



Human exposure to dioxins from clay: A case report

Alfred Franzblau¹, Elizabeth Hedgeman¹, Qixuan Chen¹, Shih-Yuan Lee¹, Peter Adriaens¹, Avery Demond¹, David Garabrant¹, Brenda Gillespie¹, Biling Hong¹, Olivier Jolliet¹, James Lepkowski¹, William Luksemburg², Martha Maier², Yvan Wenger¹

¹University of Michigan, Ann Arbor, Michigan, USA; ²Vista Analytical Laboratory, El Dorado Hills, California, USA

Introduction and Objectives

- PCDDs, PCDFs and dioxin-like PCBs ('dioxins') have been associated with chloracne, immune, reproductive and developmental disturbances. Additionally dioxins are believed to be carcinogenic.
- For most people the dominant source of exposure to dioxins is food (>90%), primarily via consumption of dairy, meat, and fish products.
- Additional circumstances of exposure that can be significant in selected subpopulations include:
 - occupational exposures
 - consumption of fish or game from contaminated regions
 - residing in the vicinity of waste incinerators
- The UMDES was designed to determine whether PCDDs, PCDFs, and dioxin-like PCBs in soil and/or house dust explain serum levels of these contaminants, after adjustment for other known risk factors (i.e. diet, occupation, age, BMI, etc.). Collected data included:
 - survey information on age, occupation, diet, residential history (n = 1324).
 - serum samples from medically eligible participants (n = 946).
 - residential soil samples (n=766) and house dust samples (n=764) from eligible participants
- The median serum TEQ (based on 29 congeners and using the 2005 WHO TEFs) in the study group was 20 ppt, range 4 – 211 ppt
- We report results of further investigations into why the subject with the highest serum TEQ had elevated levels of dioxins in her serum**

Case Study Data

Description of the index case (Case 1):

- Female; 77 years old
- Never smoked; no recent weight change
- No history of occupational exposure to dioxins
- No consumption of wild game since childhood
- Modest consumption of sport-caught fish; stopped 13 years before the study; denied ever eating fish from the Tittabawassee or Saginaw Rivers
- No gardening or consumption of vegetables from her property
- Never resided near industrial incinerators
- Had lived along the Tittabawassee River for almost 30 years, downstream from the Dow Chemical facility located in Midland, Michigan.
- Had been very involved in ceramics as a hobby from the early 1960's up to about the mid 1990's.
- Case 1 TEQ = 211 ppt

Description of ceramics activity of index case:

- She purchased clay in liquid form and poured this into plaster molds to harden
- No additions to clay except distilled water
- Rough edges of dried pieces were smoothed with a wet sponge or by sanding
- She never used gloves, respirator or other personal protective equipment
- Pottery was fired in one of 3 un-vented electric kilns in the basement of her home (1800°F, cone 6)
- Along with friends, she performed ceramics work on average about 4 afternoons or evenings per week from early 1960's to mid 1990's

*TEQ: Toxic Equivalency; PCDD: Polychlorinated dibenzo-p-dioxin; PCDF: Polychlorinated dibenzofuran; PCB: Polychlorinated biphenyl

Case Study Data, cont.

Description of ceramics friends:

- Case 2 (age = 85) and Case 3 (age = 83)
- No history of occupational exposures to dioxins; never resided along Tittabawassee River, or near incinerators; never ate sport caught fish or wild game; never smoked; no recent weight change
- The manner, time frame, frequency and duration of ceramics work was approximately the same as for the index case, except each had only one kiln, these were located in garages, not in the basement or elsewhere inside their homes, and they were used less frequently
- Case 2 TEQ = 49 ppt; Case 3 TEQ = 69

Figures 1 and 2: Serum TEQ and 2,3,7,8-TCDD concentrations by age for Case 1 (index case), Case 2 and Case 3

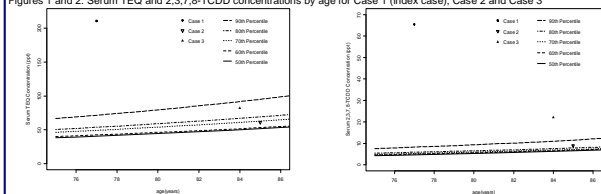


Figure 3: Distributions of PCDDs, PCDFs and PCBs in serum, clay, house dust and soil

