AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

Journal homepage: anau.am/scientific-journal

UDC 631.95+574(479.25)

The Ecological and Toxicological Condition of the Waters in the Sotk and Masrik Rivers under the Influence of the Sotk Mine Exploitation

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ARTICLE INFO

Keywords:
mining industry,
water system,
Sotk and Masrik Rivers,
organoleptic properties,
heavy metals,
contamination

ABSTRACT

The article considers the results of the studies conducted on the ecological and toxicological state of the waters in the Sotk and Masrik rivers under the influence of the Sotk mine exploitation.

Upon the investigations it has been disclosed that along with the increase of the mining industry dimensions, as well as rock dump amounts, the organoleptic and chemical indices of the waters in the Sotk and Masrik rivers have also grown up. Due to heavy metals the amount of suspended particles per liter of water has increased over the last 10 years. Taking into account that individual heavy metals (tungsten, vanadium, molybdenum, etc.) are more active in the base medium, it is necessary to install filters for their refining.

Introduction

Sevan basin management area is situated in the eastern part of Armenia. The basin of Lake Sevan makes up one sixth of the total territory of Armenia. Sevan basin management area makes 4721 square km, out of which 1279 square km is covered by the mirror of Lake Sevan (“Armhydromet” SNCO, 2017). Lake Sevan is surrounded by Geghama (from the West part), Vardenis (from the South part), Areguni (from the North-Eastern part), Sevan and Eastern Sevan (East part) mountain chains with up to 3598 m elevation (Vardenis). Sevan basin management area stretches from $39^0 87'$ to $40^0 68'$ in the northern latitude and from $44^0 76'$ to $45^0 98'$ in the eastern longitude. The maximum length from the south to north makes 90 km, while from the east to west – 103 km. One of the characteristic traits of the Sevan basin management area is that the ratio between the catchment/drainage basin area of Lake Sevan and the area of its mirror is rather small (3:1) as compared to other large lakes (averagely 10:1).

Twenty eight rivers and streamlets (including large springs in the river form) flow into Lake Sevan and only the Hrazdan river originates from the lake. In general, most of the rivers in the basin of Lake Sevan have less than 10 km length. There are only 6 rivers with 26 km length, while the Argichi river is the only one with more than 50 km length; the rivers Sotk and Masrik, with 10 km length each, are situated in the north-eastern part of the lake and are somewhat fed by the neighboring areas of the Sotk mine.

Mining industry has always been and is still a powerful factor for destabilization of the ecological conditions in the areas of all countries over the world, as a result of which the natural relief and hydrological regimes are disturbed, the vegetative cover is destroyed, a huge amount of rock dumps and technological effluents/waste waters are generated, which are piled up in the canyons and tailing dams; the environment is contaminated with heavy metals and other substances and the population's health is strongly damaged.

Heavy metals are on the top position (28 %) from the prospect of their ecological threats and environmental risk exposure. The world practice evidences that the heavy metals are one of the most toxic pollutants, the danger of which is related to their stability in the external environment, their water-solubility and to the great ability to accumulate in the soil and plants (Galstyan, 2016, Hayrapetyan and Shirinyan, 2003, Harutyunyan and Sargsyan, 2018, Saghatelyan, 2004, Galstyan, et al., 2015).

In the water environment the pollutants can be dissolved, molecular, ionic, coloidal and suspended (Hayrapetyan, et al., 2008, Burenkov, et al., 2001, Budnikov, 1998). Heavy metals pose great danger for the mentioned environment, which appear mainly in the form of suspensions. Unlike the atmosphere, where the retention capacity of heavy metals is not high, the surface waters are mostly considered to be conservative component of the environment. The content of zinc in the surface waters is higher than the content of cadmium by 1-2 degrees; the content of the discussed elements is higher in the surface waters than in the seas and oceans. In the streaming waters about 90 % zink (*Zn)* and 65 % cadmium (*Cd*) are in a suspended state (Sokolov, et al., 2008, Ashikhmina, 2005). Thus, the evaluation of the ecological state and the contamination level of the surface waste waters in general, flowing from the areas of mining industry and from its neighboring territories, as well as the related studies are rather actual and are based on the strategic developmental requirements of the given region; at the same time they have both environmental and socio-economic feasibility and address the interests of population by ensuring their healthcare and safety. Though only ore mining and transportation activities are implemented in the RA Sotk gold deposit (gold mineralization and extraction from the ores is implemented in the Ararat gold flotation plant), laying of the rock dumps appeared throughout the process of the aforementioned activities, the spread of dust and aerosols in the environment through the atmospheric streams, particularly in the waters of the Sotk and Masrik Rivers (the latter are used for irrigation purposes, the rest of the water is discharged into Sevan Lake) situated in the territories near the mining site, cause pollution with different types of ions and heavy metals.

Hence, we have set a task to study and identify the ecological state of these waters and to make appropriate recommendations for its improvement.

Materials and methods

The studies have been conducted through the water sampling from the appropriate observation points of the Sotk and Masrik Rivers situated near the Sotk mine and through determining their organoleptic and chemical indices. It has been planned to determine the dynamics of the investigated elements by comparing the obtained data with the similar indices of the water samples taken from the same observation point by the Environmental Monitoring and Information Center (EMIC), SNCO under the Ministry of Environment within the previous 10 years and to develop the needed recommendations.

