Levels, Trends and Fate of Polycyclic Aromatic Hydrocarbons (PAHs) in Dirt and Dust From Roads in the Long Creek Watershed, South Portland, Maine

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Introduction

Long Creek, located in South Portland, Cumberland County, Maine has been classified as an urban impaired stream by the Maine Department of Environmental Protection (MEDEP).[1] Causes for impairment of Long Creek are associated with extensive impervious areas, e.g. asphaltic pavement, within the watershed that effect surface water runoff. Water quality can be affected by contaminants in surface water runoff when impervious cover (IC) exceeds 10% of a watershed's total surface area. The Long Creek Watershed and sub-watersheds have IC ranging from 11% to 62%.[2, 3] Street dust, commonly associated with impervious surfaces, is a known contributor to water quality impairment. Analysis of street dust has been found to be a simple, cost-effective measure of pollutants delivered to fluvial systems via storm water runoff.[4, 5]

Recently the Long Creek Restoration Project, a collaborative community-based initiative comprised of local businesses, non-profit organizations, and state agencies convened by the City of South Portland, obtained a grant from United States Environmental Protection Agency (US EPA) and MEDEP to develop a coordinated watershed restoration plan to bring Long Creek back into compliance with state and federal water quality standards, and create new recreation opportunities for residents and visitors.

Dust samples obtained in this study were examined for polycyclic aromatic hydrocarbons (PAHs), zinc (Zn), chromium (Cr) and copper (Cu). PAHs can be categorized into four general types; pyrogenic, petrogenic, diagenic and biogenic which are indicative of their sources; combustion, petroleum, geologic processes, biological processes, respectively.[6] PAHs are an environmental contaminant of particular concern because they remain in the environmental for long durations (due to their stable structures) and they exhibit carcinogenic, mutagenic, and genotoxic properties.[6] The US EPA has deemed 16 PAHs as priority pollutants due to the various health concerns associated with them.[7] Zn, Pb and Cu are among the most common heavy metals emitted from vehicles and are a serious concern to human health.[8] Chronic exposure to heavy metals can result in damage to the nervous, cardiovascular and reproductive systems.[9]

Methods

Sample Collection and Preparation

Street dust samples (CHY2001B – CHY 2003B) were collected on September 7, 2010 by hand sweeping. Storm drain and silt samples from the Long Creek flood plain were collected intermittently during November of 2010. Samples were air-dried and sieved to retain materials with particle sizes <150 µm.

GC/MS Analysis

Extraction and analysis of PAHs were done following methods outlined in US EPA SW-846. Samples (~5.0 grams) were microwave extracted with 1:1 hexane:acetone. Cleanup of the extract employed alumina and silica gel column chromatography. Each sample was spiked at specific times during this process with isotope labeled standards. PAHs were analyzed with a GC/MS, on a DB-5HT column (30m x 0.25 µm, 0.25 mm). Additional information on GC-MS set-up can be found in US EPA method 8270D. Using this method 16 priority PAHs were analyzed in each sample.

A four point calibration curve was formulated for each PAH. THE GC/MS provided a linear response for all PAHs over a range of 0.050 to 50 ppm, and correlation coefficients varied from 0.9951 to 0.9999.

XRF Analysis

For the analysis of metals in each sample an energy dispersive polarization X-ray fluorescence (XRF, Spectro XEPOS) instrument was used. Samples (~3.0 g) were poured in cups lined with prolene® film, compressed, and analyzed using Spectro X-Lab Pro software with Turboquant method for powders. Reproducibility was with 3-5% for levels of Cu, Zn, Cr and Pb. Certified reference material (CRM) GSS-1 was run after every 12 samples, and was run in triplicate to determine reproducibility.

