

MEASUREMENTS OF HOUSEHOLD DUST CONCENTRATIONS OF PCDDS, PCDFS AND PCBS FROM A COMMUNITY IN MICHIGAN, USA

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Introduction

Dioxin-like compounds are a family of structurally related chemicals including polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs). The University of Michigan Dioxin Exposure Study (UMDES) was undertaken in response to concerns among the population of Midland and Saginaw Counties, Michigan, USA that dioxin-like compounds from the Dow Chemical Company have resulted in contamination of soils in the Tittabawassee River flood plain and areas of the City of Midland. There is concern that people's body burdens of PCDDs, PCDFs and PCBs may be elevated because of environmental contamination. A central goal of the UMDES is to determine the factors that explain variation in serum levels of PCDDs, PCDFs, and PCBs, and to quantify how much variation each factor explained. Household dust concentration of PCDDs, PCDFs, and PCBs were included in the list of potentially explanatory factors to investigate. This paper provides descriptive statistics and distributions of the household dust measurements to accompany regression models that examine the factors that explain variation in household dust levels¹.

Materials and methods

Study participants were selected from five defined populations in Michigan using a two-stage area probability household sample design. These populations were selected because they were believed to live in the most contaminated areas in the Midland/Saginaw area (the Floodplain, the Near Floodplain, and the Midland Plume), or were a referent population (Jackson/Calhoun, approximately 200 km south of Midland) where there is no known source of dioxins. The population in other areas of Midland/Saginaw (Other M/S) was chosen to allow estimation of the dioxin exposures to people who lived in the Midland/Saginaw region, but not in the most contaminated areas. In order to be eligible for participation in the survey, subjects had to be age 18 years or older and had to have lived in their residence at least five years. In order to be eligible for participation in household dust sampling, subjects had to also own their residence. Additional details on the population sampling have been previously published².

The dust sampling protocol was based on the American Society for Testing and Materials (ASTM) method "Standard Practice for Collection of Floor Dust for Chemical Analysis"³. A High Volume Small Surface Sampler (HVS3) manufactured by CS-3, Inc. (Sandpoint, ID, USA), capable of capturing 99.95% of particles above 0.3 micrometer aerodynamic mean diameter⁴, was used to collect dust sample. Dust samples were taken from easily accessible floors in frequently used living or family areas and nearby hallways in each participant's home. The complete UMDES study protocol, including the dust sampling protocol has been previously published² and is available online at www.umdioxin.org⁵.

Dust samples were analyzed using high resolution gas chromatographic mass spectrometry (GC/MS) at Vista Analytical Laboratory, Inc. (El Dorado Hills, California, USA) for the World Health Organization (WHO) list of 29

PCDD, PCDF, and dioxin-like PCB congeners⁶ using modifications of United States Environmental Protection Agency methods 1668⁷ and 8290⁸.

Dioxins in dust are reported as the congener concentration per gram of dust (pg/g or ppt, lipid adjusted). Results for concentrations that fell below the analytical limit of detection (LOD) were estimated by $LOD/\sqrt{2}$ for analysis^{9,10}. Toxic equivalencies (TEQs) were calculated based on the WHO 2005 toxic equivalency factors (TEFs)⁶. Descriptive analysis of PCDD, PCDF, and PCB household dust congener concentration was performed for each of the five geographic regions. SAS version 9.2 statistical software was utilized to complete all analyses (SAS Institute Inc., Cary, N.C.).

Results and Discussion

A total of 764 residences were sampled in the five counties in Michigan, 207 in the Floodplain region, 159 in the Near Floodplain region, 37 from the Midland Plume, 163 in other Midland/Saginaw (Other M/S), and 198 from Jackson/Calhoun. The median dust TEQ in the Midland Plume (31.3 ppt) is higher than in the other areas of Midland/Saginaw (11.3-17.6 ppt) and Jackson/Calhoun (13.8 ppt) (Table 1). The distributions are highly skewed with a long right tail (such that mean values are as high as or higher than the 75th percentile) (Table 1 and Figure 1).

