

SURVEY AND RISK ASSESSMENT EVALUATION OF AN AREA CONTAMINATED BY DIOXINS IN VIETNAM, PHONG MY COMMUNE AND A SO SITE

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Summary

Between 2006 and 2009 a detailed survey of PCDD/PCDF contamination in Phong My Commune has been carried out. Based on the results a human health risk assessment was elaborated and later second risk assessment has been done for A So site a former US military air base in Dong Son Commune. Both Communes are located in Thua Thien Hue province in central Vietnam which was heavily affected by the herbicide spraying during the war between 60s and in the beginning of 70s of the last century. As a consequence of herbicides spraying a significant amount of PCDD/PCDF has been released into the environment and is still present in the basic environment matrices (soil, sediment) and has already entered various food chains. Local inhabitants have limited information about the potential threat they are faced with and are continuously exposed to the increased concentrations of PCDD/PCDF mainly in the locally produced foodstuff.

Based on the findings of both risk assessments, dietary exposure is the most risky one and represents carcinogenic and non-carcinogenic risk at both sites. Dermal contact with contaminated soil shows increased carcinogenic and non-carcinogenic risks too at A So site. Comparison of the two sites shows some important differences in the level of risks and contamination of the environment. Higher contamination and risks were identified at the A So site, where the herbicides were stored and handled. However; Phong My Commune as a typical area affected by herbicide spraying shows significant and non-acceptable carcinogenic and non-carcinogenic risks arising from the dietary exposure.

Key words: PCDD/PCDF, Dioxins, Agent Orange, Vietnam, Risk Assessment

Introduction

The company DEKONTA, a.s. in cooperation with the unincorporated association DWW (Development Worldwide) implemented in the years of 2006-2009, in the framework of official development cooperation of the Czech Republic in the Social Republic of Vietnam a project "Rehabilitation of Thua Thien Hue province affected by dioxins". This project, which was implemented in Phong My Commune was focused on rehabilitation of an area, which was heavily affected by spraying of herbicide

preparations during the Vietnam war in the end of 60s and in the beginning of 70s of the last century.

Spraying affected approximately 10% of the Southern and Middle Vietnam (approx. 1.2 million ha). A number of military defoliants were used for these purposes, most of all the substance called "Agent orange", the mixture of 2,4-Dichlorophenoxyacetic acid (2,4-D) and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T). The dioxins and particularly the most toxic congener TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin) coming from the herbicidal mixture was identified as a contaminant in the given area. Unlike the substances 2,4-D and 2,4,5-T, which decompose relatively fast (during several months), dioxins are more stable and persist in the environment for dozens of years.

Phong My Commune

In the years of 2006 and 2007 a detailed survey of the selected area was carried out, in the framework of which 246 samples of various matrices including basic elements of environment (soils, sediments, surface and groundwater), food (meat, fat tissue, fruits and vegetables), as well as human blood. PCDD/PCDF, or as the case may be, 17 monitored congeners were analyzed in the collected samples. Apart from these substances, selected organochlorinated pesticides, PCB and heavy metals were also monitored. Based upon average detected PCDD/PCDF concentrations in food components and results of questionnaires focused on lifestyle and eating habits of inhabitants in the Phong My commune, the average lifetime daily consumption was derived in WHO-TEQ units, ranging at the level of 5 to 7 times bigger in comparison to chronic exposure to these substances in industrial countries of the Western Europe, or North America. Based upon these data a risk analysis was elaborated, which was primarily focused on a dietary exposure, with regard to significant cumulative nature of dioxins.

In the framework of assessment of health risks resulting from the PCDD/PCDF exposures of inhabitants of the Phong My commune, several key exposure scenarios were identified, for which model calculations were made on the quantitative assessment of average and lifetime exposure doses of PCDD/PCDF and non carcinogenic health risks and risks of rise of cancer diseases resulting from them.

