Heavy Metal Variations in Residential Soil Communities along an Urban to Rural Gradient

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Abstract

Questions:

1) Do heavy metal concentrations **(Cr, Ni, Cu, Zn, As, Cd and Pb)** of residential soils and arthropods vary spatially?
   a) **Regionally:** Along an urban to rural landuse gradient
   b) **Locally:** Within yard patches (front lawn, back lawn, house and road)

2)Do soil heavy metal levels affect overall arthropod heavy metal body concentrations?

3) What are potential sources of heavy metal variation in urban soil communities?

Soil communities varied regionally with inner urban soils containing significantly higher metal concentrations then rural. However, only inner-urban soil lead concentrations were significantly higher then all other landuses (outer-urban, suburban and rural). Isopod heavy metal contents strongly correlated to all soil metal concentrations except for Cu and Cd while earthworms significantly correlated only to Pb. The high accumulation of heavy metals in urban arthropods could significantly affect consumers at higher trophic levels, such as birds.

Introduction

Densely populated cities, unlike rural communities, are highly impacted by heavy metal pollutants. They possess more pre-1940 (lead-painted) homes, contain congested roadways (source of historic lead gasoline, tire dust and break lining), and receive substantial amounts of atmospheric deposition. Urban forest soils have higher metal concentrations in comparison to suburban and rural locations (Pouyat 1992), however residential soil communities have not been assessed. The Neighborhood Nestwatch program, found greater lead levels in urban birds compared to rural. Also urban American, robins substantial earthworm consumers, possessed the highest lead levels of any other species studied (Roux In Press 2005). Studying the impact of heavy metals on arthropod soil communities is important to understanding the potential long-term consequences of heavy metals on the health, structure and function of urban ecosystems.

Methods

Residences:
Part of the Smithsonian Neighborhood Nestwatch Program residing in the Baltimore and Washington D.C. Metropolitan areas.

The urban-rural gradient consisted of four categories, based on population density (#individuals/ mile^2): 1) Inner Urban (>8,000), 2) Outer Urban (8,000 – 2,000), 3) Suburban (2,000 – 300) and 4) Rural (<300) (U.S. Census Bureau 2000).

Soil Sampling:
Fifteen 10cm soil cores were taken at five different yard patches (front lawn, back lawn, house patch, road patch and backyard).

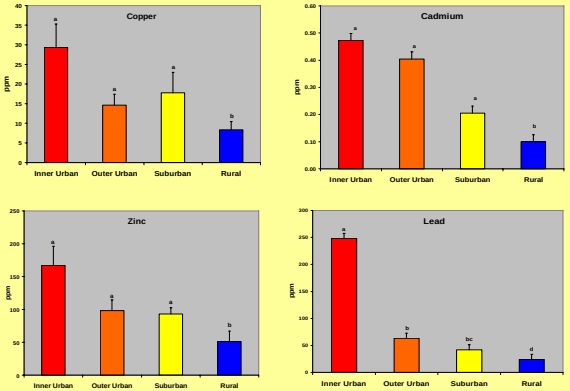
Macro-Invertebrate Sampling:
At each yard patch earthworms were sampled from a 25 x 25 cm quadrat using 5% formalin solution. For each yard patch all isopods present were collected within 30-minute sampling period.

Metal Analysis: Nitric Acid Abstraction and ICPMS (Inductively Coupled Plasma Mass Spectrometer.

Personal Management: Age of home and gardening practices (application of fertilizer or lime) were recorded for each residence.

Spatial Variation

For all metals, heavy metal soil concentrations varied regionally with inner-urban residences containing significantly higher concentrations than rural. Only inner- urban **Pb** concentrations were significantly higher then all other landuses (outer-urban, suburban and rural).



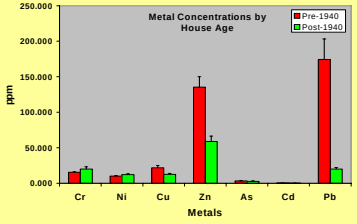
Soil Metal Correlations

The strong correlation between **Cu, Zn, Cd and Pb** suggest they share a similar source.

	Cr	Ni	Cu	Zn	As	Cd	Pb
Cr			0.46 0.029		0.64 0.001	0.51 0.012	
Ni			0.65 0.001				
Cu				0.51 0.013		0.49 0.018	0.5 0.015
Zn						0.82 <.0001	0.9 <.0001
As						0.42 0.045	

Source: House Age

Cu, Zn and Pb concentrations of pre-1940 homes were significantly higher than post-1940 homes.



Pre-1940 homes were found in all four categories of the landuse gradient, however, the **Pb and Cu** concentrations in the inner-urban regions were significantly higher than all other landuses.

Pre-1940 Houses

Landuse	Cu	Zn	Pb
Inner Urban	30.58	167.17	281.23
Standard deviation	29.65	132.31	266.68
Outer Urban	12.37	99.03	76.29
Standard deviation	5.19	60.74	84.00
Suburban	18.32	96.18	60.96
Standard deviation	9.50	48.19	62.19
Rural	6.81	139.08	76.77
Standard deviation	4.18	147.97	68.33

Inner-urban Pb levels 3X higher than other landuses

Soil and Arthropod Heavy Metal Correlations

Isopod heavy metal contents strongly correlated to all soil metal concentrations except for Cu and Cd while earthworms significantly correlated only to **Pb**.

Soil Metal	Isopod	Earthworm
Cr	0.522 0.0008	0.290 0.191
Ni	0.447 0.0049	0.217 0.332
Cu	0.088 0.601	0.285 0.199
Zn	0.570 0.0002	-0.035 0.877
As	0.598 <.0001	0.257 0.248
Cd	0.076 0.650	0.157 0.485
Pb	0.705 <.0001	0.659 0.0009

Conclusion

1) **Regional Scale** (the urban to rural landuse gradient) explains the variation of heavy metals in residential soil communities. The primary metals separating residences by landuse are: **Pb, Cd and Zn.**

2) **Age of home** is a source of **Cu, Zn and Pb** heavy metal differences, but remnant lead paint is not sole factor. Older urban homes may be intercepting metal air particles, which are accumulating in the soil.

3) Isopod heavy metal concentrations positively reflect heavy metal soil levels (excluding Cu and Cd), and earthworm lead levels significantly correlated to Pb soil concentrations. Understanding the impact of heavy metals on urban food webs is essential because many of Earth's species live and are influenced by urban areas.

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