THE DYNAMICS OF HYDRO-ECOLOGICAL INDICATORS OF RIVERS IN THE AREA OF PLACEMENT MINING ENTERPRISES OF REGION KMA

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Abstract

The results of the comparative analysis of hydro-chemical status of surface water bodies exposing of mining, on the example of the small rivers of the Belgorod region according to the results of the research carried out in 2007-2014 are presented. It is shown that the production of iron mine (Yakovlevsky mine) is influenced on the hydroecological state of the Vorskla river for over 60 km. Direct impact of the Lebedinsky and Stoylensky mining and processing plants in case of open mining is occurred within 15 km, the drains accompanying residential and industrial infrastructure increasingly influence on the hydroecological situation of the Oskol river. In general hydrochemical situation of rivers exposed by the mining industry in the Belgorod region in recent years is remained stable.

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Keywords

Hydroecological characteristics, pollution of water bodies, hydrochemical situation, the mining industry.

1 Introduction

The leading branch of the economy of the Belgorod region is the mining industry, which is based on iron ore deposits of the Kursk Magnetic Anomaly (KMA). The largest mining companies are JSC „Lebedinsky MPP“ (LMPP, Lebedinsky Mining and Processing Plant), JSC „Stoylensky MPP“ (SMPP, Stoylensky Mining and Processing Plant), Yakovlevsky mine. The development of iron ore deposits connected with complex of drainage works in the quarries and forming large technical bodies of water associated with the concentration of minerals (tailings, sludge collectors) led to the major changes in the natural water balance at the area of 450 km^2, the mixing of waters of different aquifers, common to this area, the change of surface water quality [1] due to the discharge of drainage and sewage. The rivers Vorskla, Oskolets, Chufichka, Oskol are affected by mining enterprises

2 Analysis

The mining complex of the Jakovlevsky deposit with underground method of iron ore mine dumps mine water through the retention pond in the Vorskla river in amount near 4 mill. m3 per year (0.13 m3/s) [2]. Location of the Yakovlevsky mine in the area of its disposition and schematic display of the impact of the mine and related infrastructure of hydroecological situation (drainage water, municipal sector related residential areas) are shown in Fig. 1.

Our research over the period 2007-2012 [3, 4] (Table. 1) shows that the mine water regularly diluted with a high content of nitrates in the river Vorskla, caused by agricultural run-off and its "improving" the quality of water is observed for more than 10-15 km.

The content of elements such as iron, copper, zinc, lead in the Vorskla river and in the drainage water has a complex origin. This is high natural content of copper, zinc and iron in the soils of the Belgorod region, and a large number of human lead intake sources, copper, zinc, iron in addition to mining activities, and the complex processes of the transit of iron compounds and other elements on wetland and further regulated portion of the stream prior to discharging them into the river Vorskla, the genesis is also connected with the dynamic correlation between the processes of deposition and the secondary selection in the aqueous environment, including, depending on the hydrological situation [5].

