IMPLICATIONS OF THE EPA'S NEW PRELIMINARY REMEDIATION GOALS FOR RESIDENTIAL SOIL BASED ON THE UNIVERSITY OF MICHIGAN DIOXIN EXPOSURE STUDY

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Introduction

The University of Michigan Dioxin Exposure Study (UMDES) was motivated because of concerns about possible human exposure to dioxins discharged as a result of historical industrial activities of the Dow Chemical Company located in Midland, Michigan, USA. A number of investigations have documented widespread dioxin contamination of soils in Midland downwind of incineration activities at Dow (i.e., the plume area), and in the flood plain and river sediments of the Tittabawassee River and further downstream from the Dow plant [1,2]. The congener profiles of dioxin contamination in these two areas differ, with contamination in the plume area dominated by polychlorinated dibenzo-*p*-dioxins (PCDDs), and contamination in the flood plain of the Tittabawassee River dominated by two polychlorinated dibenzofurans (PCDFs), 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF [1]. The main focus of the UMDES has been to identify and quantify potential pathways of human exposure to dioxins in the contaminated areas.

The UMDES was a large, carefully planned and executed, population-based exposure pathway study that involved cutting-edge survey methodologies, careful sample collection (blood, household dust, and soil) and state-of-the art analytical chemistry [3]. Field data collection was largely completed in 2004-2005, initial results became available in 2006, and main results were published in 2009 [4,5,6].

On December 30, 2009, the US EPA released the *Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites* (OSWER 9200.3-56), in which the agency proposed lowering the preliminary remediation goals (PRGs) for residential soil from 1,000 parts per trillion (ppt) TEQ to 72 ppt TEQ, or possibly even 3.7 ppt TEQ [7]. This paper examines possible implications of lowering the PRGs for residential soil to either 72 ppt or 3.7 ppt TEQ, based on results from the UMDES.

Materials and Methods

The UMDES involved a two-stage clustered random sampling survey design to recruit subjects from five regions in the State of Michigan, USA. The survey design of the UMDES allows for accurate estimation of serum levels of dioxins in the populations studied, and it also permits statistical estimation of the percentage of residential properties with soil TEQ (or congener-specific results) at or above a given level. The regions were: the 100-year Federal Emergency Management Agency (FEMA) floodplain of the Tittabawassee River or whether the respondent reported flooding of the home by the Tittabawassee River (FP); the near-floodplain of the Tittabawassee River (NFP); the plume area in the City of Midland downwind from the historic incineration activities of the Dow plant (PL); elsewhere in Midland and Saginaw counties and parts of Bay County outside of the floodplain, near-floodplain and plume areas (OMS); and Jackson and Calhoun Counties (located more than 200 kilometers away from the Dow facilities in Midland) that served as a control area (JC). Eligible subjects were required to be at least 18 years old and to have lived in their homes for at least 5 years. No children were included in the study, and so the study can offer no direct conclusions concerning children. Data collection for the study involved an hour-long interview and obtaining blood, household dust, and soil samples for chemical analyses from eligible subjects. Overall, 946

subjects provided blood samples (251 from JC) that were analyzed for the WHO 29 PCDDs, PCDFs and polychlorinated biphenyls (PCBs) by Vista Analytical Laboratory (El Dorado Hills, California) using modified US EPA methods 8290 and 1668, Revision A [8,9]. Soil samples were collected and analyzed from 766 properties (194 from JC), and house dust samples were collected from 764 properties (198 from JC). Serum results are reported in ppt on a lipid adjusted basis; soil and dust results are reported in ppt on a dry weight basis. TEQ values are calculated using 2005 TEFs [10]. Full details of methods for the parent study are available elsewhere [1,3]. Statistical analyses were performed using SAS version 9.1 and STATA version 10 [11,12].

Results and Discussion

The soils on residential properties in JC had a mean dioxin concentration of 9.0 ppt TEQ, with a range of 0.4 to 186 ppt. This information is likely relevant to background dioxin contamination in small cities and rural areas of the upper Midwestern United States, and possibly elsewhere.

Fifty-seven percent of the properties in Jackson/Calhoun (the control area) have soil dioxin concentrations above 3.7 ppt TEQ, and one percent have soil dioxin concentrations at or above 72 ppt TEQ (see Table 1). These percentages translate into 24,519 and 502 properties, respectively (see Table 1).

We estimate that 786 properties in the FP, 523 in the NFP, 2,631 in the PL, and 28,678 in OMS have soil dioxin levels above 3.7 ppt TEQ, yielding a total of 32,618 properties in the Midland/Saginaw area above 3.7 ppt TEQ (see Table 1). While it would be relatively straightforward to find contaminated properties in the FP, NFP, and PL, the overwhelming majority of the properties above 3.7 ppt TEQ are in OMS, not near Dow or the Tittabawassee River. There is no efficient way to figure out which properties are likely to be affected without analyzing multiple soil samples from each property at substantial cost. It is worth noting that the number of properties above 3.7 ppt TEQ in JC (n=24,519) is almost as many as in OMS (n=28,678).

While the proportion of properties with soil TEQ at or above 72 ppt TEQ is low in OMS (3%), the absolute number is substantially higher (n=1322) than in any of the other areas in Midland and Saginaw counties, simply because OMS has a far larger population and many more residential properties than the other study regions in Midland and Saginaw counties (see Table 1).