Taking into account the circumstance that reoxygenation, as well as physicochemical, biochemical processes and intensive microbial activities, sorption, desorption and other activities are taking place in water and the water organoleptic properties can change, laboratory studies on taste, flavor, color, permeability have been conducted with the standard methods (Shahinyan, 2005, Clesceri, et al., 1998). Hydrogenic index, specific electrical conductivity and salinity have been determined through the electro-chemical method: the total dissolved substances have been calculated multiplying the value of specific electrical conductivity by 0.65.

Biochemical oxygen demand (BOD) represents the amount of oxygen (mg) needed for oxidizing organic matters in 1 liter water at 20 ^{0}C under aerobic conditions over some period of time: in our case it has been determined for 5 days (Shahinyan, 2005, Clesceri, et al., 1998).

Biochemical oxygen demand (BOD) (bichromatic oxidation) has been determined in the acidic medium of potassium bichromate under the guidance of catalysers, while titration has been implemented with 0.025 N solution of the Mohr's salt. It has been determined through the following formula: $C_x = (n_1 - n_2) \times 8 \times V_2/V_1 \times 1000$, where V_1 is the volume of the investigated water, V_2 is the volume of the potassium bichromate, n_1 is the volume of the Mohr's salt when titrating the zero sample and n_2 is the volume of the Mohr's salt when titrating the sample. In drinking water the rate of BOD makes 15 mg O_2/L, while in the sanitary and irrigation waters it makes 30 mg O_2/L (Clesceri, et al., 1998). Ammonium, silicium, nitrate and phosphorus ions have been determined with KFK-2 spectrophotometry (Shimadzu 1650) at the wavelength of 360-600, 410, 536 and 708 nm respectively. Sulphate, chloride, nitrate ions have been determined through ion chromatography method (DIONEX - 1000), while the hydrocarbonate- through the back-titration method (Clesceri, et al., 1998).

The permeability, flavor, color are technical criteria, which have been determined through the visual and sensory methods. The analysis of the chemical elements (*Li, Be, B, Mg, Na, Al, P, K, Ca, Se*) in the water samples have been conducted through the inductively coupled plasma mass spectrometry (ICP-MS, ICP-MSELAN 9000) in line with the standard of ISO 17294, which is based on the use of argon inductively coupled plasma as a source for ions and the use of mass spectrometry for ion separation and their further determination (Fomin, 2000, Clesceri, et al., 1998, Davydova, 2005).

Results and discussions

Upon the results of investigations it has been disclosed that the organoleptic indices (suspension particles, color and flavor) both in the Sotk and Masrik Rivers, are different depending on the sampling times. The water quality deteriorates starting from May up to November, which is related to the rain and meltwaters, as well as to the intensive atmospheric activities. It is apparent that less amount of suspended particles in the waters of the Sotk and Masrik Rivers are found particularly in the water samples taken from the territories closer to the mining site. Thus, in November 2019, the suspended particles in the water samples taken from the territory situated1km above the Sotk community and opposite the community have made 3.5 mg/L and 11.5 mg/L respectively (Table 1), while in the waters of the Masrik river 1.5 km above V. Shorzha community and opposite the mentioned community it has made 5.5 and 19.9 mg/L respectively; at the friths of the Sotk and Masrik rivers and after interflowing of the waters their suspended particles amounted to 47.5 and 28.7 mg/L respectively (Tables 1, 2).

Table 1. Organoleptic and chemical indicators of the Sotk River waters depending on the exploitation of the Sotk gold mine*

