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Toxic Trace Metal Analysis And Tributary Confluence Sediment Mapping Within The South Branch Of The Park River (Hartford, CT)

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Abstract

The Park River is an urban river that flows through Hartford County and into the Connecticut River. The Trout Brook, a channelized tributary of the south branch of the Park River has a history of toxic trace metal discharges from several metal finishing industries, as well as the unlined West Hartford Landfill. Sediment samples were collected from the confluence of the Trout and Piper Brooks where they form the south branch of the Park River/Trout Brook. Samples were taken from the region immediately downstream from where these two rivers meet and were analyzed for nine metals including cadmium, iron, manganese, lead and zinc using Inductively coupled plasma -optical emission spectroscopy after a weak acid digestion method that extracted metals adsorbed to silt and clay sized particles (grains < 63µm). Trends in the concentrations and distributions of heavy metals throughout this sample site were analyzed to determine the sources of metal contamination, noting any abnormalities caused by hydrologic processes as well as the occurrence of sandbars and other geological structures. Contour maps for each metal were constructed in ESRI ArcGIS 10 to map spatial and temporal variations of metal concentrations within the confluence.

Introduction

The south branch of the Park River is a channelized section of river which flows through greater Hartford, CT. The Park River has had a history of heavy industrial use and is still utilized today for waste disposal of toxic trace metals. Sources of disposal include, metal finishing, metal plating, aerospace industries, and firearms manufacturing (Right-To-Know-Network, 2010). The downstream reaches of the Trout Brook, a major tributary of the south branch, were channelized for flood control in the late 1950's and its banks were lined with local basalt rip-rap. The Trout Brook drains a well urbanized area which has a high percentage of impervious surfaces resulting in "flashy" discharge events. Due to the large number of impervious surfaces, even moderate rain events can significantly increase discharge within the Trout Brook. These "flashy" storm events have the potential to transport large volumes of bedload sediments as well as distribute high concentrations of toxic trace metals into river sediment.

Previous water quality studies and sediment analysis conducted on the Park River determined the highest concentrations of contaminants to be found within the sediments of the south branch (Doñé and Gourley, 2009). Most recently, a study performed by Doñé and others (2009) examined the concentrations of heavy metals in river sediment samples taken near the South Park River confluence and they found river sediments to have heavy metal concentrations that exceeded consensus- based probable effective concentrations (PEC) which is the known concentration at which trace metals begin to have a detrimental effect on a biota (MacDonald et al. 2000). Doñé's study found levels of cadmium (Cd), lead (Pb), copper (Cu) and chromium (Cr) from the sediment that exceeded the consensus-based PEC and high levels of manganese (Mn), iron (Fe) and cobalt (Co) were also found, but these three heavy metals are not known to have a consensus based PEC concentration (MacDonald et al. 2000).

The purpose of this study is to compare the toxic trace metal distribution between two upstream sources (Trout and Piper Brooks) which are known to be contaminated and to attempt to determine sources of downstream contamination based on contamination found upstream.

Hypothesis

There is no difference between the concentrations of cadmium, chromium, cobalt, copper, iron, manganese, nickel, lead, and zinc in the sediment collected from north to south banks of the Trout/Piper Brook Confluence

