

## **Dioxins and Related Compounds in Vietnamese, Vietnamese Food and the Environment: Potential Relevance of Hot Spots from Recent Findings**

Olaf Paepke<sup>1</sup>, Hoang Trong Quynh<sup>2</sup>, Arnold Schecter<sup>3</sup>

<sup>1</sup> ERGO Research, Geierstrasse. 1, D-22305 Hamburg, Germany

<sup>2</sup> Institute for Oncology, Ha Noi, Vietnam

<sup>3</sup> University of Texas School of Public Health, Dallas Regional Campus, Dallas, Texas, U.S.A.

### **Introduction**

Agent Orange, a phenoxyherbicide mixture of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4-dichlorophenoxyacetic acid (2,4-D) was sprayed for reasons of defoliation in large amounts on about 10 % of southern Vietnam during the Vietnam war between 1962-1971. 2,4,5-T was contaminated with the highly toxic and persistent 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the low ppm-range (mg/kg). In samples collected between 1970 and 1973 Baughman et al., 1973 documented elevated levels of TCDD from Agent Orange in milk samples from southern Vietnamese woman as well as in fish and shrimp samples from sprayed areas in this region. Studies have documented the intake of 2,3,7,8-TCDD from Agent Orange in Vietnamese and in among US war veterans (Kahn et al., 1988, Schecter et al., 1995, Michalek et al., 1996; Schecter, 1990; Schecter et al., 1992).

This paper gives an overview on recent findings for PCDDs/Fs and dioxin-like PCBs and in various environmental compartments, in humans and in food. Due to the fact that 2,3,7,8-TCDD is the major dioxin congener in 2,4,5-T, many investigators focused mainly on TCDD. We found from our own investigations, that TCDD in case of dioxin contamination is still the predominant dioxin congener, but in certain instances we also found other elevated congeners as well. In some cases mixed chemical contamination of food or humans was found – originating from Agent Orange and other sources. The paper will explain the potential origin of some of the other contaminations found.

## ***Results and Discussion***

### **Areas representing local reservoirs of high dioxin contamination (“hot spots”)**

Exposure of humans and of food in areas of so called dioxin “hot spots” is still matter of concern. In such areas a long standing continuous exposure of humans is possible. Recently some specific dioxins reservoirs have been reported by Dwernychuk et al. (2002) and by Schecter et al. (2001, 2002, 2003, 2004).

Our group focused on three different areas in the southern part of Vietnam: *Bien Hoa*, north of Ho Chi Minh City, a former US air base, *Binh My*, an area where heavy fighting was occurred during the Vietnam war, and *Can Tho* in *Tra Noc District*, south of Ho Chi Ming City, a former air base also used for Agent Orange storage.

Our first step in collecting information regarding suspected hot spots was the analysis of blood samples from residents living in the areas in question. This was followed by analysis of food samples of animal origin consumed by individuals showing the route of exposure. Further analyses included environmental samples such as soil or sediments.

