Sources of metals and polycyclic aromatic hydrocarbons to transportation corridor swales in Chicago, USA

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Contamination:
Links to complex environmental and societal problems including **degradation of water resources**, spread of invasive species, climate change, human health…

**Sources** of contamination can tell
- Which releases are dominant
- What engineering or policy controls could be useful to reduce pollution
Context and justification

**Chicago**: Highly urbanized yet retains natural features

- Large network of interstate highways and waterways.
- Model city for LEAP (Landscape Ecological & Anthropogenic Processes) program at UIC.

LEAP student led research project:

“The role of contamination on poison hemlock’s (*Conium maculatum*) expansion into a disturbed urban landscape”
Research Project Goals

Determine if:

1. Soil in transportation corridors in Chicago contain elevated levels of common urban contaminants heavy metals & polycyclic aromatic hydrocarbons (PAHs).

2. Soil contamination can be apportioned to specific transportation, bio-solid, and/or industrial sources, with the largest contribution expected from transportation sources.
Methodology 1: Sample collection and analysis

Twenty eight soil cores taken at nine poison hemlock patches.

Samples characterized for physical/chemical soil parameters & analyzed for 20 PAHs and 20 heavy metals.
Sample collection & analysis

PAH and metal levels in roadside soil samples
Methodology 2: Source apportionment (SA) analysis

‘Receptor’-oriented approach to determine contributions of various pollution sources to a location of interest.

1. Indicator ratios - simple method to infer general PAH sources
Source Apportionment continued:

2 - Factor Analysis

Principal Component Analysis (PCA)

1. Sources of pollution?

2. Loading of each source to each receptor?

Positive Matrix Factorization (PMF)

\[
X = GF
\]

\(m \times n\) number of compounds, \(n \times m\) number of samples, \(p \times n\) number of sources
Signature source profiles: Source ‘fingerprints’

Highway dust is composite of Christensen and Bzdusek, 2005 & Murakami et al. 2005, all others were compiled from Li et al. 2003.
Positive Matrix Factorization Result

Two source profile plots for PAHs and metals

Source one has a strong diesel signature.

Source two has elevated coke oven or weathered biosolids signature.

Source one possible traffic combustion source.

Source two..?
Planned research activity

Build library of metal and PAH signature source profiles from raw data.
- **Quantitatively** measure similarity between PMF and signature profiles

Subject data to other SA methods for comparison.
- US EPA PMF 2.0, Chemical Mass Balance, Principal Component Analysis with multiple linear regression

Apply SA to other urban receptor sites
- PAHs, PBDEs, black carbon in *sludge* and PAHs in IL River *sediment*

**Anthropogenic impacts to urban greenspaces: sources and fate of transportation and wastewater related contaminants to the Chicago region**
Significance & limitations of SA for developing countries

Growing contamination and health risk due to rapid urbanization & increased energy demands.

SA methods relatively easy to replicate, inexpensive to use, and requires moderate information to model.

Show where to focus pollution reduction efforts, strengthen local level management where

However: not all contaminants and all matrices work equally well with all methods, lack of signature source profiles, knowledge & training; most informative in conjunction with other methods.
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Principal Component Analysis Result

Two factor loading plots for PAHs and metals

No clear sources emerge from factoring out low & high molecular weight PAHs

Vanadium may indicate a traffic source, but the other is unknown.