УДК 502.51:504.5:546.3

ОЦЕНКА КОНЦЕНТРАЦИИ ТЯЖЕЛЫХ МЕТАЛЛОВ FE, ZN, CD И PB В ПРИРОДНЫХ ВОДОИСТОЧНИКАХ

Х. Э. ФЛЕФЕЛЬ, аспирант,
М. О. ГУТОВА, аспирант,
И. М. ДОННИК, доктор биологических наук, профессор, академик Российской академии наук,
Уральский государственный аграрный университет
(620075, г. Екатеринбург, ул. К. Либкнехта, д. 42),
Ю. Г. ГРИБОВСКИЙ, доктор ветеринарных наук, ведущий научный сотрудник,
Уральский федеральный аграрный научно-исследовательский центр
Уральского отделения Российской академии наук
(454036, г. Челябинск, ул. Свердловский тракт, д. 18а)

Ключевые слова: *тяжелые металлы, физико-химические показатели, природные источники воды, загрязнение воды.*

Цель настоящего исследования – оценить загрязнение поверхностных пресноводных водоемов в Екатеринбурге и Свердловской области тяжелыми металлами: Fe, Zn, Cd и Pb. В статье приведены результаты исследований концентрации тяжелых металлов Cd, Fe, Zn и Pb в природных водоисточниках Свердловской области. Было определено содержание металлов (железо, кадмий, свинец, цинк) в точках отбора проб, концентрация которых в некоторых случаях превышала предельно допустимую концентрацию. Наряду с этим во время исследований было установлено заметное снижение содержания ряда тяжелых металлов. Также был проведен анализ ряда физико-химических показателей: pH, минерализация, общая жесткость. все значения pH были в щелочном направлении и имели заметные различия между различными участками, при этом самое низкое значение (6,8) зафиксировано у реки Исеть, а самое высокое (8,00 и 7,99) у реки Уфа и реки Тура соответственно. Общее количество растворенных твердых веществ в отобранной воде составляло от 161 до 839 мг / см3. Наибольшая минерализация отмечена в р. Позаришке и может быть связана как с природным типом воды, так и с попаданием органических веществ и твердых отходов в реку. Концентрация свинца в воде поверхностных водоемов характеризуется содержанием от десятых до нескольких микрограммов на литр. Концентрации свинца в природных водах, превышающие фоновые значения, обусловлены антропогенной нагрузкой. Значительный вклад в загрязнение объектов окружающей среды соединениями свинца.

ASSESSMENT OF HEAVY METALS CONCENTRATION FE, ZN, CD, AND PB IN NATURAL WATER SOURCES

Kh. E. FLEFEL, postgraduate student,
M. O. GUTOVA, postgraduate student,
I. M. DONNIK, doctor of biological sciences, professor, academician of the Russian Academy of Sciences,
Ural State Agrarian University
(42 K. Liebknekhta Str., 620075, Ekaterinburg),
Yu. G. GRIBOVSKIY, doctor of veterinary sciences, leading researcher,
Ural Federal Agricultural Research Center of the Ural branch of the Russian Academy of Sciences
(18a Sverdlovskiy Trakt, 454036, Chelyabinsk)

Keywords*: heavy metals, physico-chemical indicators, natural water sources, water pollution.*

The present study aimed to assess the pollution of surface freshwater flowing bodies of water in Yekaterinburg and the Sverdlovsk region with heavy metals: Fe, Zn, Cd, and Pb. In the article result of research, the concentration of heavy metals Cd, Fe, Zn and Pb in natural water sources of Sverdlovsk area are presented. The contents of metals (iron, cadmium, lead, zinc) in sampling points were determined, the concentration of which in some cases exceeded maximum allowable concentration. Along with that, an appreciable decrease of the contents of a series of heavy metals during research was installed. As well analysis of a series of physical and chemical ratings was carried out: pH, mineralization, common rigidity. all pH values were in the alkaline direction and had noticeable differences between the various sites with the lowest value (6.8) recorded by the Iset River and the highest (8.00 and 7.99) by the Ufa River and the Tura River, respectively. Total of dissolved solids substances in selected water accounted for from 161 to 839 mg / cm^3. The highest mineralization is noted in R. Pozarishke and can be connected both with a natural type of water and with a hit of organic substances and firm wastes to the river. The concentration of lead in the water of surface water bodies is characterized by a content of from tenths to a few micrograms per liter. The concentrations of lead in natural waters elevated above background values are due to anthropogenic load. A significant contribution to the pollution of environmental objects with lead compounds

Introduction

Water pollution is determined by the ingress into the aquatic environment directly or indirectly of substances or energy that have a harmful effect on the state of surface water sources and pose a threat to human health and fisheries. Anthropogenic impact leads to an increase in the content of harmful substances in fresh or sea water, sediments and organisms above the natural background level for this area and for these organisms. Among the pollutants, a special place is occupied by heavy metal salts (TM), the level of which is constantly increasing in all water bodies.