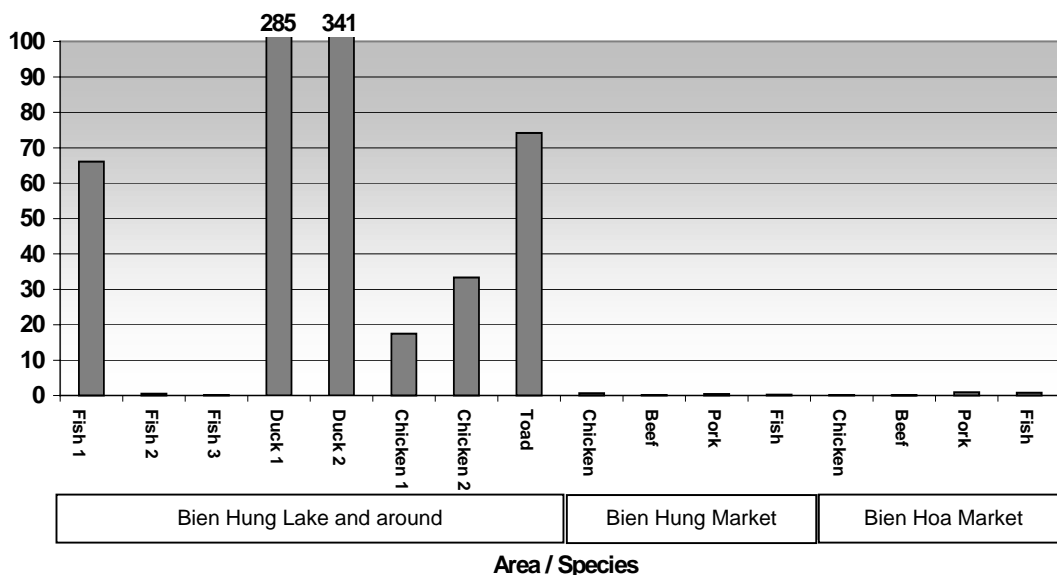
From *Bien Hoa*, 43 blood samples were analysed and 36 samples showed TCDD values above 20 pg/g lipid. The highest concentration found was 413 pg/g lipid. This person is known to have high fish consumption. Four individual and 1 pooled control samples from northern Vietnam (Hanoi) showed values between 1.2 and 2.3 pg TCDD/g lipid. The detailed results are given by Schecter et al., 2002. The 43 blood samples from *Bien Hoa* were analysed only for TCDD. Due to our new findings of elevation for certain other congeners, we started to reanalyse the *Bien Hoa* blood samples. The data will be presented of the conference.

Our first analytical data from 12 recently collected blood samples each from *Binh My* and also from *Can Thoin* in *Tra Noc District* are available and will be discussed in detail during the conference. In both groups quite different exposure patterns were found. *Binh My* residents only showed normal not elevated values or moderate elevations for TCDD between 2.2 and 10.2 pg/g lipid while in the group from *Can Tho* values between 14 and 180 pg TCDD/g lipid were detected. On the other hand the samples from *Binh My* showed remarkable PCDD/PCDF patterns (congener distributions) for samples from Vietnam. The patterns are dominated by elevated PCDFs ranging up to some hundreds for the total of Hexa to Octa – CDFs. The pattern observed in these samples have similarities to samples analyzed from persons involved in metal reclamation processes as reported by Wuthe et al., 1992 and Riss et al., 1990.

Due to the fact that food of animal origin is the major route of intake for dioxins and PCBs we analysed food samples in addition to the blood samples from the *Bien Hoa* area. The results for the food samples collected “in and around” the nearby *Bien Hung* lake frequently showed very high values for TCDD while values for samples from *Bien Hung* market and *Bien Hoa* market did not show such elevated values. Comparison data for food from Vietnam were recently published from Schecter et al., 2002 at between 0,001 and 0,05 pg TCDD/g wet weight.

## DIOXIN IN VIETNAM: CHARACTERISATION, MONITORING, REMEDIATION AND EFFECTS

Surprisingly, some of the food samples showed elevated PCB levels and thus unusual dioxin patterns with elevation of specific congeners. These unexpected elevations and the findings for Binh My resulted in a reanalysis of the blood samples from the Bien Hoa area to recognize potential PCB or other unusual patterns in the human samples. The congener profiles and levels will be shown at the conference.



**Figure 1:** PCDDs/Fs in Vietnamese Food. Values in pg TEQ/g, wet weight (Schecter et al., 2003)

In addition to PCDD/Fs and dioxin-like PCBs we found DDT and metabolites at elevated levels in some of the food samples mentioned here. (Schecter et al., 2003)

**Sediment-/soil samples:** Additional information on the Bien Hoa area was obtained from soil and sediment analyses: Grab samples of soil were collected by Le Cao Dai (Dai et al. 2002) from the Bien Hoa air base, where Agent Orange had been stored and sediment samples from the nearby Bien Hung lake, respectively. The sampling site of 'Lake Bien Hung 2' samples were close to the former air base. The Bien Hung lake empties into the Dong Nai River (Schecter et al., 2001).

