Comparative Ecological Study: Long Island Pine Barren Ponds, NY

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ABSTRACT

Comparative Ecological Study: Long Island Pine Barren Ponds, NY. LATONYA STEMLEY, HA'WANNA ST. CYR, MURTY S. KAMBHAMPATI (Southern University at New Orleans, New Orleans, LA 70126) TIMOTHY GREEN (Brookhaven National Laboratory, Upton, NY 11973).

The purpose of this research was to collect scientific ecological data on water and sediments from the Long Island Pine Barren Ponds including the ponds on Brookhaven National Laboratory (BNL) site and to compare results between the on-site (Zone-I) and off-site (Zone-II) ponds. The specific objectives were to: (a) analyze samples for physico-chemical factors; (b) compile and analyze data statistically; and (c) to identify the interrelationships between abiotic factors in ponds of two zones. We have collected 99 surface water and sediment samples (<15cm deep at 50 - 200m intervals, depending on size of each pond) randomly from 5 experimental sites (Groups 1-5). Experimental sites were plotted using eXplorist 200 Global Positioning System (GPS) and ArcInfo Geographic Information Systems (GIS). Field data were obtained on dissolved oxygen (DO), temperature, pH, turbidity, and conductivity using Yellow Spring Instruments, Inc. (YSI) probe. Water samples were analyzed using Hach DR890 colorimeter. Filtered and acidified water samples (pH<2) were used to estimate metal content using Directly Coupled Plasma Spectrometer (DCP). Sediment samples were air dried, sieved, and saved for elemental analysis using DCP. Macro and micronutrients were analyzed using LaMotte Soil Test Kits. Samples were also dried in an oven at 65^{0}C for 36-48 hr to obtain moisture. Water was acidic (5.31±0.35 to 6.84±0.13 at CP and GP, respectively) and low in DO (4.12±0.89 to

6.92±0.55 ppm at CP and SBP, respectively). Alkalinity ranged from 27.71.1±60 ppm in BNL ponds to 82.9332±0.50 ppm in GP. One-way ANOVA results indicated mean differences between groups (df = 4) and within groups (df = 28). Soil texture is mostly either sand or silt. Moisture content varied between 20.98±10.35 to 50.02±6.13% in NRP and BNL samples, respectively. Sediment ANOVA results indicated positive and negative significances ($P<0.05$ and $P<0.01$) between elements, aluminum (Al), iron (Fe), lead (Pb), and chromium (Cr). In conclusion, the Long Island Pine Barren pond water and sediments are acidic and nutrient poor.

INTRODUCTION

High acidity in the Long Island Pine Barren ponds is one of the major concerns to the Natural Resource Management group of Environmental Science at BNL and the Suffolk County Chapter of The Nature Conservancy, for several ecological reasons, such as: quality of water and sediments; role of acid rain and deposition; effect of salting roads during the winter months and its impact on the quality of water and sediments and consequently on biota including some rare and endangered species, to name a few. Water and sediment quality in wetlands of northeastern regions of the USA has been documented [1]. Available literature on ecological studies of the Long Island Pine Barren complex wetlands is very scanty and very minimal [2 & 3]. We have investigated a total of 33 ponds across the Suffolk County and collected data on a wide range of limnological factors, including heavy metals in water and sediments, to compare with previous research findings. Sediment in pond waters is an important ecological factor and plays a critical role on biotic organisms and the water quality. Phosphorus plays a critical role in water quality and plant growth in fresh water bodies [4, 5, 6, & 7].

No peer-reviewed literature published in scientific journals is available on the environmental health issues, such as water and sediment chemistry and its impact on biota, of the Long Island Pine Barren Ponds. Hence, the purpose of this research was to collect scientific ecological assessment data on water and sediments from the on- and off-sites of BNL and to establish a database for future studies, and management and conservation of natural resources on Long Island. The specific objectives were to: (a) analyze samples for physico-chemical factors; (b) compile and analyze data statistically; and (c) identify the interrelationships between abiotic factors.

