DAILY INTAKE AND RISK ASSESSMENT FOR PCDD, PCDF AND PCB EXPOSURE FROM FOOD IN IRKUTSK REGION, RUSSIA.

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Introduction

There are many large industrial enterprises situated in the Irkutsk region that are potential sources of dioxins and related compounds. These include an electronic-mechanical factory in Angarsk, timber complexes in Bratsk and Ust'-Ilimsk, a pulp and paper mill in Baikalsk, a chlorine factory in Bratsk, the Siberian branch of the Institute "chloroproekt", the combine "Sibsalt" in Usol'e-Sibirskoe and the chemical complexes "Khimprom" in Usol'e-Sibirskoe and Sayansk [1]. Investigations have been conducted into the PCDD/F and PCB distribution in different media of the Irkutsk Region environment [2,3,4,5,6] including samples of locally produced food. The aims of this work were to calculate the daily intake and to assess the carcinogenic risk of PCDD/Fs and PCBs in the investigated food.

Methods and materials

A calculation of daily intake was made on the basis of the previous measurements of PCDD/F and PCB levels in food [3,5]. The consumption rates of the investigated food categories by the Irkutsk region population in 1996 were received from the Regional Committee of Statistics. The calculation of carcinogenic risk was made using the linear model [7].
Toxic equivalents were calculated using WHO TEFs for humans.

Results and Discussion

The concentrations in the different food categories are summarized in Table 1.

The daily intake of PCDD/Fs and PCBs from food by average person living in the Irkutsk Region amounts to 184 pg TEQ-WHO/d or 2.6 pg TEQ-WHO/kg BW/d (see Table 2). This value does not exceed Russian sanitary standards or the WHO recommendations of 1998.

The changes in economic prosperity in last decade have impacted the consumption of meat, meat products, milk and milk products in the region. While the consumption rate of milk and milk products was 778 ml/d/person in 1991, this had decreased to 466 ml/d person by 1996. If it is assumed that the PCDD, PCDF and PCB levels in food in 1991were equal to the levels reported in 1998, then the daily intake in 1991 would have equaled 236 pg TEQ-WHO/d or 3.4 pg TEQ-WHO / kg BW/d.

When the maximum PCDD/F and PCB TEQ levels in Lake Baikal fish and milk (i.e. packaged milk from Angarsk) are used in calculation, the daily intake amounts to 330 pg TEQ-WHO/d or 4.7 pg TEQ-WHO/kg BW/d. This daily intake is the maximum possible value from these food categories for an average person living in the Irjutsk Region.

While the maximum daily intake does not exceed the Russian standard, it is higher than the daily intake recommended by the WHO in 1998. Persons consuming higher than average quantities of fish and milk packaged from Angarsk will have higher exposure to PCDD/Fs and PCBs.

As was found previously [5], PCDD/F and PCB TEQ levels depend on the region where this food was produced and on the type of packaging material. The daily intake of PCDD/Fs and PCBs also depends on these factors, both because of different concentrations in the food supply and different dietary habits. For example, the daily intake of PCDD/Fs and PCBs in the city of Irkutsk is 1.6 pg TEQ-WHO/kg BW/d, with fish constituting 75 % and milk 9 % of the total daily intake. In Usol'e-Sibirskoe the daily intake of PCDD/Fs and PCBs comes to 2.3 pg TEQ-WHO/kg BW/d, with the contribution from milk increasing up to 37 % and that from fish dropping to 52 %. If a person consumes milk packaged in paper containers, the daily intake rises to 3.9 pg TEQ/kg BW/d with the contribution of milk at 62 % and of fish at 31 %.

The contribution of PCBs to the total daily intake is 51.7 %, corresponding to 1.36 pg TEQ/kg BW/d. The PCDD/Fs contribute 48.3 % or 1.27 pg TEQ/kg BW/d.

The largest part of the PCBs enters the human organism with fish (64 % of the daily intake of PCBs) and cow's milk (24 %). The largest part of the PCDD/Fs enter with milk (65 % of daily intake of PCDD/F) and fish (28 %) (see Table 3).

If food consumption data for 1991 are used in the calculation, fish would comprise 54 % of the daily intake of PCBs and cow's milk 36 %. Milk would comprise 76 % of the daily intake of PCDD/Fs and fish 19 %. This indicates that the importance of fish as a source of human exposure to PCDD/Fs and PCBs has increased from 1991 to 1996.

