PCBs AND OCPs IN FISH FROM LAKE BAIKAL, DELTA OF THE LENA RIVER AND BAUNT LAKES, RUSSIA

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Abstract

The PCBs and OCPs levels were investigated in valuable species of fish (family *Coregonidae*) from Lake Baikal, the delta of the Lena River and the Oron Lake (one of the Baunt Lakes). The mean levels of the organochlorine compounds in white-fish from Lake Baikal, the Lena River and Lake Oron were 94, 19 and 36 ng/g lipids for indicator PCBs, 120, 32 and 46 ng/g lipids for DDT and its metabolites, 2.9, 3.4 and 5.8 ng/g lipids for α- and γ-HCHs, and 20.4, 4.5 and 7.3 ng/g lipids for TNCL, accordingly. The levels of the organochlorines did not exceed Russian sanitary standards for freshwater fish for consumption by adult (SanPiN 2.3.31078-01). But DDT levels in some white-fish from Lake Baikal exceeded sanitary standards for primary products for the preparation of food for children. The organochlorines levels in fish from the Lena River are comparable to the levels in fish from other regions of Russian Arctic. A decrease in the levels of DDT and its metabolites was found in fish from Lake Baikal during the last decade. No marked decrease in the levels of other organochlorines was observed in Lake Baikal fish.

Introduction

Lake Baikal is located in the Central Asia between 55°46' and 51°29' N[1]. It is 636 km long and between 25 and 79.5 km wide. More than 2000 km of shoreline encloses an area of 31,500 square km. More than 300 rivers and rivulets flow into the lake. The Angara River is the only outflowing river. In December 1996 Lake Baikal was entered into the list of UNESCO World Natural Heritage Site for its geological, biological-evolutionary significance, its natural beauty, and as a habit of outstanding importance for conservation. It has been found that significant sources of PCBs and PCDD/Fs are located on the shore of the Angara River and contaminated surrounding terrestrial and aquatic ecosystems of the Lake Baikal Region[2,3,4]. In addition, organochlorine pesticides were widely used in agriculture and forestry in the past.

The Lena River takes its rise in the west descents of the Baikal edge. The Lena River is among of the largest rivers in Asia[5]. The length of the river comes to 4400 km. The watershed basin comes to 2430 thousands kilometers. There are a lot of tributaries, small lakes and swamps in the watershed basin of the Lena River, including small Baunt lakes in the upperstream of the Vitim River, one of tributaries of the Lena River. The delta of Lena River is the site of the graziery and the wintering of valuable species of fishes [6]. The pollution of river water with discharges of industries and settlements located on the shore of the Lena River, discharges of river vessels and ports, and wood remnants after rafting are ecological problems for the river [5,6]. The mighty floods are annual phenomenon in the Lena River and its basin. The suspended matter and pollutants absorbed on suspension are precipitated and accumulated in the delta. In addition the organochlorines such as PCB and OCP are characterized by ability to long range atmospheric transport and accumulation in northern latitudes [7]. Thus, fish in delta is exposed by organochlorines comes from sources on the watershed of the river and on account of long range transport.

The aim of this work is to investigate the distribution of organochlorine compounds (PCBs, DDT and its metabolites, α- and γ-isomers of HCHs and one of components of chlordane – *trans*-nonachlor (TNCL)) in valuable species of fish (family *Coregonidae*) from Lake Baikal, the Lena River and the Oron Lake (one of the Baunt Lakes).