References

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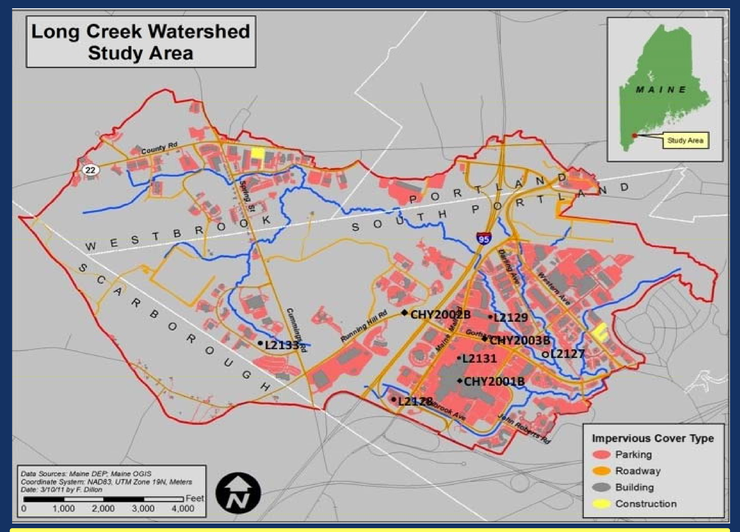

Figure 1. Map of sampling sites in the Long Creek Watershed, South Portland, ME. Symbols for sample sites are as follows; • indicates a street dust sample, ◆ indicates a storm drain sample (collected by CCSWD), and O indicates a flood plain silt sample collected along the banks of Long Creek.

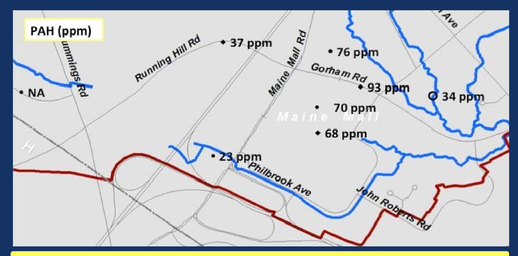

Figure 2. Total PAH levels in the Long Creek Watershed, South Portland, ME. Relative percent errors ranged from 3% to 10%.

Figure 3. Copper (Cu) levels in the Long Creek Watershed, South Portland, ME. Relative percent errors ranged from 2% to 7%.

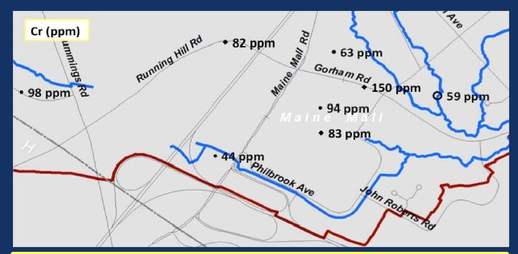

Figure 4. Chromium (Cr) levels in the Long Creek Watershed, South Portland, ME. Relative percent errors ranged from 0.8% to 12%.

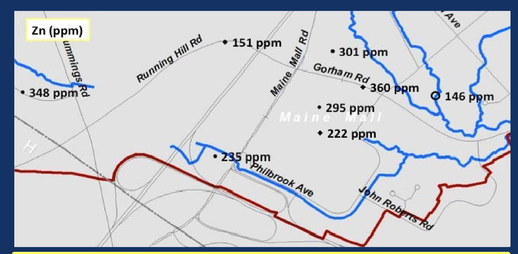

Figure 5. Zinc (Zn) levels in the Long Creek Watershed, South Portland, ME. Relative percent errors ranged from 1% to 7%.