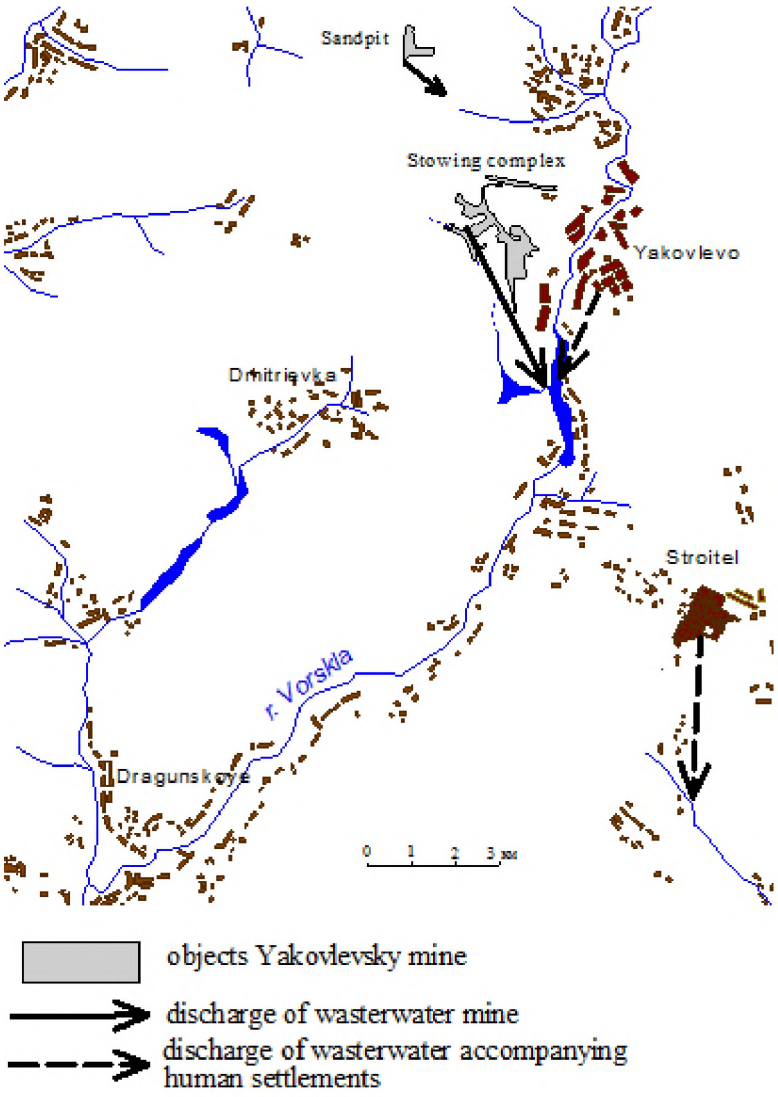

Fig. 1: Location of Yakovlevsky mine in the Vorskla River Basin

River pollution indicators. Vorskla according Roshydromet (Fig. 2) shows a similar picture. Although studies 2009, 2011, 2012, 2014 show a substantial periodic dynamics of the situation, it is obvious that Yakovlevsky Mine (underground mining) has a negative impact on the river. Vorskla on the above complex components (except for nitrates), which can be traced over a distance of up to 68 km after the discharge of effluents. As fluorine [2], sulphates, chlorides (Fig. 2), this influence is noticeable even to the border in alignment with. Kozynka (102 km after a reset).

In general, the situation the hydrochemical situation of the Vorskla river has remained stable over the last 8 years. A comparison of progress charts of the concentrations with the dynamics of river water content confirms the importance of the role of drainage flow in the content of chlorides and sulfates, as well as the conditionality of the nitrate content is largely due to runoff from the catchment area.

Table 1: The content of pollutants in the water of the river. Vorskla in the presence of mine water discharge from the settling pond (mg/l). For each year first collumn Y for s. Yakov-levo (above reset), second column K for Below Krapiv-ninskoe recervoir.

Ingredients	MPC	2007		2011		2012	
		Y	K	Y	K	Y	K
Nitrates	40.0	2.85	1.10	5.118	9.459	2.881	7.172
Nitrites	0.08	0.0514	0.023	0.223	0.219	0.036	0.030
Ammonium	*0.5*	*0.336*	*0.372*	0.390	0.381	0.156	0.183
Mineralization	-	483.35	1317.95	646.82	1103.25	699.67	1056.0
Iron	0.1	0.356	0.427	0.284	0.148	0.393	0.117
Copper	*0.001*	*0.028*	*0.031*	0.0238	0.0132	0.0049	0.0073
Zink	*0.01*	*0.004*	*0.008*	0.0198	0.0250	0.0811	0.0086
Plumbum	0.006	0.0025	0.00525	0.01581	0.00799	0.00433	0.00677
Fluorides	0.05 in addition **(0.729)**	0.679	2.418	-	-	0.123	1.635
Boron	0.5	0.128	0.6255	-	-	-	-
Chlorides	300	55.04	487.63	-	-	-	-

