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Investigations of Bottom Sediment Formation of the Ili River

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Abstract. We have investigated the content of heavy metals (Fe, Mg, Ni, Cu, Zn, Cu) in water and sediments of mouth reaches of the Ili, Kaskelen, Issyk, Turgen and Chilik rivers. The calculation of the sediment contamination affect on the quality of watercourses is also provided. Samples of water and sediments were taken from in advance-designated sites of the Ili River and its inflows for the assessment of the sediment pollution impact. The maximal concentrations of heavy metals were found in the Kaskelen and Issyk rivers.

Key words: bottom sediments, river, heavy metals, migration, secondary pollution,

Introduction

The Ili River begins in the East Tien Shan Mountains by the means of two sources; these are the Tekes River and the Kunges River flowing into the Xinjiang Region (China), and then into Balkhash Lake. The length from the point where the Tekes River and the Kunges River merge is 1001 km. From the source of the Tekes River it is 1439 km. The area of the Ili River Basin is 140 thousand km^2.

First of all, bottom sediments are products of erosion; therefore their formation, movement and accumulation occur as a result of erosive and accumulative processes. On the basis of references it was stated that soil during the summer period is also the main source of the intake of heavy metals in the river network. From arable lands, 9-12 t/hectare of the soil fertile layer is annually taken out in the region. From 9.6 million hectares of eroded lands, this soil fertile layer it is strongly washed away, which requires urgent cultivation by meadows afforestation. Most of all, up to 70% of the most fertile soils are broken, they are foothill humus, among which the part of slightly washed away increased for the last 10-12 years by 26%, and medium and strongly washed away (these are lands which, in fact, should be taken out of intensive land use) by 23%. The most subjected to washout soils of the river are the sources located highly in mountains and the foothills of the Ili, Kaskelen, Issyk, Turgen and Chilik rivers (Dostay 2005). Bottom sediments define the essential geochemical features of the rivers, as in the conditions of pollution of bottom sediments they become the sources of secondary river water pollution, and affect the processes of the river self-cleaning.

In the upper flow, there is a mountain river. The river flows further along the wide hollow bottom with low shores, which are swampy in some places; below it enters into the deep Kapchagai Canyon, where the Kapchagai hydroelectric power plant was built. After the inflow of the last Chilic River inflow, the valley broadened sharply, and the river flowed among the Sary-Ishikotrau and Taukum Sands. The dry river-bed Bakanas comes off 340 kilometres from the mouth of the Ili River; here the ancient Ili River delta starts. 100 kilometres below, there is a modern delta (area of 9000 km^2) with a great number of the rushing arms. The main arms are the Zhideli, Ili (navigable), and Topar rivers. The main inflows are the Kash, Horgos (right), Charyn, Chilic, Talgar, Kaskelen (left) rivers. The supply is glacial-snowy. The average water outflow in the mouth is 329m^3/s. It freezes in December and melts in March. The Kapchagai hydroelectric power plant also works as a water storage, and is used for irrigation.

Bottom sediments represent a difficult multicomponent system, which depends on inside water basin processes, sorption properties of sediments, and landscape features of reservoirs. In addition, properties of the substances coming into the rivers can be stores of chemicals (in particular, of heavy metals), and the source of secondary pollution of the water object (Korneyeva 2010).

Investigations of the transport of heavy metals into the system “water environment - bottom sediments” and receiving quantitative estimations of the intensity of these migratory processes are thought to be a very topical task. On the basis of these characteristics it is possible to judge the existence and absence of the danger of the secondary pollution of water objects (Korneyeva 2010). On the other hand, the urgency is defined by the fact that the problem of determination of landscape features of bottom sediments formation has still not been solved. On the basis of spatial generalizations N. I. Makkaveyev established an indissoluble connection of the bed of the river with its basin, and the surrounding landscape in total (Burlibayev *et al.* 2009).

