

Persistent Organic Pollutants in 9/11 World Trade Center Rescue Workers

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Introduction

Rescue workers, including firefighters present at the World Trade Center (WTC) following the September 11, 2001 terrorist attacks were exposed to large quantities of dust, smoke and fumes from the collapse and fire. The fire at the WTC site burned for months. Firefighters, paramedics, police and other personnel labored for weeks and months in the immediate vicinity of the WTC. Personal Protective Equipment (PPE) was not available or was ineffective in preventing the rescue workers from absorbing contaminants. This is based on the rescue workers who reported working without any protection from inhalation, ingestion or dermal exposure to the contaminants¹. In addition many of the rescue workers developed coughs, headaches, memory disturbance and other symptoms while working on the site². USEPA measurements of benzene, dioxins and polychlorinated biphenyls (PCBs) were elevated in the air in the weeks after the collapse³. Dioxins slowly returned to normal background levels after three months³. The New York (NY) Department of Environmental Conservation (DEC) analyzed dust/ash samples collected close to the WTC site after September 11, 2001.

The purpose of this study was to characterize body burdens of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and polychlorinated dioxins (PCDDs) from 11 rescue workers who worked at the WTC the day of the collapse and afterwards.

Methods and Materials

Participants in the study included self-selected volunteers who all volunteered the day of the collapse and for several days afterwards. These rescue workers were exposed to toxic substances in the air when exposure would have been theoretically the highest. These ten workers used little or no protective respiratory gear during the WTC cleanup and all of them have and currently live in New York. The average age of the rescue workers is 42 (range is 27-52).

Ten male rescue workers and one female rescue worker volunteered to have their blood drawn for purposes of measuring the levels of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and polychlorinated dioxins (PCDDs). Blood samples from the rescue workers were collected in the fall of 2003. Fifty milliliters of whole blood was drawn in chemically

cleaned glass containers prepared by the analytic laboratory with anticoagulant with Teflon® tops containing no paper products. Blood was frozen and sent frozen on dry ice to Germany for polychlorinated dioxin and furan analysis at ERGO Laboratory, a World Health Organization certified dioxin laboratory. Analysis was performed by gas chromatography/high-resolution mass spectrometry by methods previously described⁴. A comparison blood sample was obtained from 100 leftover blood samples from a Dallas, Texas clinic that was pooled and served as controls⁵. Measured levels have been converted to dioxin toxic equivalents (TEQ) using the 1998 WHO toxic equivalency factors (TEFs)⁶.

Results

Table 1 displays the mean dioxin levels and mean TEQ levels by congener in the group of rescue workers. The levels in these rescue workers are for the most part similar to levels measured in the general population.

The measured dioxin, dibenzofuran, and PCB congener levels and TEQ for the each individual rescue worker is presented in Table 2. Four rescue workers (HB50605, WB5005, WB 8008, WB 9009) have elevated 2,3,3',4,4'-PeCB (105) and 2,3',4,4',5-PeCB (118). The rest of the rescue workers were comparable to levels measured in the U.S. general population. Patient H 5-0605 was a firefighter who we tested in May 2003. PCB levels for Patient H 5-0605 are also elevated.

Brominated dioxins, brominated dibenzofurans, and polybrominated diphenyl ethers were not elevated in rescue workers as compared to the general population (data not shown).

Discussion

The elevated concentrations of the PCBs found in some rescue workers appear to be consistent with the several dozen firefighters who were noted to have elevated PCB levels above 12 PPB¹ utilizing the Webb and McCall technique⁷ (General Population average = 6ppb as reported by lab). A particular firefighter (Patient HB50605) provided us with results of his PCB value of 32ppb⁷ (Webb and McCall technique) on January 9th, 2002. The same firefighter was tested again in September 9th, 2002, where his results were 13ppb⁷ (Webb and McCall technique). He had his blood drawn and analyzed for dioxin, furan and PCB at ERGO laboratory in May 2003 (Table 2). The results show that his PCB levels were still elevated. This firefighter (Patient H 5-0605) had also worked on the day of the collapse and several subsequent days later.

A study by Edelman et al, reported an unanticipated increase in heptachlorodibenzodioxin and heptachlorodibenzofuran, which was associated with exposure to WTC⁸. However, the authors do not presume the exposure to be WTC specific.

We find similar concentrations of dioxins, dibenzofurans and PCBs in samples from most of the rescue workers and the general population. Four rescue workers did however have elevated levels of 2,3,3',4,4'-PeCB (105) and 2,3',4,4',5-PeCB (118). Further inquiry is being conducted to determine what the three subjects had in common during the period of exposure. We speculate possible reasons for these three subjects to have elevated levels might include higher exposure, longer exposure times and less protection.

