

## **Halogenated organics in Vietnamese and in Vietnam food: Dioxins, dibenzofurans, PCBs, polybrominated diphenyl ethers and selected pesticides**

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### **Introduction**

Vietnam is frequently thought of as the location of the world's largest dioxin contamination, with over 400 pounds of 2,3,7,8-TCDD from Agent Orange defoliant sprayed from 1962 to 1971. Although this is true, distribution of dioxin from Agent Orange is far from ubiquitous in Vietnam. The north was never sprayed and only certain areas of central and south Vietnam were sprayed<sup>1-6</sup>. Dioxins have been found in very high levels in human milk and in food in some select areas of Vietnam from the 1970s to the present<sup>4-6</sup>. Other pesticides including DDT and metabolites,  $\alpha$ ,  $\beta$ , and  $\gamma$  HCH, and HCB have also been found in humans and in food<sup>4,7</sup>. We review dioxin "hot spots" studied in the past with current suspect hot spots and also add to the chemicals studied in Vietnamese by measuring polybrominated diphenyl ether (PBDE) flame retardants in nursing Vietnamese women's milk and compare these to levels from other countries.

### **Methods and Materials**

Blood or breast milk was collected in chemically cleaned glass bottles and then frozen. On occasion we used potassium dichromate as a preservative for limited time periods instead of freezing<sup>8</sup>. Food was purchased at markets in Vietnam, collected in the fields or streams in the south, or purchased at Asian food markets in the USA from food marked "Product of Vietnam". Analyses were carried out as previous described by high resolution gas chromatography-high resolution mass spectroscopy<sup>9-11</sup>.

### **Results and discussion**

Selected locations we have recently sampled as suspect dioxin "hot spots" where we expect to find elevated TCDD in humans or the environment are shown in Table 1.

Levels of TCDD and total dioxin toxic equivalents in humans in the north and in the south of Vietnam in people are shown from our previous survey with pooled blood on Table 2<sup>3</sup>. Usually the

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dioxin levels in the north are much lower than in the south. It can be noted that blood TCDD is frequently elevated above background levels of approximately 2 ppt in many locations, yet total TEQ<sup>12</sup> can have substantial contributions from dioxins other than TCDD.

Table 3 shows food TCDD and TEQ data in pg/g or parts per trillion (ppt) wet weight (ww) measured in hot spots in the 1970s and 2003<sup>4,5,13,14</sup>. Quite high levels were found in some but not all food even in the same geographical area such as Bien Hoa City, where Agent Orange was stored and sprayed. In USA food and Vietnamese food exported to the USA levels much lower than the highest Vietnam levels are seen, usually with less than 0.01 ppt ww. Table 4 shows PBDE levels in milk from the US and Vietnam in ng/g or ppb, ww. Although many congeners in the two Vietnam samples were below detection limits, some congeners could be measured. Figure 1 compares the levels of polybrominated diphenyl ethers found in northern Vietnamese with other countries<sup>15</sup>. The extremely low levels of PBDE found in nursing mothers' milk in Vietnam is the first PBDE measurement in a developing country and might be representative of levels in less developed countries where these flame retardants are not common. On the contrary, U.S. levels are higher than found in any other country by one or two orders of magnitude<sup>15,16</sup>.

We previously reported elevated levels of TCDD in a number of locations in Vietnam, in people, food, wildlife, soil and sediment, but usually found quite low levels of dioxin in most of Vietnam. Other chemicals were found to be present such as DDT and its metabolites,  $\alpha$ ,  $\beta$ , and  $\gamma$  HCH, HCB, and PCBs. Health studies concerning associations between elevated dioxins and health will need to consider the spotty distribution of TCDD even in highly sprayed areas as well as the presence of other chemicals in Vietnam. We feel chemical measurement of these compounds in blood are essential for accurate exposure assessments.

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Location	Province	Samples
Binh My Commune, Tan Uyen district	Binh Duong	Blood and food
Trac Noc airbase, Can Tho City	Can Tho	Blood and food
Phu Cat airbase	Binh Dinh	Blood and food
Nha Trang city, Khanh Hoa province	Khanh Hoa	Blood
Can Gio district beach, Ho Chi Minh City	Ho Chi Minh	Blood
Bien Hoa airbase, Bien Hoa City	Dong Nai	Blood and food

Table 1. Location of suspected hotspots and samples collected in Vietnam, 2001-2004

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	Number sampled	TCDD (ppt)	PCDD/F TEQ (ppt)	Range of TCDD/TEQ for each region
<b>North Vietnam (n=168)</b>				
Hanoi Hospital 103	33	1.2	12	TCDD 1.2-2.9
Tay Nguyen (veterans)	35	6.1	40	TEQ 12-18
<b>Central Vietnam (n=490)</b>				
Thua Thien, Hue	30	11	57	TCDD 2.9-19
Da Nang, Da Nang	49	18	77	TEQ 23-119
Thua Thien, A Luoi	35	15	23	
Da Nang, Da Nang (>40 y)	100	19	118	
<b>Southern Vietnam (n=2062)</b>				
Dong Nai, Tri An (Ma Da Forest)	50	12	19	TCDD 1-33
Dong Nai, Bien Hoa	50	28	47	TEQ 8.7-105
Kien Giang, Go Cong	48	11	28	
Song Be, Tan Uyen	48	32	55	
Ho Chi Minh City, Cho Ray Hospital	48	11	30	
Minh Hai, Bac Lieu	50	11	35	
Tra Noc, Can Tho	102	33	105	
Song Be, Tan Uyen (18-40 y)	100	9.4	25	
Song Be, Ben Cat	100	12	50	

Table 2. Selected sampled locations with 2,3,7,8-TCDD and dioxin Toxic Equivalents (TEQ) (pg/g or ppt, lipid) in pooled blood from Vietnam collected 1991 through 1992<sup>3</sup>.

