Ecological-Hygienic Evaluation of the Accumulation and Distribution of Lead Compounds in the Organs and Tissues of Yakutia Freshwater Fish

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ABSTRACT

We studied the content and distribution of lead compounds in the Republic freshwater fish in the Rivers Amga (Amginskiy District), Vilyui and lakes of Vilyuisk population, Chroma riv. lower reaches, the Indigirka riv. (Allaikhovsky District) and Kolyma (Srednekolymsky District) in 1996-2011. Studies indicated insignificant level of lead in the tissues and organs as herbivorous and carnivorous fish. Exceeding was detected in some of fish where industrial mining was taking place.

Keywords: environment, the human body, lead, food chain, toxicant.

The concentrations of heavy metals are rising continuously in the environment, they accumulate in different trophic levels of aquatic ecosystems through the food chain and body surface penetrate into the body of fish. To widespread and highly cumulative elements for fish lead and its compounds relate [5, 13, 15, 18, 21]. In recent years, as a result of human impact is a significant inflow into reservoirs of toxic substances, including lead. [11] Lead is a typical toxicant of aquatic ecosystems [16]. The lead content in the earth's crust is small (10 at.%), in the adult human body, it is 120 mg. Lead is a concomitant toxic element [6].

Total reserves of lead in the world, estimated at 100 million tonnes, mainly presented in the form of sulfates. In the environment annually from suburban sources comes from volcanic emissions, soil and silicate meteorite dust, sea salt aerosols, etc. up to 230 tons. Global allocation lead from natural sources is shown in Table. 1.

Currently, most of the territory of Russia is experiencing stress from loss of lead, exceeding critical for normal functioning of ecosystems [20]. The average level of lead pollution of natural water bodies is 138 million tons / year [10].

Lead is ingested with food. Among the foods most often exposed to lead contamination - fish (throughout life they are for your breath "filtered" a huge amount of water passing from capturing her various substances).

The main objects of our study were fish ponds of Yakutia, living under conditions of anthropogenic pollution. For all fish held full general biological analysis (morphometry, size-age composition, abundance estimates, etc.), in addition evaluated anomalies by post-mortem analysis, conducted biochemical analysis of fish (blood and determining the concentration of heavy metals (HM) in the organs and fish tissues).

Lead emissions to the atmosphere have increased dramatically in the past century, reaching 1970 4265h103 t [24]. Anthropogenic lead intake is much higher than natural. The combustion of oil and gasoline in the environment comes at least 50% of the total anthropogenic emissions of lead, which is a major component in the global cycle of this element [8, 23].

Moreover, automobile exhausts give about 50% of the total inorganic lead entering the human body, which is a consequence of its high proportion (75%) of these emissions. Another important source of anthropogenic lead is smelting nonferrous and ferrous metals, while the main natural source of his income is wind dust [1, 2, 3].

Significant source of lead in the environment is the mining industry. In some cases, the content of lead in solid wastes mines can be up to 20 thousand mg / kg. Despite the fact that this is one of the most important sources of lead on the earth's surface, marine and freshwater systems is of great importance atmospheric flow [22].

In river waters, lead concentrations ranged from a few tenths to a few micrograms per 1 dm3. [4] Getting into the aquatic environment, lead migrates predominantly composed of sediment, especially during the period of maximum turbidity. In the waters of all the facilities throughout the year it is almost 100% connected in complex compounds.

The predominance of suspended its forms over dissolved, due to the high affinity to the natural metal adsorbents. At the same time, high capacity lead-marked form strong complex compounds with organic substances. Inorganic salts of lead, except for its nitrates and acetates, are poorly soluble in water [12, 16]. NI Katalevsky et al [9] noted in his paper that the lead content in water increases from spring to autumn.

Manifestation of the toxic effect of lead compounds was observed in aquatic organisms at doses of 0.1 - 0.4 mg / kg. Lead chloride at a concentration of 0.01 mg / kg in water causes death daphnia a day, while the lead nitrate has the same effect at a much higher concentration - 5 mg / l.

Are the most toxic organic compounds - tetraethyl lead and tetramethyl lead. Some fish species (rainbow trout, lamprey, three-spined stickleback) can serve as a convenient indicator of lead-contaminated aquatic environment as avoidance behavior manifested in these species even at minimal concentrations of this pollutant.