TM are common environmental pollutants. Some of them are necessary for certain physiological processes, and some of the metals of the environment cause a number of diseases, such as cancer, cardiovascular diseases, and neurological disorders. Term "heavy metals", which characterizes a wide group of the pollutants, recently was expanded considerably. In various scientific and applied works authors interpret variously this concept. In connection with that, the amount of elements related to TM group changes over a wide range. It is known that Zn, Cu, Fe, Mo they are the most important essential metals forming a part of a big number of enzymes catalyzing many redox biochemical reactions, including the antioxidant system. The physiological role of zinc is connected with more than 300 squirrels, including enzymes and hormones playing the most important role in meal, development, and growth of organisms. On importance for living organisms, Zn stands on the second place after Fe [1]. The most important anthropogenous sources of metals in water ecosystem, definitely, are sewage which is dropped by crude or with different degree of cleanliness, therefore they can cause many changes in chemical composition surface natural reservoirs. TM flows pass biogeochemical process with a different time of holding in different parts of the atmosphere. Their toxicity depends on the concentration, and the allowable range of concentration varies from metal to metal. Concentrations in which heavy metals may be present depending on the source of contamination and the characteristics of the system in which they are found, so they can vary from traces to very high concentrations.

Water and air can receive a large number of pollutants but have the ability to self-clean. Some pollutants, including TM, cause the water quality to change to such a level that it becomes useless for many purposes [2]. This TM includes cadmium (Cd), iron (Fe) and lead (Pb). Heavy metals the natural components of the crust of the earth. They cannot be degraded or destroyed. In a small degree, they fall to our bodies with food, drinkable water, and air. As microcells, several heavy metals are needed to maintain the metabolism of a human organ, for example, zinc, etc. However, during higher concentrations, they can lead to poisoning [3]. Heavy metals in ecosystem appear in different chemical forms and in different oxidative conditions, so their toxicity depending on the chemical form in which they are found. put, knowledge of the total concentration of metals in a polluted ecosystem is often insufficient for correct information about their harmful effects. Toxicity, biodegradability, bioavailability, mobility, solubility, as well as a number of other important characteristics, in particular, depend on the specific physico-chemical form in which the metal is found. Most heavy metal toxicity studies show that a free hydrated metal ion is the most toxic form [2]. One of the most important environmental hygiene problems facing the world today is environmental pollution with inorganic, organic and organometallic materials. Interest is growing in monitoring heavy metals in bioorganic [4]. heavy metals are common toxic in food and water drinking and environmental elements that have a long half-life after absorption. In humans, animals and aquatic animals, they can cause many diseases, such as damage to internal organs. Cadmium accumulation in the human body and especially in the kidneys, which can cause dysfunction with disturbance re-absorption of certain molecules, such as proteins and amino acids [5]. Exposure to lead can cause many adverse health effects, including hypertension, gastrointestinal effects, anemia, nephropathy, reduced growth, dysfunction of the immune and nervous systems, some behavioral/cognitive impairment, hearing loss, and reproductive function [6]. Cadmium and lead are toxic metals, harmful at low concentrations and not biodegradable [7].

The purpose of this work is to assess the pollution of surface freshwater flowing bodies of water in Yekaterinburg and the Sverdlovsk region with heavy metals: Fe, Zn, Cd, and Pb.

Purpose and methodology of research

Water samples for analysis were taken at 9 points – surface flowing water bodies of the Sverdlovsk region. Water samples were collected in the summer, from surface natural water sources from a depth of 50 cm into polyethylene vials, acidified with nitric acid and stored until the beginning of the analysis. The study of water for the content of Fe, Pb, Cd, Zn was carried out after preliminary filtration according to PND F 14.1: 2: 4.139-98 (2010).

The analysis was carried out on an AAS-1 flame atomic absorption spectrophotometer (Carl Zeiss, Germany). As the calibration solutions used a mixture of GSO individual ions. To construct the calibration curves, we used a nonlinear dependence of the spectrophotometer readings on the percent absorption scaleY on the concentration of the element C of the form: $Y = (100 + AC)/(1 + bC)$.

