META Environmental, Inc.

Environmental Forensic Scientists

PAHs In Urban Background: Distribution, Regulatory Relief, and Forensic Value

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ABSTRACT

Numerous studies in the U.S. and Europe have indicated that the concentrations of PAHs in surface soils can range from the low parts per billion to hundreds of parts per million depending on the proximity to and contribution from PAH sources. The results of these background PAH studies can be used in two ways:

1) to reduce investigation and cleanup costs by forming the basis for regulatory relief or as a substitute for site-specific studies; or

2) to reduce site management costs by shifting responsibility to other parties.

To date, regulatory relief has been obtained in only a few jurisdictions and most regulators still require some site-specific data. In contrast, PAH source attribution has been and is being used at many sites as a basis for cost sharing. Large data sets, such as the one discussed in this paper, are extremely valuable because they:

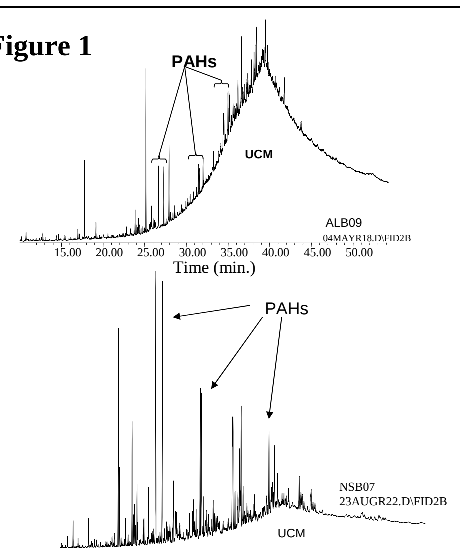
1) define the range of PAH concentrations typical of background,

2) provide the scientific data needed for defining source characteristics, and

3) add some statistical confidence to PAH allocations.

This paper summarizes the combined results of two studies of PAHs in urban surface soil in the United States. The studies were collaborative efforts between EPRI, GTI, nine electric and/or gas utilities, META Environmental, Inc., the state environmental agencies in New York, Illinois, and Pennsylvania, and many municipalities. Surface soil samples from over 500 sites in 42 population centers in four states were collected and analyzed for PAHs; this represents the most comprehensive study of PAHs in urban surface soil available. The samples were analyzed for 43 PAHs and alkylated PAHs by GC/MS.

Figure 1



SITE DESCRIPTIONS AND SAMPLES COLLECTED

Overview of EPRI/GTI Studies

EPRI Background PAH Study
- **Surface soil samples (0-6") from populated areas**
  - 102 0-1" samples and 102 1-6" samples
- **29 areas; 3 States (NY, IL, PA)**
- **319 samples**
- **Analyzed for 43 PAHs and hydrocarbon fingerprint**

GTI Background PAH Study
- **15 areas, 2 States (IL, CA)**
- **99 samples**
- **Analyzed for 43 PAHs, fingerprint, and CSIRs**

Summary of Site Uses

	Number	Percent
Rights of Way	165	39
Recreational (parks, etc.)	104	25
Municipal	76	18
Utility	35	8
Open Land	22	5
Residential	9	2
Conservation	4	1
Industrial	2	<1
Commercial	1	<1

n = 418

Summary of Area Uses

	Number	Percent
Heavy residential	203	53
Commercial	77	20
Light industrial	39	10
Light residential	40	10
Rural	14	3
Agricultural	6	2
Heavy industrial	5	1

n = 384

RESULTS

The combined PAH database contains 535 soil analysis results from 418 locations. At 301 locations, a soil from the 0-6" interval was composited and analyzed. At 117 locations, results are available for both the 0-1" and 1-6" intervals. Also, the data at the 117 locations were mathematically combined to give weighted average results for the associated 0-6" interval.

The samples contained mixtures of pyrogenic and petrogenic hydrocarbons, ranging from mostly petrogenic to mostly pyrogenic, as illustrated in Figure 1. The PAH distributions were dominated by 4-, 5-, and 6-ring parent PAHs.

