

LEVELS OF PCDDs/PCDFs IN THE ENVIRONMENT AND FOOD AFTER 3 YEAR OF FULL PLANT INACTIVITY, CHAPAEVSK, RUSSIA

Sergeyev O^{1,2}, Saharov I³, Shelepchikov A⁴, Revich B⁵, Sotskov Y³, Brodsky E⁴, Denisova T², Feshin D⁴, Zeilert V⁶

¹Samara State Medical University, Chapaevskaya, 89, Samara, Russia; ²Chapaevsk Medical Association, 446100, Lenina, 54B, Chapaevsk, Russia; ³Ecological Analytical Center, 129226, Selschozaistvennaya, 12A, Moscow, Russia; ⁴Severtsov Institute of Problems of Ecology and Evolution, Russian Academy of Sciences (IPEE RAS), 119071, Leninsky pr. 33, Moscow, Russia; ⁵Center for Demography and Human Ecology of Institute for Forecasting, Russian Academy of Sciences, 117418, Nachimovsky pr. 47, Moscow, Russia; ⁶Chapaevsk Central Hospital, 446100, Meditsinskaya, 3, Chapaevsk, Russia

Abstract

Chapaevsk is a Russian POPs hotspot. Chemical plant was the principal source of emissions of dioxins/furans, lindan and hexachlorobenzene (HCB) in this town. Production of lindan and HCB was stopped in 1987 and final stop of any production of this plant was in 2003. Since 1997 environmental remediation measures were conducted. The purpose of this study, supported by Samara regional government, was to evaluate the PCDD/Fs levels in environment and foods of Chapaevsk after 3 years of full inactivity of the plant and 10 years of rehabilitation program. 29 samples of soil, water, sediment, building wall, house dust, fish and eggs were analyzed. Levels of PCDD/Fs in soil, water and sediment have been decreased, however dioxins level remains high in building wall samples. All samples near plant had a high level. Eggs samples taken from own farms demonstrated the serious current contamination by dioxins. Highest dioxin/furans level, 7121 pg/g lipids, was found in carp caught 200 meters off the plant. The area of the plant and the adjacent residential area should be cleaned to decrease dioxin exposure on people, who lives near the plant.

Introduction

Chapaevsk, Russia, is a town of approximately 72,000 residents, located in central Russia near Samara (1000 kilometers south-east of Moscow) on the bank of the Chapaevsk river, a tributary to the Volga. Environmental pollution and public health in the town of Chapaevsk has been studied since 1994, when the local administration put forward a corresponding initiative. Chemical plants are the principal source of emissions of PCDD/Fs, lindane and hexachlorobenzene (HCB) in this town. This plant produced chlorinated organic pesticides between 1967 and 1987, and later began production of liquid chlorine, vinyl chloride etc. Production of lindan and HCB was stopped in 1987 and final stop of any production of this plant was in 2003¹. In the framework of environmental remediation program, Chapaevsk receives regional and federal financing since 1997². Construction of new water supply network and remediation of soils contaminated by dioxins were included in this program. The purpose of this study, supported by Samara regional government, was to evaluate the PCDDs and PCDFs levels in environment and foods of Chapaevsk after 3 years of full inactivity of the plant and 10 years of rehabilitation program. Levels of PCDDs/PCDFs in house dust, fish and building wall have been determined for the first time.

Materials and Methods

29 samples of soil (n=5), water (n=2), sediment (n=3), building wall (n=2), house dust (n=2), fish (n=4) and eggs (n=11) were collected in August-October 2006. Soil samples and hen eggs samples were obtained from same own farms of Chapaevsk citizens. Two soil samples (S1 and S5) and one fish sample were pooled. 4 eggs which were purchased in Chapaevsk market but were received from another regions of Russia (Tyumen, Chelyabinsk, Orenburg and Ulyanovsk) were pooled in one sample too. Only muscle meat of fish were used for analysis. All samples were analyzed using GC-HRMS technique (Hewlett Packard HP 6890 Plus, Finnigan MAT 95XP) at resolution 10000 in laboratory of Severtsov Institute of Problems of Ecology and Evolution, Russian Academy of Sciences, Moscow. 17 PCDD/Fs congeners were used for calculation of I-TEQ (1989) for environmental samples and for calculation of WHO-TEQ (1998) for fish and eggs samples.

The results of samples collected in 2006 were compared with results of samples collected in same places of Chapaevsk in 1994.

