PCDD/Fs and PCBs in human adipose tissue from the Irkutsk Oblast, Russia

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Introduction.

The Irkutsk Oblast is rich in mineral resources and as a result is home to a wide range of industries including: thermal energy, chemical manufacturing, forestry, wood-processing and pulp and paper, colour metallurgy etc. Many of these industries are potential sources of dioxins and dioxin-like compounds. High levels of polychlorinated biphenyls (PCBs) have been found in the snow cover of a number of cities in the Baikal region (1), and fish from Lake Baikal have been found to contain both PCBs and PCDD/Fs at levels of 40-50 pg TEQ/g lipid (2,3).

Despite this evidence of contamination of the Baikal environment with these compounds, there are relatively few data available on their levels in humans living in this area. A limited sampling program at the beginning of the 1990's found 18 pg I-TEQ/g lipid (international toxicity equivalents for PCDD/Fs) in blood from inhabitants of Baikalsk, 10.3 pg I-TEQ/g lipid in mothers' milk from Baikalsk, 17.3 pg I-TEQ/g lipid in mothers' milk from Irkutsk and 9.2 pg I-TEQ/g lipid in mothers' milk from Kachug (4,5).

In December 1992 there was a fire in the city of Shelekhov (20 km from Irkutsk) at the «Irkutskcable» factory. During the fire about 600 tons of polyvinylchloride granules and about 100 tons of polyvinylchloride sheeting burned. Over 600 persons were involved in extinguishing the fire, working without special protective clothing. To date 200 of these people have shown symptoms of toxic poisoning that is believed to be associated with the fire.

One of the goals of this paper was to establish whether the adverse health effects of the firefighters could be related to elevated levels of PCDD/Fs or PCBs that they may have been exposed to during the fire. To this end adipose tissue samples from 10 firefighters were analyzed. Since the data base on the background contamination of the local population with these compounds was limited, samples of adipose tissue were collected from 11 hospital patients who were undergoing surgery.

Experimental

The age, sex and home city are listed in Table 1a for the hospital patients and in Table 1b for the firefighters. All of the patients had been living in the given city for at least 10 years except for patient #7.The samples from the patients were taken in the course of operations with the assistance of the Irkutsk Regional Oncological Hospital and the Shelekhov Town Hospital

while the samples from the firefighters were taken via biopsy at the Irkutsk hospital. All of the samples were collected in August of 1997. The samples were placed in glass vials which were sealed, frozen at –20°C and transported frozen to the University of Bayreuth for analysis.

Table 1: Details of the Human Adipose Samples

a) Patients from Irkutsk and Irkutsk Oblast

Sample #	Location	Sex	Age
1	t. Angarsk	f	28
2	t. Sludyanka	f	69
3	t. Usol'e-Sibirskoe	m	53
4	t. Bodaybo	f	63
5	t. Shelehovo	m	25
6	c. Obusa	f	48
7	t. Irkutsk	f	35
8	t. Irkutsk	f	72
9	t. Irkutsk	f	49
10	t. Irkutsk	f	68
11	t. Irkutsk	f	47

b) Firefighters

Sample #	Location	Sex	Age
12	t. Irkutsk	m	49
13	t. Irkutsk	m	49
14	t. Irkutsk	m	39
15	t. Angarsk	m	32
16	t. Irkutsk	m	42
17	t. Irkutsk	m	46
18	t. Irkutsk	m	40
19	t. Irkutsk	m	40
20	t. Irkutsk	m	37
21	t. Irkutsk	m	30

The samples were worked up using modified versions of published methods. Both the PCDD/Fs and the PCBs were measured using HRGC/HRMS at a mass resolution of 8,000-10,000. The 2,3,7,8-substituted PCDD/F congeners and PCB congeners 28, 52, 77, 99, 101, 105, 118, 126, 138, 153, 156, 169, 170, 180, 199, 202 and 209 were quantified. The PCDD/F toxicity equivalents (TEQs) were calculated using the I-TEFs to facilitate comparison of the results with the literature. The TEQs for the PCBs were calculated using the TEFs for mammals recently proposed by the WHO working group.

Results and Discussion

The results are summarized in Table 2a for the patients from the city of Irkutsk, in Table 2b for the patients from the surrounding region, and in Table 2c for the firefighters.

Two of the patients (#3 and #8) had much higher levels than the rest of the cohort. They were treated as outlyers and will be discussed further below. When these samples are excluded the average concentrations are quite similar in the different groups: The overall TEQ (PCDDs, PCDFs and PCBs) is 47 pg/g lipid for residents of Irkutsk, 43 pg/g for residents of the Irkutsk Oblast and 53 pg/g for the firefighters. These levels are comparable with those that have been measured in adipose tissue of inhabitants of other industrial areas. For instance, the PCDD/F TEQs in this study largely lay between 20-35 pg/g lipid, while values of 23-26 pg/g have been reported for Bashkortostan (6) and an average of 24-28 pg/g for the USA (7). In summary, there is no evidence indicating a significant contamination of the firefighters with PCDD/Fs and PCBs as a result of the fire.