Our hypothesis was that the Long Island Pine Barren pond water and sediments would be acidic, nutrient poor, and free of contaminants. There would be no significant difference in mean values (<0.05 and 0.01) of physico-chemical factors between and within the groups. We have investigated a total of 33 ponds in two major sections of the Long Island Pine Barrens (LIPB): on-site zone (BNL: P1-10 & P21-24) and off-site zone (Near Road Ponds-NRP: P11-13; Calverton Ponds-CP: P14-16 & P25-28; Sears Bellow Ponds-SBP: P17-20; and Greenbelt Ponds-GP: P29-33) as shown in Figure 1. The experimental sites are located between 18.679729-18.727803 E and 45.27536-45.40748 N.

MATERIALS AND METHODS

Three surface water and sediment samples (not more than 15 cm deep) at 50-200 m intervals (based on pond area and accessibility) were collected from each pond, over a period of 10 weeks. Sediment samples from each pond were thoroughly homogenized and saved a representative sample in 250 mL Nalgene bottles for physical and chemical analyses. The sampling sites were plotted, as shown in Figure 1, using eXplorist 200 Global Positioning System (GPS) and ArcInfo Geographic Information Systems (GIS). Water samples were kept on ice for chemical analysis (within 24 hrs.). Field data on DO, temperature, conductivity, pH and turbidity in water were obtained using the YSI (Yellow Spring Instrument Inc.) probe. HACH-DR 890 (the colorimeter) was used to test total tannin, phosphorus, and suspended solids. The Digital Titration-16900 was used for testing total hardness and alkalinity. Approximately 2-5 mL 1:1 nitric acid:DI water was added to each sample (100 mL filtered water using Whatman 40 filter paper), and preserved the samples for trace metal analysis.

Sediment samples were air-dried and sieved through 2mm sieve to remove organic matter such as roots. Air dried samples were used to measure macro and micro nutrients using LaMotte

Soil Test Kits (pH, K, P). Percentage of moisture was obtained by drying samples in an oven at 65^{0} C for 36 to 48 h. Air-dried sediment samples were used to determine soil texture using Fisher Scientific Standard Testing Sieves (45 - 2000µm). Soil samples (5g each) were digested using 100mL Kjeldahl flasks, following EPA 3050B method. Samples were digested with concentrated 10mL nitric acid (HNO_3) and 10mL hydrochloric acid (HCl) and were allowed to soak overnight. Samples were then digested on hot plates (not more than 95^{0}C) for 3-4 h and let the samples to cool overnight and filtered using Whatman 541 filter paper. Digestion extracts were diluted with deionized distilled water and made the final volume to 100 mL using volumetric flasks, labeled, and saved in 125 mL Nalgene bottles for Directly Coupled Plasma (DCP) spectrometer analysis to estimate Al, Pb, Mo, Cr, Mg, K, Fe, Ca, and Mn.

RESULTS

Water chemistry: Water was acidic (5.31±0.35 to 6.84±0.13 at CP and GP, respectively) and low in DO as shown in Figure 3b (4.12±0.89 to 6.92±0.55 ppm at CP and SBP, respectively). Alkalinity ranged from 27.71.1±60 ppm in BNL ponds to 82.9332±.50 ppm in GP (Figure 3c). Maximum conductivity (0.29±0.04µs/cm^3) was recorded in NRP samples. Metal content in water samples is summarized in Table 2. One-way ANOVA results indicated mean differences between groups (df = 4) and within groups (df = 28) and two-tailed Pearson correlations indicated significant relationships between various physico-chemical factors at $P<0.05$ and $P<0.01$, as shown in Tables 3a & 3b.

Sediment Chemistry: The sediments were acidic 6.16±0.17 to 7.00±0.35 in NRP and GP samples, respectively) and nutrient poor. Moisture content varied from 20.98±10.35 to 50.02±6.13 % in NRP and BNL samples, respectively. One-way ANOVA results confirmed positive and negative significant ($P<0.05$ and $P<0.01$) relationships between elements, aluminum

(Al), iron (Fe), lead (Pb), and chromium (Cr). Two-tailed Pearson correlation data are summarized in Tables 4a & 4b. Among all the variables studied in sediments, Mg and Fe had highest positive significant relationship (0.922**; $P<0.001$). Most of the sediments have higher concentrations of Al. Results are summarized in Figure 4b. Trace metal concentrations are very low in all sites we studied.

