IMPACT OF CHANGES IN WHO TEF VALUES FROM 1998 TO 2005 ON MEASUREMENTS OF SOIL CONCENTRATIONS OF PCDDS, PCDFS AND PCBS IN A COMMUNITY IN MICHIGAN, USA

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Abstract

As part of The University of Michigan Dioxin Exposure Study, soil samples were collected from 766 residential properties from five counties in Michigan. When the samples were collected, the results were reported using 1998 World Health Organization toxic equivalency factors (TEFs). In 2005, the values were changed for 14 of the 29 congeners. These changes result in the decrease of the previously reported TEQ of 6.2% to 23.3%, depending on the location and type of soil sample, driven primarily by the reduction in the TEF of 2,3,4,6,8-PeCDF from 0.5 to 0.3.

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 and in Jackson and Calhoun Counties as a comparison. This study collected soil samples from 766 residential properties and analyzed them for the WHO 29 PCDD, PCDF and PCB congeners. When the initial study results were presented (Adriaens et al., 2006)[1], the reported TEQ values were based on the toxicity equivalency factor (TEF) values promulgated by the World Health Organization in 1998. In 2005, the values were changed for 14 of the 29 congeners (Appendix 1). The objective of this presentation is to discuss the impact of the changed TEF values on the soil TEQ concentrations that were reported previously.

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/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).

Sampling Technique: 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, 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)[2]. 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 (1998) represent the 75th 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)[3]. 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.

Results and Discussion

Tables 1 and 2 present the arithmetic means for the five types of composite samples for all the populations. In the Floodplain, the average reduction in TEQ from 1998 to 2005 is about 21%, whereas in the Plume and in Jackson/Calhoun, it is 9% and 14%, respectively. The difference is attributable to the different congener profiles for these populations. Figure 1 shows the contribution to the total TEQ of the PCDDs, PCDFs and PCBs. The TEQ is dominated by the PCDFs in the Floodplain population, predominantly 2,3,4,7,8-PeCDF. Thus, the reduction in TEF for this compound from 0.5 to 0.3 results in the median contribution of PCDFs to the TEQ dropping from about 60% to about 55% (Fig. 1).

Table 1. Comparison of Arithmetic Mean TEQs (pg/g) for Soil Composites from the Floodplain Population

	HP 0-1 inch	HP 1-6 inch	NR 0-1 inch	NR 1-6 inch	Garden
WHO 1998	72.2	71.9	302.1	363.4	64.4
WHO 2005	56.5	56.2	238.5	286.6	50.7
Percent change	-21.7	-21.8	-21.0	-21.1	-21.3

Table 2. Comparison of Arithmetic Mean TEQs (pg/g) for Soil Composites from the Plume, Near Floodplain, Other Midland/Saginaw and Jackson/Calhoun Populations

		HP 0-1 inch	HP 1-6 inch	Garden
Plume	WHO 1998	127.8	120.5	66.6
	WHO 2005	114.8	106.4	62.5
	Percent change	-10.2	-11.7	-6.2
Near Floodplain	WHO 1998	67.8	83.2	25.3
	WHO 2005	52.0	64.7	20.4
	Percent change	-23.3	-22.2	-19.4
Other Midland/Saginaw	WHO 1998	16.0	151.4	11.1
	WHO 2005	13.9	113.4	10.2
	Percent change	-13.1	-25.1	-8.1
Jackson/Calhoun	WHO 1998	8.3	13.2	5.5
	WHO 2005	6.9	11.2	4.9
	Percent change	-16.9	-15.2	-10.9

In contrast, the median contribution to the TEQ in the Plume is greater for the PCDDs than for the PCDFs. With 2005 TEFs, the contribution to the TEQ increases for the PCDDs, driven by the increase in the TEF for OCDD and the reduction for 2,3,4,7,8-PeCDF. In Jackson/Calhoun, the changes in congener contributions to the TEQ are similar to those observed in the Plume: the median contribution of the PCDDs increases, while that of the PCDFs decreases. Despite the changes in the TEFs for the PCBs, the contribution of this group stays relatively the same in all the populations due to the fact that the TEF for the dominant PCB in these samples, PCB 126, did not change.

