Geochemical Evidence of Landfill Seepage in a Wetland
Baker Woodlands, Lancaster, Pennsylvania

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INTRODUCTION

Located in Lancaster, Pennsylvania, Baker Woodlands is an environmental site that has been anthropogenically affected over the last century (de Wet and Richardson, 1998; de Wet et al., 1999). In the 1920's, Lancaster Brick Company established a brickworks on the site and began excavating areas of the site for clay. Beginning in 1957, these pits were used as landfills. Over the next seven years, continued dumping of industrial debris created two distinct landfills on the site. The larger landfill borders a wetland on the east, while the smaller landfill borders the same wetland on the northwest. Both of these landfills are the source of seeps that directly drain into the wetland. Evidence of surface leachate prompted us to investigate the metal distribution of the sediment in the wetlands. We collected cores from various parts of the wetland and examined the stratigraphy of each core. In order to determine the temporal and spatial distribution of trace metals in the wetland, we analyzed the sediment using various geochemical techniques. With the data acquired, we looked for a correlation between landfill seepage and metal concentration within the wetland sediment.

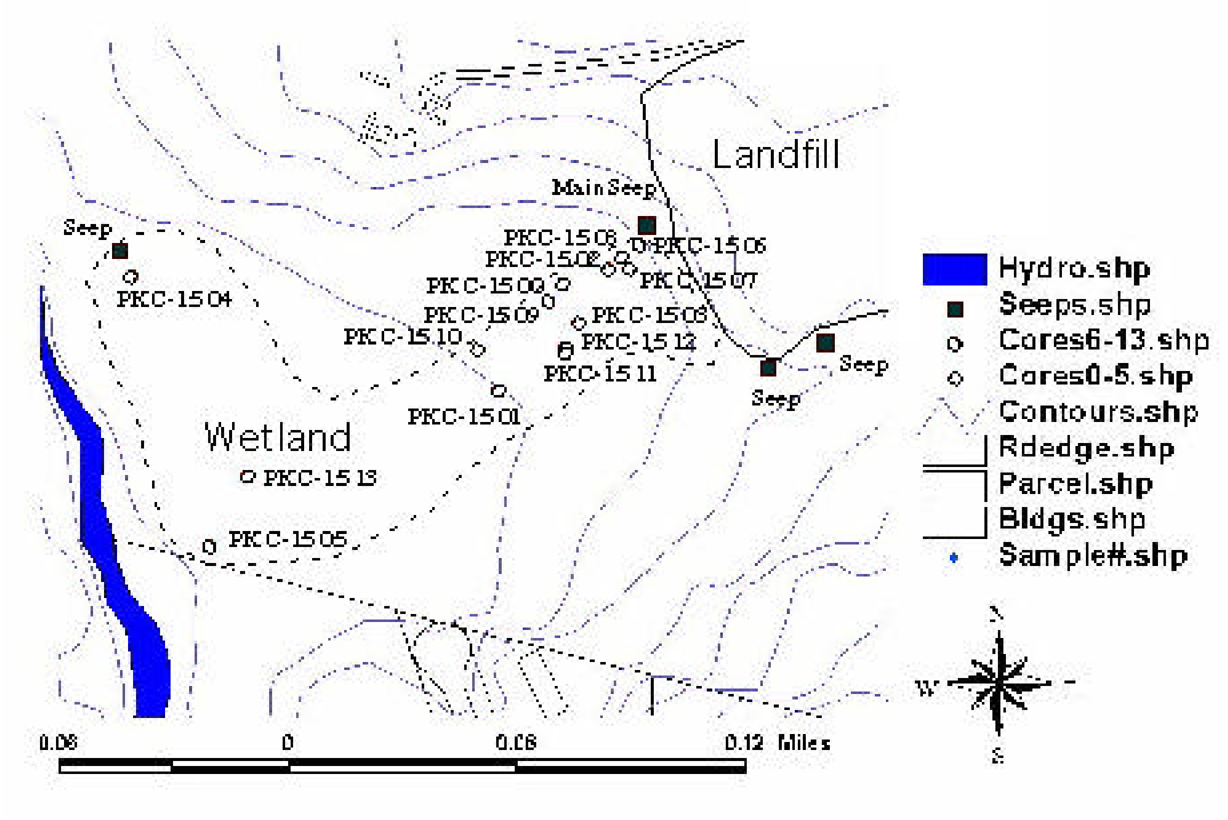

Figure 1: The Baker Campus wetland depicting core sites and nearby landfill seeps.

