# CASE STUDY OF RESIDENCES WITH ANOMALOUS SOIL CONCENTRATIONS OF PCDDS, PCDFS, AND PCBS IN A COMMUNITY IN MICHIGAN, USA

Franzblau A[1], Towey T[2], Demond A[2], Adriaens P[2], Chang SC[2], Garabrant D[1], Gillespie B[3], Gwinn D[4], Hong B[3], Lepkowski J[5], Luksemburg W[6], Maier M[6], Olson K[5], Trin H[2]

[1]Department of Environmental Health Sciences, University of Michigan School of Public Health, Ann Arbor, MI 48109; [2]Department of Civil and Environmental Engineering, University of Michigan College of Engineering, Ann Arbor, MI 48109; [3]Department of Biostatistics, University of Michigan School of Public Health, Ann Arbor, MI 48109; [4]Center for Statistical Consultation and Research, University of Michigan, Ann Arbor, Michigan 48109; [5]Institute for Social Research, University of Michigan, Ann Arbor, Michigan 48109; [6]Vista Analytical Laboratory, El Dorado Hills, California 95762

**Abstract**

As part of The University of Michigan Dioxin Exposure Study, soil samples were collected from 766 residences, a number of which had anomalously high TEQs given their location. Seven of these residences were selected for further study to elucidate the reason for the higher than expected TEQs. Open-ended interviews and further soil analyses suggested movement of soil from the contaminated areas as the dominant reason, but another property with a different congener pattern, apparently became contaminated through the sandblasting of a painted surface.

**Introduction**

The University of Michigan Dioxin Exposure Study (UMDES) was undertaken in response to concerns among the population of Midland and Saginaw Counties in Michigan USA that the discharge of dioxin-like compounds from the Dow Chemical Company facilities in Midland, Michigan (USA) had resulted in contamination of soils in the Tittabawassee River flood plain and areas of the City of Midland, leading to an increase in residents' body burdens of PCDDs, PCDFs and PCBs. To analyze the relationship between soil contamination and residents' body burden, soil samples were taken from residential properties in Midland, Saginaw and Bay Counties (Michigan, USA), and in Jackson and Calhoun Counties (Michigan, USA) as a comparison. This study collected soil samples from 766 residential properties, and analyzed them for the WHO 29 PCDD, PCDF and PCB congeners. After examining the results, it became apparent that some properties had higher TEQ values than that which would be expected based on their location. This case study presents the results from a few of those properties and discusses the hypotheses to explain the high TEQ values.

**Materials and Methods**

*Respondent Selection:* Five populations, designated as Floodplain (located in the 100-year FEMA [Federal Emergency Management Agency] floodplain of the Tittabawassee River), Near Floodplain (located in a census block that contained a portion of the 100-year FEMA floodplain), Plume (located downwind of the Dow facility in the City of Midland), Other Midland/Saginaw (located in Midland, Saginaw or Bay Counties, but outside the above areas) and Jackson and Calhoun (located in Jackson or Calhoun Counties) were sampled. A more detailed description of the populations and respondent selection methodology is reported on UMDES's website (www.umdioxin.org).

*Soil Sampling*: Up to four sampling stations were located around the perimeter of the house. If responses to interview questions indicated soil contact activities, samples were also taken at those locations (maximum of two), usually a vegetable garden and/or a flower garden. For properties located in the Tittabawassee River flood plain, one additional station near the river was sampled. Thus, there were a maximum of seven sampling stations at each residence (4 house perimeter, 2 soil contact, 1 flood plain). Samples were composited as described in Demond et al. (2006)[1]. Ultimately, each residence yielded all or some of the following composite samples for analysis: House perimeter set 0-1 inch composite (HP 0-1 inch); House perimeter set 1-6 inch composite (HP 1-6 inch); Soil contact set 0-6 inch composite (Garden); Near river set 0-1 inch composite (NR 0-1 inch); and Near river set 1-6 inch composite (NR 1-6 inch).

*Sample Analysis*: The HP 0-1 inch composite samples were analyzed for all residences. If any part of the property was in the floodplain, then all remaining composites were also submitted for analysis. If the respondent did not live in the flood plain, but had a vegetable garden or worked in a flower garden, the garden composite was analyzed. If the TEQ (WHO, 1998 values) of the HP 0-1 inch composite for any property outside the floodplain was > 8 pg/g, then the HP 1-6 inch composite was subsequently analyzed. The trigger value of 8 pg/g TEQ represents the 75$^{th}$ percentile of the background distribution for the lower peninsula of Michigan (i.e., 25% of soil samples are expected to be above 8 pg/g) (Barabas, 2004)[2]. All samples that were subjected to analysis were shipped to Vista Analytical Laboratory (El Dorado Hills, California), where they were analyzed by (HRGC/HRMS) for the WHO 29 congeners. A total of 766 residences were sampled in the five counties in Michigan from October – December 2004 and from April – September 2005, with a total of 2081 samples submitted for analysis. The measured concentrations were then sample weighted to reflect the fact that the soil samples were obtained from a subset of the population.