Concentrations of all compounds were lognormally distributed, as illustrated by benzo(a)pyrene in Figure 2. Summary statistics are shown in Table 1. The distribution of BaP by the type of area land use is shown in Table 2.

Figure 2

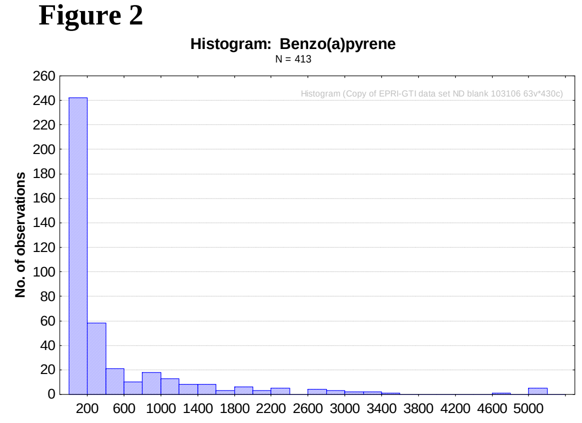


Table 2

	N	Median (ug/kg)	Range (ug/kg)
Heavy Residential	142	123	2.0 – 7,920
Commercial	61	153	1.9 – 3,360
Light Industrial	32	138	2.7 – 4,740
Light Residential	27	71	2.0 – 2,220
Rural	13	30	4.9 – 1,360
Agricultural	6	68	3.3 - 135
Heavy Industrial	4	682	267 – 2,190

n = 285 ND set to ½ EDL

Table 1

Compound	Range	Mean	Median
Naphthalene (357)	ND – 2,850	74	30
Pyrene (415)	ND – 16,800	830	200
Benz(a)anthracene (409)	ND – 9,170	475	104
Benzo(a)pyrene (413)	ND – 11,700	520	120
Dibenz(a,h)anthracene (341)	ND – 3,010	140	44
BaP Equivalents (415)	ND – 17,900	770	180

Compound	Lower Quartile	Upper Quartile	5th Percentile	95th Percentile
Naphthalene (357)	14	65	5.5	221
Pyrene (415)	65	721	10	3,290
Benz(a)anthracene (409)	34	393	5.8	2,210
Benzo(a)pyrene (413)	43	465	6.6	2,340
Dibenz(a,h)anthracene (341)	18	141	5.5	560
BaP Equivalents (415)		670		3,469

Summary of Results for Parent PAHs in All 418 Samples (µg/kg)

Results based on interval of 0 to 6 inches for all samples (µg/kg)

(xxx) – number of detections out of 418 samples

USE OF BACKGROUND DATA FOR ENVIRONMENTAL FORENSICS

Large data sets such as the EPRI/GTI background PAH data can be used to identify diagnostic chemicals, ratios, and patterns, and provide statistical boundaries on their values.

For example, Figure 3 shows the fluoranthene/pyrene ratio verses total PAHs. Most samples had Fl/Py ratios between 1.01 and 1.33; independent of PAH concentration. This contrasts with former MGP tars from CWG plants that have Fl/Py ratios between about 0.6 and 0.8.

Similarly, Figure 4 shows that the benz(a)anthracene/chrysene ratio in background samples generally was lower than that observed in coal tar and creosote samples. Because of the large data set, differences between background and site-specific samples can be assigned some statistical significance.

When compound-specific carbon isotope ratios are included, the range of typical background narrows even further relative to MGP, coal tar, and coal tar products as seen in Figure 5.