The UMDES measured household dust dioxin concentrations in the living rooms, dining rooms, kitchens and hallways of residences for which soil samples were also analyzed. Samples were not taken in locations where there was little human exposure, such as attics and behind appliances (see reference 3 for more details).

The proportions of properties having household dust dioxin contamination above 3.7, 72, 90, and 1,000 ppt TEQ are shown by study region in Table 2. More than 95 percent of residences had dust above 3.7 ppt TEQ in all five regions, including JC. The proportions of properties having household dust dioxin contamination above 72 ppt TEQ was higher in JC (17 percent) than in the Midland/Saginaw regions (1 to 11 percent). Since the soil concentrations in Midland/Saginaw were higher than in Jackson/Calhoun, this finding indicates that soil contamination is not the most important determinant of household dust contamination. The same pattern was seen at 90 ppt TEQ in dust, for which JC had a higher proportion of properties above this threshold than any of the Midland/Saginaw areas. Even for the 20 properties with the highest levels of contamination in house dust, soil was only an important contributing factor about 10% of the time [13]. The fact that JC has a higher proportion of properties with dioxin contamination in house dust suggests that this is a background pattern of contamination in house dust.

The proposed PRG only pertains to soil, and yet people spend the vast bulk of time inside their homes (70% - the EPA estimate of time spent inside homes [14]), and so the opportunity for potential exposure to dioxins in house dust would appear to be relevant. Yet, even if all residential soil were remediated to at or below 72 ppt TEQ the dioxin levels in house dust in most homes would not be affected since most soil is already below this value, and soil makes only a minor contribution to contamination in house dust. Furthermore, the majority of the homes with dust dioxin

levels above the proposed PRG of 72 ppt TEQ do NOT have soil levels above 72 ppt TEQ, and so cleaning up soil on residential properties with dioxin levels above 72 ppt TEQ will do little to reduce potential exposures from house dust (see Table 3).

The UMDES had 132 people who lived on soil with dioxin levels exceeding 72 ppt TEQ, 118 people who lived on soil with dioxin levels exceeding 90 ppt TEQ, and 21 people who lived on soil with dioxin levels between 1,000 and 11,200 ppt TEQ, indicating that the UMDES had plenty of data in the range that is relevant to the proposed PRG of 72 ppt TEQ in soil. In extensive analyses that explored the relationship between serum TEQ, soil TEQ and dust TEQ we found that: 1) the soil TEQ had no relationship to the serum TEQ; 2) the household dust TEQ had no relationship to serum TEQ [4]. Overall, we found that merely living on soil contaminated with dioxins at levels below 1000 ppt TEQ has no measurable effect on serum dioxin levels, though it is possible for dioxins in soil to get into people via indirect pathways, such as consumption of animals raised on contaminated soil [15].

Acknowledgments
Financial support for this study comes from the Dow Chemical Company through an unrestricted grant to the University of Michigan. The authors acknowledge Dr. Donald Patterson Jr., and Ms. Sharyn Vantine for their assistance, and Drs. Linda Birnbaum, Ronald Hites, Paolo Boffetta, and Marie Haring Sweeney for their guidance as members of our Scientific Advisory Board.

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Table 1. Estimated proportions (number) of properties having soil dioxin contamination above 3.7, 72, 90, and 1,000 ppt TEQ by study region.

	FP	NFP	OMS	PL	JC
≥ 3.7 ppt	0.96 (786)	0.62 (523)	0.74 (28678)	1.00 (2631)	0.57 (24519)
≥ 72 ppt	0.37 (305)	0.10 (88)	0.03 (1322)	0.44 (1158)	0.01 (502)
≥ 90 ppt	0.36 (292)	0.09 (79)	0.02 (675)	0.36 (943)	0.00 (123)
≥ 1000 ppt	0.07 (54)	0.02 (13)	0.00 (142)	0.00 (0)	0.00 (0)

Table 2. Estimated proportions (number) of properties having household dust dioxin contamination above 3.7, 72, 90, and 1,000 ppt TEQ by study region.

	FP	NFP	OMS	PL	JC
≥ 3.7 ppt	0.99 (850)	0.97 (857)	0.97 (43803)	1.00 (2740)	0.95 (41342)
≥ 72 ppt	0.11 (92)	0.01 (11)	0.08 (3731)	0.09 (255)	0.17 (7506)
≥ 90 ppt	0.09 (75)	0.01 (6)	0.06 (2709)	0.08 (214)	0.13 (5870)
≥ 1000 ppt	0.006 (5)	0.00 (0)	0.0035 (160)	0.00 (0)	0.0047 (206)

Table 3. Number of Properties, by Region, having measured soil dioxins above and below 72 ppt TEQ by household dust dioxins above and below 72 ppt TEQ

	JC Dust TEQ	JC Dust TEQ	FP Dust TEQ	FP Dust TEQ	OMS Dust TEQ	OMS Dust TEQ
Soil TEQ	≤ 72 ppt	> 72 ppt	≤ 72 ppt	> 72 ppt	≤ 72 ppt	> 72 ppt
≤ 72 ppt	159	22	102	9	142	14
> 72 ppt	0	2	72	12	6	0

FP = Tittabawassee River Flood Plain properties, NFP = Near Flood Plain properties, OMS = properties in other areas of Midland/Saginaw, PL = properties downwind of Dow plant in Midland, JC = Jackson/Calhoun county properties (see reference 3 for more details)