# DIOXIN IN VIETNAM: CHARACTERISATION, MONITORING, REMEDIATION AND EFFECTS

Area	Code	2,3,7,8-TCDD Concentration
Hanoi (Comparison)		n.d.
Bien Hung Lake	1 A / 1 B / 1C	10,4 / 14,5 / 1,6
	2 A / 2 B / 2 C	177 / 114 / 98,2
	3 A / 3 B	1,7 / 1,1
Dong Nai River	A / B	0,8 / 1,5

**Table 1 :** PCDDs/Fs in sediment samples, values in ng/kg dry matter, (Schechter et al. 2001)

Fiedler et al., 1999 reported on environmental levels measured in different countries for soil and for sediment in Europe. For comparison, these data are given in table 2

As can be seen from table 2 typical background values for dioxins in sediments and in soil samples in the European Union are between 1 and 20 ng TEQ/kg. The typical congener distribution is similar to the pattern found in deposited particulate matter/ambient air samples: increasing concentration with increasing number of chlorine's for PCDDs and decreasing concentration with increasing number of chlorine's for PCDFs. Considering the total dioxin toxicity or TEQ, 2,3,7,8-TCDD normally contributes less than 10 - 20 %.

For the sediment sample from the Hanoi area a TEQ of 6.5 ng/kg was found. Calculating with the detection limit of 1 ng/kg for TCDD, a maximum contribution for TCDD to total TEQ of less than 20 % can be estimated. For the sediment samples from Bien Hung Lake the TEQ is dominated by TCDD.

	Sediment			Soil		
	Background	Urban	Contaminated	Any type	Pasture/Rural	Contaminated
Austria					1.6 – 14	332
Belgium				2.7 – 8.9	2.1 – 2.7	
Finland	0.7-100		80 000			85 000
Germany	1.2 – 19	12 – 73	>1500	0.1 – 42	0.1 – 30	38 000
Greece				2 – 45		1144
Ireland				0.2 – 8.6	0.8 - 13	
Italy	0.1 – 10	0.5 – 23	570	0.1	0.1 - 43	
Luxembourg		2.4 – 16		1.8 – 20	1.4	
Netherlands	1 – 10		4000	2 – 55	2.2 – 17	98 000
Spain			0.2 – 57	0.6 – 8.4	0.1 – 8.4	
Sweden	0.8 – 207		1692		0.1	11 446
U. Kingdom		2 – 123	7410	0.8 – 87	0.8 – 20	1585

**Table 2:** Summary of PCDD/PCDF concentrations in sediment and soils from the EU member states, concentrations in ng TEQ/kg dry matter (Fiedler et al, 1999)

In the soil samples collected at Bien Hoa Air Base site, a former Agent Orange storage facility, 2,3,7,8-TCDD levels were detected at over 1 million ng/kg. This value is – to the best of our knowledge – the highest soil level for TCDD measured in Vietnam to date.

## DIOXIN IN VIETNAM: CHARACTERISATION, MONITORING, REMEDIATION AND EFFECTS

The dioxin results for the soil samples as well as the results for the sediment samples strongly indicate that Agent Orange was the source of contamination.

In conclusion we feel that the examples presented here demonstrate the possible influence of consumption of contaminated food from some locations in the south of Vietnam to the human body burden. It seems reasonable to conclude that much of this uptake was recent and occurred many years after the spraying ended. These findings suggest that this substantial contamination is probably from dietary intake of TCDD from contaminated food of animal origin like fish, poultry or eggs consumed long after Agent Orange spraying ended early in 1971.

Finally it should be noted that due to the unexpected high dioxin values found in the human samples collected in the various areas special attention should be given to potential exposure of babies during the breast feeding period.