STATISTICAL ANALYSIS

Mean, variance, standard deviation, standard error, Pearson two-tailed correlations, and one-way ANOVA were applied to measure significance levels between and within groups of sample sites (Zones 1 & 2) using SPSS 10.0 version.

DISCUSSION AND CONCLUSION

Historically, a majority of the Long Island Pine Barren Ponds is shallow with acidic waters and sediments with low concentrations of essential nutrients such as nitrogen and phosphorus. Research results have indicated high acidic sediments along with excess amounts of Al and acidic waters in the Long Island Pine Barren Ponds. Borg (1987) made similar observations that surface water in North America has become acidic due to acid compounds and metals [7]. Ramachandran *et al* (1997) reported that carbon dioxide concentrations are higher in the summer, which can lead to the cause of the water being very acidic. They have also observed that the suspended solid concentrations were higher in the summer when compared to autumn [8]. Experimental results indicated that all our study sites have low DO, and excessive amounts of tannins and suspended solids in acidic waters and sediments. Studies have shown, however, when the pH is higher the nitrogen levels decline or were at a minimal [9]. Singer and Stumm (1970) suggested that there are multiple factors, including biological and chemical factors, affecting the pH of water [10]. Kemp (1970) reported that waters of low pH have higher alkalinity and total hardness and water of high permanent hardness should be corrosive [11]. Salzman et al. (2001) opined that the chemical behavior of water could be affected by the oxygen's direct influence by plants [12]. Our results indicated NRP water samples have high conductivity, which could be attributed to salting during winter seasons and their consequent run-off into roadside ponds. We found that higher concentrations of Al in acidic soils. This particular feature has influence on Ca concentrations as reflected in Figure 5 and Tables 4a and 4b.

In conclusion, experimental results were in partial agreement with our hypothesis (nutrient poor, low DO, and high turbidity). However, we reject null hypothesis, since our hypothesis was proven wrong regarding contaminants and mean differences among the groups of data sets. We have also observed that water and sediments of ponds in different locations of the LI Pine Barrens have higher concentrations of metals (Al and Fe).

ACKNOWLEDGEMENTS

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Tables

Elements	DL
Ca	0.044
Mg	0.002
Fe	0.028
Mn	0.014
Ni	0.036
Al	0.05
K	0.24
Cr	0.022
Pb	0.097

Table 1. Detection Limits for Directly Coupled Plasma (DCP) Spectrometer.

Site		Ca	Mg	Fe	Mn	Ni	Al	K	Cr	Pb
BNL	**Mean**	1.78	0.88	0.52	0.05	0.01	0.10	0.93	0.01	0.07
n = 14	**SE**	0.44	0.19	0.12	0.01	0.01	0.01	0.21	0.01	0.02
NPR	**Mean**	5.55	2.53	1.30	0.15	-0.01	0.05	2.03	0.00	0.17
n = 3	**SE**	1.64	0.42	0.54	0.05	0.00	0.01	0.47	0.01	0.16
CP	**Mean**	2.05	1.04	1.10	0.04	0.00	0.08	1.09	0.01	0.10
n = 7	**SE**	0.50	0.18	0.26	0.01	0.00	0.03	0.41	0.01	0.06
SBP	**Mean**	1.17	0.85	1.98	0.05	0.02	0.09	0.57	0.03	0.07
n = 4	**SE**	0.27	0.11	0.96	0.01	0.01	0.03	0.19	0.01	0.06
GP	**Mean**	5.46	2.65	0.37	0.04	0.08	0.08	1.63	0.07	0.26
n = 5	**SE**	2.08	0.90	0.12	0.01	0.07	0.06	0.69	0.06	0.22

Table 2. Results on various elements (macronutrients and toxic metals) in the Long Island Pine Barren Ponds.

Temp	Tan	-0.425
Temp	Mn	-0.346
pH	Cond	0.356
pH	Turb.	-0.388
Cond.	Alka.	0.433
Turb.	TSS	0.383
Turb.	Mg	0.375
Acid.	Al	-0.37
Alka	K	0.436
Ca	Al	-0.394
Ca	K	0.435

Table 3a. Pearson Correlations: Water Quality (n = 33; P < 0.05).