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

Material and Methods

The investigations of the migration of heavy metals in the system of "reservoir - water environment - bottom sediments" have been executed for the Ili, Kaskelen, Issyk, Turgen and Chilik rivers.

Samplings of bottom sediments and water were carried out during the summer period in 2012-2013 in the mouth reaches of the rivers. The quantity determination of various elements has been performed under the following techniques:

1. Chemical techniques: gravimetric (settlement method); titrimetry;
2. Physicochemical methods: photometry; flame photometry;
3. Physical methods: atomic-emission spectrometry; atomic absorption spectrometry.

In samples, the priority number of heavy metals was determined - Fe, Mn, Cu, Zn and Ni. The preliminary sample preparation of solid samples was carried out according to STATE STANDARD 29269 including a number of operations: drying, crushing, hashing, reduction (Beremzhanov 1989). The analytical work was carried out in the National Scientific Laboratory of JSC "Centre of Sciences about the Earth, Metallurgy and Enrichments". For obtaining the analyses of samples the following devices were used: atomic and absorbing spectrometer "Hitachi", model 180-50 (Japan); - flame photometer PFP7 (Great Britain); - optical emission spectrometer with inductive and connected plasma Optima 2000 DV (USA).

Authors calculated the impact of bottom sediments on the quality of water courses taking into account the entered coefficient of the migration of heavy metals from the bottom sediments into water.

The quantitative assessment of the influence of heavy metals on the quality of water courses is defined per each metal separately, proceeding from their content in 100 g of ground deposits.

The concentration of ions of heavy metals in the water course water due to their coming from bottom sediments is calculated under the following formula. Where P is the probable transition value of each form of heavy metals into water from bottom sediments, kg. W is the volume of the water course water, or its site, m^3.

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

All recalculations of measured units to the united system were executed by the means of the recalculation coefficient (Moon and Bekturova 1992).

The probable transition value of each form of heavy metals into water from bottom sediments is as follows.
C is the content of each of the mobile forms of heavy metal ions in 100 g of bottom sediments, mkg/100 g;
h is the active layer of bottom sediments (usually 10 cm layer);
d is the volume weight of bottom sediments, kg/dm^3;
S is the square of the investigated zone of the water course, m^2;
Km is the coefficient of the migration of heavy metals.

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

The coefficient of migration was received on the basis of theoretical data of heavy metals phase distribution in water and water sediments depending on physical and chemical factors (Shaukharbayeva 2008). The interpretation of the migration coefficient testifies that at the reduction of this coefficient the transition of heavy metals from bottom sediments into water occurs more intensively.

The volume of the water course water or its site is calculated according to the following formula.
Q is the water course water discharge, m^3/s;
L is the water course extent, or its site, m;
U is the medium speed of the stream, m/s.

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

The increase of concentration of heavy metals ions in water course water due to their coming from bottom sediments is presented in Table 1.

Results and Discussion

The highest value of the material transferred by the rivers is transported at the same time both in the form of solutions as well as in the form of mechanically weighed material. Such components with complicated forms of movement include $CaCO_3$, compounds of Fe, Mg, Zn, Cu, Ni, organic substances and the group of chemically settled substances (Dzhetimov and Andasbayev 2012). Levels of metals are shown in Table 1 and Fig.1.

The maximum concentration of heavy metals is fixed for the Kaskelen River and the Issyk River. This testifies the breaking of the balance in the system of "water - bottom sediments" and the existence of sources of the secondary pollution of water courses on these sites.

Thus, on the basis of the provided technique of assessment, the influence of bottom sediment pollution on the quality of water courses, potentially dangerous sites of rivers with the secondary pollution of Lake Balkhash, has been established.