*Case Study*: This case study did not consider residents from the Floodplain or Plume populations since these areas were known to be contaminated. Instead, this study focused on Other Midland/Saginaw and Jackson/Calhoun populations. To be eligible for the study, the participant must have elected to receive his soil sampling results and have at least one composite total TEQ value greater than 2.0 standard deviations above the mean of the log-transformed data for that population (1998 WHO TEF values). Seven respondents who met these criteria were recruited to participate. These respondents completed an open-ended interview covering questions about house characteristics (age of house, history of flooding, location relative to industrial activity, prior use of property, etc.), soil movement (onto or off property during construction, renovation, landscaping, etc.), habits of residents (hobbies, trash burning, pesticide spraying, etc.). Also, uncomposited soil samples from the original soil sampling survey were submitted for analysis to help elucidate any hypotheses drawn from the responses to the interview questions.

**Results and Discussion**

The results and discussion presented here focus on three of the seven respondents, one from the Jackson/Calhoun and two from the Other Midland/Saginaw populations. These three particular cases were selected because the interview and subsequent sampling elucidated possible reasons as to why the soil concentrations were elevated despite the fact that the properties were neither in the Tittabawassee River floodplain nor located downwind of Dow Chemical.

*Case 1*: Jackson/Calhoun. The TEQ (2005) from the HP 0-1 inch composite was 186.2 pg/g, but the HP 1-6 inch composite was only 5.7 pg/g. While the TEQ of the HP 1-6 inch composite was below the mean measured in Jackson/Calhoun of 6.9 pg/g (Demond et al., 2007)[3], the HP 0-1 inch composite was one of the highest values measured in the study for this population. Thus, the contamination seemed to impact the surface only. The TEQ was dominated by PCBs, with PCB 126 and PCB 118 the largest contributors (Table 1). The PCBs with the highest concentrations were PCB 118, followed by PCB 105. This pattern is suggestive of an industrial product such as paint or caulk, which often contained Arochlor 1254, whose composition is mostly pentachlorinated biphenyls. From the interview, we learned that the home was built in 1966 on farmland. The current owners were the second owners. They bought the house directly from the builder who had owned the house for 18 months. In 1969, they installed a pool and brought in soil to fill in around the perimeter of the pool. In the mid-1980's, they installed flower gardens adjacent to the pool and house, which required the emplacement of additional soil. In 1993, they removed multiple layers of pool paint by sandblasting. This operation created a fine layer of dust over the entire property, but was concentrated particularly in the backyard where the pool was located. Subsequent analysis of the uncomposited HP 0-1 samples yielded a TEQ for the backyard of 448.4 pg/g, but a TEQ in the front yard of only 19.0 pg/g. Based on the fact that the property had no industrial history, that the contamination seemed to be confined to the surface soil predominantly in the backyard, and that the contamination had a profile similar to the PCBs used in paint, it appeared that the property had become contaminated through the sandblasting of the swimming pool.

*Case 2*: Other Midland/Saginaw. The TEQ (2005) of the HP 0-1 inch composite was 5.5 pg/g, below the arithmetic mean measured in this study for Jackson/Calhoun of 6.9 pg/g. However, the TEQ of the garden composite was 89.4 pg/g, considerably higher than that of the HP sample. In addition, this sample had a preponderance of PCDFs, a pattern found in contaminated soil from the Tittabawassee River floodplain, yet this home was located a considerable distance from the floodplain. From the interview, we learned that the house was built in 1967 on farmland, and the current owner was the original and only owner of the house. In September 1986, the property had flooded, not by the Tittabawassee River, but by the back-up of storm sewers. Bags of topsoil had been purchased for the garden, but no fertilizers had been used. Commercial lawn care had been used for the entire time they had lived in the house, but it was limited to the grassy areas. About 5 or 6 years ago, they had brought in mulch from a township composting facility for the garden. This facility is located only about 200 meters from the Tittabawassee River, well within its floodplain. Subsequent analysis of the HP 1-6 inch composite confirmed that the soil around the house was uncontaminated, so the flooding of the property, although related to the historic flooding event of 1986, did not result in the contamination of the property. Commercial top soil has been shown to contain dioxins (Luksemburg, 2004)[4], although the TEQ is generally below the value measured here for the garden composite and in addition, its congener pattern differs from that seen here. Thus, it appears that the mulch from the township composting facility was the source of the garden contamination. This conclusion confirms a concern of area residents that the contamination from the Tittabawassee River has been spread through the movement of materials from the vicinity of the river.