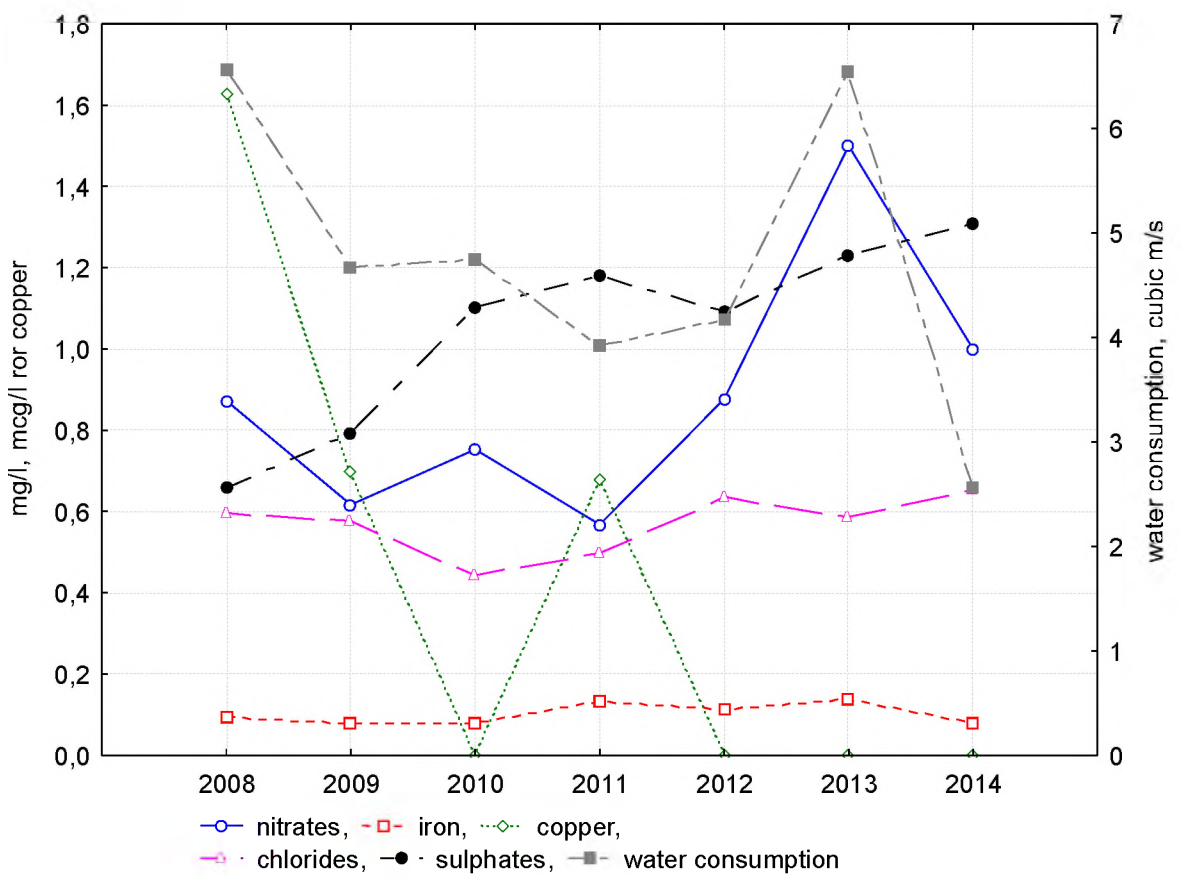

Fig. 2: The content of pollutants in the river Vorskla according RosHydroMet (sulphates and chlorides mg / liter x 10-2).

Location LMPP and SMPP and schematic display of the impact of plants and related infrastructure on hydroecological situation (drainage water, municipal sector related residential areas) are shown in Fig. 3 [6].

