INCREASING SALINITY AFFECTS ON HEAVY METAL CONCENTRATION

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Abstract. Global climate change is being accelerated because of many anthropogenic reasons. This contributes to many ecosystems alterations throughout the world. Warmer temperatures and melting sea ice are two factors that contribute greatly to sea level rise, which is causing salt-water intrusion into many ecotones. The Hudson River wetland ecosystems will potentially experience this salt intrusion phenomenon. Salinity is increasing within tidal freshwater wetlands, altering these important ecosystems and their functionality. Wetlands along the Hudson River have also historically experienced high levels of heavy metal pollution; therefore, the sediments have stored heavy metals. The questions that I addressed are: 1) Will an increase in water salinity within the Tivoli wetlands draw stored lead out of the sediment? 2) Will the increase in salinity affect the lead absorption properties of the sediment? My hypothesis is that an increase in water salinity at the Tivoli wetlands will displace the lead stored in the sediment, increasing the heavy metal concentrations in the water and also decreasing the sediment's capacity to absorb lead from the overlaying water. Through a manipulative experiment, I tested the effects of multiple saline and lead solutions on Tivoli wetland sediment cores. There was not a significant increase of lead, within the overlaying water, that leached out of the sediment exposed to different salinities. Although all sediment cores continued to have lead absorption properties after the saline soak, there was a significant relationship between an increased saline water level and less absorption of lead from the overlaying water. This implies that an increase in salinity could contribute to lower uptake levels of lead pollution from wetland sediments.

INTRODUCTION

Tidal freshwater marshes are ecosystems present in the Hudson River watershed that are extremely threatened by sea level rise. These wetlands provide vital ecosystem services to human societies such as: waste filtration, biological productivity, ecosystem disturbance regulation, and aquifer recharge.

Due to these unique properties of wetland production, they are known to sequester various forms of pollution through sediment trapping and biological productivity. Within the Hudson River watershed, there has been much research on the presence of lead and other heavy metals, but not many studies on salt water intrusion effects on the behaviors of these metals in natural ecosystems in which they are present (Sritrairat 2012).

Lead pollution is an issue when present in any ecosystem because of its harmful properties that can cause neurological issues, blood disorders, and cancer in humans and other mammals (Ouadjenia-Marouf 2010). The lead pollution that is present in the Hudson River is largely due to New York's long history of manufacturing since the industrial revolution. Leaded gasoline, lead pipe, and lead paint production on the river have largely contributed to the concentrations of lead stored in the sediment throughout the watershed. Lead poisoning can occur from very low concentrations and is also known to affect children health severely.

Like lead, salt within seawater is a positively charged and when interacting with lead has a potential to experience a chemical reactions; such as an ion exchange. Water salinity widely influences wetland biogeochemical processes through chemical and physical aspects (Bia et al. 2012). The Tivoli wetland sediment contains various amounts of silt, which has properties that attract heavy metals (Sritrairat 2012 and Ouadjenia-Marouf 2010). An increased salinity, which is a cation, may contribute to cation displacement of heavy metal stored in the sediment. Lead could experience a cation exchange with salt thereby releasing Pb to the overlying water. If an ion exchange occurred between saline compounds and ionic lead compounds, it could release lead into overlaying water and contaminate the freshwater source with dangerous pollutants. It has been observed that an increasing level of salinity may be correlated with an increasing level of metals, but causation has not been established (Ouadjenia-Marouf 2010).

An increase in salinity also has the potential to completely saturate the cation exchange capacity of the sediment, which could decrease the sediments ability to store lead and decrease the wetlands capacity to sequester lead pollution from the natural environment. These attributes would theoretically prevent the attraction of heavy metals into the sediment; increase the availability of heavy metals in the water.