Materials and Methods

Whitefish was collected in large channel of Maloe More and the Chivyrkuy Bay in the middle part of Lake Baikal [8], in the delta of the Lena River [9] (the area of the settlement of Tit-Ary) and in the Lake Oron with the assistance of fishermen (Table 1, Fig. 1). Among the investigated fish there were following species of the family *Coregonidae*: muksun (*Coregonus muksun*), omul (C*oregonus autumnalis*), least cisco (*Coregonus sardinella*) and inconnu (*Stenodus leucichthys nelma*) from the delta of the Lena River, lake whitefish (*Coregonus lavaretus baicalensis*) from the Maloe More Channel and the Chivyrkuy Bay in Lake Baikal, omul (*Coregonus autumnalis migratorius*) from the Maloe More in Lake Baikal and baunt whitefish (*C. lavaretus baunti)* from the Oron Lake (the system of Baunt lakes) (Table 1). The fish were wrapped in aluminum foil and frozen until analysis. Several fish were pooled for each sample. The samples storage at -20^0C prior to the analysis. Samples were analyzed for PCBs, *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDD, *p,p'*-DDE, α-HCH, γ-HCH and *trans*-nonachlor (TNCL) at the laboratories of the Institute of Geochemistry in Irkutsk (Russia). Published methods were used [4,10]. The POPs were analyzed using gas chromatography with a ^{63}Ni electron-capture detector (GC-ECD). The Hewlett – Packard 5890 series II GC was equipped with a 0.25 μm × 60 m DB-5 capillary column (J&W Scientific).

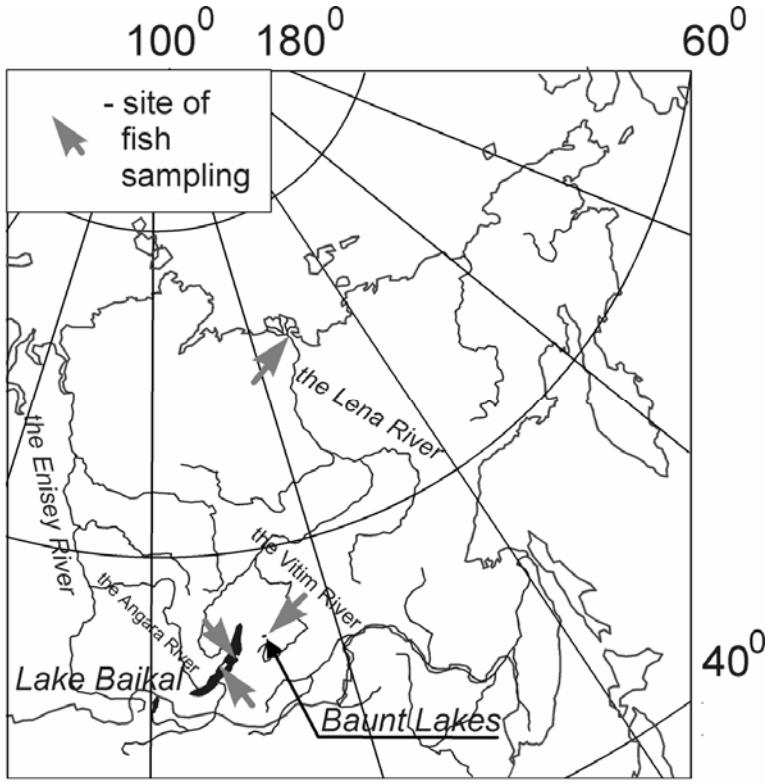

Figure 1. The scheme of fish sampling in the delta of the Lena River, Lake Baikal and Baunt Lakes.

Results and Discussion

The results are presented in Figures 2 and 3.

PCBs. Mean levels of 29 PCB congeners comes to 225 ng/g lipids in fish from Lake Baikal, 50 ng/g lipids in fish from the delta of the Lena River and 70 ng/g lipids in fish from the Lake Oron. The levels of six indicator PCBs comes to 94, 19 and 36 ng/g lipids, accordingly. The lowest sum of six indicator PCBs was found in muksun sampled in 2008 (9 ng/g lipids), while in samples of muksun collected in 2005 the sum of indicator PCBs comes to 27 ng/g lipids. It is possible that the variation is a result of different age and diet of the fish included in the samples.

Table 1. Description of the fish samples.