# DIOXIN IN VIETNAM: CHARACTERISATION, MONITORING, REMEDIATION AND EFFECTS

## References

- Baughman R. W., Messelson M., An analytic method for detecting TCDD (dioxin) levels TCDD in samples from Vietnam, *Environ. Health Perspect.*, 9, 27-35, 1973
- Dai L.C., Schecter A., Päpke O., The lasting effects of Agent Orange in Bien Hoa Airbase. Vietnam – United States Scientific Conference on Human Health and Environmental Effects of Agent Orange /TCDD, March 3-6, 2001, Hanoi, Vietnam
- Dwernychuk W., Hoang Dinh Cau, Hatfield C., Boivin T., Tran Manh Hung, Phung Tri Dung, Nguyen Dinh Thai, Dioxin reservoirs in southern Vietnam-A legacy of Agent Orange, *Chemosphere*, 47, 117-137, 2002
- Fiedler H. Buckley-Golder D., Coleman P., King K., Petersen A.; Compilation of EU Dioxin Exposure and Health Data: Environmental Levels, *Organohalogen Compounds*, 43, 151- 154, 1999
- Kahn P. C., Gochfeld M., Nygren M., Hanson M., Rappe C., Velez H.; Dioxins and Dibenzofurans in blood and adipose tissue of Agent Orange-exposed Vietnam veterans and matched controls *JAMA*, 259, 1661-1667, 1988
- Michalek J. E., Pirkle J. L., Caudill S. P., Tripathi R. C., Patterson D., Needham L.; Pharmacokinetics of TCDD in veterans of Operation Ranch Hand: 10-year follow-up, *J. Toxicol. Environ. Health*, 47, 209- 220, 1996
- Riss A. Hagenmaier H.P., Weberuss U., Schlatter C., Wacker R.; Comparison of PCDD/PCDF Levels in Soil Cows milk, Human Blood and Spruce Needles in an Area of PCDD/PCDF Contamination through Emission from a Metal Reclamation Plant; *Chemosphere*, 21, 1451-1456, 1990
- Schecter A., Ryan J.J. Constable J.; Polychlorinated Dibenzo-p-dioxin and Polychlorinated dibenzofuran levels in Human Breast Milk from Vietnam compared with Cows milk and Human Breast Milk from the North American Continent, *Chemosphere* 16, 2003-2016, 1987
- Schecter A., Dai L. C., Thuy L. T.; Agent Orange and the Vietnamese: the persistent of elevated dioxin levels in human tissues, *Am J. Public Health*, 85, 516-522, 1995
- Schecter A., Dai L.C., Päpke O., Prange J., Constable J., Matsuda M., Thao V. D. Piskac A.; Recent Dioxin Contamination from Agent Orange in Residents of a Southern Vietnam City, *JOEM*, 43, 435-443, 2001
- Schecter A., Dai L.C., Päpke O., Prange J., Constable J., Matsuda M., Thao V. D. Piskac A.; Dioxin Levels in Vietnamese People, Food and Environmental Samples: Evidence of Current Contamination with 2,3,7,8-TCDD from Agent Orange Sprayed over 30 Years Ago; *Organohalogen Compounds*, 52, 156-160, 2001
- Schecter A., Le Cao Dai, Pavuk M., Päpke O. and Constable J.D. "Letter to the Editor: A follow-up: High level of dioxin contamination in Vietnamese from Agent Orange, three decades after the end of spraying." . *JOEM*. 44, 218-220, 2002
- Schecter A., Quynh H.T., Pavuk M., Päpke O., Malisch R. and Constable J.D., New Findings of Dioxins, Dibenzofurans, PCBs, DDT/DDE, HCB, and HCHs in Food from a Vietnam TCDD Contaminated Area and Comparison Area; *Organohalogen Compounds*, 64, 227-230, 2003.
- Schecter A., Quynh H.T., Päpke O., Malisch R. and Constable J.D., Tung KC.; Halogenated Organics in Vietnamese and in Vietnam Food: Dioxins, Dibenzofurans PCBs, Polybrominated Diphenyl Ethers and Selected Pesticides, Submitted to *Dioxin* 2004
- Wuthe J., Hagenmaier HP., Päpke O., Kettmann C., Frommberger R., Lillich W. Dioxin and furan (PCDD/PCDF) levels in human blood and milk of people living in a PCDD/ PCDF contaminated area. *Chemosphere*, 23, 1135-1140, 1992