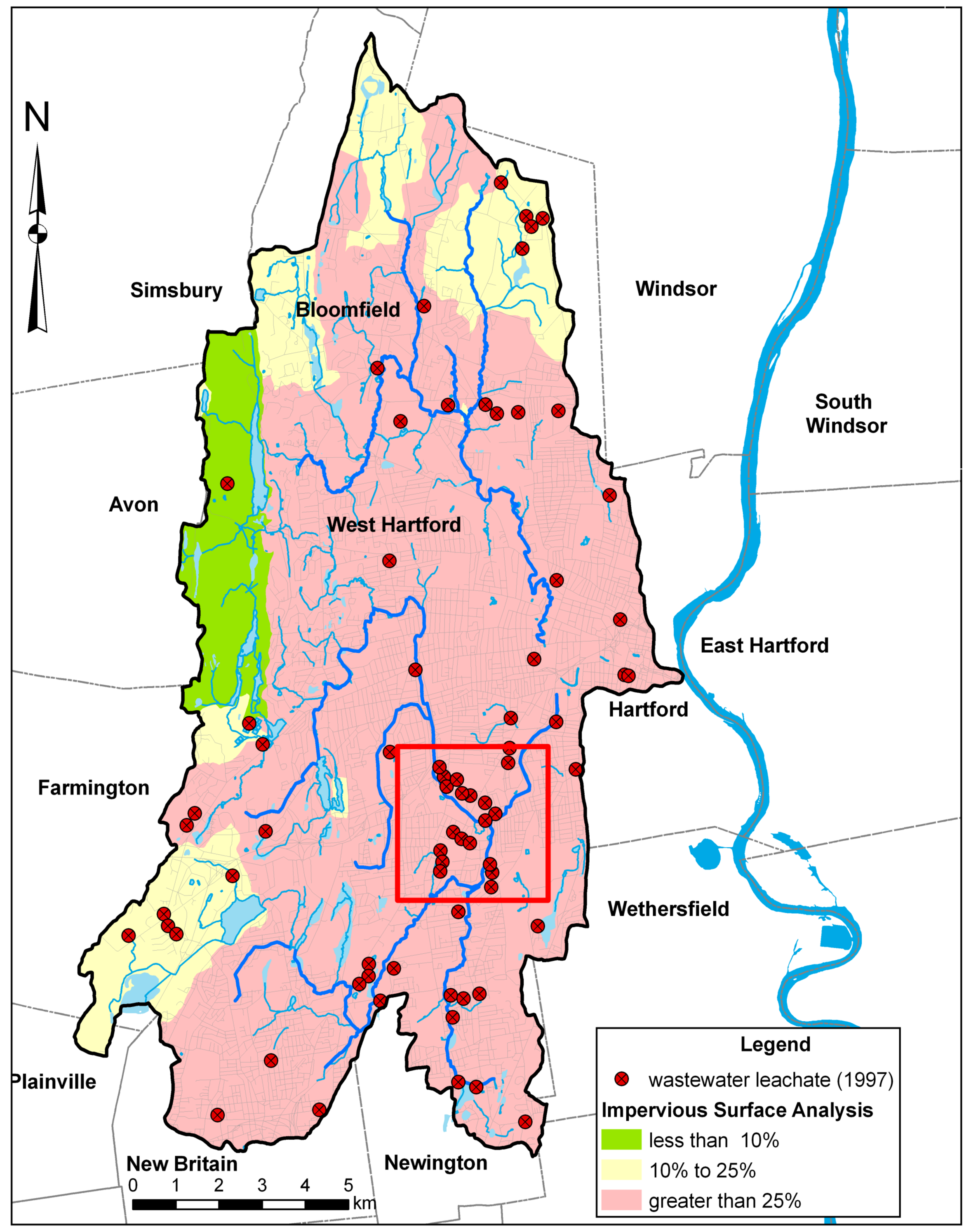
Methods

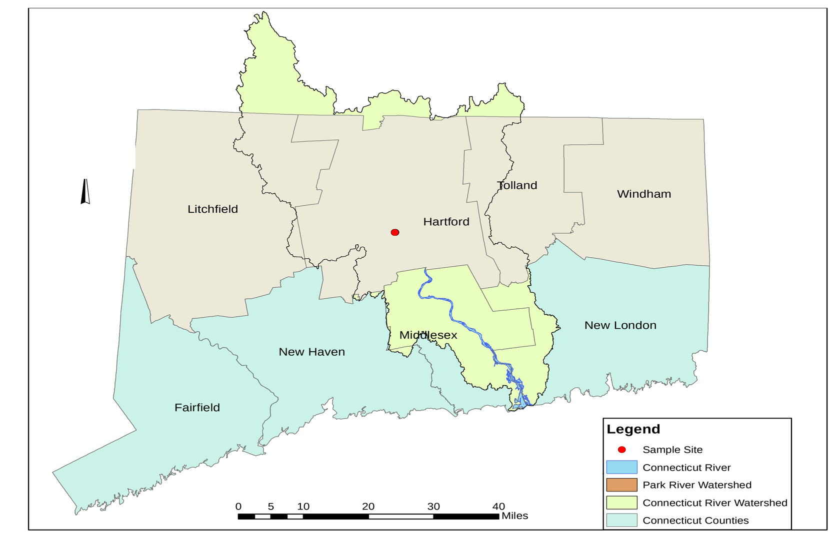
Sample Collection:

Sediment samples were taken immediately downstream of the confluence, as well as im the upstream section of the Piper Brook. Samples were collected from areas with the thickest observable sediment deposits. Substrate was scooped from the stream bed using acid-washed plastic scoopers, sediment was wet-sieved through a 63 µm nylon filter into a #2 HDPE bottle. A 5% hydrochloric acid solution was used to clean all sampling equipment.