Physical and chemical indicators of water were determined according to the following methods: water pH value – according to RD 52.24.495-2005, hardness – ac-

Table 1

Concentration of heavy metals in the water of a number of rivers and lakes of the Sverdlovsk region in 2017, mg/dm³ ± relative error with a probability P = 0.95

An object	*Fe*	*Cd*	*Pb*	*Zn*
R. Pozarishka	*0,029 ± 0,009*	*0,0063 ± 0,0019*	*0,106 ± 0,027*	*0,057 ± 0,016*
R. Brusyanka	*0,045 ± 0,014*	*0,0047 ± 0,0014*	*0,083 ± 0,021*	*0,187 ± 0,037*
R. Eset	*0,097 ± 0,029*	*0,0031 ± 0,0009*	*0,062 ± 0,016*	*0,063 ± 0,018*
R. Baltim	*0,064 ± 0,019*	*0,0047 ± 0,0014*	*0,083 ± 0,021*	*0,084 ± 0,024*
L. Baltim	*0,074 ± 0,022*	*0,0015 ± 0,0005*	*0,062 ± 0,016*	*0,063 ± 0,018*
R. Pishma	*0,029 ± 0,009*	*0,0015 ± 0,0005*	*0,083 ± 0,021*	*0,084 ± 0,024*
R. Manchage	*0,045 ± 0,014*	*0,0015 ± 0,0005*	*0,106 ± 0,027*	*0,107 ± 0,021*
R. Ufa	*0,037 ± 0,011*	*0,0047 ± 0,0014*	*0,133 ± 0,033*	*0,106 ± 0,021*
R. Tora	*1,910 ± 0,290*	*0,0015 ± 0,0005*	*0,083 ± 0,021*	*0,084 ± 0,024*
Mean [95 % CI]	*0,259 [0,042; 0,676]*	*0,0033 [0,0022; 0,0045]*	*0,089 [0,076; 0,104]*	*0,093 [0,072; 0,120]*
MPC	*0,1*	*0,005*	*0,006*	*0,01*

Table 2

Physico-chemical properties in the water of a number of rivers and lakes of the Sverdlovsk region in 2017

An object	*PH*	*Total Stiffness*	*Ion Sum (TDS)*	*Dry Residue*
R. Pozarishka	*7,13 ± 0,10*	*8,99 ± 0,90*	*839*	*509*
R. Brusyanka	*7,28 ± 0,10*	*3,86 ± 0,39*	*357*	*227*
R. Eset	*6,80 ± 0,10*	*3,24 ± 0,32*	*279*	*138*
R. Baltim	*7,09 ± 0,10*	*3,27 ± 0,33*	*284*	*148*
L. Baltim	*7,05 ± 0,10*	*1,98 ± 0,20*	*161*	*108*
R. Pishma	*7,66 ± 0,10*	*3,87 ± 0,39*	*337*	*272*
R. Manchage	*7,18 ± 0,10*	*6,03 ± 0,60*	*535*	*335*
R. Ufa	*8,00 ± 0,10*	*3,53 ± 0,35*	*292*	*192*
R. Tora	*7,99 ± 0,10*	*2,41 ± 0,24*	*191*	*115*
Mean	*7,35*	*4,13*	*363,88*	*227,11*

cording to GOST 31865-2012, GOST 31869-2012, mineralization (sum of ions) – according to GOST 18164-72, GOST 27065-86 During statistical processing of the obtained data, an average value was calculated with a 95 % confidence interval (95 % CI) obtained by the non-parametric bootstrap procedure (percentile method, n = 99999).

Research results

Hydrogen rating pH. Measurement pH and alkalines are important and are frequently defined by tests for analysis of quality of water. A PH of water is important because he influences solubility and availability of nutrients, as well as on how they can be used by water organisms [8]. According to the present studies, all pH values were in the alkaline direction and had noticeable differences between the various sites with the lowest value (6.8) recorded by the Iset River and the highest (8.00 and 7.99) by the Ufa River and the Tura River, respectively (Table 2, Fig. 1). The high pH of the water in the river indicates an alkaline environment, the pH level increases as a result of increased pollution. In most studies conducted on water bodies, the pH value is usually indicated in the range from 6 to 9. The pH range, which is not lethal for fish, is from 5 to 9 [9].

Solids include suspended and dissolved substances. They are very useful parameters that describe the chemical components of water and can be considered as edaphic relationships that contribute to the increase of pollutants in a water body [10]. Total of dissolved solids substances in selected water accounted for from 161 to 839 mg/cm³. The highest mineralization is noted in R. Pozarishke and can be connected both with a natural type of water and with a hit of organic substances and firm wastes to the river [10].

