Assessment of Pollution Influence of Bottom Sediments on Quality of Water of the Ili River

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Abstract: The content of heavy metals (Fe, Mn, Cu, Zn, Cu) in water and bottom sediments of the mouth reach of the rivers Ili, Kaskelen, Issyk, Turgen and Chilik was researched. Calculation of influence of pollution of bottom sediments on quality of waterways was done. The main reaches of the rivers with secondary pollution of water were determined. For assessment of pollution influence of bottom sediments some samples of water and bottom sediments from the reaches of the Ili river designated before and its inflows were taken. The rational choice of the analysis methods was done taking into account metrological characteristics (precision indicators, the limits of determined contents, selectivity in relation to auxiliary components etc.), power, available laboratory technology and economic factors.Quantitative determination of different elements in the raw samples and products was realized according to the following methods: 1) chemical methods: gravimetry (sedimentation method); titrimetry; 2) physical-chemical methods: photometry; flame photometry; 3) physical methods: atomic and emission spectrometry; atomic and absorptive spectrometry. Analyzing the condition of the waters being anthropogenic influenced, it is reasonable to rely on geochemical methods of their assessment established for natural water systems. Polluting substances come to open reservoirs with waste industrial waters, from the atmosphere, are washed away from the ground and go to the ground flow. Chemicals with water flows can migrate in the dissolved condition and as a part of suspensions.

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Introduction

Bottom sediments represent complicated multicomponent system which depending on intra-water processes, sorption characteristics of the sediments, landscape features of basins, and also features of the substances coming to the rivers, can be receivers of chemicals (in particular heavy metals) and a source of secondary pollution of the water object [1].

Detection of the main laws of heavy metals migration in the system " basin - water environment - bottom sediments" is rather difficult question requiring doing natural researches, analysis of large volume of materials of observations and assessment of the role of heavy metals migration on trophic chains (sequence). Thus, researches of heavy metals moving in the system «water environment - bottom sediments" and receiving quantitative estimates of intensity of these migration processes is quite topical task. On the basis of these characteristics it is possible to judge about presence and absence of danger of secondary pollution of water objects [1, p. 124]. But on the other hand, it is topical because the problem of determination of landscape features of forming bottom sediments is still not solved.

Today, researches of forming bottom sediments taking into account landscape features are being done intensively thanks to works of many scientists and specialists. Important results in this direction were received in due time by many researchers like Alabishev, VA. Berg, R.S., Glushkov, V.G., Grodzinsky, M.D., Kostrikov S. V. On the basis of spatial generalizations Makkaveyev, N. I. ascertained indissoluble connection of the riverbed with its basin and surrounding landscape in whole [2].

The aim of the research is research of migration of heavy metals in the system "water environment – bottom sediments" and also detection of the main sources of secondary pollution in the rivers Ili, Kaskelen, Issyk, Turgen and Chilik.

Materials and research methods

Researches of heavy metals migration in the system "basin - water environment - bottom sediments" were done for the rivers Ili, Kaskelen, Issyk, Turgen and Chilik.

Samplings of bottom sediments and water were done during the summer period of 2012-2013 in the mouth area of the rivers.

In the samples the priority number of heavy metals – Fe, Mg, Cu, Zn, Ni, Ca were detected.

Preliminary preparation of solid samples according to State Standard 29269 was done which included a number of operations like drying, crushing, mixing and reduction [3,4]. Analytical work was carried out in the National Scientific Laboratory "Center of Science about the Earth, Metallurgy and Enrichment" JSC. For doing analyses of the samples the atomic-absorptive spectrometer "Hitachi", model 180-50 (Japan), flame photometer PFP7 (Great Britain), optical emission spectrometer with inductive coupled plasma Optima 2000 DV (USA) were used.

Table 1. The Content of Heavy Metals Ions in Bottom Sediments of the Rivers of Ili Basin

Sample №	Sampling place	Date	Water t (°C)	pH	Ions content						Sum of ions
					Ca″	Mg''	Ni "	Zn''	Fe"	Cu ''	
1	Ili river (Aidarly bridge)	19.09.2012			22,6	18,6	63,2	180	63,3	35,5	390,6
2	Ili river (Bakbakty village)	10.10.2013			34,2	17,1	46,2	220	42,7	22,3	382
3		«	16	8,1	40,1	22,2	47,8	268	38,6	25,1	442
4	Ili river (bridge)	22.10.2013	16	7,9	42,2	14,6	48,9	244	35,4	24,5	410
5			17	7,7	38,4	19,5	38,2	220	40,3	253	381,7
6	Ili river (Kuigan village)	22.10.2013	17	7,7	36,1	17,1	38,6	220	31,3	22,3	355
7			17	7,6	36,1	20,6	32,2	20,7	39,4	23,7	359,5
	Average value			7,7	35,9	18,52	45,01	222,7	41,57	25,52	388,6
8	Kaskelen river (Railway bridge)	21.09.2012	16	7,5	36,1	7,3	8,6	146,4	8,61	7,3	214,5
9	Kaskelen river (bridge of Almaty motorway)	21.09.2012	18	7,2	36,1	-	-	97,6	4,1	4,1	142
10	«	22.10.2013		7,4	18,4			109,8	4,1	3,6	201
11	Isyk river (Isyk village)	21.10.2013	16	7,3	47,0	19,8	45,25	231,8	86,4	15,5	445
12		21.10.2013	17	7,3	53,1	16,74	56,0	231,8	80,6	6,9	445
13	Turgen river ()	25.09.2013	18	7,5	36,1	48,65	196	439,2	151,3	103,6	100,6
14		«	18	7,5	44,2	46,2	196	414,8	157,3	100,1	1007
15		«	18	7,6	28,1	51,1	184	414,8	153,3	100,1	955,4
16	Turgen river ()	25.09.2013	17	7,4	28,1	51,1	182,8	414,2	144,3	105,7	950,8
	Average value			7,4	37,44	50,31	184,22	422	140,4	104,4	976,4
17	Chilik river (v.)	29.09	12	7,3	28,1	51,2	1203	982	1434	392	4912
18		2013		7,3	1,21	3,63	45,15	13,91	25,80	9,54	
19		29.09.2013	15	7,3	28,3	94,3	998,4	878	1251	327	3662
Source: Dzhetimov (2013)											