I conducted this experiment to determine if increasing salinity in the Tivoli wetlands will affect lead release or sorption by these sediments. This could occur in two ways; drawing the lead out of the sediment, and preventing the sediment from filtering lead pollution out of the environment. The implication of increasing heavy metal concentrations is harmful to the water quality, wildlife, ecology, and the surrounding human populations. These findings are important because this issue could threaten potable water availability and affect movement of heavy metals in all areas where these contaminants are present. This could be another contributing factor to the water crisis that is already underway due to climate change.

METHODS AND MATERIALS

I tested the initial lead and salinity levels in the Hudson River water samples with the Inductively Coupled Plasma Optical Emission Spectrometer (ICPOES) at the CIES Analytic Lab to determine the lead concentration, and a Conductivity meter to test the salinity concentration before any treatment was given. I collected a total of 30 sediment cores at 42°02'30.5"N 73°55'13.1"W within the wetlands in the Tivoli bay wildlife management area in Red Hook, NY. These cores were all at least 10 centimeters long and were stored within 2inch PVC pipes. All of the glassware used in this experiment was washed with nitric acid by the standard procedures.

To test the effects of salinity on lead displacement properties in the soil, there were 5 salinity treatments made with Instant Ocean as solute and Hudson River water as the solvent. The 5 treatment concentrations were 0ppt salinity, 2ppt salinity, 8ppt salinity, 15ppt salinity, and 35ppt salinity. There were 6 cores for all treatments. I soaked the cores in the salinity treatment for 3 days by placing the solution on top of the core without removing the sediment from the pipe. I extracted the solution with a syringe and stored them in test tubes in the refrigerator. There were 3 cores that had to be excluded from the salinity treatment and 1 core that had to be excluded from the lead treatment because of contamination.

To test the lead absorption property of the saline saturated sediment cores I mixed an 18ppt solution of PbNO3 and I immediately poured the lead solution on all sediment cores after the saline treatment, using the 0ppt treatment as a control (Figure 1). I extracted the lead solution from the sediment cores with a syringe after 48 hours, acidified the lead samples with nitric acid to a pH of 2, and stored them in the refrigerator for one day before testing all of the solutions for lead. I tested all of the solutions with the ICP-OES.

The saline solution and the lead solution data sets were analyzed with analysis of variance (ANOVA) tests to determine any significant differences in lead concentrations between salinity treatments.

RESULTS

The initial salinity level and lead level in the Hudson River water sample was 0ppt and 0ppm respectively. The ANOVA analysis of Pb in the five salinity treatments showed that there was no significant difference between the treatments with a P-value of 0.2 (Figure 2). The means between treatments were not significantly different. There is no causation between an increase in saline and an increase in release of stored Pb from the sediment. The ANOVA analysis between the lead solutions showed a significant difference in lead concentration with a P-value of 0.003 (Figure 3). The largest difference was demonstrated by the 35ppt saline treatment, which had the least capacity to absorb the lead from the solution.

DISCUSSION

Global climate change is a danger to wetlands, which are among the most important ecosystems and provide important services, such as: storm protection, groundwater recharge, water filtering, removing pollutants, and carbon sequestration. As the sea level rises, these ecosystems along the Hudson River are particularly threatened because they are at danger of becoming submerged and altered dramatically by the changing environment. Due to the geographical location and the elevation, the Tivoli wetlands are likely to experience seawater intrusion in the future if the current rate of climate change continues.

Historically, the Hudson River had a high concentration of lead, which the sediments showed the capability to store this lead (Sritrairat 2012). The lead filtration properties of the sediment are very beneficial to the ecosystem because it keeps the metal from causing havoc on the surrounding ecological community. If these ecosystems continue to disappear as they have been, largely due to urban development, they could cease to perform important functions necessary for ecological health.