Matrices	Unit	Average concentration	Maximal concentration
Soil and sediments	[pg.kg ⁻¹]	1678 ± 863	5100
Fish	[pg.kg ⁻¹]	780 ± 1090	4800
Poultry	[pg.kg ⁻¹]	640 ± 450	1700
Other meat	[pg.kg ⁻¹]	57 ± 38	130
Vegetables (sweet potatoes, casawa)	[pg.kg ⁻¹]	16 ± 2	18
Fruit (bananas, papaya)	[pg.kg ⁻¹]	25 ± 5	30

Table 1: Average and maximal concentration of PCDD/PCDF in the mayor matrices, Phong My Commune

The dietary exposure was clearly the most risky scenario, most of all with regard to detected PCDD/PCDF concentrations in foodstuffs, especially in fish and poultry, which exceeded the maximum permissible limits determined for these substances by the European legislation by order of magnitude. The most risky foodstuffs from the perspective of PCDD/PCDF intake were especially fish, poultry and wild animals (snakes, frogs). Consumption of vegetables and fruits insufficiently cleaned/peeled from soil particles containing contaminants were also potentially risky. This concerns above all root vegetables, underground bulbs, low growing foliage vegetables, etc.).

Calculations were made according to standard equations for calculation of exposure and health risks, for which exposure parameters recommended by the US EPA and the Ministry of Environment of the Czech Republic were used. Further to this, results of a questionnaire were used for more detailed specification of exposure parameters, these questionnaires served as the most crucial source of information on a monitored population of inhabitants, including their dietary habits (e.g. a number of individual meals during the day and their composition).

The results of model calculations proved that prerequisites connected with this exposure scenario were justifiable and both the noncarcinogenic and carcinogenic risk coming from the dietary exposure was confirmed for all studied groups of inhabitants.

Ascertained values of the HI risk index in the case of noncarcinogenic risk in the monitored age categories ranged from 13.3 to 17.7 for the maximum PCDD/PCDF concentrations in foodstuffs, while the ILCR values (Incremental Lifetime Cancer Risk) in the monitored population groups ranged from $2.8 \cdot 10^{-5}$ to $1.5 \cdot 10^{-3}$, which corresponds to the probability of development of cancer disease approximately in the range of 28 individuals out of the group of 1,000,000 of inhabitants to 15 individuals out of 10,000. The cumulative lifetime risk of development of cancer diseases in the monitored population corresponded to the value of $2,1 \cdot 10^{-3}$ for the maximum ascertained PCDD/PCDF concentrations in foodstuffs.

Age category	Noncarcinogenic risk		Carcinogenic risk	
	CID [mg.kg ⁻¹ .den ⁻¹]	HI	LCD [mg.kg ⁻¹ .den ⁻¹]	ILCR
1 – 2	4,6E-09	4,6	6,5E-11	9,8E-06
2 - 6	5,1E-09	5,1	2,9E-10	4,4E-05
6 – 10	5,7E-09	5,7	3,3E-10	4,9E-05
10 – 18	6,1E-09	6,1	7,0E-10	1,0E-04
18 – 70	4,6E-09	4,6	3,4E-09	5,1E-04
Lifetime exposure	-	-	4,8E-09	7,2E-04

Table 2: Total exposure dose and health risks from dietary PCDD/PCDF exposure derived from average values of concentrations of PCDD/PCDF in foodstuffs, Phong My Commune

Age category	Noncarcinogenic risk		Carcinogenic risk	
	CID [mg.kg ⁻¹ .den ⁻¹]	HI	LCD [mg.kg ⁻¹ .den ⁻¹]	ILCR
1 – 2	1,3E-08	13,3	1,9E-10	2,8E-05
2 - 6	1,5E-08	14,6	8,4E-10	1,3E-04
6 – 10	1,7E-08	16,6	9,5E-10	1,4E-04
10 – 18	1,8E-08	17,7	2,0E-09	3,0E-04
18 – 70	1,3E-08	13,3	9,9E-09	1,5E-03
Lifetime exposure	-	-	1,4E-08	2,1E-03

Table 3: Total exposure dose and health risks from dietary PCDD/PCDF exposure derived from maximum values of concentrations of PCDD/PCDF in foodstuffs, Phong My Commune

A So site

A So site is a former US military air base in Dong Son Commune where the herbicides and number of agents were stored and later pumped into the planes and sprayed. This site is reported as one of the contaminated sites with “Agent Orange” e.g. PCDD/PCDF. As a part of the project a risk assessment has been done for the site. No site survey was done; however previously the site has been investigated by Hatfield Consultants (1998).

Data presented in this report were used for the calculation of the identified human health risk scenarios (same as for Phong My Commune). Risk Assessment was primarily focused on a dietary exposure. A questionnaire campaign has been done the same way as in Phong My Commune to specify exposure parameters, especially their dietary habits.