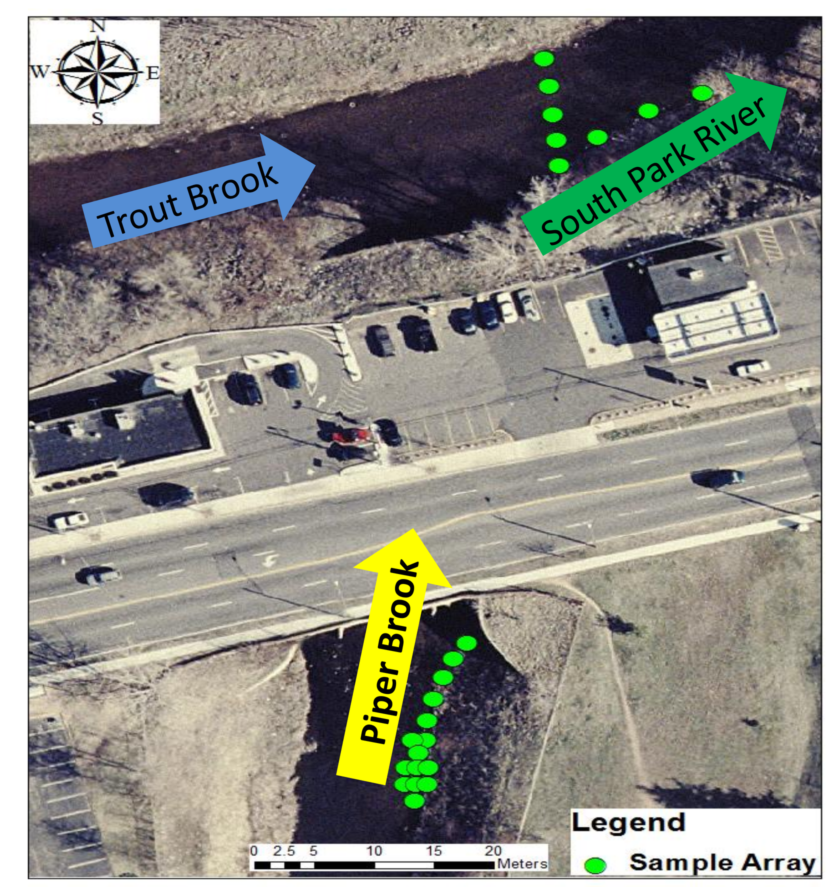
Sample Analysis:

We followed a weak-acid digestion method presented in Giddings et al. (2000). Sediment was poured into porcelain crucibles and dried out at a constant temperature of 85ºC. Dried were transferred into digitubes. A 0.5 g portion of each sample was digested in 10 mL of 0.6 N HCl and agitated for two hours using an oscillator. Samples were refrigerated and allowed to settle overnight, the samples were then filtered with a 0.45 µm Teflon Membrane Filter. Remaining liquid was analyzed using Inductively Coupled Plasma – optical emission spectrometer (ICP-OES)