The concentrations reported in this paper, with some notable exceptions (WB-5005, WB 8-008, WB 9-009), are not elevated. Dioxins and dibenzofurans have long half-lives¹⁰. The rescue workers we studied might have been exposed to high dioxin levels but for too short a time period to note elevation this long after exposure, despite previous positive findings decades after exposure in chemical workers¹⁰. We only can measure elevated dioxins in the human body if the total uptake adds significantly to the body burden. For comparison: The intake via food ranges between 50 and 100 pg TEQ/day. A typical air concentration may be at 0.05 pg TEQ/m³. Even at a 1000 times elevated air concentration, 24 h inhalation (20 m³) adds “only” 1000 pg to the body burden (equivalent to about 10 days additional uptake from food).

Additional limitations of our study include a small study sample.

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Table 1. PCDDs, PCDFs and PCBs in U.S. Human Blood

Congeners	Exposed n=10	Control n=100
	Average Concentration* [range]	Concentration*
2.3.7.8-Tetra-CDD	2.0 [nd(1)-3.4]	3.8
1.2.3.7.8-Penta-CDD	5.0 [2.1-8.1]	8.5
1.2.3.4.7.8-Hexa-CDD	4.2 [1.8-6.5]	7.5
1.2.3.6.7.8-Hexa-CDD	28.4 [11.0-49.0]	41.3
1.2.3.7.8.9-Hexa-CDD	4.4 [1.3-7.2]	5.7
1.2.3.4.6.7.8-Hepta-CDD	34.0 [10.0-62.0]	45.1
OCDD	173.2 [47.0-437.0]	374.4
2.3.7.8-Tetra-CDF	n.d.(1)	n.d.
1.2.3.7.8-Penta-CDF	n.d.(1)	n.d.
2.3.4.7.8-Penta-CDF	5.0 [2.0-7.7]	5.0
1.2.3.4.7.8-Hexa-CDF	5.6 [2.3-9.2]	7.4
1.2.3.6.7.8-Hexa-CDF	4.0 [1.5-7.5]	4.0
1.2.3.7.8.9-Hexa-CDF	n.d.(1)	n.d.
2.3.4.6.7.8-Hexa-CDF	2.0 [n.d.(2)-3.5]	n.d.
1.2.3.4.6.7.8-Hepta-CDF	4.5 [2.3-6.4]	4.1
1.2.3.4.7.8.9-Hepta-CDF	n.d.(1)	n.d.
OCDF	n.d.(3)	2.5
3,3',4,4'-TCB (77)	n.d.(12)	n.d.
3,4,4',5-TCB (81)	n.d. (2)	5
3,3',4,4',5-PeCB (126)	28.8 [6.2-64]	42
3,3',4,4',5,5'-HxCB (169)	21.8 [4.7-48.0]	31
2,3,3',4,4'-PeCB (105)	2595 [537-7908]	3333
2,3,4,4',5-PeCB (114)	839 [182-1906]	1338
2,3',4,4',5-PeCB (118)	12751 [3028-20670]	17283
2',3,4,4',5-PeCB (123)	228 [47-492]	307
2,3,3',4,4',5-HxCB (156)	5732 [969-9759]	7852
2,3,3',4,4',5'-HxCB (157)	1199 [194-2042]	1753
2,3',4,4',5,5'-HxCB (167)	1064 [273-2029]	2044
2,3,3',4,4',5,5'-HpCB (189)	462 [78-952]	685
Total PCDDs/PCDFs	273 [81-587]	509.2
Total non-ortho-PCBs	51 [11-112]	78
Total mono-ortho-PCBs	24870 [5344-52417]	34595
TEQ (WHO) based on PCDD/F	15	21.903
TEQ (WHO) based on PCB	8.6	12.143
TEQ(WHO)	23.4	34.046

*Values in pg/g (ppt), lipid based; sample from human blood; () = Detection limits DL

HUMAN LEVELS AND TRENDS

Table 2. Measured dioxin, dibenzofuran, and polychlorinated biphenyl levels* in 11 rescue workers, NY 2004.