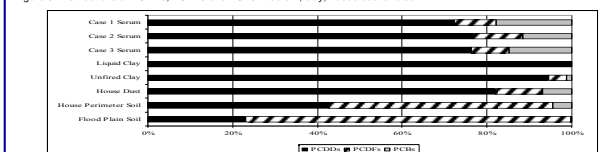


Table 1: Concentrations of PCDDs, PCDFs, and PCBs in serum, house dust, soil, clay, and Published Concentrations for Ball Clay

Compound	WHO 2005 TEFs ^a	Case 1	Case 2	Case 3	House Dust	House Perimeter	Flood Plain	Liquid Clay	Unfired Clay	Fired Clay	Processed Clay ^b	Clay Mixture ^c	Unfired Clay ^d	Fired Clay ^d
2,3,7,8-TCDD	1	65.4	9	22.1	2.49	2.67	65	31	5.34	0.05	1480	191	212	0.1
1,2,3,7,8-PeCDD	1	59.8	17	18.4	2.85	2.52	10.6	85	46.1	0.15	1220	155	157	0.4
1,2,3,4,7,8-HxCDD	0.1	30.8	12.1	17.5	5.98	2.42	8.7	86.5	44.7	0.14 ^e	271	32	30	0.4
1,2,3,6,7,8-HxCDD	0.1	189	83.6	82.3	84.7	6.36	58.6	142	63.5	0.28	777	103	93	0.4
1,2,3,7,8,9-HxCDD	0.1	32.4	10.7	14.1	31	4.66	12.9	454	388	0.28	2890	395	363	0.4
1,2,3,4,6,7,8-HpCDD	0.01	149	74.7	57.1	4620	110	652	2430	1280	1.92	7500	1130	1080	0.4
OCDD	0.0003	541	914	615	20900	851	5800	48500	18400	7.26	97900	29700	23000	1.4
2,3,7,8-TCDF	1	1.09	0.264 ^f	0.716	9.96	20	836	0.07	11	0.09	ND	ND	ND	ND
1,2,3,7,8-PeCDF	0.03	0.4 ^f	0.141 ^f	0.533	6.85	12	543	0.08 ^f	17.5	0.21	ND	ND	ND	ND
1,2,3,4,7,8-HxCDF	0.3	50	12.4	13.7	7.97	13.7	442	0.07 ^f	7.88	0.13 ^f	ND	ND	ND	ND
1,2,3,4,7,8-HxCDF	0.1	27	8.46	10	10.4	12.2	375	0.07 ^f	4.73	0.08 ^f	ND	ND	ND	ND
1,2,3,6,7,8-HxCDF	0.1	24.7	8.56	7.96	7.73	5.36	126	0.50	5.2	0.16	ND	ND	ND	ND
1,2,3,7,8,9-HxCDF	0.1	1.06 ^f	0.390 ^f	0.326 ^f	2.11	3.06	80.4	1.65 ^f	1.67	0.07 ^f	ND	ND	ND	ND
2,3,4,6,7,8-HxCDF	0.1	4.23	1.63	1.33	6.79	5.85	48.7	0.1 ^f	1.7	0.13	ND	ND	ND	ND
1,2,3,4,6,7,8-HpCDF	0.01	9.45	5.24	6.73	289	53.5	771	0.16	3.29	0.62	ND	ND	ND	ND
1,2,3,4,7,8,9-HpCDF	0.0003	146 ^f	235 ^f	0.540 ^f	9.4 ^f	3.41	65	0.07 ^f	1.84	0.08	ND	ND	ND	ND
OCDF	0.0003	2.1 ^f	1.04 ^f	1.06	636	92.6	1740	4.57	5.27	0.34	ND	ND	ND	ND
PCB 81	0.0003	9.33	1.18 ^f	3.77	40.2	1.58	16.1	0.15 ^f	2.21	0.27	NR	NR	NR	NR
PCB 77	0.0001	6.39	2.36	5.72	869	17.4	258	0.42	300	18.3	NR	NR	NR	NR
PCB 126	0.1	309	30	66.5	48.9	7.77	9.5	0.25 ^f	9.41	5.58	NR	NR	NR	NR
PCB 169	0.03	116	43.5	51.8	2.03	1.16	2.2	0.19 ^f	0.67 ^f	0.07 ^f	NR	NR	NR	NR
PCB 105	0.00003	9220	2300	4690	790	4.41	27	0.07 ^f	1184	5.38	NR	NR	NR	NR
PCB 114	0.00003	4620	2220	2400	455	7.36	34.7	0.25 ^f	214	8.5	NR	NR	NR	NR
PCB 118	0.00003	60100	19200	33100	16500	286	1080	419	8900	345	NR	NR	NR	NR
PCB 123	0.00003	1450	2140	1400	1400	18.9	27	0.07 ^f	1184	5.38	NR	NR	NR	NR
PCB 156	0.00003	21500	14000	13700	1570	68.4	110	0.21	1390	25.5	NR	NR	NR	NR
PCB 157	0.00003	5200	2990	2890	332	18.9	26.8	0.08 ^f	98.2	5.07	NR	NR	NR	NR
PCB 167	0.00003	7350	3300	3440	682	33.4	47	0.09 ^f	575	7.15	NR	NR	NR	NR
PCB 189	0.00003	1920	800	775	103	9.19	15	0.06 ^f	215	1.44	NR	NR	NR	NR
Total TEQ		211	49	69	85	18	397	223	126	0.5	3190	419	435	<1