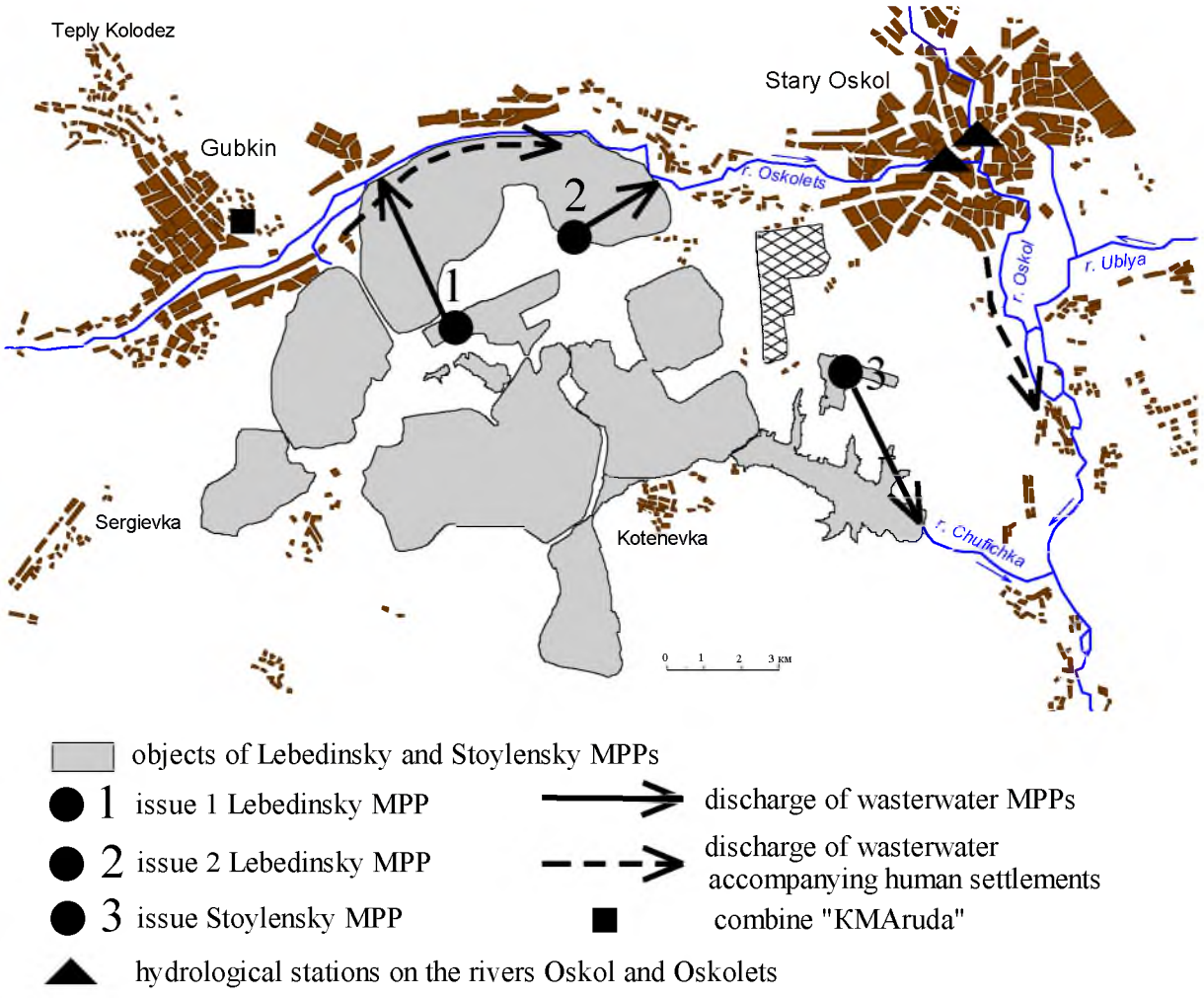

Fig. 3: Location of the Lebedinsky and Stoylensky MPP in Oskol River Basin

JSC „Lebedinsky MPP“ produces iron ore by open way. Enterprise resets industrial waste water and part of the drainage water directly into the river Oskolets. Contribution of LGOK drainage water flow into the river Oskolets (annual average of 1.26 m3/s) is about 0.44 m3/s, or 35%.

Research data of the hydrochemical composition of water (2007) shows that the content of pollutants (except dry residue and sulphate) after hitting LMPP sewage into the river Oskolets is declining (oil products - from 3.4 to 0.6 MPC, iron - from 5 to 3 MPC; manganese - from 3.5 to 2.5 MPC, copper - from 9 am to 3 MPC). Solids and sulfates after the discharge of waste water increased marginally by 1.07 and 1.03 times, respectively. The variation of pollutants is shown in Fig. 4.

Research of the LGOK impact on the river Oskolets conducted in 2014 show that the original runoff comes from the highly urbanized residential-industrial area city of Gubkin. Therefore, background rates of pollutants in the river Oskolets according to environmental services in a number of ingredients observations: sulphates (1.12 MPC), ammonium ion (1.08 MPC), nitrite (10.06 MPC), total iron (3.16 MPC), phosphates (4.09 MPC), BOD5 (1.74 MPC) - exceed fishery maximum permissible concentration (MPC).