#	Species	N	Site of sampling	Time of sampling	Age, yr	Weight, grams	Length, cm	% lipids
	Lake Baikal							
1.	lake whitefish (*Coregonus lavaretus baicalensis)*	8	Maloe More	I.1998	9+-10+	730-1500	41,3-45,3	13.7
2.	lake whitefish (*Coregonus lavaretus baicalensis)*	2	Chivyrkuy Bay	XII.1997	10+	980-1180	42,6-45,0	7.5
3.	lake whitefish (*Coregonus lavaretus baicalensis)*	5	Maloe More	IX.2006	4+	204-317	23.7-29.5	2.4
4.	omul (*Coregonus autumnalis migratorius)*	5	Maloe More	X.2005	6+-8+	236-286	27.0-30.0	3.3
5.	omul (*Coregonus autumnalis migratorius)*	5	Maloe More	IX.2006	5+	198-229	25.0-27.3	3.0
	the Lena River							
6.	muksun (*Coregonus muksun*)	24	The delta of the Lena River	XII.2005	7+-12+	534-859	33.8-40.3	1.5
7.	muksun (*Coregonus muksun*)	5	- " -	XII.2008	9+	891-972	40.0-41.0	2.5
8.	omul (Co*regonus autumnalis*)	8	- " -	XII.2005	8+-11+	865-1311	39.6-46.2	5.9
9.	least cisco (*Coregonus sardinella*)	8	- " -	XII.2005	6+-10+	162-267	24.6-29.7	7.5
10	inconnu (*Stenodus leucichthys nelma*)	5	- " -	XII.2005	8+	1218-2705	46.7-61.0	2.0
	the Baunt Lakes							
11	baunt lake whitefish (*Coregonus lavaretus baunti)*	15	Lake Oron	IV.2009	6+	31.7-43.8	14.6-16.9	1.4

The highest PCB levels in fish from the Lena River delta are comparable with the lowest PCB levels in fish from Lake Baikal and Lake Oron and with levels found in other regions of Russian Arctic [11] (Figure 2). The variation of PCB levels in fish from Lake Baikal probably results from the age of the investigated fish and the character of diet of the fish in the age. The further investigations are needed to determine whether a time trend of the pollutants is available in Lake Baikal fish. The levels of the total PCBs did not exceed Russian sanitary standards for freshwater fish for consumption by adults (2 mg/kg wet weight for total PCBs) (SanPiN 2.3.31078-01).

The fish samples from Lake Baikal are characterized with higher levels of tri- and tetra-CL-substituted congeners while fish from the Lena River is marked by higher part of penta-substituted CB congeners. The homological PCB patterns in fish from both Lake Baikal and Lena River are similar to ones in Sovol [12].

DDT and its metabolites. Mean levels of the sum of DDT and it metabolites comes to 120 ng/g lipids in fish from Lake Baikal, 33 ng/g lipids in fish from the delta of the Lena River and 46 ng/g lipids in fish from the Lake Oron. The levels of DDTs did not exceed Russian sanitary standards for freshwater fish for consumption by adults (0.3 mg/kg wet weight) (SanPiN 2.3.31078-01). But DDT levels in some white-fish from Lake Baikal exceeded sanitary standards for primary products for the preparation of food for children (0.01 mg/kg wet weight). The DDTs levels in fish from the Lena River are comparable or lower than levels in fish from other regions of Russian Arctic [11](Figure 3).

The relations of *pp'*-DDT, *pp'*-DDD and *pp'*-DDE in fish from the Lena River differ from ones in fish from Lake Baikal and Lake Oron. But the indexes are similar to relation found in fish from other regions of Russian Arctic (Figure 3). The composition of DDT and its metabolites in fish from Lake Oron are similar to those found in Lake Baikal. *pp'*-DDT/ *pp'*-DDE ration comes to 0.07-0.33 in Lake Baikal fish, 0.09 in Lake Oron fish, 0.65-1.69 in fish from the Lena River. The index comes to 0.28-2.45 in other regions of Russian Arctic[11]. The DDT/DDE ratio is higher than one assumes recent entrance of the pesticides in the environment. However, the *pp'*-DDD/ *pp'*-DDE ratio in fish from Lake Baikal, Lake Oron and the Lena River comes to 0.02-0.10, 0.06 and 0.39-1.77, accordingly. The *pp'*-DDD/sum DDTs ratio amounts to 0.02-0.09, 0.05 and 0.19-0.32, accordingly. The indexes can be explained by both the predominance of anaerobic DDT decomposition in the delta of Lena River and character of diet of fish from Lena River. It is confirmed by the data concerning the increasing of trophic status of the Lena River water [5,6]. In addition the diet of the fish from Lena River includes benthos organisms, while whitefish in Lake Baikal is a pelagic species.