Since the sampling was conducted almost 5 years after the fire, it could be that the contaminants were present at that time but have since disappeared. However, these compounds are known to be very persistent in humans. Measurements of clearance in exposed individuals indicate that the half lives are at a minimum 5 years and for many congeners much longer (8). Even conservatively assuming a half life of 5 years for the TEQ, the levels directly after the accident would only have been two times higher than in the samples analyzed in this study.

These levels would also have been in the range typically found in the patients studied who were undergoing surgical operations.

Table 2: TEQs for the PCDDs, PCDFs and PCBs in the human adipose tissue (pg TEQ/g lipid)

a) Patients from Irkutsk City

Sample #	# 7	# 8	# 9	# 10	# 11	Mean[1)]
PCDD TEQ[2)]	13	18	9	9.3	11	10.4
PCDF TEQ[2)]	12	34	19	16	13	15.1
∑ PCDD/F TEQ	25	52	28	25	24	26
PCB TEQ[3)]	17	75	23	32	17	22
∑ PCDD/F+PCB TEQ	42	127	51	55	41	48

b) Patients from the Irkutsk Oblast

Sample #	# 1	# 2	# 3	# 4	# 5	# 6	Mean[4)]
PCDD TEQ	9	9	21	15	3.7	6	8.5
PCDF TEQ	12	13	83	12	4.5	12	10.7
∑ PCDD/F TEQ	21	22	104	27	8.2	18	19.2
PCB TEQ	22	32	216	38	5.7	17	22.9
∑ PCDD/F+PCB TEQ	43	54	320	65	14.9	35	42.1

c) Firefighters

Sample #	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	Mean
PCDD TEQ	11	14	9	12	8	11	7	15	10	18	11.5
PCDF TEQ	20	14	15	9	12	18	13	18	12	17	14.8
∑ PCDD/F TEQ	31	28	24	21	20	29	20	33	22	35	26.3
PCB TEQ	33	25	23	22	15	43	23	29	24	35	26.4
∑ PCDD/F+PCB TEQ	64	53	47	43	35	72	43	62	46	70	52.7

1) Sample #8 not included in the mean
2) Toxicity equivalency factors according to NATO-CCMS
3) Toxicity equivalency factors according to WHO (1997)
4) Sample #3 not included in the mean

The PCBs make a major contribution to the total dioxin-like toxicity in all of the samples. The average ratio of the PCB TEQs to the PCDD/F TEQs is 0.88 for the patients from Irkutsk,1.19 for the patients from the Irkutsk region and 1.05 for the fire fighters. Similar ratios were obtained in human milk in all FSU republics. However, in the USA this ratio is about 0.25 and in Japan it is about 0.5 (international toxicity equivalents for PCDD/Fs) (9).

OCDD, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF were the dominant PCDD/F congeners in all of the samples. The ratios of 1,2,3,4,7,8-HxCDF to 2,3,4,6,7,8-HxCDF are particularly interesting. They exceeded 5:1 in all but 3 of the samples and 10:1 in half of them. In Germany, where combustion processes are the primary source of PCDD/Fs, this ratio is typically around 2:1 (10). The PCDF contamination of technical PCB typically shows very high ratios of these two congeners. The high ratios observed in the adipose tissue together with the high PCB TEQ to PCDD/F TEQ ratios indicates that technical PCB is the primary source of the PCDFs present in the Irkutsk population. This conclusion is supported by analyses of soil from the Irkutsk region which show PCDD/F profiles typical of those found in technical PCB (11).

Returning to the two outlyers, sample 8 was collected from a 72 year old women. The levels of all congeners were systematically higher in this woman. This can be attributed to her advanced age or to contact with dioxins and related compounds at work. It has been shown that PCDD/F levels in humans increase with age (12).

Sample 3 was taken from a 53 year old man. The concentrations of most of the PCDD/F congeners in this man were similar to the levels in the other subjects. However, the concentrations of 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF were 7-10 times higher than the average for the subjects from the Irkutsk region. These are marker congeners for PCDD/Fs that have originated from technical PCB. The ratio of the two HxCDF congeners discussed above was 68:1 in this sample. The PCB concentrations in this man were 10 times higher than the average (see Table 2b). This suggests that the elevated levels in this man are due to exposure to technical PCB. This man was the only member of the cohort from Usol'ye-Sibirskoe. Milk sampled from the dairy in this city contained elevated levels of both PCDFs and PCBs (13). A soil sample taken close to the city contained the highest levels of PCDD/Fs and PCBs measured in the Irkutsk region (11). It would appear that there is or was a source of technical PCB close to Usol'ye-Sibirskoe that has caused widespread contamination of the environment. There is an urgent need for more study to ascertain the extent to which the local population has been effected and to establish whether the emissions are ongoing.

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