Results and Discussion

The results of PCDDs/PCDFs levels in sediment and fish of Chapaevsk area are presented in Table 1. Very high level of PCDD/Fs, 93.9 pg/ g fresh weight (7121.2 pg/g lipids), was found in crucian carp caught 200 meters off the plant. Estimated age of this carp was 1.5-2 years old. The congeners of dioxins and furans of this sample are presented in Table 2. Despite of 3 years of full stop of any production on this plant, the level of 2378-TCDD is high, 47.2 pg/g fresh weight. However, the levels of PCDD/Fs in pooled sample of pikes caught in same place was low and doesn't exceed the maximum level recommended by European Commission Regulation No 199/2006 as 4.0 pg/g fresh weight³.

Table 1. Levels of PCDDs/PCDFs in sediment (I-TEQ) and fish (WHO-TEQ) of Chapaevsk area.

Samples	Chapaevka river, before city	Chapaevka river, after city, very close to plant	Lake Ilmen, place of common bathing	Lake Beryozovoe, near new water source
Sediment, pg/g	0.67	17.11	0.18	-
Pike, pg/g fresh weight	0.13	0.18*	-	0.39
Pike, pg/g lipids	17.63	32.35*	-	44.16
Crucian carp, pg/g fresh weight	-	93.94	-	-
Crucian carp, pg/g lipids	-	7121.2	-	-

* - three pikes were pooled in one sample.

Table 2. Individual levels of PCDDs/PCDFs in crucian carp caught 200 meters off the Chapaevsk chemical plant.

Congeners	pg/g fresh weight	pg/g lipids	Congeners	pg/g fresh weight	pg/g lipids
2378-TCDD	47.21	3578.59	23478-PeCDF	8.40	636.42
12378-PeCDD	27.65	2096.13	123478-HxCDF	19.94	1511.50
123478-HxCDD	36.60	2774.71	123678-HxCDF	3.22	243.96
123678-HxCDD	73.07	5539.36	123789-HxCDF	0.13	10.08
123789-HxCDD	9.32	706.31	234678-HxCDF	1.99	151.23
1234678-HpCDD	34.39	2606.92	1234678-HpCDF	2.47	186.92
OCDD	7.47	565.93	1234789-HpCDF	1.23	93.02
2378-TCDF	0.52	39.52	OCDF	0.29	22.21
12378-PeCDF	0.46	34.52	TEQ_{PCDDs/PCDFs}	93.94	7121.25

Levels of dioxins/furans in soil and hen eggs are different depending on distance from chemical plant (Table 3). Eggs and soil are more contaminated near the plant. Maximum level of PCDDs/PCDFs TEQ was found in farm located on 0.5 km from plant, 51.0 pg/g for soil sample and 38.1 pg/g (279.7 pg/g lipids) for egg sample. The mean TEQ of Chapaevsk soil is 14.4 pg/g, growing up 5.6 pg/g far from the plant to 27.7 pg/g near the plant. The mean TEQ of Chapaevsk eggs is more than recommended by EC maximum level 3.0 pg/g lipids. This mean is 6.8 pg/g (51.2 pg/g lipids), growing up 2.6 pg/g (21.3 pg/g lipids) far from the plant to 11.9 pg/g (88.7 pg/g lipids) near the plant. Although all chicken had eaten non-local forage, contaminated soil probably contaminates the eggs too.

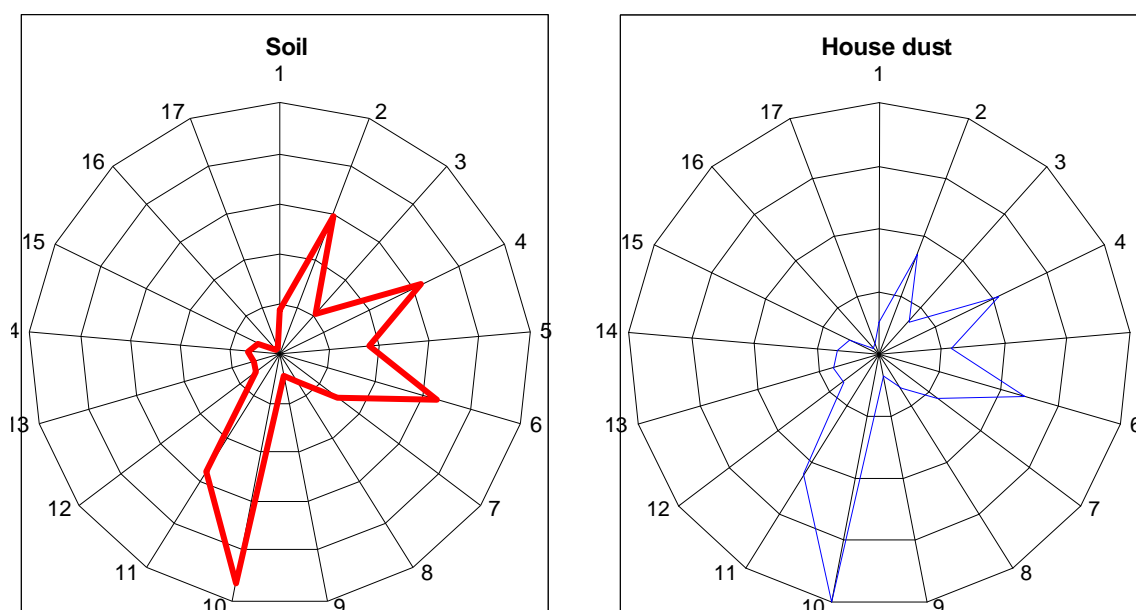
Table 3. PCDDs/PCDFs levels in soil and hen eggs samples from own farms of Chapaevsk citizens by distance from chemical plant.

