DAILY INTAKE AND RISK ASSESSMENT FOR DIOXINS AND RELATED COMPOUNDS EXPOSURE FROM FISH IN LAKE BAIKAL, THE SELENGA RIVER AND ANGARA RIVER, RUSSIA

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Introduction

The biggest freshwater lake of the world - Lake Baikal is located in the East Siberia, Russia. Above 336 rivers inflow into Lake Baikal. The Selenga River is the main tributary of Lake Baikal. Only the Anagara River outflows from Lake Baikal. The large industrial complexes of the East Siberia are concentrated on the shores of Lake Baikal and main rivers of the region. They include industrial complexes on oil refinery in Angarsk, mechanical engineering in Irkutsk and Usol'e-Sibirskoe, chemical enterprises in Angarsk and Usol'e-Sibirskoe, timber complexes in Selenginsk, Baikal'sk, Bratsk, Ust'-Ilimsk, aluminum enterprises in Bratsk and etc. There is scale River Angara Chain of hydro-electric power plants (Irkutsk, Bratsk and Ist'-Ilimsk hydro-electric power plants).

The previous investigations show that the fish consumption makes significant contribution in the entrance of dioxins and related compounds into organisms of residents of the region (up to 28 % of PCDD/F and 65 % of PCB) [1]. However, the concentrations in fish will vary from sites of fishing. Accordingly, the daily intake and individual risk will vary too. Both traditional pattern of life and social-economical situation of population living on the shore of Lake Baikal and rivers result in predominance of fish in diet of people. Fish is becoming the main source of protein for this population. This study presents some data on average and maximal intake of dioxins and related compounds into organisms of residents of large basin shores of the region.

Methods and materials

A calculation of daily intake was made on the basis of the previous measurements of PCDD/F and PCB levels in fish [2-5]. The average consumption rates of fish by the Irkutsk region population in 1991-96 were received from the Regional Committee of Statistics (34-35 g fish / a day). The value has not significant changes in this period of time. For the population of settlements located on Angara River the maximum range of consumption rate comes to 200 g fish / a day [6]. This value was assumed to be maximum consumption rate in our calculations. The average people weight 70 kg was used in daily intake from the soil too. 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 of PCDD/F and PCB in the fish samples are presented in Fig. 1. PCDD/F+PCB TEQ levels in fish samples are lower a Russian sanitary limit (88 pg TEQ/g lipids). The highest PCDD/F TEQ level was found in grayling caught lower Ust'-Ilimsk dam in under course of the Angara River outflowing from Lake Baikal [4]. The least PCDD/F TEQ level was found in perch and roach from the Upper Angara River inflowing into the north part of Lake Baikal[3]. The mean PCDD/F TEQ concentration found in fish from basins of the Lake Baikal Region comes to 10.5 pg TEQ/g lipids or 0.49 pg TEQ/ g wet weight. Data on PCB TEQ are available only for fish from Lake Baikal and the Upper Angara River. The average PCB TEQ level in omul from Lake Baikal reaches as high as 33.4 pg TEQ/g lipids that in 8-23 times higher than is fish from the Upper Angara River [3].

PCDFs make the main contribution in total PCDD/F TEQ (62-93 %) except grayling sample below Ust'-Ilimsk dam where PCDF and PCDD contributions are about equal. (53 and 47 % respectively).

In using of average fish consumption rate (35 g in a day), the daily intake of PCDD/F from fish varies from 0.009-0.012 pg TEQ/kg BW in a day for people consuming fish from tributaries of the north part of Lake Baikal to 0,29-0,42 pg TEQ/kg BW*day^{-1} for people living in Balagansk and other settlements located in about 100 km downstream from Usol'e-Sibirskoe. It can be expected that this value will be higher from fish caught in site of sewage discharge of enterprises of Usol'e-Sibirskoe. The maximum daily intake was found for people consuming fish from the Angara River below Ust'-Ilimsk dam where it comes to 1.05 pg TEQ/kg BW * day^{-1}. The daily intake for population from fish caught along the Angara River increases in 8.3 times. The mean daily intake of PCDD/F from fish comes to 0.24 pg TEQ/kg BW*day^{-1}.

The average daily intake of PCB from fish from Lake Baikal is about 0.87 pg TEQ/kg BW*day^{-1} and from the Upper Angara River up to 0.037 pg TEQ/kg BW*day^{-1} under assuming mean fish consumption rate.

