The purpose of this research was to collect comprehensive physico-chemical health data on water and sediments from the remediated and natural sites of Peconic River (PR) headwaters complex at Brookhaven National Laboratory (BNL) and to compare results with available earlier findings. 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 physico-chemical factors. We hypothesized that waters of PR would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. We have collected 54 surface water and sediment samples from ten sites at 15 m intervals (Table 1&2). Experimentally, we attempted to compare our findings with available earlier findings. 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 physico-chemical factors. We hypothesized that waters of PR would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. We have collected 54 surface water and sediment samples from ten sites at 15 m intervals (Table 1&2). Experimentally, we attempted to compare our findings with available earlier findings.

Introduction

Brookhaven National Laboratory (BNL), owned by the U.S. Department of Energy (DoE) and operated by associated Universities, Inc., is located on Long Island, NY, and encompasses about 2,765 acres of the native Long Island Pine Barrens ecosystem (Figure 1). Experimental data of DoE at BNL indicated the presence of organic and approximately 14 inorganic contaminants (metallic mercury, copper, mercury-, Fe, Al, Cr, Cd, and Pb) in the sediments of the PR, due to the laboratory practices during the 1940’s through the 1989 [1,2]. Sediment in monitoring waters is an important ecological factor and plays a critical role on benthic organisms and the water quality. Pollution load in a watershed is established independently of the river flow of the river and concluded that low flow periods or when the capacity of the river is reduced, the level of DO can fall which eventually prevents survival of aquatic species [3]. Problems such as low DO, fish extinctions, and algal blooms in flowing waters were discussed [4]. Data on the total concentrations of phosphorus (P), calcium (Ca), and Fe in surface sediments were investigated on several locations of Thames catchments, River Swale in Yorkshire, and the headwaters of the Great Ouse [5]. Phosphorus plays a critical role in water quality and plant growth in fresh water bodies [6,7,9].

Statistical Analysis

Mean, variance, standard deviation, median, standard error, student t-test, Pearson two-tailed partial correlations, and one-way ANOVA (Tukey and Duncan tests) were applied to measure significance levels between groups (remediated and natural sites) using SPSS 13.0 version.

Materials and Methods

Eight surface water and sediment samples (not more than 15 cm deep) at 15 m intervals were collected, from each site of a total of seven experiment sites from PR headwater complex at BNL over a period of 15 m interval from May to July 2000. Nickel bottles, respectively. The sampling sites were plotted, as shown in Figure 1, using Experstar 200 Global Positioning System (GPS) and Archio Geographic Information Systems (GIS). Water samples were kept in a cooler for chemical analysis. Field data on DO, temperature, conductivity, pH, turbidity, and water color were obtained using the YSI Yellow Spring Instrument, Inc. probe. Hach DR900 (the colorimeter) was used to test total chlorine, nitrate and ammonia N, inorganic, sulfates, phosphates, and suspended solids. The Digital Titrator-T800 was used for testing total hardness and alkalinity. The open titration method was used for alkalinity and chlorides, nitrate in samples in an open at 60°C to 80 °C. For 46 h. Air-dried sediment samples (each) were digested with 100 mL, Kjeldahl flask, following EPA 3050B method. Samples were digested with concentrated HNO3 (18ML) and HNO3, and HCl and (HNO3) and (HCl) and (HNO3) were allowed to cool overnight. Subsamples were then digested on hot plates (test more than 95 °C) for 3 h and for the samples to cool-off overnight and filtered using Whatman 541 filter paper. Digested extracts were diluted with deionized distilled water and made the final volume to 100 mL, using volumetric flask, labeled, and sealed in 15 mL. Nickel bottles for ICP analysis were replicated and at least five replicates for each sample was used for the ICP (Inductive Coupled Plasma) emission spectrometer analysis to estimate Ag, Al, Cu, Ni, Cr, Mo, Cu, Mg, Fe, Pb, Mn (EPA3050B method).

Results

Water chemistry

Water was acidic (pH 4.0±0.1 to 5.7±0.04 at LH2 and LH3, respectively) and low in DO as shown in Figure 2 (1.49±0.17 to 5.4±7.30 mg/L at LH4 and LH3, respectively). Samples had traces to zero chlorides, nitrates, and ammonia nitrogen, and sulfates. Alkalinity ranged from 0.00 to 6.25 mg/L at LH2 to 83.13±20 mg/L at LH7. Sediment ANOVA results indicated positive correlations (P<0.05 and P<0.01) between elements, aluminum (Al), iron (Fe), lead (Pb), and chromium (Cr). In conclusion, water and sediments of PR naturally have higher concentrations of metals (Al, Fe, Pb) than the remediated sites. In some instances, however, current elemental contents of Al, Cd, Fe, Pb, Mg, and potassium (K) in sediments of remediated sites were greater than the earlier observations (2003 and 2005).