METHODS

We used a Vibracore to extract fourteen cores (labeled PKC -1500 through PKC-1513) throughout the wetland, concentrating on the main drainages (Figure 1). We determined the location of our cores by using the Trimble differential Global Positioning System (GPS) and entering this data into the ArcView Geographic Information System (GIS). The cores were then cut to obtain a clear view of their stratigraphy. We recorded changes in the stratigraphy based on color and grain size. The color was determined using the Munsell Soil Color Chart. In addition, we noted the organic content, soil friability, and presence of any debris.

Based on the stratigraphic data, we obtained homogenous samples within each core for geochemical analysis. The samples were dried overnight and then crushed and sifted. Using a modified EPA technique, we digested the sediment using nitric acid and hydrochloric acid. We ran each sample through the Inductively Coupled Argon Plasma Spectrometer (ICAP 61) to acquire trace element concentrations. The elements we tested for were Ba, Cd, Co, Cr, Fe, Mg, Mn, Pb, V, Zn. Industrial waste is considered to be the source of Fe, Mg, Zn, while Cd commonly results from industrial discharge (Sparks, 1995).

We selected twelve individual particles from core PKC-1502 to observe under the Zeiss DSM 962 Scanning Electron Microscope (SEM). We prepared each particle for the SEM by mounting it on a carbon adhesive and carbon coating it. Under the Secondary Electron Imaging (SEI) mode, we looked at the surface morphology of the individual particles. Using the Back-scatter Imaging (BSI) mode, we obtained a qualitative analysis of the chemical composition of the particles.

RESULTS

Using the ICAP, we found the trace metal concentrations of the wetland sediment. Below is an outline of the general spatial and temporal trends of each element:

•Barium shows a decrease in concentration as core depth increases. The highest concentrations of barium occur closest to the main landfill seep. These concentrations are significantly higher than the cores furthest from the main seep.

•Cadmium generally decreases in concentration as core depth increases. However, PKC-1500 and PKC-1502, have their highest concentrations near the bottom of the cores.

•Cobalt did not show significant temporal or spatial variation in concentration throughout the cores.

•Chromium concentration generally increases as core depth increases. The concentration of chromium does not correspond to the location of the seeps.

•Iron concentration is very high in cores taken near the main seep. The concentration decreases significantly both temporally and spatially in each core (Figure 2).

•Magnesium shows high concentrations at greater core depths. The highest concentrations are found closest to the main seep.

•Manganese is found in high concentrations at the surface of most cores. It drops off rapidly as core depth increases. PKC-1503 shows exceptionally high concentrations of manganese.

•Lead concentration within the cores shows no clear temporal distribution pattern. Moreover, the highest lead concentrations do not correspond to the location of the main seep.

•Vanadium does not show significant temporal or spatial variation in concentration throughout the cores.

•Zinc shows no clear spatial or temporal distribution patterns and has widely fluctuating concentration values. The highest zinc concentrations within the lower layers of PKC-1500 and PKC-1502 correlate with very high cadmium concentrations within those layers (Figure 3).

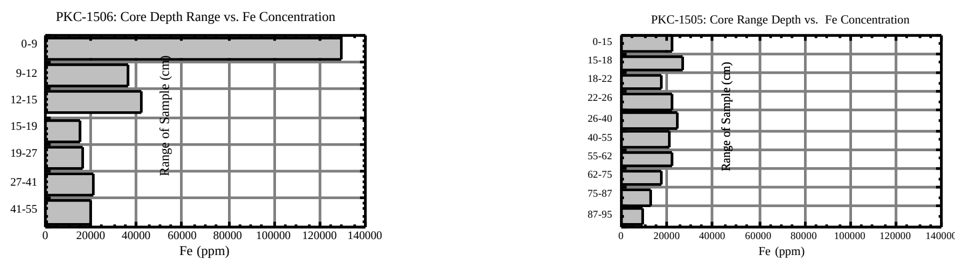

Figure 2: Plots showing both temporal and spatial distribution of Fe. PKC-1506 shows a decrease in metal concentration as core depth increases. Comparison of the two plots shows that PKC-1506, which was taken by the main seep has much higher metal concentration than PKC-1505, which was taken on the side of the wetland farthest from the seep.