Collection Date	Location and item	TCDD (pg/g, ppt, ww)	PCDD TEQ (ppt)
2003 Vietnam domestic food	Binh My chicken	0.13	1.05
	Binh My fish	0.21	0.45
	Tan Uyen fish	0.26	0.76
	Trac Noc pork	0.03	0.24
	Trac Noc carp	0	0.03
	Troc Noc catfish	0.04	0.25
	Bien Hoa fish <sup>4</sup>	65	66
	Bien Hoa chicken <sup>4</sup>	15	33
	Bien Hoa duck <sup>4</sup>	276	285

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1970	Bien Hoa pork <sup>4</sup>	0.86	0.91
	Bien Hoa beef <sup>4</sup>	0.082	0.095
	Dong Nai river fish <sup>5</sup>	1020	na
2002 <sup>14</sup> Vietnam exports to USA	Vietnam exported fish	0.01	0.47
	Vietnam exported shrimp	0.053	0.076
2001 <sup>13</sup> USA food	USA freshwater fish	0.149	0.472
	USA beef	nd(0.025)	0.189
	USA chicken	nd(0.025)	0.097
	USA pork	nd(0.032)	0.124

Table 3. Selected food TCDD and TEQ data in pg/g or parts per trillion or (ppt) wet weight (ww) measured in dioxin hot spots in the 1970s and 2003. nd: non detected with detection limit. na: not applicable

PBDE congener	Hanoi, Vietnam (n=2)		USA (n=52)		
	Sample 1	Sample 2	Minimum	Median	Max
<i>PBDE #17</i>	nd(0.01)	nd(0.01)	nd(0.01)	0.01	0.18
<b>PBDE #28</b>	0.03	0.03	0.2	1.2	16.1
<b>PBDE #47</b>	0.14	nd(0.12)	2.9	18.4	272
<b>PBDE #66</b>	nd(0.01)	0.01	nd(0.01)	0.14	6.7
<b>PBDE #77</b>	nd(0.01)	nd(0.01)	nd(0.01)	na	0.16
<b>PBDE #85</b>	nd(0.01)	nd(0.01)	0.08	0.41	7.7
<b>PBDE #99</b>	0.06	nd(0.09)	0.7	5.7	111
<b>PBDE #100</b>	0.05	0.04	0.5	2.9	47
<b>PBDE #138</b>	nd(0.01)	nd(0.01)	nd(0.01)	0.09	6.9
<b>PBDE #153</b>	0.09	0.09	0.4	2	22
<b>PBDE #154</b>	0.01	0.01	0.06	0.22	7.2
<b>PBDE #183</b>	0.02	nd(0.03)	nd(0.01)	0.07	1.3
<b>PBDE #209</b>	nd(0.17)	nd(0.24)	nd(0.01)	na	8.2
<b>Total</b>	0.50	0.45	6.2	34	419

Table 4. PBDE levels in human milk from Hanoi, Vietnam and USA. 2003. (ng/g or ppb, lipid) nd: non detected with detection limit. na: not applicable.

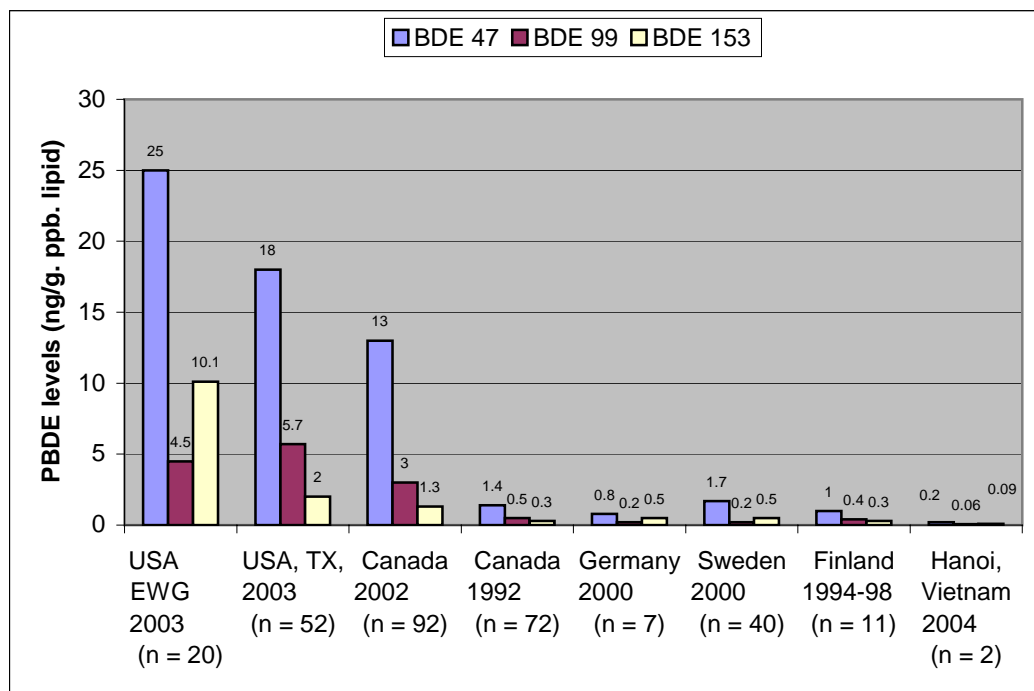


Figure 1. Levels of polybrominated diphenyl ethers (PBDEs) found in Vietnam and other countries (ng/g or ppb, lipid)

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