

DIOXINS AND DIBENZOFURANS IN SEDIMENT FROM AGENT ORANGE SPRAYED AND NOT SPRAYED AREAS IN LAOS AND VIETNAM AS WELL AS FROM EUROPEAN COUNTRIES AND THE U.S.A.

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Introduction

Between 1962 and 1971, Agent Orange herbicide was heavily sprayed over Vietnam, Laos and Cambodia. Agent Orange, a mixture 2,4-D and 2,4,5-T, was contaminated with 2,3,7,8-TCDD. It has been relatively easy to document elevated TCDD from Agent Orange in Vietnam in people, food, soil and sediment. This documentation began in the 1970s and continued through 2002¹⁻⁶.

TCDD has not previously been looked for in Agent Orange sprayed areas of Laos. In 2001, we attempted to correct this by sampling Laotian human blood, milk, food, and sediment. This paper reports our findings in Agent Orange sprayed areas of Laos, Xepone or Sepone Village, and in a control area, Vientiane, the capitol of Laos. These findings are compared with levels found in Vietnam, in the USA and in Europe.

Samples from Lakes Michigan, Erie, Ontario, Zurich, Balderg and Lugano were collected and analyzed for dioxin at the University of Indiana⁷. During the 1980s, the Dong Nai River, and Red Rivers in Vietnam were analyzed for TCDD and for other dioxins and dibenzofurans^{5,6}. Vietnam samples from Hanoi and Bien Hung Lake in Bien Hoa City were collected in 2001.

Methods

Grab samples were collected in the Mekong river in Vientiane Laos, and in local rivers in Xepone, Laos. They were air dried and shipped to the dioxin laboratory in Germany. The same was done for the Vietnam and European samples. High resolution gas chromatography-high resolution mass spectrometry (gc-ms) were used for the analysis³.

Findings and Discussion

Table 1 shows the new Laotian sediment data in three columns as well as recent Vietnam data. The samples from the Mekong River in Vientiane show low levels of PCDD/Fs and no TCDD. The first samples from Xepone show no detectable TCDD and low PCDD and PCDF levels. The second Xepone samples show somewhat higher PCDD/F values and measurable TCDD at 0.3 ppt. The samples from Vietnam show low levels of TCDD and other congeners in certain areas, such as the Red River sediment from Hanoi, which was not sprayed with Agent Orange, and some parts of the Dong Nai River in the south. TCDD levels varied from not detected in Hanoi to 177 ppt in one part of Bien Hung Lake that is downstream from an Agent Orange storage and staging area.

Other areas sampled included 114 ppt in a different section of Bien Hung Lake, as little as 0.8 elsewhere, and 1.5 ppt from a Dong Nai River sample. Total measured PCDD/F varied from 15.11 to 237 ppt dry weight in Laos, 302 in Bien Hung Lake near the Agent Orange storage area and 473 in Hanoi sediment, where no spraying occurred, to 2,104 ppt in one part of Bien Hung Lake. The latter was from the same area where 177 ppt of TCDD was measured.

Table 2 compares total measured PCDD/Fs from European and American Lakes with Vietnam rivers. The measured level in Lake Zurich, Lake Baldegg and Lake Michigan ranges from 1500-1600 ppt to a high of 11,000 ppt in Lake Ontario. Vietnam sediments, measured in the 1980s, had TCDD concentrations of ND (DL 21 and 47) and 210 ppt dry weight in a contaminated river, and in a north of Vietnam non-contaminated river⁶. This points out the usefulness of Air Force Ranch Hand fixed wing aircraft Agent Orange spray records to suggest where TCDD from Agent Orange may be found and of gc-ms analysis to confirm where it actually is present. The total measured PCDD/F in the Vietnam rivers ranges from 240 ppt in the north to 6800 ppt in the river where the highest TCDD was measured. This indicates dioxin contamination in Vietnam from sources other than Agent Orange as well as from Agent Orange. Measurement of all dioxins and dibenzofurans other than TCDD is needed to determine total dioxin toxicity.

In Table 3 we put the data from Laos and Vietnam in perspective by presenting newer findings in European sediment. These are dry weight reported in parts per trillion (pg/gm) TEQ. Rural background levels vary from 0.1-10 or 0.8-207, 0.7-100 ppt to as high as 80,000 ppt PCDD/F WHO TEQs contaminated areas. Background findings from 0.1-20 ppt, urban findings of 2-123, and contaminated in industrial country sediment from 0.2-80,000 ppt TEQ point out that in sediment of one area in Laos dioxins are as high as some lowest levels measured in Europe.

Sediment dioxin and dibenzofuran levels in Laos are quite low, although there is some variation in the levels of TCDD and other dioxins. These are low in the north of Vietnam where no Agent Orange was sprayed and fewer dioxin-contaminated chemicals were used than in the south. In the south of Vietnam from low to rather high levels of TCDD and other dioxins can be found in sediments and in people at this time. European sediment data is presented for comparison. Elevated 2,3,7,8- TCDD from Agent Orange used in Laos has yet to be located. Dioxin toxicity reported here in TEQ is highest in Europe, then much lower in the Vietnam areas sampled, and lowest in Laos.

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Table 1. Dioxin and Dibenzofuran Congeners in Laos and Vietnam in ppt dry weight.

