# SOURCE EVALUATION OF DIOXINS/FURANS, PAHS, AND PENTACHLOROPHENOL IN SOIL SAMPLES NEAR A WOOD TREATING SITE IN THE SOUTHEASTERN USA

Shields WJ[1]*, Edwards MR[1], Abrahams JA[2], Ferrara RA[3], Bollinger M[4], Paul LS[5]

[1]Exponent, 15375 SE 30th Place, Bellevue, WA, USA; [2]GeoTrans, Inc., 10860 Gold Center Dr., Rancho Cordova, CA, USA; [3]Omni Environmental LLC, 321 Wall Street, Princeton, NJ, USA; [4]Beazer East, Inc., 1910 Cochran Road, , Mt. Lebanon, PA, USA; [5]Koppers Inc., 436 Seventh Avenue, Pittsburgh, PA, USA

**Introduction**

A source evaluation was conducted to evaluate potential sources of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs),and pentachlorophenol in soil samples collected in drainage swales and residential yards near the Koppers Inc., wood treatment plant (the Site) in Tie Plant, Mississippi, USA.

**Materials and methods**

Soil samples were collected[1] by GeoTrans, Inc. from 59 locations in residential yards (0- to 15-cm and 15- to 30-cm depths) and drainage pathways (0- to 15-cm and 15- to 30-cm depths) in the Site vicinity, from 6 locations onsite to establish source fingerprints, and from 20 locations within Grenada and Montgomery Counties to provide regional background congener compositions. The interpretation of these sample results was augmented with analytical results for soils sampled from 43 offsite locations in the Tie Plant vicinity in 2004 and 2005.

The PAH and pentachlorophenol analyses were performed by Columbia Analytical Services in Kelso, Washington, USA. PAH analysis used U.S. Environmental Protection Agency (EPA) Method 8270 SIM and included 38 alkylated PAHs in addition to the 17 priority pollutants. Pentachlorophenol was analyzed by EPA Method 8151M. Analytical Perspectives Laboratory in Wilmington, North Carolina, USA, performed the PCDD/F analyses using EPA Method 8290.

The primary transport pathway of concern was surface water transport of PCDD/Fs (associated with pentachlorophenol use) and PAHs (associated with creosote use). Omni Environmental LLC (Omni) conducted a surface water drainage pattern analysis of historical and current transport from onsite areas to offsite areas. The Site lies within the Batupan Bogue watershed and is adjacent to a residential neighborhood known as Carver Circle. The focus of the analysis was whether drainage from the Site flows or has flowed into (a) Carver Circle, and/or( b) other residential areas in the Tie Plant area. In this regard, a detailed evaluation of drainage patterns between 1937 and the present was completed.

Source evaluation was conducted by Exponent using both spatial (geographic) analysis and chemical fingerprinting techniques.

**Results and discussion**

***Surface water drainage patterns*—**Analysis demonstrated that only a limited opportunity existed for drainage from the Site to have entered Carver Circle. Drainage from approximately 10% of the Site had the opportunity to flow along an open primary drainage channel through a small area on the northwest corner of Carver Circle for a limited period of time. No other portions of Carver Circle were ever subject to drainage from the active Koppers Site. Chemical analyses of ditch sediment samples, discussed below, were consistent with this hydraulic analysis.

***Spatial evaluation of contaminant concentration data*—**The spatial distribution of PCDD/F concentrations (as indicated by toxicity equivalents [$TEQ_{WHO-05}$]), pentachlorophenol, and PAH concentrations (as indicated by benzo[a]pyrene toxicity equivalents [BaP-TE]) were evaluated using "dot maps" and bar charts. These maps and

charts will be presented at the conference. Data from the earlier sampling events (2004 and 2005) were also included in the spatial analysis.

This analysis had two significant findings. First, the heterogeneity of concentrations within the community is more likely attributable to area-specific sources rather than a large regional source (i.e., surface water or aerial discharges from the Site), which would result in more uniform concentrations with much less variability between residential yards. Second, elevated concentrations downstream of the primary stormwater outfall (Outfall 6) indicate historical transport of these constituents along the historical drainage pathways. This is consistent with the analysis of historical surface drainage patterns.

***Chemical fingerprinting***—The PCDD/F congener composition for the onsite samples was, with several notable exceptions, distinct from the offsite samples based on a principal component analysis (PCA) as shown in Figure 1. The factor loadings and percent variability accounted for by the first three factors from the PCA are shown in Table 1. Congener compositions of samples from the Carver Circle area (shown as residential soils and drainage way samples in Figure 1) were more similar to regional (i.e., background) samples than to the onsite samples, with the exception of the drainage way samples historically downstream from Outfall 6. The fingerprint of these samples (from locations DW-16 and DW-21) were more similar to the fingerprints of the onsite drainage way samples. The similarity of these downstream drainage way samples to upstream onsite samples demonstrates that the PCDD/F fingerprinting method was robust and useful in identifying (or eliminating) potential sources.