DO	P	-0.463
Temp.	TSS	-0.5
pH	Tan.	-0.442
pH	Acid.	0.617
pH	Alka	0.522
pH	Ca	0.642
pH	Fe	0.45
Cond.	Acid.	0.487
Cond.	Ca	0.494
Cond.	Mn	0.643
Turb.	Tan.	0.451
TSS	Tan.	0.78
TSS	Mg	0.545
TSS	Al	0.486
Tan.	Mg	0.679
Tan.	Al	0.456
Acid.	Ca	0.951
Acid.	Fe	0.824
Acid.	K	0.454
Alka.	Ca	0.813
Alka.	Fe	0.827
Ca	Fe	0.739
Mg	Al	0.484
Fe	K	0.451
Ni	Al	0.537
Ni	Cr	0.985
Al	Cr	0.483

Table 3b. Pearson Correlations: Water Quality (n = 33; P<0.01).

Ca	Pb	0.415
Ca	Mn	0.431
Ca	Al	0.42
Mg	Mn	0.405
Mn	Ni	0.369
Mn	Al	0.393

Table 4a. Pearson Correlations: Sediment Quality (n = 33; P<0.05).

Ca	Mg	0.602
Ca	K	0.469
Ca	Cr	0.568
Ca	Fe	0.598
Ca	Ni	0.483
Mg	K	0.828
Mg	Cr	0.543
Mg	Fe	0.922
Mg	Al	0.892
K	Cr	0.498
K	Fe	0.843
K	Mn	0.48
K	Al	0.876
Cr	Fe	0.516
Cr	Mn	0.483
Cr	Ni	0.781
Cr	Al	0.463
Fe	Mn	0.55
Fe	Al	0.82

Table 4b. Pearson Correlations: Sediment Quality (n = 33; P<0.01).

Figures

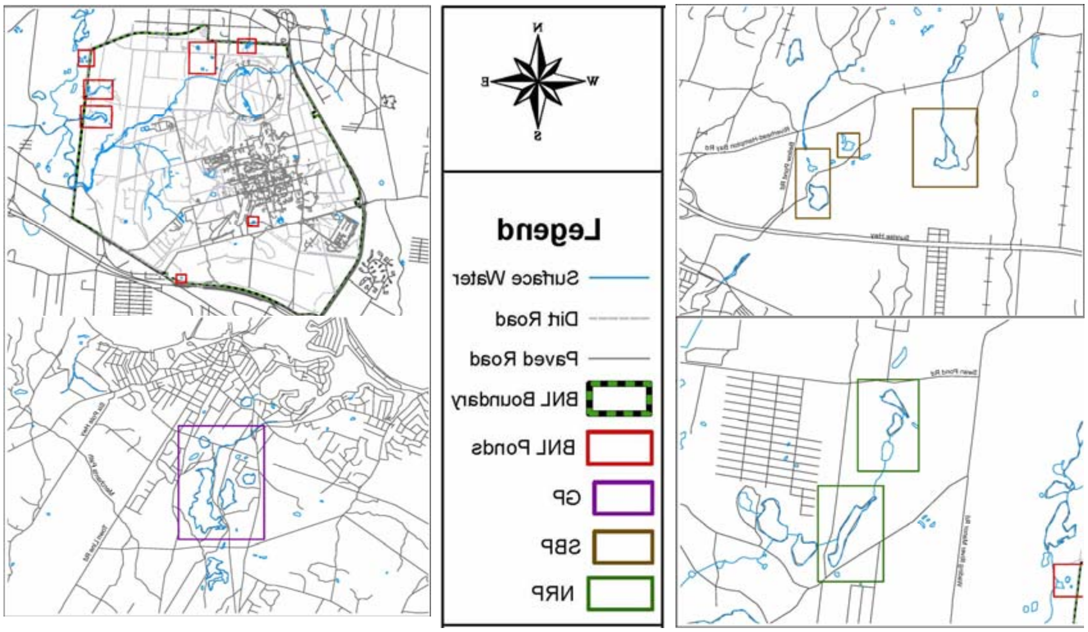

Figure 1. The Long Island Pine Barren Ponds: Experimental Sites.

