

# Human Exposure to Dioxin-Like Compounds in Fish, Eggs and Soil

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## Background

- Polychlorinated dioxins (PCDDs) and polychlorinated furans (PCDFs), referred to collectively as “dioxin-like compounds” or DLCs are persistent compounds that build up in the body, and remain stored in fat and other tissues for years.
- Health effects of DLCs observed in human studies include: cancer; chloracne; diabetes; disruption of the endocrine, immune and reproductive systems; and developmental effects in children.
- DLC toxic equivalents (TEQs) are calculated by multiplying the measured level of each DLC by its toxicity equivalency factor (TEF) and summing the results to determine the total dioxin TEQ concentration.
- High levels of DLCs, predominantly PCDFs, have been found in sediments of the Tittabawassee River and soils in the river flood plain downstream of the city of Midland, Michigan.
- The Tittabawassee River frequently overflows its banks, sometimes more than once per year, carrying DLC contamination onto residential properties.
- We report the results of investigations conducted at a residential property in the Tittabawassee River flood plain where residents consumed local-caught fish and eggs from chickens raised on their property.

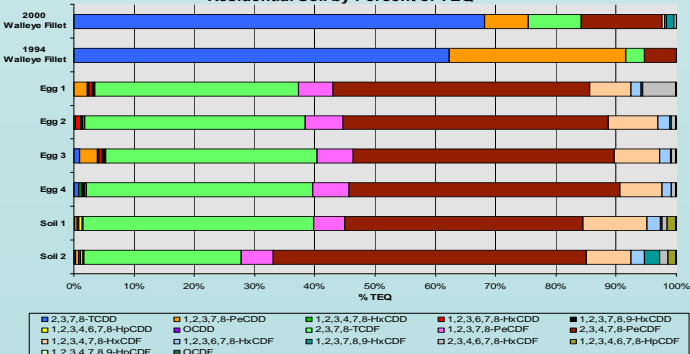
## Fish, Chicken Egg and Soil Data

Table 1. Concentrations of DLCs in parts per trillion (ppt) in local-caught walleye, chicken eggs and soil samples collected from a property in the Tittabawassee River flood plain

Analyte	WHO 2005 TEF <sup>1</sup>	1994 Walleye Fillet <sup>2</sup>	2000 Walleye Fillet <sup>2</sup>	Egg 1 <sup>3</sup>	Egg 2 <sup>3</sup>	Egg 3 <sup>3</sup>	Egg 4 <sup>3</sup>	Soil 1 <sup>4</sup>	Soil 2 <sup>4</sup>
2,3,7,8-TCDD	1	0.88	0.63	ND	ND	0.33	0.09	2	4
1,2,3,7,8-PeCDD	1	0.42	0.07	0.86	ND	0.91	ND	9	7
1,2,3,4,7,8-HxCDD	0.1	ND	ND	0.78	0.98	0.73	0.5	7	5
1,2,3,6,7,8-HxCDD	0.1	ND	ND	2.2	2.4	1.9	ND	59	28
1,2,3,7,8,9-HxCDD	0.1	ND	ND	1.2	1.4	1.1	0.7	14	10
1,2,3,4,6,7,8-HpCDD	0.01	ND	ND	4.8	6.8	4.8	2.9	1,167	465
OCDD	0.0003	ND	0.0002	6.9	12.9	7.3	5.4	11,431	4,619
2,3,7,8-TCDF	0.1	0.43	0.8	129	114	111	43.2	3,368	3,440
1,2,3,7,8-PeCDF	0.03	0.01	0.02	72.8	66	62.7	23.2	3,691	2,329
2,3,4,7,8-PeCDF	0.3	0.25	0.41	54	45.7	45.5	17.3	2,990	2,255
1,2,3,4,7,8-HxCDF	0.1	ND	0.04	26.2	25.5	23.7	7.9	2,296	971
1,2,3,6,7,8-HxCDF	0.1	ND	0.03	6.5	6.3	6	1.9	490	291
1,2,3,7,8,9-HxCDF	0.1	ND	0.02	0.65	0.77	0.53	ND	74	325
2,3,4,6,7,8-HxCDF	0.1	ND	0.14	21	2.2	2.1	0.72	187	191
1,2,3,4,6,7,8-HpCDF	0.01	ND	ND	4.6	4.9	3.9	1.9	2,981	1,666
1,2,3,4,7,8,9-HpCDF	0.01	ND	ND	0.31	ND	ND	ND	187	128
OCDF	0.0003	ND	ND	ND	ND	ND	ND	3,864	1,766
Total TEQ (ppt)		1.62	0.92	38.1	31.2	31.6	11.5	2,187	1,317

