from each sample was placed in a pre-weighed container and oven dried for 48 hours at 65°C. The remaining soil was air dried for 24 hours. Soil color, both wet and dry, was observed and recorded using Munsell Soil Color Charts. Each soil sample was tested for pH, nitrate nitrogen, potassium, phosphorus, magnesium, calcium, chloride, ferric iron, sulfate, and aluminum using LaMotte Combination Soil and LaMotte Soil Micronutrient Kits.

Five grams of air-dried soil from the north, south, east, west and center samples of each pond was digested using EPA method 3050B for Acid Digestion of sediment, sludge, and soil and then tested for copper, iron, molybdenum, magnesium, cadmium, aluminum, chromium, manganese,

Fig. 3 Collecting soil sample from BP9

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RESULTS

•Natural ponds had lower pH values than anthropogenic ponds (fig.4)

•Soil temperatures of anthropogenic ponds were higher than the soil temperature of natural ponds (fig.5)

•The levels of various elements were greater in the sediment sample than the perimeter soil samples (Table 1)

SAMPLE	Mo (ug/g)	Cu (ug/g)	Ag (ug/g)	Cr (ug/g	Al (ug/g)	Fe (ug/g)	Mg (ug/g)	Mn (ug/g	Pb (ug/g)
BP6 SOIL	3.220	25.732	7.261	12.221	4548.300	2131.700	399.920	145.710	38.578
BP6 SEDIMENT	0.000	11.208	3.210	30.968	26948.000	6788.000	1089.200	86.200	150.080
BP7 SOIL	0.000	44.328	0.000	22.231	8934.000	8924.000	892.200	104.050	73.059
BP7 SEDIMENT	5.800	195.040	0.000	87.680	22124.000	21760.000	2650.000	180.360	25.940
BP9 SOIL	5.015	6.591	1.907	4.966	2905.900	2007.900	139.547	66.110	63.594
BP9 SEDIMENT	0.000	0.000	0.000	14.708	2138.000	1119.600	85.000	62.480	111.080
BP13a SOIL	0.000	7.841	0.000	13.801	6696.000	8346.000	741.400	109.840	84.630
BP13a SEDIMENT	11.752	24.776	0.000	36.092	21116.000	20448.000	2242.000	169.600	258.040
MM SOIL	0.000	17.985	0.750	20.115	7285.333	9606.667	698.800	133.707	22.080
MM SEDIMENT	0.000	15.620	13.644	0.000	5796.000	8708.000	673.200	193.120	0.000
CONTROL	0.000	0.657	30.340	4.988	55.160	0.000	0.000	76.680	0.000

Table1. ICP-AES for Soil and Sediment

Site	pH	Soil Temp	Litter Depth (mm)	Nitrate (lb/ac)	Phosphorus (lb/ac)	Calcium (ppm)	Chloride (ppm)	Sulfate (ppm)
BP6	5.26	18.9	14.5	3.89	15.56	77.78	144.44	0
BP7	6.07	24.9	13.4	6.67	13.89	116.67	0	0
BP9	4.82	19.6	30.9	3.89	15.56	0	0	0
BP13	5.96	27.1	1	7.22	29.44	0	2.78	0
MM	5.838	25.7	0	3.75	1	0	12.5	0

Table 2. LaMotte soil test results

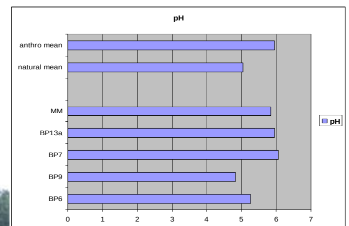

Fig.4. Soil pH

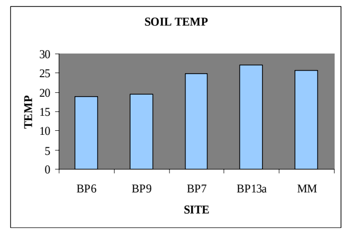

Fig. 5. Soil Temperature

DISCUSSION AND CONCLUSION

The landscapes of the three anthropogenic ponds differed from those of the two natural ponds. The anthropogenic ponds lack a canopy (fig.2), the soil mainly covered with herbaceous vegetation within the testing perimeter. The natural ponds possess a canopy consisting of a mixture of hardwoods and pitch pine (*Pinus rigida*) (fig.1). Hardwoods commonly present include red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and oaks (*Quercus alba*, *Q. coccinea*). The shrub layer is dominated by blueberry (*Vaccinium corymbosum*). Greenbrier (*Smilax* sp.) is also common. The absence of a canopy is assumed to have an active role in some of the differences observed between the pond types. The soil temperature is higher around the anthropogenic ponds (BP7, BP13, MM) than the natural ponds (BP9, BP6). The soil sample sites around the anthropogenic ponds were in direct sunlight, increasing the soil temperature. The natural pond soil sample sites were completely shaded from the sun, causing the soil temperature to be lower. The presence of a canopy also played a role in the amount of litter around a pond. Soils of natural ponds are covered with more litter than the soils of anthropogenic ponds. The presence of decomposing organic matter at the natural ponds had an affect on soil pH, causing it to be more acidic than that of the anthropogenic ponds (fig. 4).

The presence of a canopy seems to have no effect on the presence of tiger salamanders. Tiger salamanders have been known to breed at both types of ponds on BNL. Valorie Titus, a researcher of tiger salamanders at BNL for the past few years, stated that: "Tiger salamanders are optimistic breeders; they are attracted to minimal disturbance." All of the ponds in this study have been successful breeding sites for salamanders at one time, and some continue to be. The three anthropogenic ponds presently are productive; one of the natural ponds (BP9) holds the same status. The other natural pond (BP6) is less productive. This lack of productivity is due to an alteration in hydrology.

The primary goal of an anthropogenic habitat is to function similar to or better than a natural habitat [5]. This study has revealed that the chemistry of the soil that surrounds anthropogenic and natural ponds is different at BNL. Though these differences exist, both types of ponds accomplish the goal of providing suitable breeding sites for tiger salamanders (*Ambystoma tigrinum*).

Fig.6. Tiger salamanders (*Ambystoma tigrinum*)

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