It should be noted that a decrease in the levels of DDT and its metabolites was found in fish during the last decade. *p,p'*-DDE and *p,p'*-DDT levels in omul from the central part of Lake Baikal in 1993 were equal to 15-58 and 6-21 ng/g wet weight[13]. In white-fish in 1998 they were 21 and 2.5 ng/g wet weight, while the levels in omul were 2.8 and 0.95 ng/g wet weight in 2005, and 0.88 and 0.11 ng/g wet weight in 2006, respectively. No marked decrease in the levels of other organochlorines was observed.

HCHs. Mean levels of the sum of α- and γ-HCHs comes to 2.9 ng/g lipids in fish from Lake Baikal, 3.3 ng/g lipids in fish from the delta of the Lena River and 5.8 ng/g lipids in fish from the Lake Oron. There is no significant difference between HCHs level in fish samples from Lake Baikal, Lake Oron and Lena River. But the α- / γ- HCH ratio comes to 3.2-5.6, 2.3 and 0.9-2.3, accordingly. The levels of the HCHs did not exceed Russian sanitary standards for freshwater fish for consumption by adults (0.03 mg/kg for HCHs) (SanPiN 2.3.31078-01).

TNCL. Mean levels of the TNCL comes to 20 ng/g lipids in fish from Lake Baikal, 4.5 ng/g lipids in fish from the delta of the Lena River and 7.3 ng/g lipids in fish from the Lake Oron. The lowest TNCL levels were found in inconnu 4 years old (1.5 ng/g lipids). It should be noted that the TNCL in inconnu 7-8 years old is in 6.5 times higher than in young fish that results from the diet of young and elder fish. The same phenomenon was found for other organochlorines levels in the fish species. The highest TNCL level was found in whitefish sampled in 2006 from Lake Baikal (32 ng/g lipids). In spite of younger age of fish collected in 2006 the TNCL level in the sample was in 1.5 times higher than in elder fish caught in 1998. Previous investigations indicate that TNCL was not found or found in trace concentrations in fish from the Angara River and tributaries of Lake Baikal except for the Selenga River [9]. The investigation is needed to observe time trend of TNCL in Lake Baikal in future.