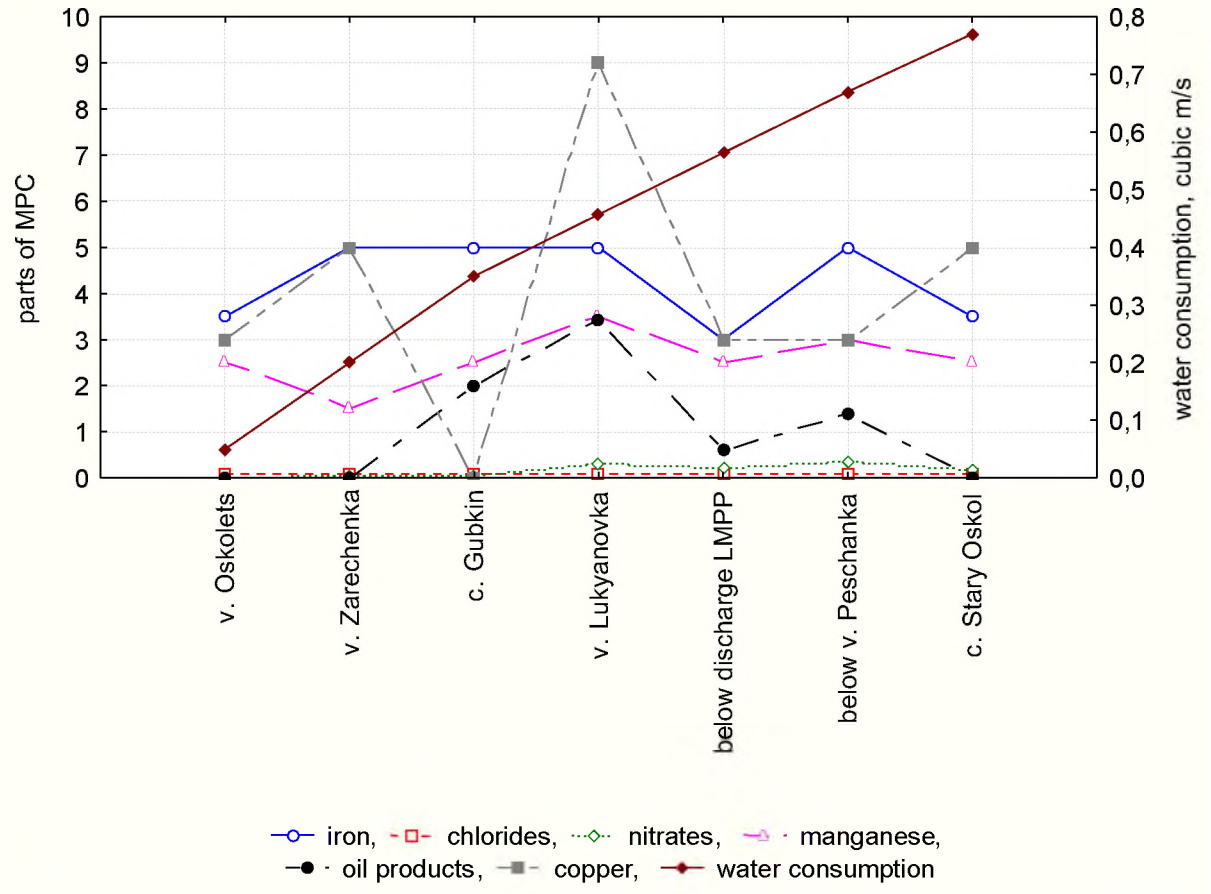

Fig. 4: Dynamics of pollutants along the river Oskolets 2007. [2]

In the first discharge of the LMPP drainage water the exceeding the current fishery MPC sulfates, nitrites, iron general, BOD5 is observed in sewage. Relatively high levels of nitrites, iron, BOD5 are determined by significant background content of these ingredients in the river Oskolets, water of which comes partly to the drainage water of the pit and then get into the drainage water. In the second discharge of drainage water we observed the similar picture: the same as in the previous case, the second discharge significantly impairs the hydrochemical conditions of the river Oskolets only by sulphate and concentrations of other ingredients in comparison with the background part are improved, which is also due to the high natural content of nitrites and BOD5 in the river Oskolets water-which comes partly in the drainage system of the LMPP quarry, looking back through the quarry, actually gets affingpurification.