According to the calculation done both dietary and dermal exposure represent a carcinogenic and non-carcinogenic risks to local inhabitants. Significant non-carcinogenic and carcinogenic risk for all population groups studied from dietary exposure, primarily from the consumption of fish and poultry has been proved. The lifetime risk of cancer development for the studied population corresponds to the maximum detected concentrations of PCDD / PCDF in food value of $9.25 \cdot 10^{-3}$. Contact with contaminated soil, where transport through dermal contact and incidental ingestion of contaminated soil pose a significant exposure pathways of PCDD / PCDF in terms of non-carcinogenic and carcinogenic health risks. Especially for children non-carcinogenic risk and carcinogenic risk arise from lifetime exposure.

Matrix	Unit	Average concentration	Maximal concentration
Soil	[pg.kg ⁻¹]	44610	897000
Sediments	[pg.kg ⁻¹]	2520	17600
Fish	[pg.kg ⁻¹]	7610	51300
Poultry	[pg.kg ⁻¹]	4710	82000
Beef	[pg.kg ⁻¹]	280	1800
Eggs	[pg.kg ⁻¹]	2400	12900
Vegetables (sweet potatoes, cassava)	[pg.kg ⁻¹]	16	18
Fruits (bananas, papaya)	[pg.kg ⁻¹]	25	30
Rice	[pg.kg ⁻¹]	150	-

Table 4: Average and maximal concentration of PCDD/PCDF in the major matrices, A So site (Dong Son Commune)

Age category	Noncarcinogenic risk		Carcinogenic risk	
	CID [mg.kg ⁻¹ .den ⁻¹]	HI	LCD [mg.kg ⁻¹ .den ⁻¹]	ILCR
1 – 2	3,68E-08	36,8	5,26E-10	7,90E-05
2 – 6	2,46E-08	24,5	1,40E-09	2,11E-04
6 – 10	1,84E-08	18,4	1,05E-09	1,58E-04
10 – 18	1,23E-08	12,2	1,40E-09	2,11E-04
18 – 70	6,72E-09	6,7	4,99E-09	7,48E-04
Lifetime exposure	-	-	9,38E-09	1,41E-03

Table 5: Total exposure dose and health risks from dietary PCDD/PCDF exposure derived from average values of concentrations of PCDD/PCDF in foodstuffs, A So site

Age category	Noncarcinogenic risk		Carcinogenic risk	
	CID [mg.kg ⁻¹ .den ⁻¹]	HI	LCD [mg.kg ⁻¹ .den ⁻¹]	ILCR
1 – 2	2,43E-07	243,3	3,48E-09	5,22E-04
2 – 6	1,62E-07	162,2	9,27E-09	1,39E-03
6 – 10	1,22E-07	121,6	6,95E-09	1,04E-03
10 – 18	8,11E-08	81,1	9,27E-09	1,39E-03
18 – 70	4,40E-08	44,0	3,27E-08	4,91E-03
Lifetime exposure	-	-	6,17E-08	9,25E-03

Table 6: Total exposure dose and health risks from dietary PCDD/PCDF exposure derived from average values of concentrations of PCDD/PCDF in foodstuffs, A So site

Conclusion

As expected the level of contamination is much higher at the site where the herbicides with trace content of PCDD/PCDF were stored and handled (A So site) to sprayed areas (Phong My Commune). However; the level of contamination in sprayed areas is still increased and accumulated PCDD/PCDF in some of the animals exceed significantly the limit values for these chemicals in foodstuff according to the EU standards and WHO recommendation of daily intake. At both sites dietary expose scenario shows unacceptable carcinogenic and non-carcinogenic risks for local inhabitants.

Fairly low PCDD/PCDF concentration in soil and sediment in Phong My Commune doesn't represent any human health risk, however; much higher concentration at A So site represents a serious carcinogenic and non-carcinogenic risk for dermal contact with contaminated soil/sediment.

Reference

HC (1998): Preliminary Assessment of Environmental Impacts Related to Spraying of Agent Orange Herbicide During the Vietnam War. Hatfield Consultants Ltd., 201 – 1571 Bellevue Avenue, West Vancouver, BC, Canada V7V 1A6 (<http://www.hatfieldgroup.com>)