*Case 3*: Other Midland/Saginaw. The TEQ (2005) of the HP 0-1 inch composite was 125.1 pg/g and that of the HP 0-1 inch composite was 64.6 pg/g. The congener pattern of these samples had a preponderance of PCDFs, similar to the pattern found in contaminated soil from the Tittabawassee River floodplain, yet this home was outside the floodplain. From the interview, we learned that the house was built in 1974 and the current owners had occupied the house since July 1986. The house was not flooded in September 1986. Bagged commercial soil had been brought in periodically for the gardens. More soil had been brought in by truck to build a berm in the backyard. There had been some pesticide spraying of the property, but that had stopped about 10 years ago. Subsequent analysis of uncomposited samples showed that the west side of the yard had a TEQ of 304.7 pg/g, considerably higher than the value on the east side of house of 61.5 pg/g or in the back yard of 5.0 pg/g. Since the majority of soil that had been brought in had been placed in the back yard, the soil that had been emplaced since 1986 did not seem to be the source of the contamination. Upon looking at the topography of the house site and its elevation relative to the neighboring houses, it appeared that the site had been leveled by building up one side, the west side, of the site. From this observation, it was inferred that contaminated soil from the Tittabawassee River floodplain had been used in the construction of the house to level the site. This conclusion was reinforced by the analysis of some of the other cases in this study that are not detailed here, lending additional support to the concern that the contamination from the Tittabaswassee River has become more widespread through movement of soil from the vicinity of the river.

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## References

1. Demond A, Towey T, Chang SC, Adriaens P, Luksemburg W, Maier M, Favaro K, Wenning R, Kennington B. *Organohalogen Comp* 2006; 68.
2. Barabas N. Personal communication. LimnoTech, Ann Arbor, MI, 2004.
3. Demond A, Adriaens P, Towey T, Chang SC, Franzblau A, Garabrant D, Gillespie B, Hong B , Lepkowski J, Luksemburg W, Maier M, Trin H. *Organohalogen Comp* 2007 (forthcoming).
4. Luksemburg W. Personal communication. Vista Analytical Laboratories, El Dorado Hills, CA. 2004.