The total hardness of water is not a specific component but is a variable and complex mixture of cations and anions. Basically, the hardness of water is changed by ions, such as calcium and magnesium. The total hardness of water samples had different values (from smaller to larger), so, in the lake. Baltim 1.98 and 8.99 mg / l in the Pozarishka river. The highest total hardness in water was recorded in the Pozarishka River – 8.99 mg / l, due to the presence of high calcium and magnesium in addition to sulfate and nitrate [11].

The results showed that the content of heavy metals (iron, cadmium, lead) in the water of some rivers and lakes of the Sverdlovsk region is higher than the MPC for fresh water (iron in the Tura river was 1.91, and cadmium in the Pozarishka river was 0.0063, which exceeds this indicator at all points from 0.062 to 0.133 mg/cm³). While zinc was below its levels at all points of selection. (Table 1)

The concentration of lead in the water of surface water bodies is characterized by a content of from tenths to a few micrograms per liter. The concentrations of lead in natural waters elevated above background values are due to anthropogenic load. A significant contribution to the pollution of environmental objects with lead compounds, along with the activities of chemical and metallurgical industries, is made by the burning of coal and the use of lead compounds in motor fuels [12].

Summary. Recommendations

From this research, it becomes clear that the concentration of lead and zinc exceeds admissible levels in all points. A concentration of elements of iron and cadmium exceeded admissible percent in one selection point, and other points were less than an admissible percent. Increased concentration of investigated TM in water is caused by the presence of industrial pollution either unhealthy substances in water bodies or the presence of exhaust motor cars gases and use of pesticides in agriculture then discharged in water bodies.

References

1. Bury N. R. Nutritive metal uptake in teleost fish // Journal of Experimental Biology. 2003. Vol. 206. No. 1. Pp. 11–23.

2. Odobasic A. Determination and Speciation of Trace Heavy Metals in Natural Water by DPASV // Water Quality Monitoring and Assessment. 2012. No. 4. Pp. 429–456.

3. Valavanidis A., Vlachogianni T. Metal Pollution in Ecosystems. Ecotoxicology Studies and Risk Assessment in the Marine Environment // Science Advances on Environment, Toxicology and Ecotoxicology Issues [Electronic resource]. URL: chem-tox-ecotox. org/wp/wp-content/uploads/2010/01/02-Metals-17_01_2010. pdf.

4. Al Zabadi H., Sayeh G., Jodeh S. Environmental exposure assessment of cadmium, lead, copper and zinc in different Palestinian canned foods // Agriculture and Food Security. 2018. Vol. 7. No. 1. Pp. 1–7.

5. Godt J. [et al.] The toxicity of cadmium and resulting hazards for human health // Journal of Occupational Medicine and Toxicology. 2006. Vol. 1. No. 1. Pp. 1–6.

6. Ezzati M., Lopez A., Rodgers A., Murray C. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors // World Health Organization. 2004. Pp. 497–596.

7. Osman A., Kloas W., Fisheries I. Water Quality and Heavy Metal Monitoring in Water, Sediments and Tissues of the African Catfish Clarias gariepinus (Burchell, 1822) from the River Nile, Egypt // Journal of Environmental Protection. 2010. No. 1 (04). Pp. 389–400.

8. Srivastava S., Srivastava A. K., Suprasanna P., Souza S. F. D. Comparative biochemical and transcriptional profiling of two contrasting varieties of Brassica juncea L. In response to arsenic exposure reveals mechanisms of stress perception and tolerance // Journal of Experimental Botany. 2009. Vol. 60. No. 12. Pp. 3419–3431.

9. Maurya Q. U. Determination of Physico-Chemical Parameters and Water Quality Index (Wqi) of Chandlodia Lake, Ahmedabad, Gujarat, India // Journal of Environmental and Analytical Toxicology. 2015. Vol. 05. No. 04. Pp. 1–6

10. Moss B. The Influence of Environmental Factors on the Distribution of Freshwater Algae: An Experimental Study: II. The Role of pH and the Carbon Dioxide-Bicarbonate System // J. Ecol. 1973. Vol. 61. No. 1. P. 157.

11. Studies on Physico-chemical analysis of Mohabala Lake near Bhadrawati, District Chandrapur (MS), India // International Journal of Life Sciences. 2017. Vol. 5. No. 3. Pp. 438–446.

12. Nikanorov A. M. Handbook of hydrochemistry. – Leningrad, 1989. – 392 p.