PAH Levels (ppm) and Percent Organic Matter

	CHY2001B	CHY2002B	CHY2003B	L2127	L2128	L2129	L2131
Anthracene	3.1±0.1	1.58±0.07	5.6±0.2	1.59±0.07	0.60±0.03	2.7±0.1	2.7±0.1
Benzo[a]pyrene	3.6±0.2	2.2±0.1	6.0±0.3	2.3±0.1	1.58±0.08	0.55±0.03	4.7±0.2
Pyrene	11.3±0.5	5.6±0.2	11.2±0.5	4.7±0.2	3.2±0.1	12.1±0.5	11.6±0.5
Benzo[b]fluoranthene	6.3±0.4	3.9±0.2	9.0±0.5	3.8±0.2	2.8±0.2	8.3±0.5	6.6±0.4
Chrysene	7.8±0.3	3.3±0.1	9.7±0.4	3.6±0.1	2.33±0.09	9.8±0.4	7.1±0.3
Phenanthrene	3.3±0.2	1.7±0.1	5.8±0.4	1.7±0.1	0.68±0.05	2.8±0.2	2.8±0.2
Indeno[1,2,3-cd]pyrene	2.8±0.3	2.0±0.2	6.0±0.6	1.9±0.2	1.3±0.1	3.8±0.4	3.9±0.4
Benzo[a]anthracene	3.1±0.2	1.17±0.06	4.9±0.3	1.46±0.08	1.02±0.05	5.1±0.3	3.8±0.2
Napthalene	0.069±0.002	ND	0.138±0.003	ND	ND	ND	ND
Benzo[k]fluoranthene	5.6±0.3	3.1±0.1	8.4±0.4	3.2±0.2	2.2±0.1	8.1±0.4	6.2±0.3
Benzo[ghi]perylene	2.6±0.1	1.81±0.09	6.2±0.3	1.82±0.08	1.24±0.06	3.4±0.2	3.8±0.2
Fluoranthene	18±1	10.3±0.6	18±1	7.7±0.5	5.7±0.3	18±1	15.8±0.9
Dibenz[a,h]anthracene	0.82±0.04	0.68±0.03	2.2±0.1	0.53±0.03	0.49±0.03	0.76±0.04	0.31±0.01
% Organic Matter (%)	4.07±0.08	NA	3.3±0.1	NA	2.40±0.09	2.9±0.1	6.9±0.08

Table 1. Levels of all PAHs and organic matter analyzed in the Long Creek samples. NA represent samples not analyzed. ND represents compound was not detected.

Discussion

Results and Conclusions

- Levels of PAHs, Cu, Zn, and Cr in street dust from the Long Creek Watershed were highest on Gorham Rd (CHY2003B), which is an area with high traffic and frequent vehicle idling.
- Concentrations of PAHs, Cu, Zn and Cr were consistent in both street dust and storm basin samples collected from highly utilized parking areas.
- The lowest levels of PAHs, Cu, Zn and Cr were found at sites with the lowest impact from vehicular traffic.
- Levels of Pb were relatively consistent between sampling sites evaluated, and ranged from 35 ppm to 50ppm, relative errors average ~2.5%.
- Percent organic matter varied between 2.4% and 6.9%, and does not appear to correlate with contaminant levels found in street dust.

Levels of PAHs and metals in both street dust and catch basin samples evaluated as part of this study indicate a correlation between the amount of traffic observed in an area and contaminant concentrations in street dust or catch basin samples from that area. In highly trafficked areas, namely Gorham Road and The Maine Mall (CHY 2003B and CHY 2001B), contaminant levels were higher than in areas with little or no automobile traffic (CHY 2002B and L2128). In addition, levels of PAHs and metals appear to correlate with one another depending the extent of automobile traffic in a sample area. Samples from Gorham Road (the highest trafficked area in this study) exhibited the highest levels of both PAHs and metals when compared to the other sample sites. Furthermore, contaminant concentrations do not appear to be dependent on a specific sample media. Levels of PAHs and metals appear proportional to one another between street dust and catch basin samples collected from the same or similar areas.

Future Work

Based on results of this study, additional sampling of street dust, catch basin sediment and other sample media will be conducted to 1) support data collected during this phase, and 2) augment the study area to larger sections of the watershed. Results of PAH analyses in this study, however, do not indicate a solely petrogenic source. To evaluate the distribution of high and low molecular weight PAHs, additional analysis is needed to evaluate whether other upgradient sources, or other factors (such as makeup of the road surface) may contribute to the mixing of the two PAH compound classes.

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