Individual carcinogenic risks were calculated on the basis of the daily intake. The individual carcinogenic risk from PCDD/Fs and PCBs in the food investigated came to 410×10^{-6} in 1996. This is equivalent to 410 additional cases of cancer among 1 million people in 1996 and is higher than the acceptable risk adopted by US EPA [7]. This value comprises 0.25 % of total carcinogenic morbidity in Irkutsk region or 16 additional case of cancer in the whole region.

If the alterations in food consumption between 1991 and 1996 are considered and it is again assumed that the contaminant concentrations did not change, then the risk decreased 1.3 times during this period.

The individual risk for PCDD/Fs and PCBs depends on the type of milk packaging used and on the region where the milk is produced. If a person consumes milk packaged in paper containers without aluminum foil, the individual risk comes to $380*10^{-6}$. For a person consuming Irkutsk milk packaged in a paper container with aluminum foil, individual risk decreases to $22*10^{-6}$, and for a person consuming milk packaged in a polyethylene container from Usol'e-Sibirskoe the individual risk is to $130*10^{-6}$. Thus the individual carcinogenic risk from cow's milk packaged in a paper container will be 2.9 times higher than if the milk had been packaged in a polyethylene container from Usol'e-Sibirskoe and 17.2 times higher than if the milk had been packaged in a paper container from Irkutsk. The individual risk of PCDD/Fs and PCBs from milk from Usol'e-Sibirskoe is 6 times higher than one from milk from Irkutsk.

The daily intake and the individual carcinogenic risk were calculated for the average resident of the whole Irkutsk Region. However, considerable variability can be expected depending on the region and customs. It can be hypothesized that residents of the Lake Baikal and Angara River coast (fishermen and members of their families) consume more fish and fish products than the average person in the whole region and hence have a higher exposure and risk. Similar concerns arise for sub-populations living near sources and consuming home-grown food (for example, in the region impacted by the industrial factories in Usol'e-Sibirskoe). These questions require further investigation.

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Table 1. PCDD/Fs and PCBs TEQ levels in food from the Irkutsk Region (pg TEQ-WHC/g wet weight).

Food category	PCDD/F TEQ	PCB TEQ	PCDD/F+PCB TEQ
Cow's milk			
From Irkutsk packaged into paper container covered inside with aluminum foil	0.006	0.015	0.02
From Angarsk packaged into paper container	0.32	0.05	0.37
From Usol'e-Sibirskoe packeged into polyethylen container	0.04	0.09	0.13
Average of cow's milk	0.12	0.05	0.17
Butter	0.25	0.61	0.86
Beef	0.01	0.04	0.05
Pork	0.07	0.06	0.13
Chicken	0.06	0.06	0.12
Fish (omul), average	0.70	1.76	2.46
Fish (omul), max	1.27	2.78	4.05

Table 2. The daily intake and values of individual carcinogenic risk for PCDD/F and PCB exposure from food.

	PCDD/F	PCB	Σ PCDD/F + PCB
Daily intake, pg TEQ/ day	88.8	95	184
Daily intake, pg TEQ/kg BW/ day	1.27	1.36	2.63
Individual carcinogenic risk	$198*10^{-6}$	$212*10^{-6}$	$410*10^{-6}$
The percent of total carcinogenic morbidity, %	0.12	0.13	0.25
The amount of case in region	8	9	17

Table 3. The contribution of food categories into the daily intake (DI) of PCDD/F and PCB and total daily intake (TDI) of PCDD/F+PCB.

	Consumption rate, gram	PCDD/F DI (pg TEQ/kg BW/d)	% of PCDD/F DI	PCB DI (pg TEQ/kg BW/d)	% of PCB DI	PCDD/F+PCB TDI (pg TEQ/kg BW/d)
Fish	34.8	0.35	28	0.87	65	1.23
Cow's milk	466	0.82	65	0.33	24	1.15
Butter	7.4	0.03	2	0.06	4	0.09
Beef	128	0.01	1	0.04	3	0.05
Pork		0.03	2	0.03	2	0.06
Chicken		0.03	2	0.03	2	0.06
Total		1.27	100	1.36	100	2.63