Towards Measuring the Bioaccessibility of PAHs in soil – the story so far

Mark Cave

USEPA Contract with Exponent

PAH Interactions with Soil and Effects on Bioaccessibility and Bioavailability to Humans
ER-1743

Objective

Polycyclic aromatic hydrocarbons (PAHs) have emerged as one of the most important contaminants driving risk estimates and remedial decisions for soils at Department of Defense (DoD) sites. Substantial research efforts have focused on PAH bioavailability from solid matrices, including investigations into the chemistry of PAH interactions with soil and sediments, the oral and dermal uptake of PAHs into ecological and human receptors, extraction methods that are predictive of bioavailability measures, and in situ methods to reduce the bioavailability of PAHs in soil and sediments. This research has yielded an extensive understanding of PAH chemistry and bioavailability. However, the ability to apply these research findings broadly to human exposures at contaminated sites remains elusive due to the narrow focus of prior studies.

The objective of this project is to examine the fundamental physical and chemical interactions between PAHs and soils and how these interactions control the oral and dermal bioavailability of PAHs in soil to humans. A broad-based understanding will be achieved by tying together research on soil/PAH chemistry with in vivo measures of bioavailability across a diversity of soil types and contaminant sources.
Human Exposure

- Inhalation
- Dermal absorption
- Ingestion

Key spatial datasets: landuse classification options NLUD

- Domestic Buildings
- Domestic Gardens
- Non Domestic Buildings
- Road
- Rail
- Path
- Greenspace
- Water
- Other Land Uses
- Unclassified Land

NLUD urban rural (log):
- 0.081 - 4.3
- 2.8 - 0.044
- 0.2 - 2.9
Background Concentrations

CE-PBET university of Reading

Colon extended physiologically based extraction test system (CE-PBET)

1.2 g of OECD soil spiked with PbN added to stomach
Add bile, pancreas, adjust pH
Sample centrifuged, and supernatant taken for analysis
water medium added to soil pellet
FOREhST In-vitro laboratory test mimics the human stomach to measure the bioaccessibility of Polyaromatic Hydrocarbons in Soil

In-vitro laboratory method simulates stomach and intestine fluids with food

Extract and analyse PAHs

Results agree with an independent method

Contaminated soil

Benzo[a]pyrene

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Comparison of Batch Mode and Dynamic Physiologically Based Bioaccessibility Tests for PAHs in Soil Samples

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New Study

- 26 soil samples from 3 gas works sites of varying ages
- 8 samples from a small horizontal gasworks that was closed in 1950,
- 5 samples from an uncontaminated urban garden,
- 4 samples from a small gasworks which was closed 1900 and
- 9 samples from an early small gasworks closed in 1860.
- The samples were freeze dried and sieved to <250 µm. Total PAH and FOREhST extractions
- NIR and Mid-IR spectra of the soils
PAHs studied

N  naphthalene
Ay  acenaphthylene
Ae  acenaphthene
F   fluorene
Ph  phenanthrene
An  anthracene
Fl  fluoranthene
Py  pyrene
BaA benz[a]anthracene
Ch  chrysene
BbF benzob[1]fluoranthene
BkF benzok[1]fluoranthene
BjF benzoj[1]fluoranthene
BeP benzop[e]pyrene
BaP benz[a]pyrene
Per perylene
IdPy indeno[1,2,3-cd]pyrene
DBA dibenz[a,h]anthracene
BPer benzo[g,h]perylene
Noise reduction by PCA filtering

Model Interpretation

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Model Predictions

Able to predict BA values for PAHs not analysed

Second study explains first study anomalies
Further Work

- In-vivo validation of the PAH bioaccessibility test
- Trial the modelling approach on a wider variety of soils
- Inter-laboratory trials
- Current data can be used as supporting evidence in a risk assessment

Acknowledgments

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