NR = not reported; ND = not detected (below limit of detection); ^aVan den Berg et al. 2006; ^bFerrario and Byrne 2002; ^cBelow limit of detection (LOD); all concentrations below the LOD were substituted with LOD/2. Serum results are reported as parts per trillion on a lipid adjusted basis, all other results are reported as parts per trillion on a dry weight basis.

Discussion and Conclusions

- Most of the serum TEQ for the cases is attributable to PCDDs, not PCDFs or PCBs.
- The liquid clay and unfired clay is contaminated with PCDDs, while the soil, particularly from the flood plain, is dominated by PCDFs.
- The high PCDD/PCDF ratio suggests that the dioxin contamination in the clay, and not the dioxin contamination in soil from the index case's property, was the dominant source of dioxin contamination in the subject's serum.
- Possible exposure pathways from clay:
 - direct absorption of dioxins through the skin while handling liquid clay or unfired ceramics
 - Inhalation of dioxins volatilized when ceramic pieces were fired in the un-vented kilns
 - ingestion of clay or clay particles that landed on food items in the home or during food handling
 - inhalation of clay dust from handling and sanding unfired ceramic items
 - inhalation of clay dust that became mixed with house dust
- Cases 2 and 3 are approximately the same age as Case 1, and handled clay in a manner that was similar to Case 1, but their TEQ and specific congener levels in serum were dramatically lower compared to the index case.
- The major distinction appears to be that Cases 2 and 3 each had only one kiln, and these were located in garages, not in the basement or elsewhere inside the living space of their homes.
- These results suggest that inhalation of dioxins volatilized when ceramic pieces were fired in the un-vented kilns in the basement of the home was the dominant route of exposure for Case 1.
- The fact that Cases 2 and 3 had above-average TEQ and 2,3,7,8-TCDD levels in their serum (after adjustment for age) could be due to their more limited exposure to kilns, and/or a limited role for exposure from direct handling of clay materials
- Our subjects reported that they purchased clay from regional retail sales outlets, but the precise geological source of the clay used by our subjects is not known.
- The magnitude of the public health significance of our findings is not clear, but the number of people exposed to dioxins in clay could vary considerably. We do not know what fraction of clays used by schools in art classes, ceramics enthusiasts, professional potters or in commercial operations is contaminated with dioxins, and the extent of the contamination may vary.
- Further investigations are warranted to better determine routes of exposure, in particular to confirm whether volatilization of dioxins during firing is the most important route of exposure, and also to determine the extent of dioxin contamination of clay used by ceramicists and in commercial operations.

For more information see:

Franzblau A, Hedgeman E, Chen Q, Lee S-Y, Adriaens P, Demond A, Garabrant D, Gillespie B, Hong B, Jolliet O, Lepkowski J, Luksemburg W, Maier M, Wenger Y. Human Exposure to Dioxins from Clay: A Case Report. Environmental Health Perspectives. doi:10.1289/ehp.10594 (available at <http://dx.doi.org/>) Online 5 October 2007

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