Eggs and tadpoles tested amphibian species are also highly sensitive to the toxic effects of lead compounds, and adults of the same species react biochemical changes (increase of ekskreatsii aminolevulinic acid) for lead content in the diet at doses above 10 mg / kg [12, 16].

Content and distribution of lead compounds in freshwater fish has been studied in pp republic. Mayya Amginskogo area vilui population, lower chrome, Indigirka (Allaykhovskiy) and Kolyma (Srednekolymskiy) in 1996 - 2011.

These studies, monitoring of water bodies of the Far North are absolutely necessary, as the lead on the food chain can be ingested.

The results obtained showed a slight level of lead content in the organs and tissues, such as herbivorous and carnivorous fish. Only in certain organs of certain species of fish lead levels exceeding MRLs.

As can be seen from the data (Table 2-6), lead found in all organs and tissues of freshwater fish Yakutia.

In the organs and tissues of fish caught from the river Vilyuy lead content greater than in the organs and tissues of fish caught from the river Indigirka Allaykhovskiy district and the Kolyma River Srednekolymsky district. Chrome on the river lead content in the organs and tissues of fish were more than Vilyuy river. On the river Mayya lead content in the organs and tissues of fish was less than all, due to the fact that there are not conducted industrial mining and natural water were unaffected by anthropogenic factors (Table 2).

Do carp caught from lakes Dengkyuda Nyurbinsky district and Ebe Vilyui area - small and large individuals - lead content does not exceed the maximum permissible levels for freshwater fish (MRL of 1.0 mg / kg). At the same time lead accumulates in the organs and tissues of the carp population in the following order: liver> bone> muscle> gill> intestine.

Published data on the accumulation and distribution of lead in the organs and tissues of freshwater fish are rather contradictory. For example, according K.H.Zhukusova et al [7], lead accumulates in amounts of 1.5 - 2 times higher than the MRLs in the gills, and research Wojciech J. (1989) (cited by [17].) more likely, it accumulates in the liver freshwater fish. By physiological and histological of the liver can be successfully and relatively accurately judge the state of the external conditions of the environment of a particular individual. [14] This is accompanied by various kinds of pathological changes. These include parenchymal degenerative changes - diffuse vacuolation, circulatory disorders and necrosis [19].

The examined fish Amginskogo district (b. Mayya) MAC exceedances of lead were found (Table 2).

The lead content in the liver of large individuals perch (Table 3) from 5 + to 7 + years, caught in the river Vilyuy, exceeded MRLs for fish products and was 1.305 mg / kg, and in the winter studies in the same population of perch content lead was 1.192 mg / kg.

Young specimens of pike river chromium (Table 4) lead content in the liver (in the summer) is approaching the maximum allowable level and is equal to 0.97 mg / kg, while in the adult muscle in the summer was 1.28 mg / kg, in the winter - 1.16 mg / kg, liver summer - 1.54 mg / kg, in the winter - 1.66 mg / kg, which was in excess of MRL pike muscles from 1.2 to 1.3, in liver - 1.5 - 1.7 times. Exceeding the MRL also manifested in the gills in adults in the summer up to 1 times and bone formations from 1.3 to 2.0 times, the young - to 1.1-fold (Table 4).

In the river Indigirka (Table 5) in adult perch in the liver exceeding MRLs of 1.29 mg / kg, which is more than 1.3 times the MRL values.

Perch of the Kolyma River, there was a slight excess of lead in the liver MRLs large individuals in the summer study, which was 1.21 mg / kg, from the river Indigirka it was 1.29 mg / kg (Table 5, 6).

In roach from the River Vilyuy large individuals aged 6 + to 8 + years in the liver of lead slightly exceed the maximum permitted levels of 1.11 mg / kg (Table 3).

Do chukuchana of Indigirka River (Table 5) in all organs and tissues of the lead content within the maximum permissible levels. Distribution of organs and tissues have been similar, as in other species.

It should be noted that the lead is one of the priority pollutants. At present time, a huge amount of information about the toxic effects of lead on the human body, the behavior of this element in natural environments.

Risk to human health, especially children, is compounded by the high toxicity of lead and its ability to accumulate in the human body.