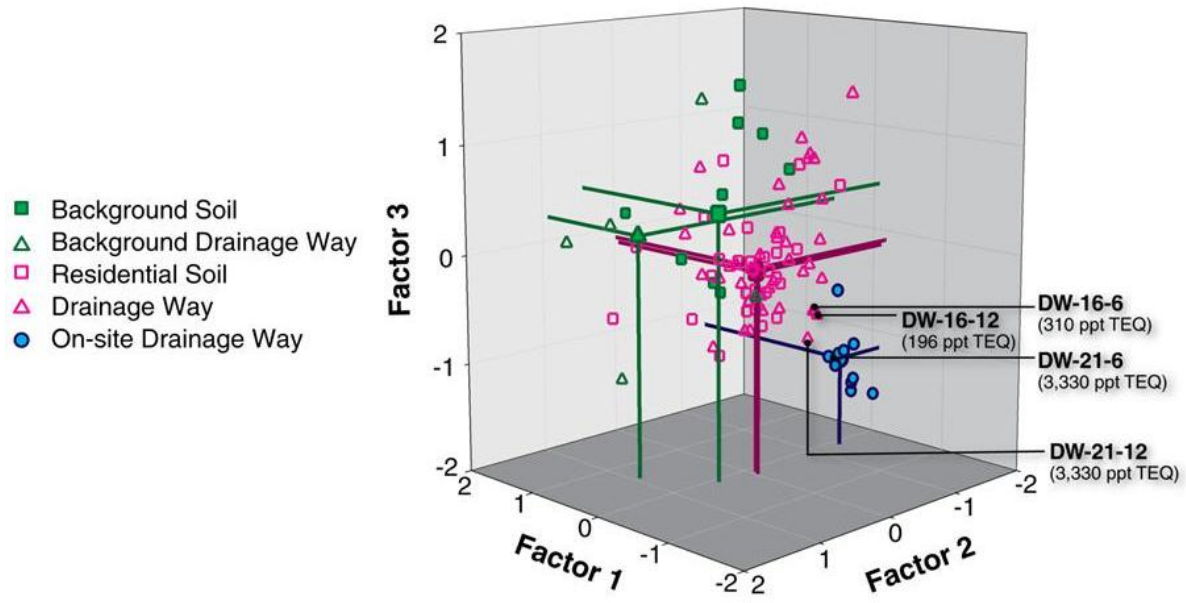


**Figure 1. Three-dimensional plot of PCA factor scores with the offsite drainage way samples from stations DW-16 and DW-21 indicated**

PAH fingerprinting was less informative than PCDD/F fingerprinting in identifying or eliminating potential sources. This was because the PAH compositions of the onsite samples were similar to those of some background samples. Also, the PAH compositions of the onsite samples were more variable (i.e., not as uniform) than those of the PCDD/F congeners.

**Table 1. Factor loadings and percent of variability explained for first three factors in the PCDD/F principle components analysis**

| Congener | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| **Dioxins** | | | |
| 2,3,7,8-TCDD | 0.25 | **0.72** | -0.39 |
| 1,2,3,7,8-PeCDD | 0.39 | **0.71** | -0.41 |
| 1,2,3,4,7,8-HxCDD | 0.46 | 0.52 | -0.41 |
| 1,2,3,6,7,8-HxCDD | **0.78** | 0.04 | -0.20 |
| 1,2,3,7,8,9-HxCDD | 0.54 | 0.64 | -0.43 |
| 1,2,3,4,6,7,8-HpCDD | 0.20 | 0.04 | **-0.62** |
| OCDD | **-0.62** | 0.56 | 0.54 |
| **Furans** | | | |
| 2,3,7,8-TCDF | 0.58 | 0.38 | 0.45 |
| 1,2,3,7,8-PeCDF | **0.75** | 0.27 | 0.35 |
| 2,3,4,7,8-PeCDF | **0.87** | -0.14 | 0.35 |
| 1,2,3,4,7,8-HxCDF | **0.92** | -0.15 | 0.29 |
| 1,2,3,6,7,8-HxCDF | **0.92** | -0.12 | 0.23 |
| 2,3,4,6,7,8-HxCDF | **0.92** | -0.20 | 0.19 |
| 1,2,3,4,6,7,8-HpCDF | **0.83** | -0.36 | 0.17 |
| 1,2,3,4,7,8,9-HpCDF | 0.40 | -0.55 | **-0.61** |
| OCDF | 0.15 | **-0.65** | **-0.64** |
| Variance Explained (%) | 42.7 | 19.9 | 17.7 |
| Cumulative Variance (%) | 42.7 | 62.7 | 80.3 |

**Note:** 1,2,3,7,8,9-HxCDF was excluded from the PCA because of a high percentage of non-detect results.

Factor loadings greater than 0.6 or less than -0.6 are shown in bold.

Spatial analysis and chemical fingerprinting indicate that alternate sources (aside from the Site) were the cause of several anomalous concentrations of PCDD/Fs, PAHs, and pentachlorophenol found in the Carver Circle community soils. These elevated concentrations were not subject to surface water runoff from the Site. They could not have been a result of aerial deposition from the Site because that would have resulted in more uniform concentrations and could not account for the high yard-to-yard variability. Open burning of trash and yard waste was a common practice in this community, including a trash incinerator, which were more likely sources of PCDD/Fs and PAHs than runoff or aerial emissions from the Site. Resident-specific use of pentachlorophenol has been documented and is a more probable explanation of the anomalous concentrations of both PCDD/Fs and pentachlorophenol, rather than runoff from the Site.

**Acknowledgements**
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**References**
1. GeoTrans, Inc. (2010) Final Draft Sampling Report, Additional Sampling, Koppers Inc., Tie Plant Facility, Tie Plant, Mississippi; Prepared for Beazer East, Inc. and Koppers Inc. and submitted to U.S. Environmental Protection Agency, Atlanta, Georgia, USA on December 22, 2010.