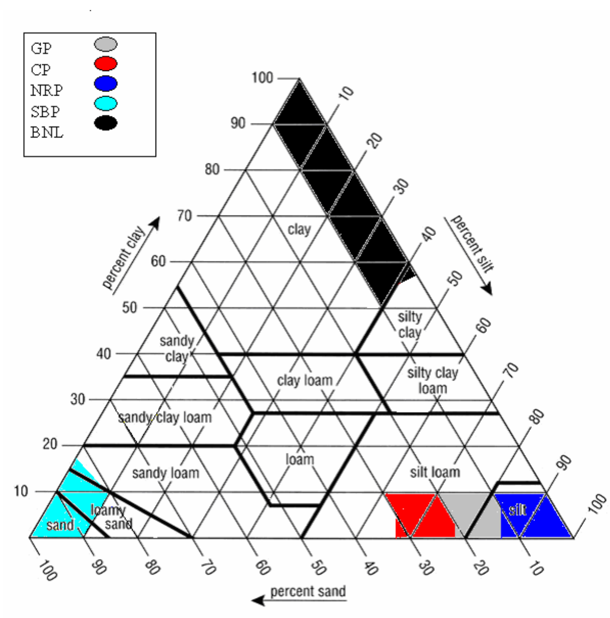

Figure 2. Sediment Texture (Soil Triangle: http://soils.usda.gov/technical, [14]).

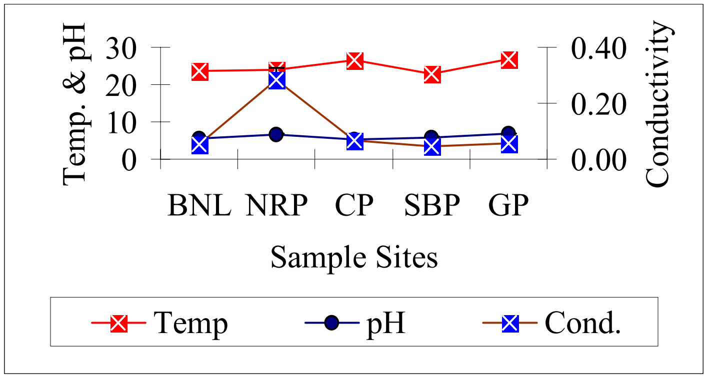

Figure 3a. Water Quality of Long Island Pine Barren Ponds: Temperature (^{0}C), pH, and Conductivity (µS/cm^{3}).

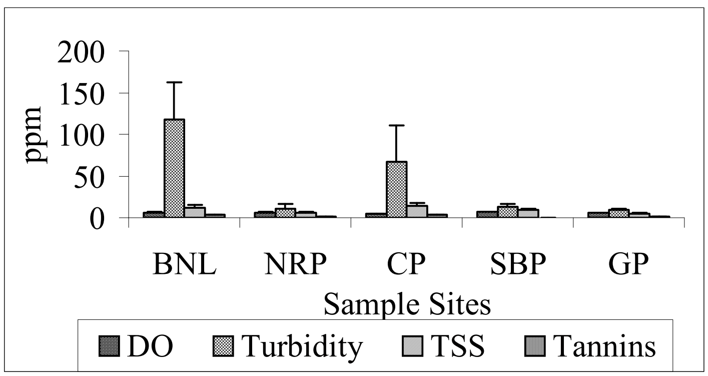

Figure 3b. Water Quality of Long Island Pine Barren Ponds: Dissolved Oxygen, Turbidity, Total Suspended Solids, and Tannins (ppm).