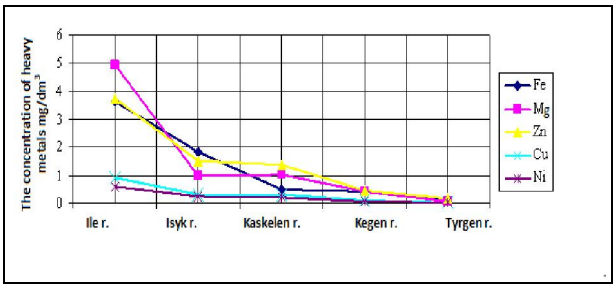

Fig. 1 — Increase In Ions Concentration of Heavy Metals in the Water of Waterways due to their Coming from Bottom Sediments

Results and discussions

First of all, bottom sediments are products of erosion therefore their formation, movement and accumulation results from erosive and accumulative processes. On the basis of literary sources it was ascertained that soils during the summer period are also the main source of coming of heavy metals to the river network. From arable lands in the region 9-12 t/hectare of fertile soil layer are washed annually. From 9,6 million hectares of eroded lands they are heavily washed, which require urgent re-cultivation by grassland foresting. Most of all (up to 70%) the most fertile soils - foothill black earth are damaged among which the part the weakly washed soils increased for the last 10-12 years by 26%, and average and heavily washed by 23% (these are lands which in fact must be taken out of intensive land use). The most eroded (washed out) soils are the rivers which heads are located high in the mountains and the foothills of the rivers Ili, Kaskelen, Issyk, Turgen and Chilik. [5]. Bottom sediments determine essential geochemical features of the rivers as in the conditions of pollution of bottom sediments they

become sources of secondary pollution of waters of the rivers and influence the processes of self-purification of the rivers.

The Research Ecology Institute developed the project "Methods of accounting influence of bottom sediments of the rivers". According to these methods the authors calculated influence of bottom sediments on the quality of waterways taking into account the introduced migration coefficient of heavy metals from bottom sediments into the water. The accounting of assessment of influence of bottom sediments on quality of waterways is necessary for forecasting the processes which can lead to secondary pollution of water objects.

Quantitative assessment of influence of heavy metals on quality of waterways is determined for each metal separately, based on their content in 100 g of bottom sediments.

Ions concentration of heavy metals in the waterway water due to their coming from bottom sediments is calculated according to the following formula:

$$K = \frac{P}{W}, \text{ mg/dm}^3,$$

where P is the value of expected transition of each form of heavy metals into water from bottom sediments, kg;

W – volume of water of waterway or its segment, m^3.

All recalculations of units of measure to the uniform system were made with the recalculation coefficient (Kovalenko M. S.)

The value of expected transition of each form of heavy metals into water from bottom sediments is:

$$P = C \cdot h \cdot d \cdot S \cdot K_м, \text{ kg}$$

where C is the content of each mobile form of ions of heavy metals in 100 g of bottom sediments, mkg / 100g.

h is an active layer of bottom sediments (usually 10 centimeters layer);

d is the volume weight of bottom sediments, kg/dm^3;

S is the square of the researched zone of a waterway, sq. m;

K_m – coefficient of migration of heavy metals.

Migration coefficient was calculated on the basis of theoretical data of phase distribution of heavy metals in water and bottom sediments depending on physical and chemical factors [6]. Interpretation of migration coefficient shows that at reduction of this coefficient transition of heavy metals from bottom sediments into water is more intensive.

The volume of water of a waterway or its segment is calculated according to the following formula:

$$W = Q\frac{L}{U}, \text{ m}^3$$

where, Q is water flow of a waterway, m^3/s;

L is the length of a waterway or its segment, m;

U is average speed of a current, m/s.

Increase in ions concentration of heavy metals in water of waterways due to their coming from bottom sediments is shown in table 1.

Conclusions

The mass of the material of overwhelming size carried by the rivers, is transported at the same time and both in the form of solutions and in the form of mechanically weighed material. These components with irregular forms of migration include: $CaCO^3$, compounds of Fe, Mg, Zn, Cu, Ni, organic substances and a group of chemically settleable solid [7].

Depending on anthropogenic factors and landscape features of the water-collecting area calculation of influence of bottom sediments on quality of waterways taking into account the introduced migration coefficient of heavy metals was done. On the basis of the offered methods the maximum concentration of heavy metals were registered in the rivers Kaskelen and Isyk that indicates misbalance in the system “water - bottom sediments” and presence of sources of secondary pollution of waterways in these segments.

Thus, on the basis of these methods of assessment of influence of pollution of bottom sediments on quality of waterways potentially dangerous segments of the rivers with secondary pollution for Lake Balkhash were ascertained. In particular, determination of pollution of bottom sediments can be used for explanation of the structure of water-protective measures.

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