**Table 1: Contributions to TEQ of PCDDs, PCDFs, PCBs in Soil Samples (pg/g) (2005 TEFs)**

| Case Number/Soil Sample Type | 1 HP 0-1 Comp | 1 HP 1-6 Comp | 1 HP 0-1 back | 1 HP 0-1 front | 2 HP 0-1 Comp | 2 HP 1-6 Comp | 2 Garden 0-6 Comp | 3 HP 0-1 Comp | 3 HP 1-6 Comp | 3 HP 0-1 west | 3 HP 0-1 east | 3 HP 0-1 back |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,3,7,8-TCDD | 3.72 | 1.35 | 10.7 | 0.346 | 1.81 | 0.934 | 1.06 | 1.11 | 0.74 | 1.29 | 0.669 | 0.523 |
| 1,2,3,7,8-PeCDD | 1 | 0.182 | 1.49 | 0.682 | 0.79 | 0.471 | 1.22 | 2.35 | 1.36 | 2.59 | 1.11 | 1.43 |
| 1,2,3,4,7,8-HxCDD | 0.108 | 0.0386 | 0.0929 | 0.0806 | 0.085 | 0.0501 | 0.108 | 0.2 | 0.132 | 0.201 | 0.0968 | 0.143 |
| 1,2,3,6,7,8-HxCDD | 0.246 | 0.0845 | 0.303 | 0.236 | 0.237 | 0.121 | 0.274 | 0.528 | 0.312 | 0.652 | 0.26 | 0.281 |
| 1,2,3,7,8,9-HxCDD | 0.297 | 0.0905 | 0.295 | 0.241 | 0.188 | 0.0896 | 0.192 | 0.369 | 0.21 | 0.394 | 0.195 | 0.258 |
| 1,2,3,4,6,7,8-HpCDD | 0.629 | 0.194 | 0.868 | 0.715 | 0.554 | 0.265 | 0.607 | 0.759 | 0.503 | 1.21 | 0.472 | 0.366 |
| OCDD | 0.2016 | 0.0585 | 0.2811 | 0.2112 | 0.153 | 0.0621 | 0.1671 | 0.207 | 0.1308 | 0.339 | 0.1251 | 0.0669 |
| 2,3,7,8-TCDF | 2.48 | 0.0925 | 5.97 | 0.218 | 0.19 | 0.116 | 31.6 | 40.7 | 18.5 | 102 | 16.7 | 0.195 |
| 1,2,3,7,8-PeCDF | 0.2634 | 0.02682 | 0.702 | 0.02982 | 0.0312 | 0.02106 | 4.08 | 6.3 | 3.21 | 15.24 | 3.27 | 0.0462 |
| 2,3,4,7,8-PeCDF | 3.57 | 0.2001 | 10.08 | 0.684 | 0.405 | 0.2796 | 35.7 | 48.6 | 26.79 | 128.7 | 25.08 | 0.633 |
| 1,2,3,4,7,8-HxCDF | 0.789 | 0.0359 | 1.9 | 0.205 | 0.199 | 0.122 | 8.34 | 14.5 | 7.12 | 31.6 | 8.01 | 0.207 |
| 1,2,3,6,7,8-HxCDF | 0.411 | 0.141 | 0.865 | 0.102 | 0.122 | 0.0544 | 2.13 | 3.33 | 1.95 | 6.71 | 1.7 | 0.151 |
| 1,2,3,7,8,9-HxCDF | 0.125 | 0.0107 | 0.746 | 0.13 | 0.035 | 0.0654 | 1.65 | 2.68 | 1.33 | 3.94 | 0.942 | 0.177 |
| 2,3,4,6,7,8-HxCDF | 0.316 | 0.0515 | 0.336 | 0 | 0.084 | 0.0245 | 1.13 | 1.64 | 0.936 | 6.37 | 1.55 | 0.0503 |
| 1,2,3,4,6,7,8-HpCDF | 0.164 | 0.167 | 0.215 | 0.171 | 0.134 | 0.0791 | 0.497 | 1.16 | 0.762 | 2.61 | 0.683 | 0.112 |
| 1,2,3,4,7,8,9-HpCDF | 0.0185 | 0.00301 | 0.0398 | 0.00961 | 0.0091 | 0.00603 | 0.0538 | 0.1 | 0.0628 | 0.221 | 0.0589 | 0.00706 |
| OCDF | 0.01005 | 0.003 | 0.01212 | 0.01293 | 0.01059 | 0.00588 | 0.0204 | 0.0444 | 0.02982 | 0.0975 | 0.02643 | 0.00489 |
| PCB 81 | 0.0972 | 0.042 | 0.2148 | 0.00654 | 0.000564 | 0.000248 | 0.000546 | 0.000687 | 0.000453 | 0.000969 | 0.000711 | 0.000241 |
| PCB 77 | 0.917 | 0.000338 | 2.31 | 0.0654 | 0.00288 | 0.00121 | 0.00167 | 0.00187 | 0.0016 | 0.00203 | 0.00268 | 0.000859 |
| PCB 126 | 133 | 2.29 | 327 | 11.8 | 0.451 | 0.253 | 0.489 | 0.474 | 0.435 | 0.466 | 0.53 | 0.348 |
| PCB 169 | 0.879 | 0.02763 | 1.872 | 0.0933 | 0.0198 | 0.01206 | 0.0288 | 0.0288 | 0.0252 | 0.02964 | 0.01941 | 0.01644 |
| PCB 105 | 9.63 | 0.1491 | 24.87 | 0.789 | 0.00573 | 0.00273 | 0.00642 | 0.00372 | 0.00369 | 0.00354 | 0.00699 | 0.002556 |
| PCB 114 | 0.516 | 0.00738 | 1.341 | 0.0414 | 0.000216 | 0.000126 | 0.000405 | 0.000324 | 0.000226 | 0.000564 | 0.000363 | 8.22E-05 |
| PCB 118 | 21.39 | 0.345 | 42.3 | 1.701 | 0.00924 | 0.0045 | 0.01278 | 0.00804 | 0.00759 | 0.00786 | 0.01308 | 0.00537 |
| PCB 123 | 0.39 | 0.00531 | 1.026 | 0.02808 | 0.000292 | 0.000161 | 0.000261 | 0.000222 | 0.000191 | 0.000206 | 0.000312 | 0.000143 |
| PCB 156 | 3.18 | 0.0426 | 7.77 | 0.2598 | 0.001548 | 0.000804 | 0.002829 | 0.001509 | 0.001245 | 0.001224 | 0.002004 | 0.000948 |
| PCB 157 | 0.699 | 0.00918 | 1.752 | 0.0564 | 0.00039 | 0.000196 | 0.000621 | 0.000321 | 0.000327 | 0.000294 | 0.000504 | 0.000262 |
| PCB 167 | 1.077 | 0.01461 | 2.745 | 0.09 | 0.000615 | 0.00033 | 0.001071 | 0.000549 | 0.000546 | 0.000489 | 0.000876 | 0.000423 |
| PCB 189 | 0.1245 | 0.00170 | 0.2934 | 0.00948 | 0.000101 | 5.79E-05 | 0.000483 | 0.000124 | 0.000119 | 0.000118 | 0.000141 | 7.23E-05 |
| **Total TEQ** | **186.2** | **5.7** | **448.4** | **19.0** | **5.5** | **3.0** | **89.4** | **125.1** | **64.6** | **304.7** | **61.5** | **5.0** |

Gray shading indicates original soil analyses. White shading indicates soil samples submitted as part of the case study.