Table 1. Statistical description of dust TEQ*

Zone	N	TEQ(ppt)					
		Mean(S.E.)	Median	75 th %ile	95 th %ile	Min.	Max.
Overall	764	36.7(4.2)	16.2	29.7	126.4	1.4	1748.3
Floodplain	207	38.9(6.9)	16.4	36.3	107.9	2.3	1748.3
Near Floodplain	159	16.5(1.6)	11.3	20.1	41.7	1.4	188.7
Midland Plume	37	38.8(6.1)	31.3	41.8	90.7	8.2	334.1
Other Midland/Saginaw	163	35.0(6.5)	17.6	28.5	87.7	1.6	1401.0
Jackson/Calhoun	198	38.8(6.1)	13.8	32.2	176.9	2.1	1114.1

* TEQ is combined for the 29 congeners recognized by the WHO as having dioxin-like activity⁶.

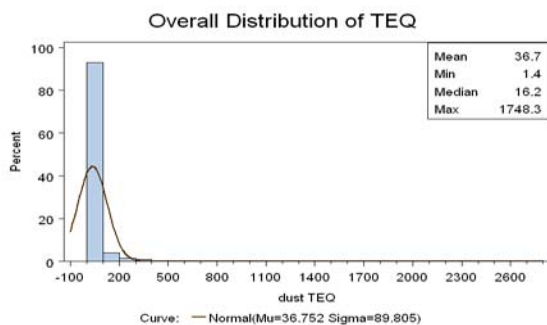


Figure 1. Overall distribution of dust TEQ

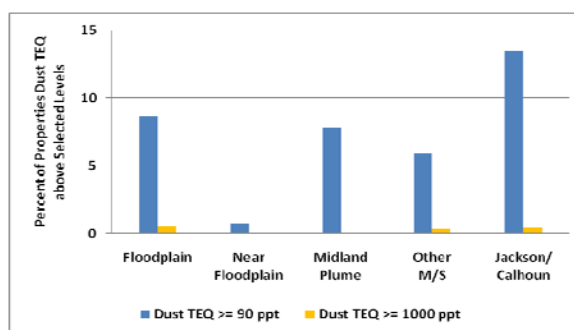


Figure 2. Percent of properties dust TEQ over selected levels

Because the UMDES used a multistage, population-based sample and the sample weights were maintained in the analyses, these results apply to the households of the general population of M/S and J/C. Although there are state and federal regulations regarding soil contamination by dioxins, there are no regulations for household dust contamination by dioxins. Therefore, for purposes of comparison, we describe our household dust results with reference to benchmarks for soil. Figure 2 shows the estimated percent of homes above the Michigan Department of

Environmental Quality (MDEQ) direct contact criterion for residential soil (dioxin TEQ 90 ppt) and the United States Environmental Protection Agency's (EPA) residential soil action level (dioxin TEQ 1000 ppt) in each of the five areas in the UMDES. Nine percent of homes in the Floodplain, 1 percent of homes in the Near Floodplain, 8 percent of homes in the Midland Plume, and 6 percent of homes in Other Midland/Saginaw are estimated to have a dust sample with a TEQ over 90 ppt. The estimated percent in Jackson/Calhoun is even higher than that in Midland/Saginaw area with 13 percent of the homes are estimated to have a dust sample over MDEQ's criterion. Half of one percent of home in the Floodplain, less than on half of 1 percent of homes in the Other Midland/Saginaw, and no homes in the near Floodplain and Midland Plume are estimated to have dust level higher than 1000 ppt. 0.47% of the homes in Jackson/Calhoun are estimated to have a dust sample that exceeds 1000 ppt.