№ samples	Selection place	Date	temperature (˚ C)	pH	Contents of ions						
					Ca″	Mg''	Ni ,,	Fe ''	Zn''	Fe´´´	Cu ''
1	Ili River (Aydarly)	19.09.2012			22.6	18.6	63.2		180.0	63.3	35.5
2	Ili River (Bakbakti village)	10.10.2013			34.2	17.1	46.2		220.0	42.7	22.3
3		«	16	8.1	40.1	22.2	47.8		268.0	38.6	25.1
4	Ili River(bridge)	22.10.2013	16	7.9	42.2	14.6	48.9		244.0	35.4	24.5
5	Ili River(bridge)	22.10.2013	17	7.7	38.4	19.5	38.2		220.0	40.3	253.0
6	Ili River (village)	22.10.2013	17	7.7	36.1	17.1	38.6		220.0	31.3	22.3
7	Ili River (village)	22.10.2013	17	7.6	36.1	20.6	32.2		20.7	39.4	23.7
	Medium value			7.7	35.9	18.5	45.0		222.7	41.6	25.5
8	Kaskelen River on r/w bridge	21.09.2012	16	7.5	36.1	7.3	8.6		146.4	8.6	7.3
9	Kaskelen River (Almaty motorway bridge)	21.09.2012	18		36.1	-	-		97.6	4.1	4.1
10		22.10.2013			18.4				109.8	4.1	3.6
11	Issyk River (Issyk village)	21.10.2013	16		47.0	19.8	45.3		231.8	86.4	15.5
12		21.10.2013	17		53.1	16.7	56.0		231.8	80.6	6.9
13	Turgen River (Yenbek village)	25.09.2013	18		36.1	48.7	196.0	32.0	439.2	151.3	103.6
14		«	18		44.2	46.2	196.0	48.0	414.8	157.3	100.1
15		«	18		28.1	51.1	184.0	24.0	414.8	153.3	100.1
16	Turgen River (Konyr village)	25.09.2013	17		28.1	51.1	182.8	24.0	414.2	144.3	105.7
	Medium value				37.4	50.3	184.2	37.6	422.0	140.4	104.4
17	Chilik River (Topar village)	29.09.2013	12		28.1	51.2	1203.0	25.8	982.0	1434.0	392.0
18		29.09.2013			1.2	3.6	45.2	0.7	13.9	25.8	9.5
19		29.09.2013	15		28.3	94.3	998.4	85.8	878.0	1251.0	327.0

Table 1. The content of heavy metals ions in bottom sediments of the rivers of the Ili Basin.

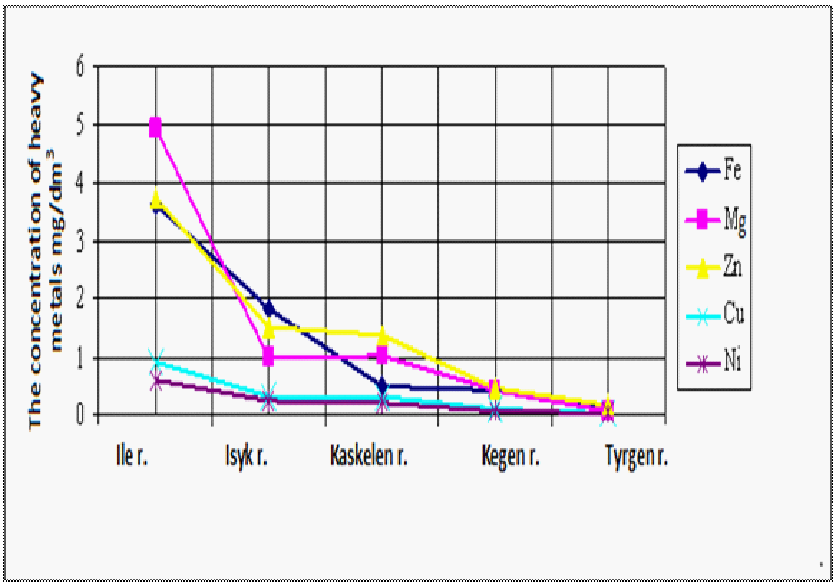

Fig. 1. The concentration of heavy metals (mg/dm^3).

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