South Park River Confluence



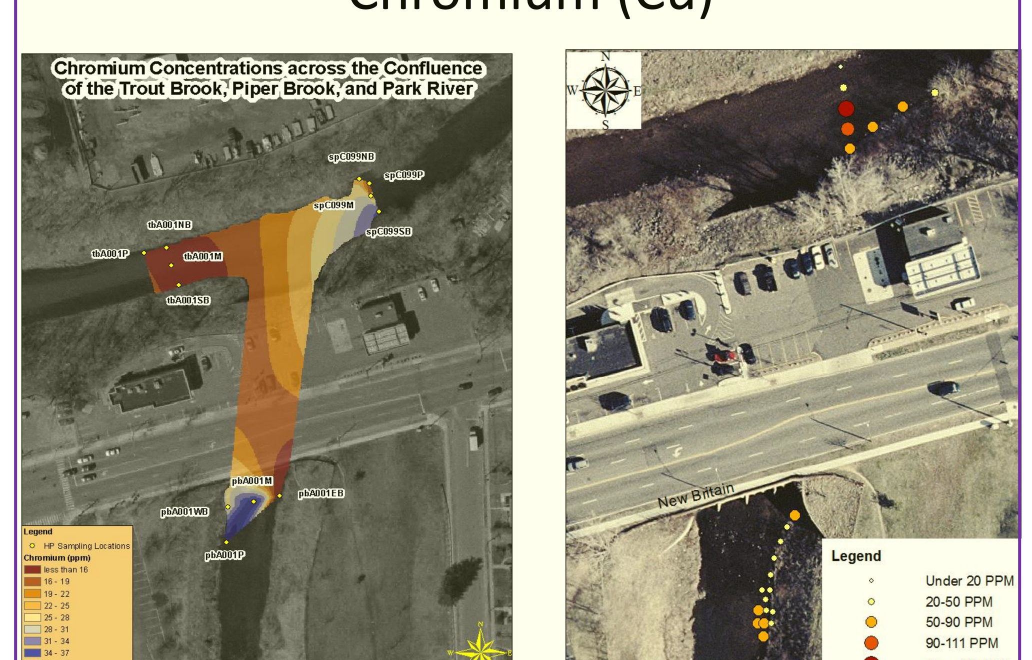
Cadmium (Cd)

2009 2011

Copper (CU)

2009 2011

Chromium (Cu)



2009 2011

Lead (Pb)

2009 2011

Results

The data analyzed by the ICP-OES were mapped using ESRI ArcGIS 10. The ranges of concentrations are presented in a succession of colors with the darkest colors being the areas of the highest concentrations. Regions with metal concentrations that are above the PEC values are colored in red.

- Concentrations of cadmium and copper found directly downstream of the confluence do show concentrations along the south bank which exceed consensus based PEC. The distribution of cadmium and copper are consistent with data collected in 2009 and suggest a Piper Brook origin.
- Concentrations of lead found directly downstream of the confluence do are highest in the middle of the stream and exceed consensus based PEC levels. The distribution of lead and chromium are consistent with data from 2009 and suggest contamination from both upstream sources.
- Chromium is distributed similarly as lead but based on 2009 data has a Piper Brook origin.
- Further sampling of the Piper brook confirm that it is the main contributor of both cadmium and copper.

Discussion

Based on our current data, we are unable to fully accept or reject our hypothesis. In the cases of cadmium and copper, we do see a trend in that higher concentrations were found closer to the south bank, directly downstream of the Piper Brook. Referring to data collected in 2009, we see that high concentrations of cadmium, copper and chromium were found just upstream of the confluence, within the Piper Brook, while very low levels of cadmium, copper and chromium were found in the Trout Brook. High levels of cadmium and copper resulting downstream of the Piper Brook suggests that it is the main contributor of cadmium and copper for the South Park River. In the case of chromium and lead, we see that the highest concentrations are found near the middle of the river, directly downstream of the confluence. Referring to data collected in 2009, in the case of chromium, we see that concentrations found in the Trout Brook are very low and concentrations found in the Piper Brook are very high. Although our sample concentrations for chromium do not display the same pattern as cadmium and copper, based on past data we are able to say that the Piper Brook is the likely main contributor of chromium for the South Park River. In the case of lead, the data collected in 2009 shows high concentrations of lead in both the Trout Brook and the Piper Brook. The convergence of these two sources of contamination results in high levels of contamination within the middle of the confluence.

Conclusion

Although we are unable to fully accept or reject our hypothesis, based on the findings current and past data, we can say that the Piper Brook is the main contributor of cadmium and copper contamination in the South Park River.

In order to better determine sources of contamination downstream of the confluence, more sampling must be conducted in the upstream sections of both the Piper ad Trout Brooks.

In order to determine the movement patterns of contaminated sediment within the South Park River, sampling must be extended further downstream of the confluence.

Further sample collection may aid in future remediation efforts as well as be used to identify specific upstream sources of heavy metal contamination between both the Trout Brook and Piper Brook.

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