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Table 1

Release of lead from natural sources (tons per year) [11]

natural source	range units	average value
Windblown soil particles	0,30 - 7,5	3,9
Sea salt spray	0,02 – 2,8	1,4
Volcanoes	0,54 – 6,0	3,3
Forest fires	0,06 – 3,8	1,9
Biogenic particles continental	0,02 – 2,5	1,3
Biogenic volatiles continental	0,01 – 0,38	0,2
Marine biogenic sources	0,02 – 0,45	0,24
Total emission	0,90 - 23	12,0

Table 2

Accumulation and distribution of lead in organs and tissues

of freshwater fish in Amga R. basin

research period	fish age	muscles	liver	intestines	gills	bones
Luce (*Esox lucius*)						
summer	до 2+	0,047±0,033	0,041±0,029	0,040±0,028	0,149±0,105	0,023±0,016
	от 4+ до 6+	0,130±0,092	0,109±0,077	0,062±0,044	0,250±0,177	0,047±0,133
winter	до 2+	0,032±0,023	0,035±0,025	0,027±0,019	0,118±0,083	0,018±0,013
	от 4+ до 6+	0,078±0,055	0,084±0,059	0,043±0,030	0,189±0,134	0,031±0,022
Roach (*Rutilus rutilus*)						
summer	до 2+	0,154±0,109	0,297±0,210	0,094±0,066	0,038±0,027	0,074±0,052
	от 4+ до 6+	0,280±0,198	0,376±0,266	0,197±0,139	0,075±0,053	0,200±0,141
Perch (*Perca fluvialitus*)						
summer	до 2+	0,057±0,040	0,069±0,049	0,042±0,030	0,146±0,103	0,318±0,225
	от 4+ до 6+	0,103±0,073	0,126±0,089	0,087±0,061	0,250±0,177	0,470±0,332
winter	до 2+	0,061±0,043	0,057±0,040	0,036±0,025	0,128±0,090	0,237±0,167
	от 4+ до 6+	0,099±0,070	0,102±0,072	0,074±0,052	0,265±0,181	0,401±0,283

Table 3

Accumulation and distribution of lead in organs and tissues

of freshwater fish in Vilyui R. basin

research period	fish age	muscles	liver	intestines	gills	bones
Luce (*Esox lucius*)						
summer	до 2+	0,510±0,360	0,589±0,416	0,098±0,069	0,285±0,201	0,311±0,220
	от 4+ до 6+	0,940±0,664	1,014±0,717	0,220±0,155	0,490±0,346	0,397±0,281
winter	до 2+	0,726±0,513	0,413±0,292	0,081±0,057	0,402±0,284	0,289±0,204
	от 4+ до 6+	1,127±0,796	0,978±0,691	0,512±0,362	0,970±0,685	0,421±0,297
Roach (*Rutilus rutilus*)						
summer	до 2+	0,703±0,497	0,583±0,412	0,164±0,116	0,288±0,203	0,161±0,114
	от 4+ до 6+	0,714±0,505	1,106±0,782	0,677±0,478	0,344±0,243	0,298±0,211
winter	до 2+	0,544±0,384	0,422±0,298	0,171±0,121	0,253±0,179	0,099±0,070
	от 4+ до 6+	0,876±0,619	0,711±0,502	0,277±0,196	0,411±0,290	0,160±0,113
Perch (*Persa fluviatilis*)						
summer	до 2+	0,785±0,555	0,577±0,408	0,358±0,253	0,531±0,375	0,470±0,332
	от 4+ до 6+	1,536±1,085	1,305±0,922	0,794±0,561	1,026±0,725	0,428±0,302
winter	до 2+	0,934±0,205	0,455±0,321	0,329±0,232	0,613±0,433	0,357±0,252
	от 4+ до 6+	1,859±1,314	1,192±0,842	0,613±0,433	0,815±0,576	0,401±0,283