	Chapaevsk market, eggs from 4 Russian regions	All samples	closer 3 km from chemical plant	3 km and more from chemical plant
Soil	-	<i>N</i> =5	<i>N</i> =2	<i>N</i> =3
I-TEQ, pg/g	-	14.44	27.73	5.57
Eggs		<i>N</i> =9	<i>N</i> =4	<i>N</i> =5
WHO-TEQ, pg/g	0.07	6.76	11.90	2.64
WHO-TEQ, pg/g lipids	0.77	51.21	88.65	21.26

We also collected the house dust in two families who lives near the plant and gets soil and eggs samples from their farm (Table 4). The farm in adjacent to plant residential area is much more contaminated, TEQ PCDDs/PCDFs in house dust was 79.9 pg/g on 0.5 km from plant and 19.9 pg/g on 2.0 km. The distribution of congeners in contaminated sample of house dust and soil was very similar as presented at Figure 1.

Table 4. Individual levels of TEQ PCDDs/PCDFs in house dust, soil and hen eggs samples of two families, who lives near the chemical plant.

	House dust, pg/g	Soil, pg/g	Egg, pg/g (pg/g lipids)
Own house and farm 0,5 km from plant	79.88	51.04	38.10 (279.73)
Own house and farm 2 km from plant	19.92	4.42	4.42 (41.26)

**Figure 1. Distribution of 17 dioxin and furan congeners in contaminated samples of house dust and soil, 0.5 km from Chapaevsk plant.**

The building wall samples also have different levels of TEQ PCDDs/PCDFs. The old building located 200 m from chemical plant has 89.2 pg/g, but TEQ of age-matched building which located 2.5 km from plant, is 2.4 pg/g.

The comparative results of contamination in 1994 and in 2006 are presented in Table 5. All environmental samples, including water, soil and sediment, were more contaminated in 1994. However, levels of PCDDs/PCDFs in eggs samples are doesn't decrease currently. Moreover level of dioxins/furans in one sample of egg near the plant was increased, 38.1 pg/g, more than 10 times than maximum level, 3 pg/g, recommended by EC.

We suppose that despite of successful rehabilitation program on the residential area which locates far from plant, the untreated plant area is remains the source of dioxin exposure of Chapaevsk citizens, particularly who lives near this plant and grows vegetables, raises cattle, poultry on polluted lands as well as uses fishing from local polluted river Chapaevka. These areas should be cleaned to decrease population' exposure to dioxins and furans.

Table 5. Levels of PCDDs/PCDFs in environment (I-TEQ) and eggs (WHO-TEQ) of Chapaevsk area in 1994 and 2006.

Samples	Place of samples collection	1994	2006
Water		2.14	0
Soil		35.05	14.44
Sediment	Chapaevka river, before city	1.83	0.67
	Chapaevka river, after city, very close to plant	17.12	17.11
	Lake Ilmen, place of common bathing	20.37	0.18
Hen eggs	closely to plant	18.12	38.10
	1-3 km	2.38	3.18
	more 3 km	1.98	2.64

Acknowledgements

This research was financially supported by Samara government (Contract # 11/2006). The authors wish to thank Mr. N. Malakhov, the Mayor of Chapaevsk, and Mr. A. Ivanov, the director of Chapaevsk rehabilitation program. The technical assistance of staff of Chapaevsk Medical Association is gratefully acknowledged.

References

1. Revich B., Sergeev O., Shelepchikov A., Brodsky E., Zeilert V., Kretov I. *Organohalogen Comp* 2006; 68:2351 – 2354
2. Program «Social and Economic development and environmental rehabilitation of Chapaevsk, Samara region, for the period 2003-2010».
3. COMMISSION REGULATION (EC) No 199/2006 of 3 February 2006 amending Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs as regards dioxins and dioxin-like PCBs *Official Journal of the European Union* 2006;32 http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_032/l_03220060204en00340038.pdf