ASSOCIATION OF SOIL DIOXIN CONCENTRATIONS WITH SERUM DIOXIN CONCENTRATIONS IN MIDLAND, MICHIGAN, USA

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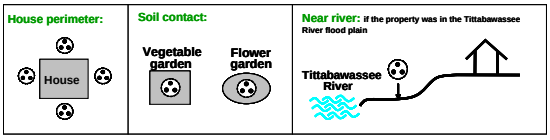
INTRODUCTION & OBJECTIVES

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 the discharge of dioxin-like compounds from the Dow Chemical Company facilities in Midland, Michigan (USA) has 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 understand the relationship between soil contamination and residents' body burden, 946 people participated in an interview and gave blood samples for analysis of the WHO 29 dioxin-like compounds. Soil samples were taken from 766 of their residential properties and analyzed for the same set of congeners. The participants were a multistage, stratified sample of the general population of five counties in Michigan, USA. The objective of this presentation is to **discuss the relationship between soil dioxin concentrations and blood serum dioxin concentrations in Midland, Michigan USA.**

METHODS

- The entire protocol for the University of Michigan Dioxin Exposure Study can be found on our study website. www.umdioxin.org
- Each residence yielded up to 7 composite soil samples for analysis.



- For each property, we also calculated the maximal dioxin concentration found in any sample found on the property.
- The relationship between serum dioxins and soil dioxins was modeled using linear regression.
- The outcome variable was the $\log_{10}$ serum dioxin concentration and the predictors were soil dioxin measurements, variables derived from the questionnaire, and household dust dioxin concentrations.
- Backward stepwise selection was used to identify other variables that were significant predictors of the serum dioxin concentration.
- We also converted the soil dioxin concentrations to categorical variables, so that we could estimate their relationships to the serum dioxin concentrations without assuming any linear relationship.
- In addition, we calculated the R^2 for each regression model. When we compared models we calculated the decrease in R^2 after removing a soil variable from the model.
- The TEQs were calculated using the 2005 WHO TEFs.

RESULTS

- There are statistically significant positive associations between blood dioxin concentrations and soil dioxin concentrations for TEQ, 23478-PeCDF, 2378-TCDD and PCB-126. **(Table 1)**
- The variation in serum dioxin levels explained by the soil parameter did not exceed 1.3% for any soil parameter. **(Table 1)**
- The magnitudes of the associations were small. $10^{\text{parameter estimate}}$ = percent change of the blood dioxin concentration associated with one unit increase of the soil dioxin concentration. Predicted blood dioxin concentrations for different soil dioxin levels were calculated for an average person to better illustrate the magnitudes of the associations. **(Figure 1)**
- An interaction term was added to the model for 23478-PeCDF **(Table 2)**. **Figure 2** showed that the slopes of the associations were different for the flood plain region and the other regions for the 23478-PeCDF maximum soil concentration. There was no evidence of interaction for the TEQ, 2378-TCDD, or PCB-126.

Table 1. Parameter estimates for models in which each soil variable was forced to enter separately

	TEQ			2,3,4,7,8 PeCDF			2,3,7,8 TCDD			PCB_126		
Parameter	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)
House perimeter 0-1"	-7.76E-05	0.5215	0.016%	-9.83E-05	0.2264	0.048%	0.0026	0.2957	0.122%	6.53E-04	<0.0001	0.980%
House perimeter 1-6"	5.26E-06	0.0811	0.008%	-4.50E-06	0.0319	0.018%	0.0045	0.1971	0.180%	9.97E-04	0.1184	0.322%
Near river 0-1"	1.57E-05	0.4449	<0.001%	3.48E-05	0.1166	0.010%	-7.04E-04	0.5622	<0.001%	0.0034	0.0573	0.014%
Near river 1-6"	2.96E-05	0.0768	0.006%	4.47E-05	0.0020	0.020%	1.44E-04	0.9059	<0.001%	0.0016	0.1047	0.012%
Soil contact 0-6"	4.42E-04	0.2399	0.098%	9.62E-06	0.9285	<0.001%	0.0065	<0.0001	0.558%	5.69E-04	<0.0001	0.360%
Maximum soil concentration	5.85E-06	0.0294	0.012%	-3.97E-06	0.0510	0.014%	0.0030	0.1306	0.214%	6.09E-04*	<0.0001	1.278%

Each model was adjusted for several other variables derived from the questionnaire
Highlighted indicated statistically significant association; blue indicated positive association and yellow indicated negative association
ΔR²=(R² from model including soil parameter) - (R² from model excluding soil parameter)
*70% of the maximum soil concentrations are house perimeter 0-1"

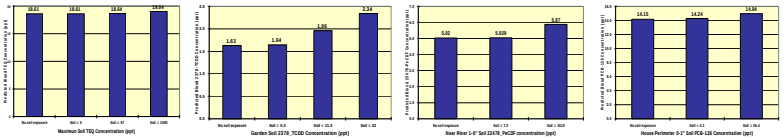


Figure 1. The examples of the relationships between soil dioxin concentrations and blood dioxin concentrations. Here, the predictions were calculated for the person whose value of every predictor, except soil, was the mean value of the population. The first three soil levels were 0, 5th percentile of soil concentrations, and 95th percentile of soil concentrations, respectively. For TEQ, the increase of blood TEQ associated with an increase of 1000 ppt of TEQ was shown to illustrate how small the magnitude is for the parameter. For TCDD, the predicted blood TCDD associated with median level garden soil TCDD of plume population was shown.

Table 2. Parameter estimates for models in which maximum soil concentration and its interaction with flood plain region were forced separately

	TEQ			2,3,4,7,8 PeCDF			2,3,7,8 TCDD			PCB_126		
Parameter	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)	Estimate	p-value	ΔR²(%)
Region_FP	-0.0319	0.2428	-	-0.0055	0.8132	-	-0.0123	0.8079	-	0.1697	0.0025	-
Maximum soil concentration	5.55E-06	0.0500	0.012%	-4.52E-06	0.0280	0.032%	0.0034	0.1221	0.238%	6.08E-04	<0.0001	0.278%
Region_FP*Maximum soil concentration	1.42E-05	0.3810		3.65E-05	0.0187		-0.0029	0.2275		3.97E-04	0.6189	

Each model was adjusted for several other variables derived from the questionnaire
Highlighted indicated statistically significant association; blue indicated positive association and yellow indicated negative association
ΔR²=(R² from model including soil parameter) - (R² from model excluding soil parameter)

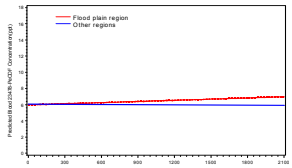


Figure 2. The interaction between flood plain region and maximum soil concentration for 23478-PeCDF. The x-axis and y-axis are truncated at observed 95th percentile of the flood plain population.

- Models based on categories of soil dioxin concentration were examined for each of the six soil variables by each of the four dioxin congeners (24 models, not shown). There was no clear relationship between the soil dioxin level and the blood dioxin level.

CONCLUSIONS

• In most instances, soil concentrations had little effect on the serum levels for TEQ, 2378-TCDD, 23478-PeCDF, or PCB-126. The one exception to this was the relationship between 2378-TCDD in serum and garden soil (soil contact zone), for which serum TCDD increased by approximately 50% as soil TCDD increased by 22 ppt.

• The findings for 23478-PeCDF indicated that the relationship between serum and soil levels was different in the flood plain population than in the other groups. Additional analyses are underway to explore this interaction.

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