Table 4

Accumulation and distribution of lead in tissues and organs of pike

and broad whitefish Chroma R. basin

research period	fish age	muscles	liver	intestines	gills	bones
Luce (*Esox lucius*)						
summer	до 2+	0,72±0,51	0,97±0,68	0,55±0,39	0,59±0,42	1,16±0,82
	от 4+ до 6+	1,28±0,90	1,54±1,09	0,97±0,68	1,03±0,73	1,97±1,39
winter	до 2+	0,57±0,40	0,88±0,62	0,43±0,30	0,87±0,61	0,98±0,69
	от 4+ до 6+	1,16±0,82	1,66±1,17	0,82±0,58	0,94±0,66	1,32±0,93
Chir (*Coregonus nasus*)						
summer	до 2+	0,54±0,38	0,82±0,58	0,46±0,32	0,59±0,42	0,93±0,66
	от 6+ до 8+	0,91±0,64	1,58±1,12	0,51±0,36	0,71±0,50	1,36±0,96
winter	до 2+	0,44±0,31	0,63±0,44	0,28±0,20	0,51±0,36	0,68±0,48
	от 6+ до 8+	0,78±0,55	1,37±0,97	0,46±0,32	0,70±0,49	1,27±0,90

Table 5

Accumulation and distribution of lead in organs and tissues of freshwater fish in Indigirka R. basin

research period	fish age	muscles	liver	intestines	gills	bones
Luce (*Esox lucius*)						
summer	до 2+	0,27±0,19	0,41±0,29	0,12±0,08	0,28±0,20	0,31±0,22
	от 4+ до 6+	0,74±0,52	0,91±0,64	0,62±0,44	0,52±0,37	0,69±0,49
winter	до 2+	0,29±0,20	0,36±0,25	0,15±0,11	0,34±0,24	0,49±0,35
	от 4+ до 6+	0,41±0,29	0,60±0,42	0,32±0,23	0,28±0,20	0,52±0,37
Dace (*Leuciscus leuciscus*)						
summer	до 2+	0,38±0,27	0,57±0,40	0,44±0,31	0,51±0,36	0,38±0,27
	от 4+ до 6+	0,67±0,47	0,81±0,57	0,63±0,44	0,59±0,42	0,67±0,47
winter	до 2+	0,45±0,32	0,48±0,34	0,47±0,33	0,55±0,39	0,49±0,35
	от 4+ до 6+	0,41±0,29	0,62±0,44	0,45±0,32	0,69±0,49	0,52±0,37
Perch (*Persa fliviatilis*)						
summer	до 2+	0,51±0,36	0,81±0,57	0,42±0,30	0,49±0,35	0,72±0,51
	от 4+ до 6+	0,77±0,54	1,29±0,91	0,59±0,42	0,63±0,44	0,81±0,57
winter	до 2+	0,46±0,32	0,76±0,54	0,38±0,27	0,50±0,35	0,52±0,37
	от 4+ до 6+	0,74±0,52	0,87±0,61	0,51±0,36	0,67±0,47	0,77±0,54

Table 6

Accumulation and distribution of lead in organs and tissues of freshwater fish in Kolyma R. basin

research period	fish age	muscles	liver	intestines	gills	bones
Dace (*Leuciscus leuciscus*)						
summer	до 2+	0,31±0,22	0,41±0,29	0,14±0,10	0,29±0,20	0,31±0,22
	от 4+ до 6+	0,79±0,56	0,92±0,65	0,57±0,40	0,51±0,36	0,84±0,59
winter	до 2+	0,35±0,25	0,37±0,25	0,17±0,12	0,38±0,27	0,45±0,32
	от 4+ до 6+	0,38±0,29	0,58±0,41	0,29±0,20	0,31±0,22	0,51±0,36
Chukuchan (*Catostomus catostomus*)						
summer	до 3+	0,45±0,32	0,73±0,52	0,29±0,20	0,39±0,28	0,65±0,46
	от 6+ до 8+	0,61±0,43	0,84±0,59	0,41±0,29	0,45±0,32	0,91±0,64
winter	до 3+	0,41±0,29	0,57±0,40	0,25±0,18	0,41±0,29	0,67±0,47
	от 6+ до 8+	0,58±0,41	0,73±0,52	0,59±0,42	0,64±0,45	0,98±0,69
Perch (*Perca fluviatilis*)						
summer	до 2+	0,51±0,36	0,83±0,59	0,41±0,29	0,48±0,34	0,71±0,50
	от 4+ до 6+	0,69±0,49	1,21±0,85	0,58±0,41	0,58±0,41	0,88±0,62
winter	до 2+	0,42±0,30	0,72±0,40	0,38±0,27	0,51±0,36	0,48±0,34
	от 4+ до 6+	0,66±0,47	0,98±0,69	0,43±0,30	0,66±0,47	0,81±0,57