Figure 5

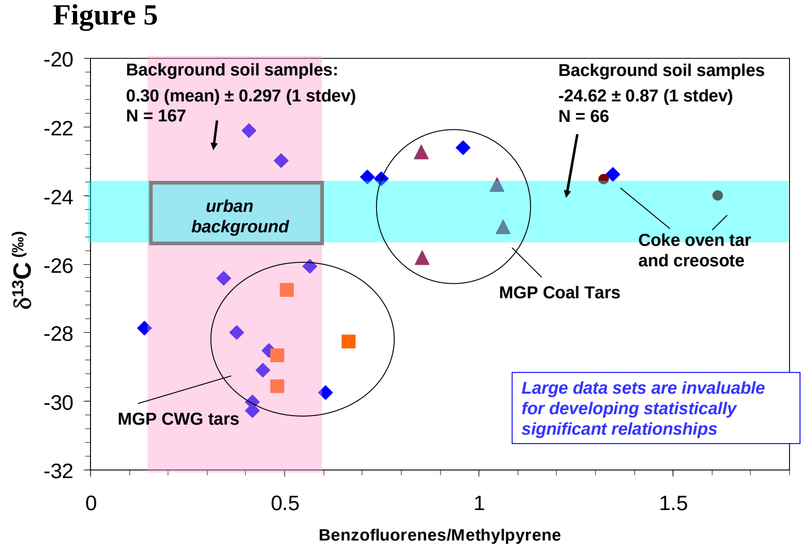


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Figure 3

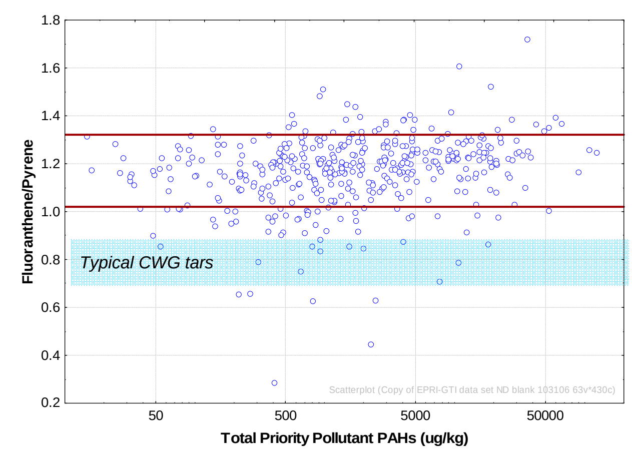
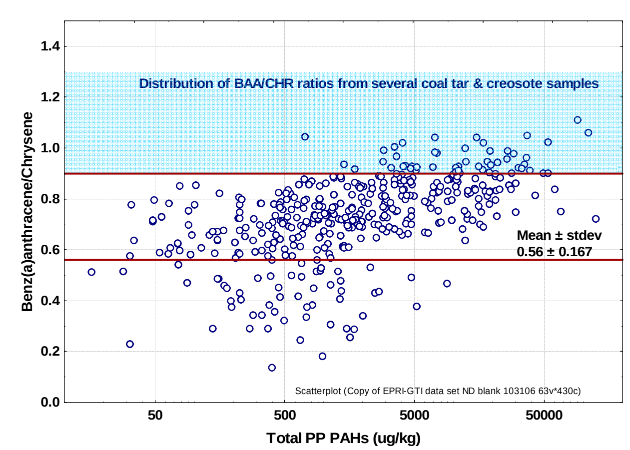


Figure 4



SUMMARY

- •PAHs were detected in nearly all 535 samples
- •58% of sites exceeded residential RBC for B(a)P (0.087; EPA Region 3, 1994)
- •Possible higher concentrations at immediate surface (0-1")
- •Data are log-normally distributed
- •Concentrations of HPAHs typically much higher than LPAHs
- •Samples collected in industrial and commercial areas have higher PAH concentrations than those collected in residential areas

CONCLUSIONS

Changes in State cleanup criteria, guidance, etc.?

Not easy

Better tools for PAH risk communication

Scientifically valid data sets provide solid basis for arguments that PAHs are background – establish a context

Help communicate lack of risk when PAHs detected

Better tools for site-specific PAH source identification

Distributions/ranges supported by large data sets

Basis for new/better source identification factors

e.g., isotopes

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