I failed to support my hypothesis that the lead currently stored in the soil will be drawn out, which is an optimistic outcome. The other aspect of my hypothesis was supported, suggesting that the sediments ability to filter lead pollution out of the environment will be affected negatively. The results of this experiment have both positive and concerning implications. One aspect declares that the lead pollution that is stored in the Tivoli wetland soil after many years of pollution will not be drawn out due to seawater intrusion. On the other hand, seawater intrusion may cause this wetland to have less capacity to absorb the lead pollution that still resonates today. Considering that lead poisoning can occur in very small concentrations this could be dangerous to a growing population in the future.

ACKNOWLEDGMENTS

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APPENDIX

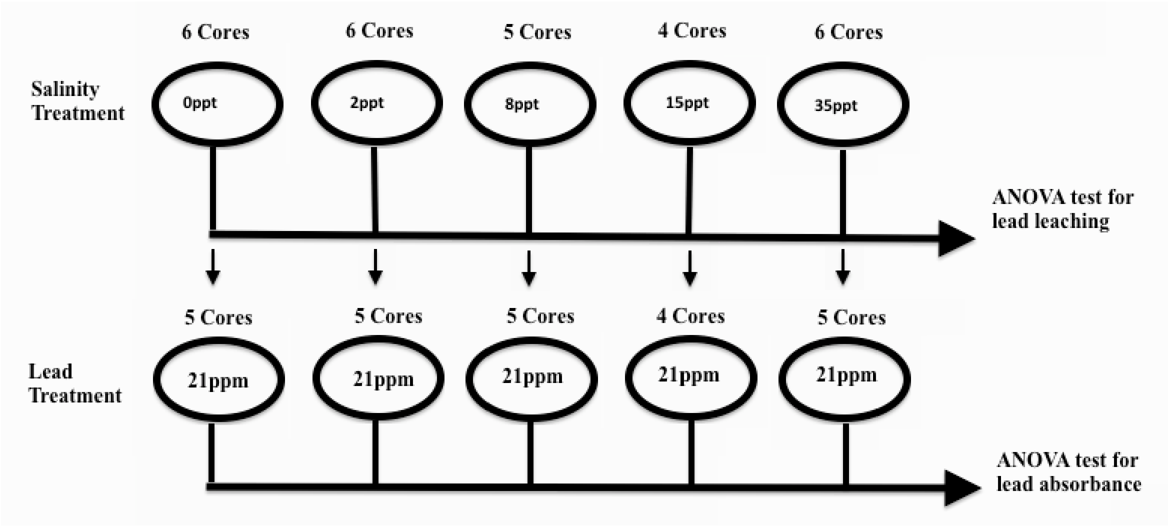

FIGURE 1. This is a diagram showing the experimental design of the sediment cores, the treatments that they received, and the tests that the solutions were analyzed with.