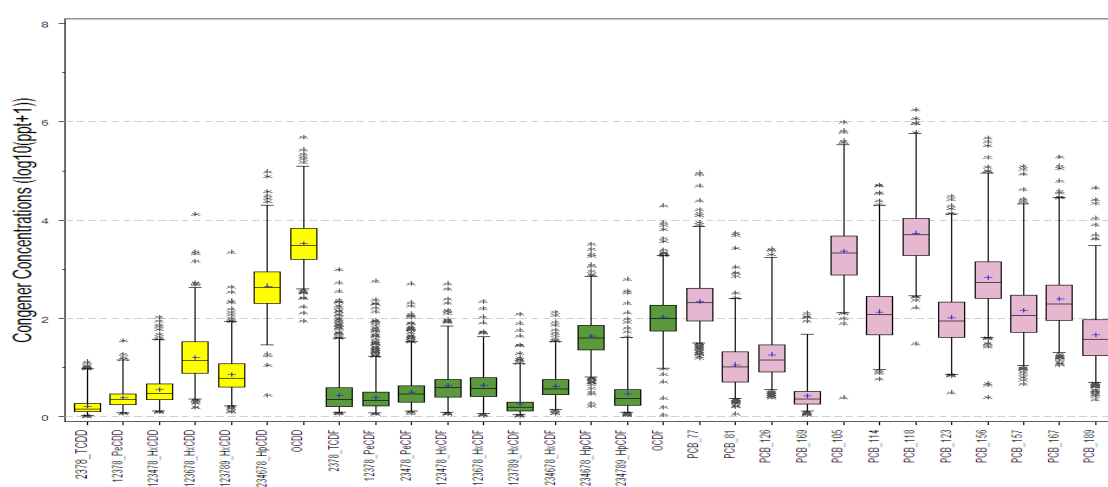


Figure 3. Box and whisker plots of the distribution of dust PCDD, PCDF, and PCB concentrations in household dust for each of the 29 WHO dioxin congeners.

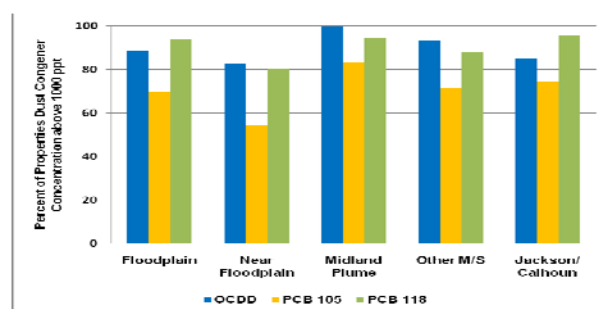


Figure 4. Percent of properties with congener concentrations over 1000 ppt.

Among all 29 congeners, OCDD, PCB 105, and PCB 118 are the 3 highest concentration congeners in dust (Figure 3). Figure 4 shows the estimated percent of homes above 1000 ppt for OCDD, PCB 105, and PCB 118 by five areas. Eighty-nine percent of homes in the Floodplain, 82 percent of homes in Near Floodplain, 100 percent of homes in the Midland Plume, 93 percent of homes in Other Midland/Saginaw, and 85 percent of the homes in Jackson/Calhoun have dust level higher than 1000 ppt for OCDD. Seventy percent of homes in the Floodplain, 55

percent of homes in Near Floodplain, 83 percent of homes in the Midland Plume, 72 percent of homes in Other Midland/Saginaw, and 74 percent of the homes in Jackson/Calhoun have dust level higher than 1000 ppt for PCB 105. Ninety four percent of homes in the Floodplain and the Midland Plume, 80 percent of homes in Near Floodplain, 88 percent of homes in Other Midland/Saginaw, and 95 percent of the homes in Jackson/Calhoun have dust level higher than 1000 ppt for PCB 118.

The UMDES is the largest study on dust contamination of PCDDs, PCDFs, and PCBs to date and provides important information on dust concentrations in an area with known soil contamination, as well as in a reference community (Jackson/Calhoun) with no known source of exposure to PCDDs, PCDFs, and PCBs. Dust contamination is evident in all five regions. Jackson/Calhoun has comparable dust concentrations as the contaminated area, suggesting that sources inside the residence were important contributors to dust concentrations.

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