Sediment Chemistry

The sediments were acidic (pH 4.0±0.0 to 6.2±0.04 at LH2 and LH5, respectively) and nutrient poor. Moisture content varied between 33.10±6.58 to 67.56±0.00 at LH3 and LH4, respectively (Figure 3). One-way ANOVA results confirmed positive and negative significant (P<0.05 and P<0.01) relationships between elements, aluminum (Al), iron (Fe), and lead (Pb), respectively. Two-tailed independent sample t-test and two-tailed Pearson correlations were used. The pH of 6.67% at LH1 LH2 LH3 LH4 LH5 LH6 LH7. Mercury (Hg) concentrations ranged from 0.00 (LH2) to 6.67 mg/kg at LH7. Sediment ANOVA results indicated a significant relationship between values of Fe and Pb and Mo and K. However, these values are still in excess of the earlier data published in BNL’s investigative reports, even in the remediated sites. In addition (Ca), and Fe in surface sediments were investigated on several locations of Thames catchments, River Swale in Yorkshire, and the headwaters of the Great Ouse [5]. Phosphorus plays a critical role in water quality and plant growth in fresh water bodies [6,7,9].

Discussion

BNL has a long history of inorganic and organic contaminants in sediments (1980s-1990s) and is listed as one of the US Environmental Protection Agency’s (EPA) National Priorities List. It is necessary to quantify the extent of risks to these contaminants. BNL has been a center of research for over 60 years. Measurements were made on a daily basis at the four sampling locations for each parameter. In this study, we attempted to investigate the interrelationships between physico-chemical factors. We hypothesized that waters of PR would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. We have collected 54 surface water and sediment samples from ten sites at 15 m intervals (Table 1&2). Experimentally, we attempted to compare our findings with available earlier findings. 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 physico-chemical factors. We hypothesized that waters of PR would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. We have collected 54 surface water and sediment samples from ten sites at 15 m intervals (Table 1&2). Experimentally, we attempted to compare our findings with available earlier findings.

Sediments of PR headwaters have a maximum of 38.89±29.37µgCu/g Dry Wt. at LH1, where we have observed an increased flow in Thames River [13]. Stow (2001) reported that symptoms of excessive eutrophication are algal blooms, low dissolved carbon dioxide concentrations are higher in the summer, which can lead to the cause of the water being very acidic. They have also observed excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. An additional 54 samples were obtained from this runoff, where sulfuric acid had been used for testing total hardness and alkalinity. The open titration method was used for alkalinity and chlorides, nitrate in samples in an open at 60°C to 80 °C. For 46 h. Air-dried sediment samples (each) were digested with 100 mL, Kjeldahl flask, following EPA 3050B method. Samples were digested with concentrated HNO3 (18ML) and HNO3, and HCl and (HNO3) and (HCl) and (HNO3) were allowed to cool overnight. Subsamples were then digested on hot plates (test more than 95 °C) for 3 h and for the samples to cool-off overnight and filtered using Whatman 541 filter paper. Digested extracts were diluted with deionized distilled water and made the final volume to 100 mL, using volumetric flask, labeled, and sealed in 15 mL. Nickel bottles for ICP analysis were replicated and at least five replicates for each sample was used for the ICP (Inductive Coupled Plasma) emission spectrometer analysis to estimate Ag, Al, Cu, Ni, Cr, Mo, Cu, Mg, Fe, Pb, Mn (EPA3050B method).

Conclusions

Experimental results were in partial agreement with our hypothesis (nutrient poor, low DO). We have rejected null hypothesis. However, our hypothesis was proven wrong regarding contaminations and mean differences among the groups of data sets. We have also observed that water and sediments of PR natural sites have higher concentrations of metals (Al, Fe, Pb) and lower in the remediated sites. In some instances, however, current elemental contents of Al, Cd, Fe, Pb, Mg, and K in sediments of remediated sites were greater than the earlier observations (2003 and 2005).

Acknowledgements

SUNY-FaST expresses sincere gratitude to the National Science Foundation (18RD-0163282/REBD-0622844) and the Department of Energy for the opportunity and financial support to participate in Peconic River Headwaters Research at BNL. Our special thanks are due to Henry Hardy, Joe Omojola and Carl Johnson (PESMaCT-SUNO); Noel Blackburn (FaST Program Manager), and Tim Green (our team leader) for the opportunity and financial support to participate in Peconic River Headwaters Research at BNL. Our special thanks are due to Henry Hardy, Joe Omojola and Carl Johnson (PESMaCT-SUNO); Noel Blackburn (FaST Program Manager), and Tim Green (our team leader) for the opportunity and financial support to participate in Peconic River Headwaters Research at BNL.