<sup>1</sup>WHO 2005 TEFs; <sup>2</sup>MDEQ 2009; <sup>3</sup>MDEQ 2003; <sup>4</sup>Weston 2008  
 ND = Not detected above the limit of detection (LOD); measurements were assigned a value of zero.  
 Notes: Walleye data are average concentrations for 1994 (n=10) and 2000 (n=10) sampling, and are representative of fish consumed by the residents prior to blood testing. Soil data shown represent the 95% upper confidence limit on the mean soil concentration for each of two parcels at this property.

Figure 1. Distribution of DLCs in Local-Caught Walleye, Chicken Eggs, and Residential Soil by Percent of TEQ



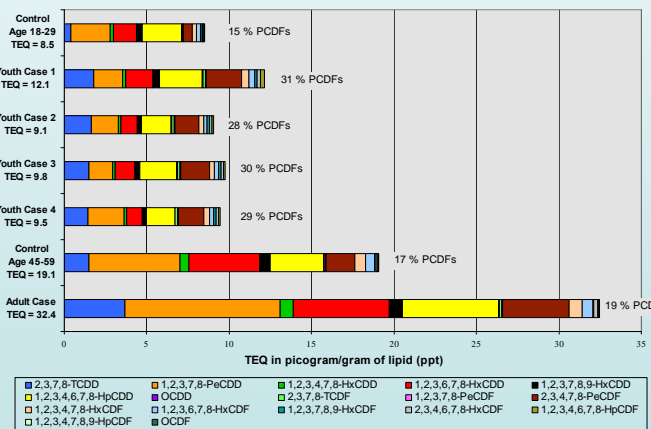
## Human Blood Serum

Table 2. Concentrations of DLCs in picograms per gram of lipid (pg/g) in serum of Michigan-specific controls and five Tittabawassee River flood plain residents.

Analyte	WHO 2005 TEF <sup>1</sup>	Youth Control (Age 18-29) <sup>2</sup>	Youth Case 1 <sup>3</sup>	Youth Case 2 <sup>3</sup>	Youth Case 3 <sup>3</sup>	Youth Case 4 <sup>3</sup>	Adult Control (Age 45-59) <sup>2</sup>	Adult Case <sup>3</sup>
2,3,7,8-TCDD	1	0.4	ND	ND	ND	ND	1.5	3.7
1,2,3,7,8-PeCDD	1	2.4	ND	ND	2.08	2.19	5.5	9.4
1,2,3,4,7,8-HxCDD	0.1	1.9	ND	ND	ND	ND	5.5	7.7
1,2,3,6,7,8-HxCDD	0.1	14	16.6	9.67	12.1	9.84	43.1	58.6
1,2,3,7,8,9-HxCDD	0.1	3.4	3.86	2.5	3.02	2.5	6.5	7.6
1,2,3,4,6,7,8-HpCDD	0.01	24.1	26.1	18.2	22.3	17.2	32.2	58.6
OCDD	0.0003	99.5	85.2	52.2	69.4	56.1	285	164
PCDD TEQ		7.2	8.4	6.5	6.9	6.7	15.8	26.4
2,3,7,8-TCDF	0.1	0.3	ND	ND	ND	ND	0.3	1.3
1,2,3,7,8-PeCDF	0.03	0.4	ND	ND	ND	ND	0.4	2.3
2,3,4,7,8-HxCDF	0.3	1.8	7.05	4.83	5.85	5.16	5.9	13.4
1,2,3,4,7,8-HxCDF	0.1	2.6	4.55	3	3.21	3.44	6.2	7.8
1,2,3,6,7,8-HxCDF	0.1	2.5	3.41	ND	2.45	2.34	5.9	6.7
1,2,3,7,8,9-HxCDF	0.1	0.9	ND	ND	ND	ND	0.8	0.3
2,3,4,6,7,8-HxCDF	0.1	0.6	ND	ND	ND	ND	0.8	2.6
1,2,3,4,6,7,8-HpCDF	0.01	7.4	23.6	6.83	7.55	11.9	7.1	7.5
1,2,3,4,7,8,9-HpCDF	0.01	0.8	ND	ND	ND	ND	0.7	0.3
OCDF	0.0003	2.0	7.05	ND	ND	4.53	2.1	0.9
PCDF TEQ		1.3	3.8	2.5	2.9	2.7	3.3	6.0
Total TEQ		8.5	12.1	9.1	9.8	9.5	19.1	32.4