When maximum consumption rate of fish is used in the calculation of daily intake of PCDD/F, this index increases up to 0.053-0.071 pg TEQ/kg BW*day^{-1} for people eating fish from the Upper Angara River, 2.02 pg TEQ/kg BW*day^{-1} for people living on the shore of Lake Baikal, 1.64-2.41 pg TEQ/kg BW*day^{-1} for people living in Balagansk and 6.03 pg TEQ/kg BW*day^{-1} for people eating fish caught downstream of the Ust'-Ilimsk dam.

Individual carcinogenic risks were calculated on the basis of average and maximum PCDD/F daily intakes from fish. The average individual carcinogenic risk from PCDD/Fs in fish investigated from the Baikal Region comes to $46 * 10^{-6}$. This is equivalent to 46 additional cases of cancer among 1 million people. The value of individual carcinogenic risk varies form $1.4\text{-}1.9 * 10^{-6}$ from fish from the Upper Angara River to $55 * 10^{-6}$ from fish from Lake Baikal and $45\text{-}65 * 10^{-6}$ from fish from 100 km downstream of Usol'e-Sibirskoe and $163 * 10^{-6}$ from fish from downstream of Ust'-Ilimsk dam. The individual risks from about all fish samples from the Lake Baikal Region are higher than the acceptable risk adopted by US EPA [7] and admitted by Russian standard. Thus, the highest average individual risk from PCDD/F in fish was found for population consuming fish caught downstream of Ust'-Ilimsk dam. This value is in 81-163 times higher than that for population eating fish from the Upper Angara River, in 3 times higher than that for people eating fish from Lake Baikal and in 8 times higher than that for people eating fish from the upper reaches of the Angara River. The individual risk from PCDD/F in Lake Baikal fish varies from $20 * 10^{-6}$ to $98 * 10^{-6}$ and average up to $55 * 10^{-6}$ that in 27-55 times higher that one in fish from the Upper Angara River, in 5-6 times higher than one in fish from the Selenga River, in 2.7 times higher than one in fish from the upper reach of the Angara River and similar to one in fish from upstream of Balagansk. Such distribution of concentrations and accordingly individual risks along basins of the region is due to allocation of industrial complexes, their discharge sites of sewage and atmosphere influence on surrounding area.

In addition the individual risk from investigated PCB in Lake Baikal fish [3] reaches to 136 * 10^{-6}. This value is 16-44 times higher than one in fish from the Upper Angara River. Thus, PCBs increase the risk in 2.5 times.

In should be noted that if the maximum daily intake of PCDD/F is used in calculation, the individual risk will come to 220 * 10^{-6} and will vary from 8.2-11 * 10^{-6} for the population eating fish from the Upper Angara River to 940 * 10^{-6} for population eating fish caught downstream of Ust'-Ilimsk dam.

The evaluation of daily intake and the calculated individual carcinogenic risk in this study include only PCDD/F values. While PCBs increase concentrations and accordingly risk from PCDD/F in 2.5 times. The further investigation is to include the analyses of PCB too. In addition the fish sampling should comprise more number of site sampling to reach more accurate risk calculation. So these questions require further investigations.

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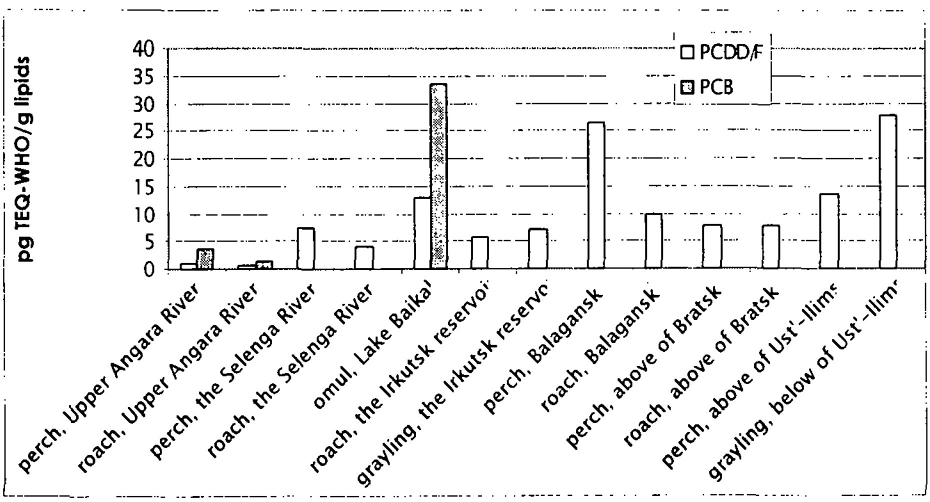

Fig. 1. The PCDD/F and PCB TEQ levels in fish from the Baikal Region [2-5].