Congener	LAOS				VIETNAM							
	Mekong R, (Vientiane)	Xepone	Xepone	Hanoi	Bien Hung Lake1		Bien Hung Lake2		Bien Hung Lake3		Dong Nai River	
		A	B		A	B	A	B	A	B	A	B
2,3,7,8-TCDD	n.d. (0.1)	n.d. (0.1)	0.3	n.d. (0.1)	14.5	1.6	177	114	1.7	1.1	0.8	1.5
1,2,3,7,8-PCDD	n.d. (0.1)	n.d. (0.1)	0.3	0.9	0.4	0.2	4.2	3.7	n.a.	n.a.	0	n.a.
1,2,3,4,7,8-HxCDD	n.d. (0.1)	n.d. (0.1)	0.3	0.6	n.d.	n.d.	4	1.9	0.6	1.2	n.d.	n.d.
1,2,3,6,7,8-HxCDD	n.d. (0.1)	n.d. (0.1)	0.5	1.7	1.6	2.3	7.5	6	1.3	3	0.2	0.5
1,2,3,7,8,9-HxCDD	n.d. (0.1)	n.d. (0.1)	0.6	1	3.6	3.8	7.1	5.5	1.5	3	0.6	0.9
1,2,3,4,6,7,8-HpCDD	n.d. (1.1)	n.d. (0.9)	3.7	25.7	22.2	48.1	160	119	32	42.9	11.6	16.5
OCDD	22.1	14.93	207	373	249	476	1610	1163	660	446	529	695
2,3,7,8-TCDF	n.d. (0.2)	n.d. (0.2)	1.1	9.8	3	1.4	62.3	43.2	2.7	3.6	0.4	1.3
1,2,3,7,8-PeCDF	n.d. (0.1)	n.d. (0.1)	1.4	5.7	0.7	1.1	3	1.8	1	1.1	0.1	0.4
2,3,4,7,8-PeCDF	n.d. (0.1)	0.05	0.9	4.3	0.3	0.1	1.3	1.1	0.5	0.6	0.1	0.3
1,2,3,4,7,8-HxCDF	n.d. (0.1)	n.d. (0.1)	3.2	9.7	0.3	0.2	2	2.7	0.7	1.1	0.1	0.3
1,2,3,6,7,8-HxCDF	n.d. (0.1)	n.d. (0.1)	1.7	3.4	0.4	0.2	4.4	3.3	0.5	0.7	0.1	0.2
1,2,3,7,8,9-HxCDF	n.d. (0.1)	n.d. (0.1)	0.3	1.2	1.9	2.9	1	1.5	0.4	0.4	0.1	0.2
2,3,4,6,7,8-HxCDF	n.d. (0.2)	0.12	2.1	1.8	0.3	0.4	2.3	2.2	0.8	0.8	0.2	0.3
1,2,3,4,6,7,8-HpCDF	n.d. (0.2)	n.d. (0.3)	6.3	8.2	1.3	0.7	13.2	9.9	2.9	4	0.2	0.9
1,2,3,4,7,8,9-HpCDF	n.d. (0.1)	n.d. (0.1)	1.6	2.7	n.d.	n.d.	2	1.7	0.4	0.4	n.d.	0.1
OCDF	n.d. (0.8)	n.d. (0.7)	5.6	23.5	2.9	2.8	42.3	31.5	8.9	15.7	0.8	2.9
Measured Total PCDD	22.1	14.9	207	403	291	532	1970	1413	697	497	543	715
PCDD TEQ	0.02	0.02	0.78	1.4	15.7	3.3	185	120	3	2.7	1.6	2.5
Measured Total PCDF	n.d.	0.18	24.2	70.3	11	9.9	134	98.8	18.9	28.5	2.1	6.8
PCDF TEQ	0.0	0.04	1.45	5.1	0.77	0.6	8.2	6.05	0.9	1	0.2	0.4
Measured Total PCDD/PCDF	22.1	15.11	237	473	302	542	2104	1512	716	526	545	721
Total TEQ	0.02	0.05	2.23	6.5	16.5	3.9	193	126	3.9	3.7	1.8	2.9

n.d.: not detectable.

n.a.: not applicable

(): detection limit.

Table 2. Average measured concentrations of PCDD/F in PG/G for uppermost lake sediments and Vietnam river sediments in parts per trillion (ppt) dry weight^{5,6}.

U.S. and European Lake Sediments		Vietnam River Sediments		
Site	Total PCDD/F	Site	TCDD	Total PCDD/F
Lake Michigan	1600	South of Vietnam		
Lake Erie	2150	Saigon River	210 (6)	6800
Lake Ontario	11000	Dong Nai River	n.d.(21)	1200
Lake Zurich	1500			
Lake Balderg	1500	North of Vietnam		
Lake Lungano	2000	Red River	n.d.(47)	240

Table 3. Summary of PCDD/PCDF concentrations in sediment from the European Union member states, concentrations in ppt TEQ dry weight⁸.

	Rural Background	Urban	Contaminated
Finland	0.7-100		80 000
Germany	1.2 – 19	12 – 73	>1500
Italy	0.1 – 10	0.5 – 23	570
Luxembourg		2.4 – 16	
Netherlands	1 – 10		4000
Spain			0.2 – 57
Sweden	0.8 – 207		1692
U. Kingdom		2 – 123	7410

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