<sup>1</sup>WHO 2005 TEFs; <sup>2</sup>UMDES 2009; <sup>3</sup>MDEQ Unpublished Data.  
 ND = Not detected above the limit of detection (LOD); measurements were assigned a value of LOD/2.  
 NR = Not Reported.  
 Note: Control data represent the median serum congener-specific concentration for a Michigan reference population (UMDES 2009)

Figure 2. Distribution of DLCs in Human Serum



### Description of the adult case

- Male: 47 years old
- No history of occupational exposure to DLCs
- Lived on this property on the Tittabawassee River for 19 years
- Ate garden produce grown in the floodplain
- Ate several home-produced eggs per week for 2 years
- Ate local fish and wild game once a week for more than 15 years
- Stopped eating these foods 3 years before blood was tested

### Description of the youth cases

- Four females: ages 14 to 17 years old
- Lived on this property on the Tittabawassee River since birth
- Ate several home-produced eggs per week for 2 years
- Ate local fish and wild game (frequency unreported)
- Stopped eating these foods 4 years before blood was tested

## Conclusions

- High levels of PCDFs are predominant in soil samples collected at this property, and in soil and sediment samples throughout the Tittabawassee River flood plain.
- The distribution of DLCs in eggs from chickens raised on this property is very similar to that of soil samples. Chickens likely ingest soil directly during free-range feeding.
- In contrast, TCDD constitutes a higher percentage of the TEQ found in walleye, which feed primarily on smaller fish. The congener-specific half-lives of DLCs in biota range from a few months to several years. Congeners with longer half-lives, such as TCDD, are therefore more likely to biomagnify in the food chain.
- No congener-specific background serum DLC data are available for people under the age of 18 years. Data presented here for 18 to 29 year olds likely overestimates background levels in youth aged 14 to 17 years because serum TEQ concentrations are known to be positively correlated with age.
- Serum TEQ levels in all four Youth Cases are greater than the median background level in a Michigan control population aged 18 to 29 years. In addition, the percent contribution of PCDFs to the total TEQ in the Youth Cases is roughly twice that of control data.
- The serum TEQ level in the Adult Case is greater than the median background level of an age-appropriate Michigan control population. In addition, the percent contribution of PCDFs to the total TEQ in the Adult Case (19%) is greater than that of the control data (17%).
- These results suggest that living on contaminated soil in the Tittabawassee River flood plain, eating eggs from chickens kept there, and eating local-caught fish are sources of DLC contamination in the residents serum.



Tittabawassee River

## References

MDEQ (Michigan Department of Environmental Quality). 2003. Phase II Tittabawassee/Saginaw River Dioxin Flood Plain Sampling Study. Appendix II Soil and Egg Dioxin Results. Lansing, Michigan.

MDEQ (Michigan Department of Environmental Quality), Water Bureau. 2009. Fish Contaminant Monitoring Program. Lansing, Michigan. [http://www.michigan.gov/deq/0,1607,7-135-3313\\_3686\\_3728-32393--,00.html](http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-32393--,00.html)

Patterson Jr., D.G. et al. 2007. Total TEQ reference range (PCDDs, PCDFs, PCBs, mono-PCBs) for the US. Chemosphere, doi:10.1016/j.chemosphere.2007.05.074

UMDES (University of Michigan Dioxin Exposure Study). 2009. Ann Arbor, Michigan. <http://www.sph.umich.edu/dioxin/>

Van den Berg et al. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicological Sciences 93(2): 223-241.

Weston (Weston Solutions, Inc.). 2008. Site Assessment Report for Residential Floodplain Sampling, Exposure Unit 001, Saginaw County, Michigan.