Congener	TEF	Identification number											Control n=100 Mean
		H50605 ⁺	WB 1001	WB 2002	WB 5005	WB 6006	WB 7007	WB 8008	WB 9009	WB 10010	WB 11011	WB 12012	
2,3,7,8-Tetra-CDD	1	2.6	n.d.(1)	1.9	3.2	2.2	1.3	1.9	1.4	n.d.(3)	3	3.4	3.8
1,2,3,7,8-Penta-CDD	1	6.3	2.1	5.3	7.1	8.1	3	4	5.8	3.4	4.1	7.3	8.5
1,2,3,4,7,8-Hexa-CDD	0.1	6	1.8	4	6.5	6.1	3.3	5.1	5.8	3.3	2.4	4	7.5
1,2,3,6,7,8-Hexa-CDD	0.1	40.6	11	31	38	49	17	28	33	20	20	39	41.3
1,2,3,7,8,9-Hexa-CDD	0.1	5.6	1.3	2.8	5.6	5.1	3.1	6.1	4	3.3	5.4	7.2	5.7
1,2,3,4,6,7,8-Hepta-CDD	0.01	47.4	10	26	56	48	21	62	51	25	21	20	45.1
OCDD	0.0001	185.9	47	94	272	437	72	327	195	115	66	108	374.4
2,3,7,8-Tetra-CDF	0.1	1.3	n.d.(1)	n.d.(1)	1.2	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	1.6	n.d.
1,2,3,7,8-Penta-CDF	0.05	1.9	n.d.(1)	n.d.(1)	1.3	n.d.(1)	1	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	1	n.d.
2,3,4,7,8-Penta-CDF	0.5	9.1	2	3.4	10	7.7	3.8	4.7	4.7	2.5	3.5	7.7	5.0
1,2,3,4,7,8-Hexa-CDF	0.1	10.4	2.3	4.3	9.2	8.2	4.5	4.3	7.3	4.2	3.8	7.7	7.4
1,2,3,6,7,8-Hexa-CDF	0.1	7.2	1.5	3.2	7	7.5	3	3.3	3.9	2.9	2.3	5.7	4.0
1,2,3,7,8,9-Hexa-CDF	0.1	n.d.	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(2)	n.d.(1)	n.d.
2,3,4,6,7,8-Hexa-CDF	0.1	2.1	n.d.(2)	1.4	3.5	2.3	1.7	1.1	2.5	1.5	1.6	2.3	n.d.
1,2,3,4,6,7,8-Hepta-CDF	0.01	6.1	2.3	3.1	4.8	5.7	3.4	4.3	5.9	6.4	3.6	5.1	4.1
1,2,3,4,7,8,9-Hepta-CDF	0.01	n.d.	n.d.(2)	n.d.(2)	n.d.(1)	n.d.(1)	n.d.(2)	n.d.(2)	n.d.(1)	n.d.(3)	n.d.(2)	n.d.(2)	n.d.
OCDF	0.001	n.d.	n.d.(5)	n.d.(4)	n.d.(3)	n.d.(3)	n.d.(3)	n.d.(4)	n.d.(4)	n.d.(5)	n.d.(6)	n.d.(4)	2.5
3,3',4,4'-TCB (77)	0.0001	68	n.d.(15)	n.d.(14)	n.d.(13)	n.d.(12)	n.d.(14)	n.d.(20)	n.d.(18)	n.d.(19)	n.d.(17)	n.d.(16)	n.d.
3,4,4',5'-TCB (81)	0.0001	12	n.d.(2)	n.d.(2)	2.5	n.d.(2)	n.d.(3)	1.8	2.4	n.d.(2)	n.d.(3)	n.d.(3)	5
3,3',4,4',5'-PeCB (126)	0.1	197	6.2	23	44	64	20	30	41	17	20	24	42
3,3',4,4',5,5'-HxCB (169)	0.01	51	4.7	21	23	48	16	20	26	11	23	24	31
2,3,3',4,4'-PeCB (105)	0.0001	41765	573	1203	7908	537	3073	3975	4050	726	1881	2025	3333
2,3,4,4',5'-PeCB (114)	0.0005	17746	182	675	1906	1253	665	784	980	325	771	850	1338
2,3',4,4',5'-PeCB (118)	0.0001	207921	3028	6153	31225	4665	14040	20670	20163	4117	9408	14044	17283
2',3,4,4',5'-PeCB (123)	0.0001	1900	47	232	492	283	225	288	245	78	149	240	307
2,3,3',4,4',5'-HxCB (156)	0.0005	95751	969	8045	6987	9759	4115	4468	6478	4028	7501	4965	7852
2,3,3',4,4',5'-HxCB (157)	0.0005	18706	194	1596	1396	2042	856	946	1480	815	1550	1118	1753
2,3',4,4',5,5'-HxCB (167)	0.00001	18881	273	756	2029	1096	891	1514	1683	391	1047	963	2044
2,3,3',4,4',5,5'-HpCB (189)	0.0001	2324	78	531	475	952	343	370	594	267	523	483	685
Total PCDDs/PCDFs		332.5	81	180	424	587	138	452	320	187	136	220	509.2
Total non-ortho-PCBs		328	11	44	70	112	36	52	70	28	43	48	78
Total mono-ortho-PCBs		404994	5344	19191	52417	20587	24208	33016	35673	10747	22832	24688	34595
TEQ (WHO) based on PCDD/F		21.4	4	13.9	23.1	22.4	9.8	13.6	15.8	8.5	12.7	21.7	21.903

HUMAN LEVELS AND TRENDS

TEQ (WHO) based on PCB	111.9	1.7	8.4	13.8	14.0	6.7	8.9	11.3	4.9	8.4	7.8	12.143
TEQ(WHO)	133.3	5.7	22.3	37.0	36.5	16.5	22.5	27.1	13.4	21.0	29.4	34.046

Values in pg/g (ppt), lipid based; Samples from Human Blood

+ Patient H 5-0605 blood tested in 5/2003 [firefighter sent us his PCB value of 32ppb (Webb and McCall) on 1/9/02]