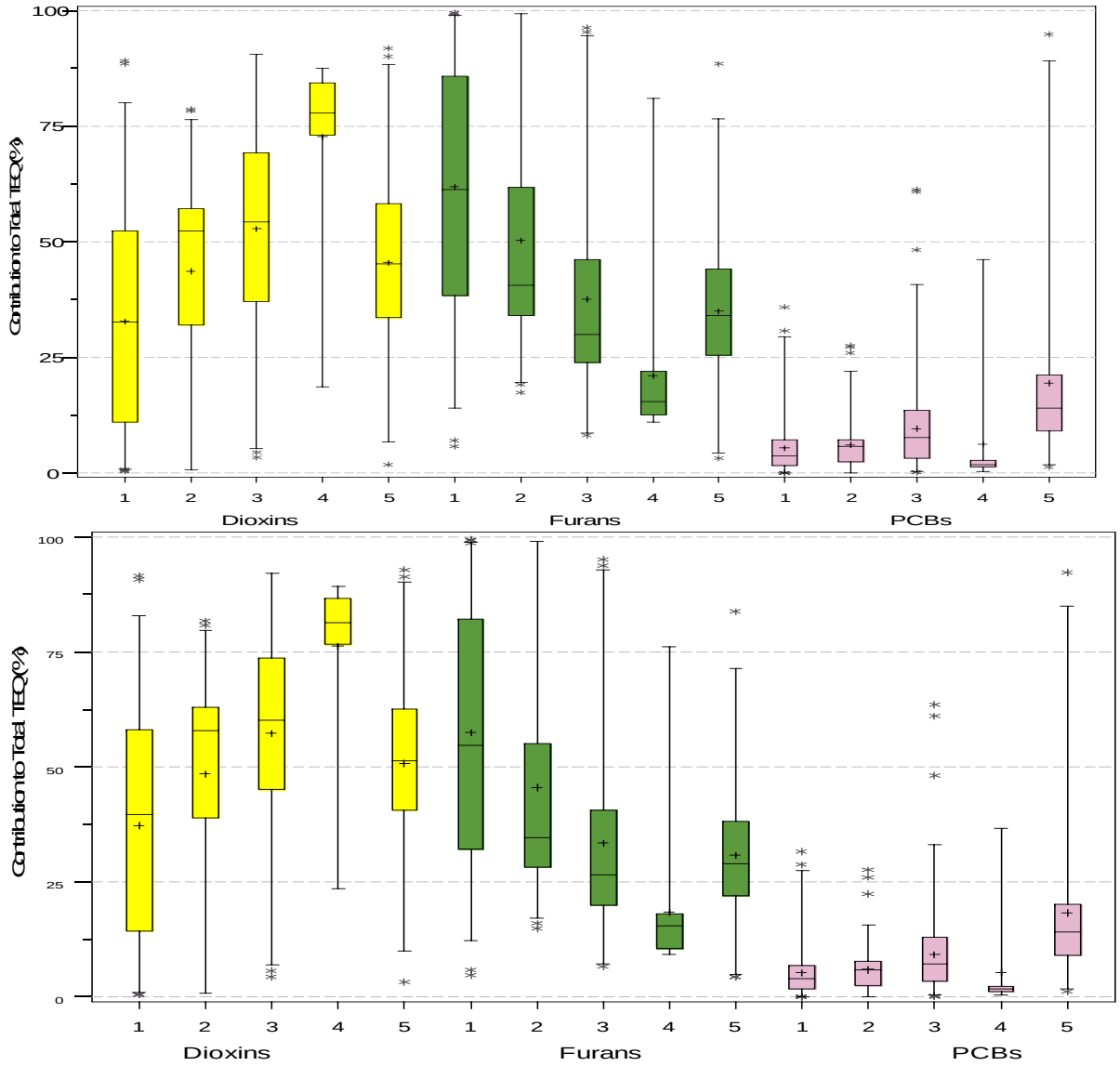

Figure 1. Contributions to total TEQ of the WHO 29 congeners for the HP 0-1 inch composites, Top: 1998, Bottom: 2005. 1: Floodplain, 2: Plume, 3: Near Floodplain, 4: Other Midland/Saginaw, 5: Jackson/Calhoun. Plus sign is geometric mean; horizontal line across box is median, lower and upper margins of the box are 25th and 75th percentiles, respectively; upper tick extends to the 99th percentile, lower tick extends to the 1st percentile; stars show values above the 99th percentile or below the 1st percentile.

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Appendix 1: Summary of WHO 1998 and WHO 2005 TEF values

Compound	**WHO 1998 TEF**	**WHO 2005 TEF***
chlorinated dibenzo-p-dioxins		
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	1	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.0001	**0.0003**
chlorinated dibenzofurans		
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	**0.03**
2,3,4,7,8-PeCDF	0.5	**0.3**
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,6,7,8,9-HpCDF	0.01	0.01
OCDF	0.0001	**0.0003**
non-ortho substituted PCBs		
PCB 77	0.0001	0.0001
PCB 81	0.0001	**0.0003**
PCB 126	0.1	0.1
PCB 169	0.01	**0.03**
mono-*ortho substituted PCBs*		
PCB 105	0.0001	**0.00003**
PCB 114	0.0005	**0.00003**
PCB 118	0.0001	**0.00003**
PCB 123	0.0001	**0.00003**
PCB 156	0.0005	**0.00003**
PCB 157	0.0005	**0.00003**
PCB 167	0.00001	**0.00003**
PCB 189	0.0001	**0.00003**

* numbers in bold indicate a change in TEF
Source: http://www.who.int/ipcs/assessment/tef_update/en/index.html