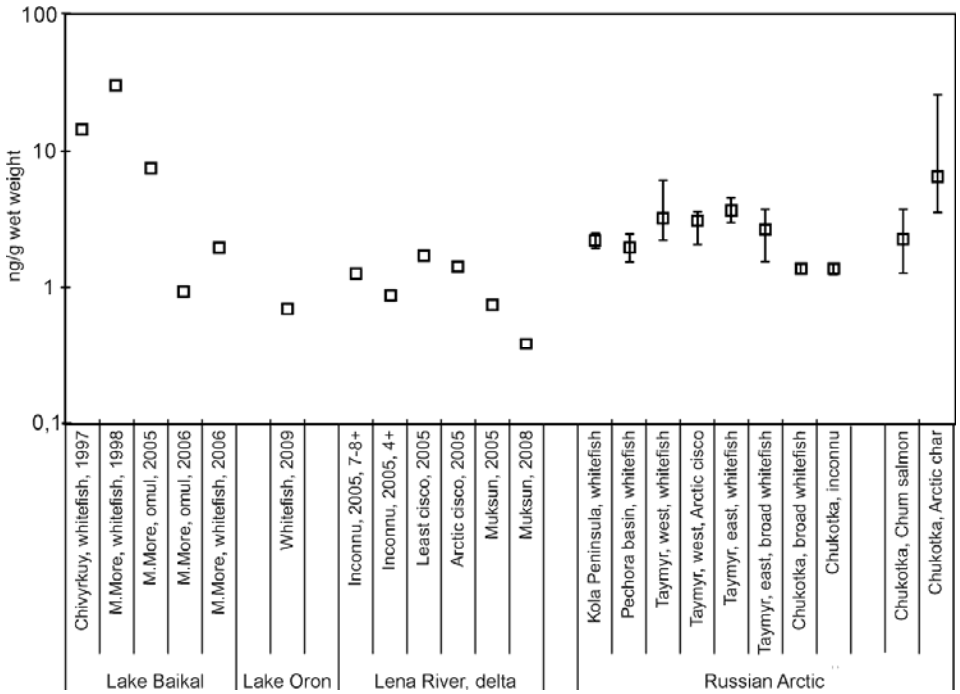

Figure 2. The comparison of indicator PCBs in fish from Lake Baikal, the Lena River delta, and Lake Oron and Russian Arctic[11] (ng/g wet weight).

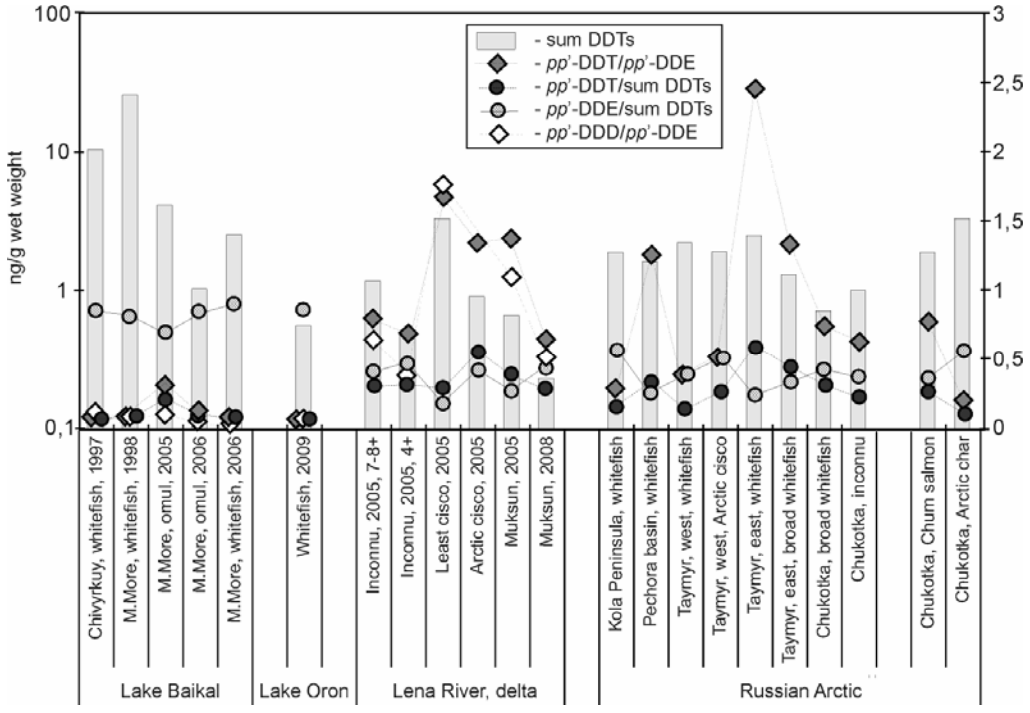

Figure 3. The comparison of DDT and its metabolite in fish from Lake Baikal, the Lena River delta, and Lake Oron and Russian Arctic[11] (ng/g wet weight).

The ratio of the mean concentrations of the different organochlorines was indicator PCBs : DDTs : TNCL : HCHs = 1 : 1.37 : 0.29 : 0.04 in Lake Baikal fish, 1 : 2.03 : 0.30 : 0.19 in Lena River fish and 1 : 1.27 : 0.20 : 0.16 in Lake Oron fish. It should be noted that the DDT:PCB ratio was 0.63 in fish sampled from the water bodies of the Irkutsk Region [11].

Acknowledgments

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