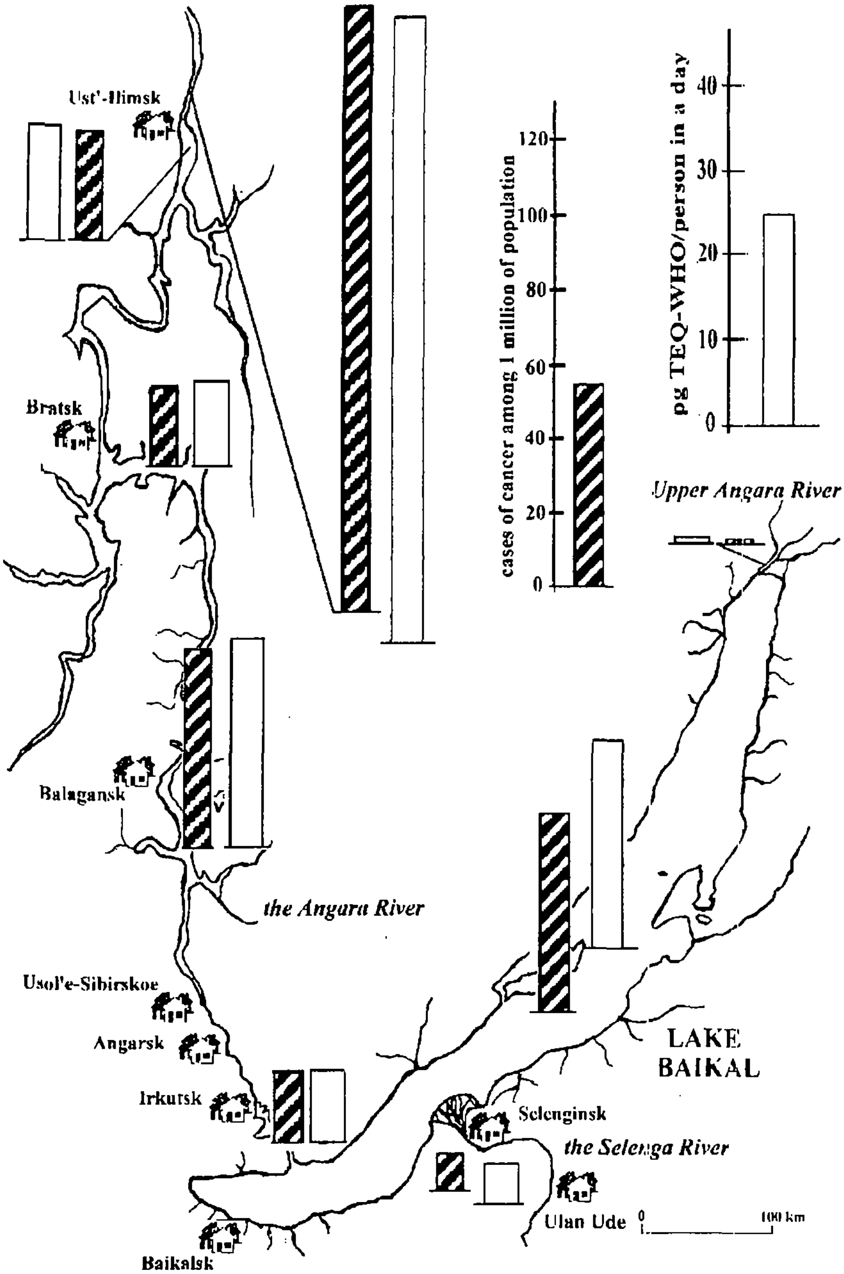

Fig. 2. The distribution of daily intakes and individual risks from PCDD/F in fish.