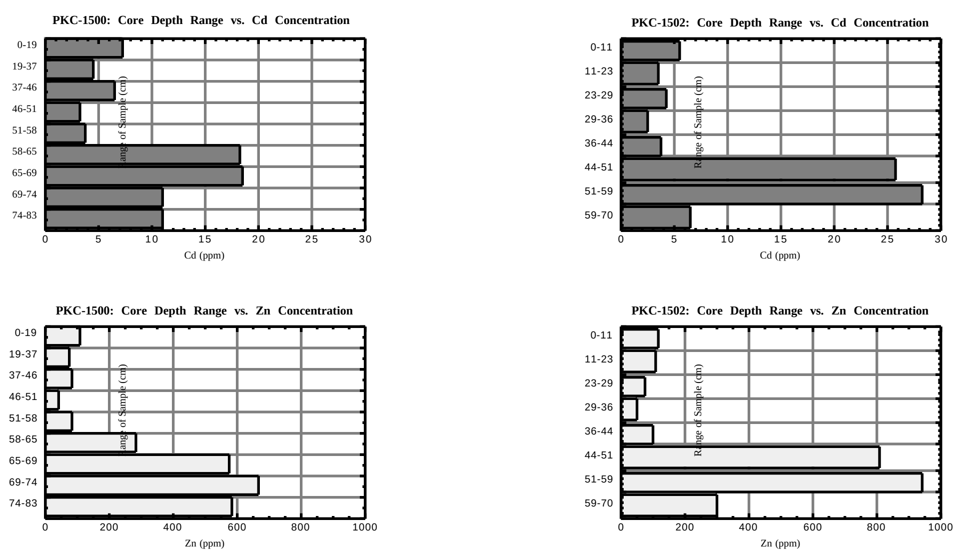

Figure 3: Plots showing Cd and Zn concentrations with respect to depth in cores PKC-1500 and PKC-1502. Both the Cd and Zn graphs show the highest concentrations at identical depths.

In addition, we found pieces of linoleum, plastic, and slag in PKC-1502. There were brick fragments found in PKC-1503. At the bottom of PKC-1504, there were poorly sorted and rounded cobbles and pebbles within a clay matrix.

Observation of sediment grains under the SEM did not reveal any anomalous data. By analyzing the composition of the slag from PKC-1502 we determined that it was mainly composed of Al, Si, Fe, Mg, K, Ca, P, O, and Ti.

DISCUSSION

There is qualitative and quantitative evidence of landfill seepage into the wetland. The cores taken from next to the main seep show high levels of metal concentration, suggesting that the metals originated from the landfill. As the landfill matured, the metals may have risen to the surface through the seeps and drained into the wetland. There is a decrease in metal concentration as the distance from the main seep increases. This type of spatial distribution suggests that the wetland is filtering metals that are draining out of the main seep. We also noticed that as the core depth increases, generally, the concentration of metals decreases. However, temporal and spatial distribution can be complicated by a number of factors, including grain size, pH of groundwater, the presence of organic matter, and other factors.

It is interesting to note that core PKC-1504, taken in the seep from the smaller landfill, did not contain any unusually high metal concentrations. In comparison to the metal concentrations of sediment found closer to the main seep, this seems rather unusual. This anomaly may be the result of compositional differences between the large and small landfill. Variance in landfill maturation may also lead to different metals draining from the landfill.

The items found in PKC-1502 (plastic, linoleum, and slag) and PKC-1503 (brick fragments) are convincing evidence that the adjacent landfill has had an effect on the wetland. The items themselves may provide a sampling of the type of materials contained in the main landfill.

The correlation between the high concentrations of cadmium and zinc in PKC-1500 and PKC-1502 may be linked to an Superfund site located close to the northeastern border of Baker Woodlands. Historically, this was the site of a battery factory, which may have later been used as dumping grounds for batteries. The high concentrations of cadmium and zinc may be related to seepage of chemicals from the battery factory.

The poorly sorted and rounded pebbles and cobbles found in PKC-1504 suggest that the Little Conestoga Creek was located further to the east in the past.

The grain composition observed under the SEM confirmed the presence of siliciclastic sediment and clay. Many elements found in the slag correspond to trace metals found in the seep. Trace metals in the wetland sediment may be due to the weathering of slag.

CONCLUSIONS

- There is abundant evidence for seemage from the main landfill seepage into the wetland.
- The wetland acts as a filter for metals coming out of the landfill and moving toward the Little Conestoga Creek.
- Further study should be done to determine the reason for the lower metal concentrations in the core sediment extracted near the minor seep.
- The items found in PKC-1502 indicate that there has been at least 44 cm of sediment deposition since the creation of the landfill.

ACKNOWLEDGMENTS

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