In general, the overall impact if the mining on hydroecological situation of the river Oskolets is characterized by the following process:

- The contribution of drainage water into the river Oskolets consumption (annual value of 1.26 m^3/s) is about 0.44 m^3/s, or 35 %, which has a positive effect on the value of river runoff;
- In the river Oskolets due to additional dilution nitrite reduces (from 10.06 MPC above the reset of the first issue up to 3.4 MPC below the reset of the second issue) and BOD5 (with 1.74 MPC above the reset of the first issue to 1.49 MPC below reset second Edition), which leads to a slight improvement of the situation according to hydroecological components;
- There is a slight increase in the concentration of sulphate.

The Oskol River is most strongly influenced by the mining of the Starooskolsco-Gubkinsky industrial area, since ultimately all waste waters somehow get it to her. The total length of the river is 472 km, 220 km of which account for the Belgorod region, the average water consumption in Stary Oskol with the supply of 95 % is 3.52 m^3/s. LMPP influenced by discharge of sewage in the river Oskolets which

is a right tributary of the Oskol river. SMPP acts on river Chufichka, which is also a right tributary of the Oskol. Oskolsky Elektrometallurgical Plant discharges waste water directly into the river Oskol in an area of Golofeevka. Water from the tailings of LMPP and SMPP filtered into underground aquifers with subsequent discharge in the river Oskol - the so-called unorganized diffuse release into the river Oskol.

Conducted in 2007-2008 researches have shown that the content of a number of pollutants such as petroleum products, manganese, strontium, sulfate, zinc fluoride, compared to their content mining exposure zone (to the north if Stary Oskol) increases, and in some substances (particulate matter mineralization, dry matter, COD, iron, magnesium, chloride) - decreases (v.Yablonovo, 14.8 km after the last discharge) [7].

Further, in Fig. 5-6, are presented updated information on indicators of pollution of the studied rivers according to Roshydromet.

When analyzing the data of Roshydromet it is obvious the Gubkin influence on to increasing of the nitrate content in the river Oskolets, that it may be associated with the release of wastewater public utility. Moderate impact of Gubkin and LMPP on the iron content can be seen in some years. LMPP and Gubkin moderate influence on the increasing of sulfate content.

The variation of the content of heavy and non-ferrous metals, zinc, nickel, and, for example, copper (Fig. 5), on hydrochemical situation of the river Oskolets indicates a significant impact not only the mining industry of the residential-industrial area of Stary Oskol.. In this case the metals concentration increases on the average 2.7 times. In general, the impact of residential-industrial area of Stary Oskol on the hydrochemical situation river Oskolets is much more noticeable than the effect of the LMPP, which has the impact on the increasing of sulfate concentration.