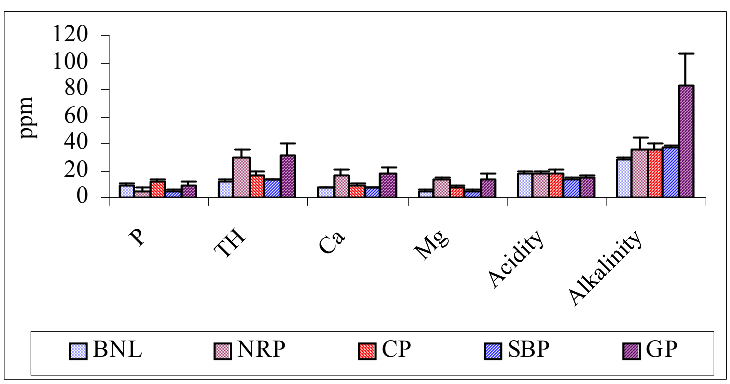

Figure 3c. Water Quality of Long Island Pine Barren Ponds: Phosphorus, Total Hardness, Calcium, Magnesium, Acidity, and Alkalinity (ppm).

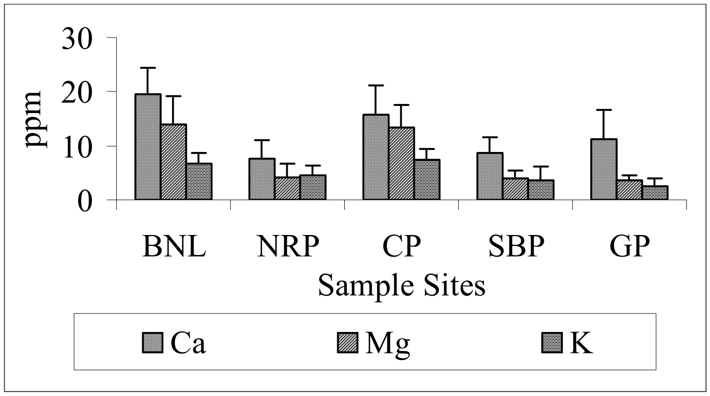

Figure 4a. Sediment Quality of Long Island Pine Barren Ponds: Calcium, Magnesium, and Potassium (ppm).

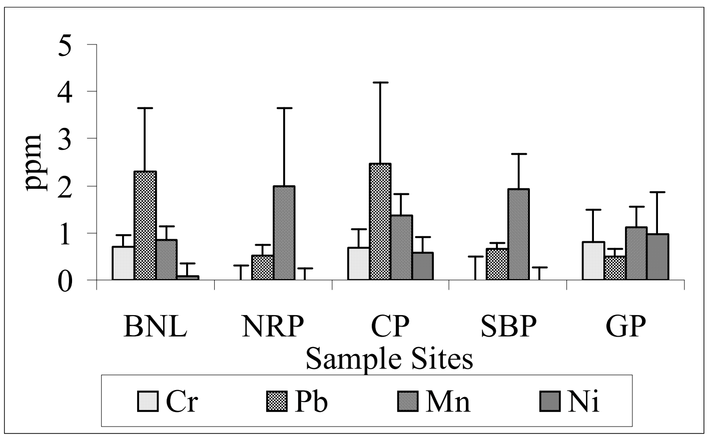

Figure 4b. Sediment Quality of Long Island Pine Barren Ponds: Chromium, Lead, Manganese, and Nickel (ppm).

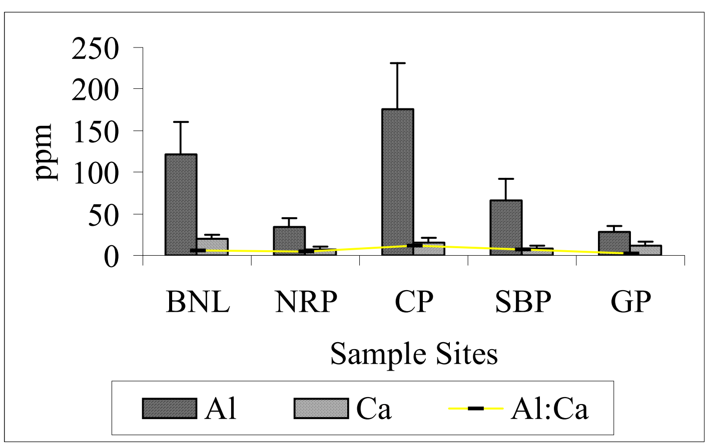

Figure 5. Sediment Quality of Long Island Pine Barren Ponds: Aluminum and Calcium Ratios (ppm).