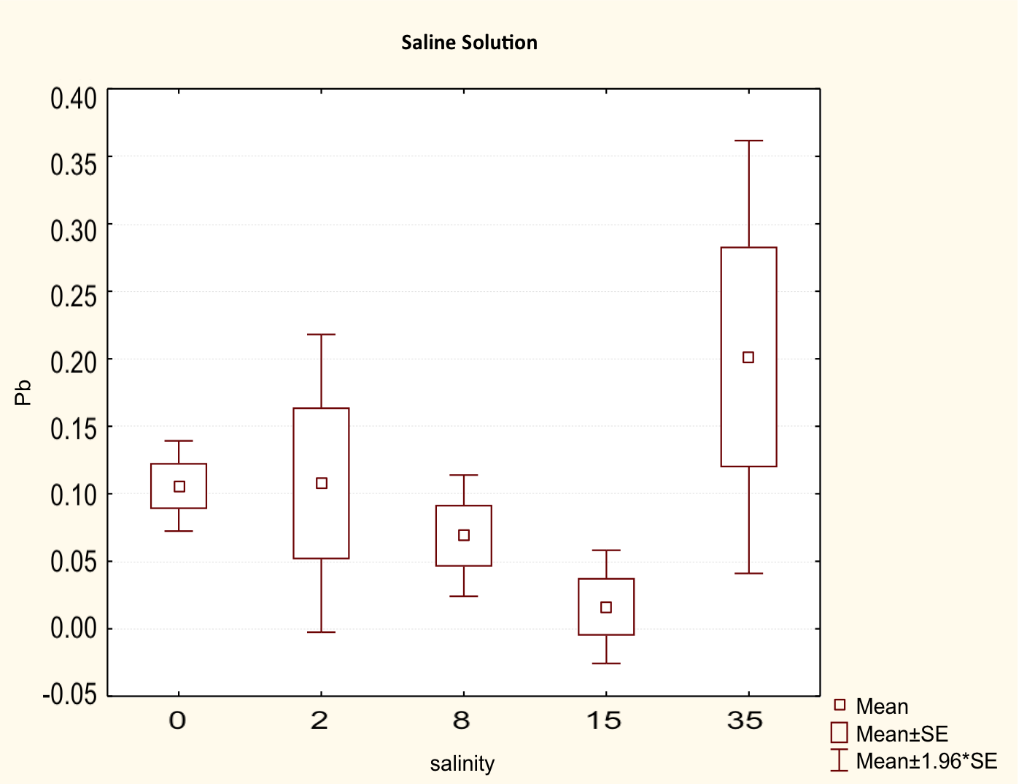

FIGURE 2. The saline solution ANOVA box and whisker graph showing the means in the middle of a box showing the standard error, and error bars multiplying the standard error by 1.96.

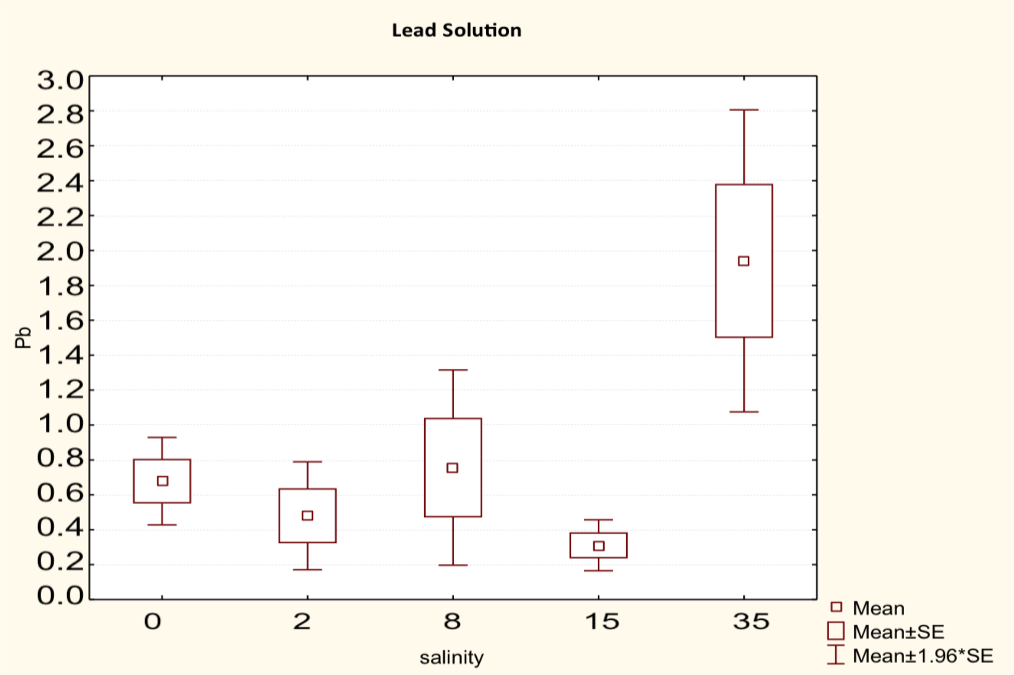

FIGURE 3. The lead solution ANOVA box and whisker graph showing the means in the middle of a box showing the standard error, and error bars multiplying the standard error by 1.96.