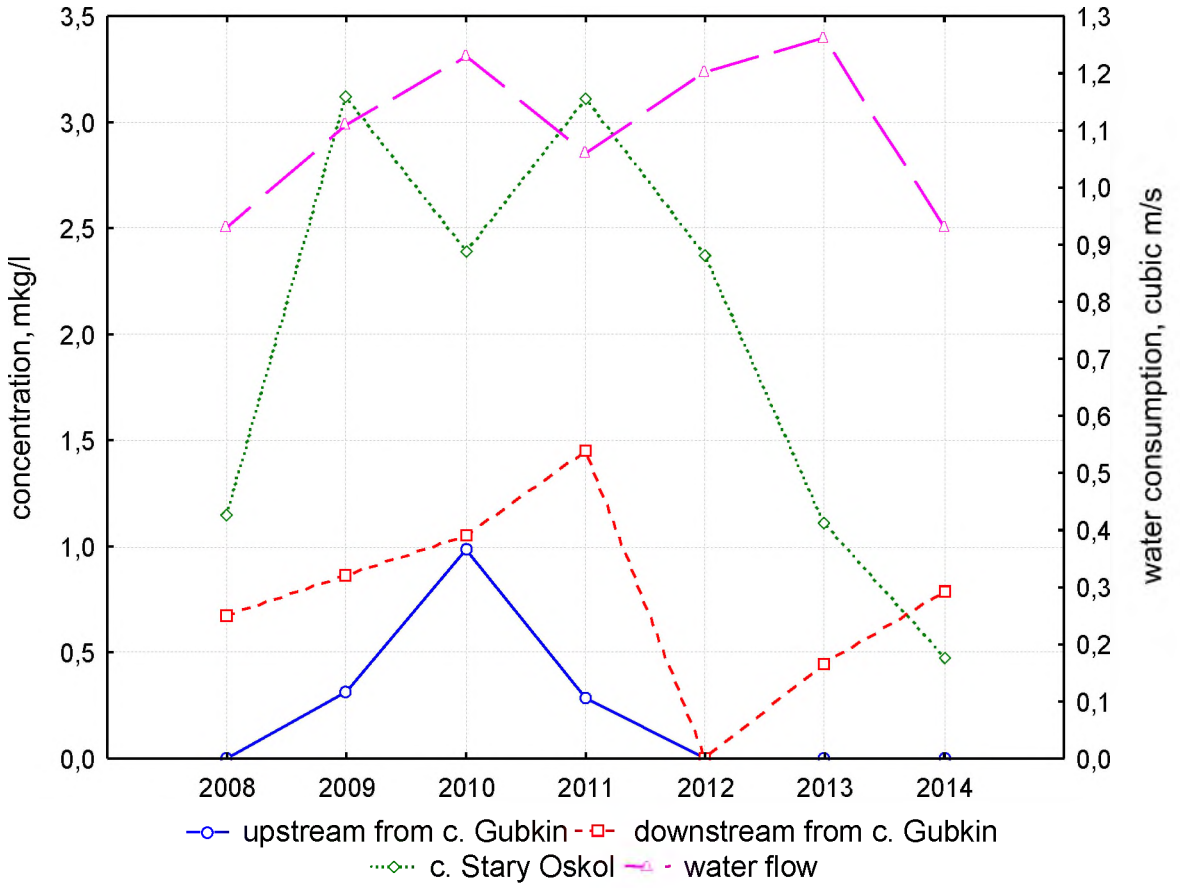

Fig. 5: The copper content in the river Oskolets

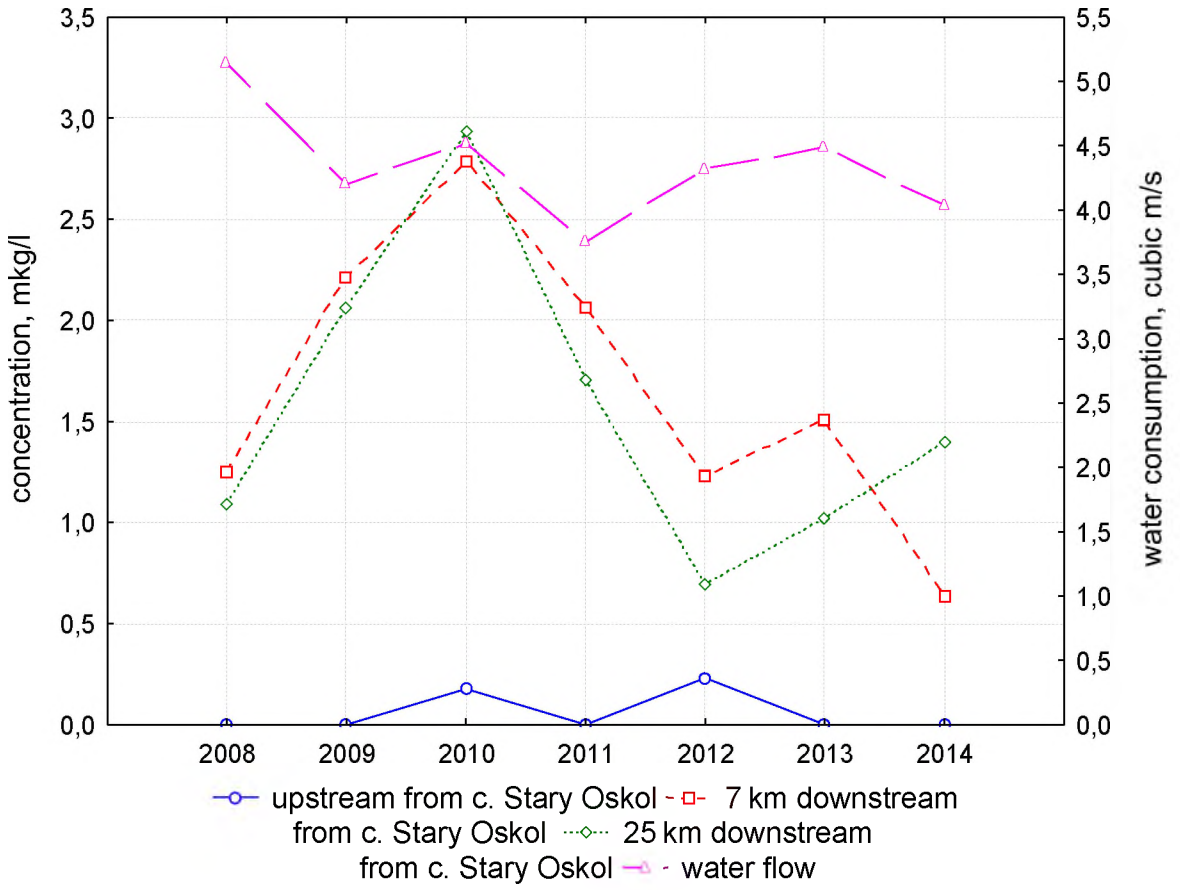

Fig. 6: The copper content in the river Oskol

Downstream the Oskol river nitrate content, iron, sulfates are gradually increased. The most noticeable impact of residential-industrial area of Stary Oskol and unorganized agricultural runoff is manifested by the nitrate content increasing. Moderate impact of the above drains on the content of iron and sulfate is observed.The content of zinc, lead and, for example, copper (Fig. 6) is markedly increased in the post below 7 km from Stary Oskol (about 8 times) and then the downstream processes of self-cleaning occurs and the content of these metals is reduced approximately 5-15 %.

In general, the impact exerted by the mining and metallurgical enterprises complex Starooskolsco-Gubkinsky industrial area on the river Oskol and its tributaries, is multidirectional. Influence of the Lebedinsky MPP (open method of production) on the surrounding small rivers (river Oskolets) has a dual character: on the one hand - the content of most of the observed pollutants after discharge is reduced, on the other - by reducing the water content of the river by 46 % (from 2.32 m^3/s during the 1933-1974 undisturbed flow to 1.26 m^3/s during the disturbed flow in the present), significantly reduced self-purification capacity of the Oskolets against diffuse residential and agricultural pollutant runoff [2, 8]. For the period of natural flow, with an average annual rainfall 511 mm average annual rate was equal to 2.32 m^3/s, and in the period of disturbed flow with the largest rainfall 613 mm/year flow has not changed. If there were no man-made disturbances runoff, sediment layer with 613 mm average annual runoff was to be equal to 2.78 m^3/s. The coefficient reducing the average annual flow by the technogenic effects for the period is 0.85 [9].

3 Conclusions

Thus, as in earlier studies [10-13] it was confirmed the ambiguous nature of the impact of mining on the hydroecological water resources of the Belgorod region.

Obviously, Yakovlevsky Mine (underground mining) has a negative impact on the river Vorskla by the complex of components (except nitrates), which can be traced over a distance of up to 68 km after the discharge of effluents. As fluorine, sulphate, chloride, this effect is noticeable right up to the border in alignment with v. Kozynka (102 km after discharge).

The zone of influence of mining activities on the river Oskol was observed at a distance of 15 km (v. Yablonovy). But much more important factor in the impact of the river is not the influence if the mining companies, and the accompanying residential-industrial effluents [7]. In particular, the assessment of the Stoilensky GOK impact on the river Oskol by wastewater discharges in the river. Chufichka indicates that it has no significant impact on the hydrochemical composition of water in the river Oskol.

In general hydrochemical situation of rivers exposed to mining district of KMA remained stable over the last 8 years. In addition, the water quality at the aggregate biological parameters can be estimated by the category "moderately polluted water," which is a background condition for the Chernozem region. The species compositions of plant and animal species, the ecological state of water protection zones for many years have remained stable, despite high pressure of industrial mining companies, as well as recreational pressure the part of the associated infrastructure.

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