N/N	Indicators	Measuring unit	October-November, 2010				October-November, 2015				November, 2019			
			The indices of cellar pit, October-November	1.0 km above the Sotk community	Opposite the Sotk community	River mouth (frith)	The indices of cellar pit, October-November	1.0 km above the Sotk community	Opposite the Sotk community	River mouth (frith)	1.0 km above the Sotk community	Opposite the Sotk community	River mouth	After interflowing of the Sotk and Masrik Rivers
1.	Hydrogenic index		8.30	8.20	8.40	8.74	8.40	8.36	8.44	8.40	8.43	8.37	8.35	8.78
2.	Dissolved oxygen	mg/L	10.20	9.20	6.40	10.30	9.8	6.40	7.60	6.60	7.20	6.80	9.30	5.40
3.	BOD_5	mgO_2/L	1.80	2.00	1.30	2.20	2.0	2.15	2.18	2.10	1.79	1.00	2.70	1.91
4.	BOD	mgO/L	-	-	18.0	-	15.40	28.0	15.0	27.0	15.0	35.00	17.00	30.0
5.	Total phosphorus	mg/L	0.02	0.01	0.05	0.00	0.03	0.05	0.01	0.05	0.02	0.02	0.01	0.04
6.	Ammonium ion	mgN/L	0.30	0.25	0.19	0.18	0.41	0.14	0.09	0.14	0.23	0.12	0.14	0.19
7.	Nitrite ion	mgN/L	0.01	0.00	0.01	0.01	0.06	0.04	0.03	0.03	0.00	0.00	0.01	0.04
8.	Nitrate ion	mgN/L	0.00	-	1.31	-	0.01	2.23	0.26	2.18	0.37	0.45	3.46	2.44
9.	Phosphate ion	mg/L	0.05	0.05	0.10	0.05	0.07	0.18	0.03	0.17	0.00	0.01	0.17	0.07
10.	Chloride ion	mg/L	2.65	2.34	2.31	8.30	2.45	5.26	1.62	5.13	2.43	3.27	7.96	7.58
11.	Sulphate ion	mg/L	20.40	21.64	28.45	65.11	19.62	30.30	8.46	29.30	6.80	15.75	41.53	43.37
12.	Total dissolved salts	mg/L	239.0	246.4	306.0	299.6	261.4	330.0	202.0	309.0	210.0	230.8	285.0	253.5
13.	Electroconductivity	mSm/cm	829.0	379.0	470.0	461.0	972.4	507.0	311.0	502.0	323.0	355.0	439.0	390.0
14.	Suspended particles	mg/L	6.90	2.70	15.40	1.60	7.80	64.40	5.90	62.40	3.50	11.50	47.50	14.1
15.	Permeability	cm	29	29	30	30	27	29	29	29	26	27	28	28
16.	Color (visual)	degree	4	4	4	3	4	4	5	4	4	4	4	4
17.	Flavor	point	Slight flavour 2	2	2	2	3	2	2	3	3	2	2	3

*Composed by the authors based on the data of Environmental Monitoring and Information Center.

Table 2. Organoleptic and chemical indicators of the Masrik River waters depending on the exploitation of the Sotk gold mine*

N/N	Indicators	Measuring unit	October-November, 2010			October-November, 2015			November, 2019				
			1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	The mouth (frith) of the Karchaghbyur river	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	0.5 km below the river mouth after interflowing
1.	Hydrogenic index		9.20	9.00	8.49	8.50	8.41	8.14	7.3	7.88	8.38	8.24	7.55
2.	Dissolved oxygen	mg/L	11.40	11.2	10.00	8.90	7.00	7.30	7.9	7.70	4.10	6.70	6.90
3.	BOD_5	mgO_2/L	2.80	2.4	2.80	1.62	1.00	1.33	1.2	1.50	1.05	2.60	2.15
4.	BOD	mgO/L	-	8	5.00	8.00	11.4	18.0	10.4	10.0	30.00	15.00	20.0
5.	Total phosphorus	mg/L	0.01	0.0061	0.1274	0.07	0.09	0.16	0.01	0.03	0.03	0.12	0.27
6.	Ammonium ion	mgN/L	0.10	0.1012	0.1944	0.06	0.06	0.07	0.21	0.06	0.11	0.08	0.14
7.	Nitrite ion	mgN/L	0.08	0.092	0.0276	0.01	0.03	0.06	0.13	0.00	0.00	0.03	0.11
8.	Nitrate ion	mgN/L	-	0.5534	0.4944	0.33	0.56	0.93	0.03	0.26	0.76	1.43	2.76
9.	Phosphate ion	mg/L	0.01	0.0142	0.3390	0.40	0.39	0.37	0.12	0.04	0.07	0.28	0.23
10.	Chloride ion	mg/L	4.35	4.4061	4.6562	3.06	2.62	2.41	1.10	1.19	2.15	3.09	4.92
11.	Sulphate ion	mg/L	11.61	11.69	16.54	5.16	5.81	6.96	10.4	4.06	6.96	15.01	20.97
12.	Total dissolved salts	mg/L	152.1	152.60	156.6	154.0	162.6	176.00	114.2	69.0	146.90	141.00	171.00
13.	Electroconductivity	mSm/cm	234.0	230.60	241.0	236.0	247.4	271.00	118.2	106.0	226.00	218.00	267.00
14.	Suspended particles	mg/L	1.80	1.87	15.80	60.20	23.60	18.50	2.14	5.50	19.90	28.70	19.90
15.	Permeability	cm	31	31	30	30	32	31	31	32	31	32	32
16.	Color (visual)	degree	3	3	4	4	4	4	4	3	3	3	3
17.	Flavor	point	Slight flavor 2	2	3	3	With flavor 4	4	3	3	3	3	3

*Composed by the authors based on the data of Environmental Monitoring and Information Center.

If we compare the mentioned indices with the similar average data of the last previous10 years, it becomes obvious that along with the increase of mining industry dimensions, as well as with the increase of rock dumps amount, the quantity of the suspended particles have also grown up and, as to the mentioned studies, the amounts of the suspension particles per liter of water have increased by 210.2-317.0 % as compared to the water samples taken within the same period in 2010; to be more precise, in waters of the Sotk River they have increased by 32.10 mg/L and in waters of the Masrik River – by 13.2 mg/L (Tables 1, 2). The suspension particles have a great impact on the water permeability, its color, flavor, as well as on its biological and bio-chemical indicators, which is more clearly described in the tables below.

Electrical conductivity is considered to be one of the vital ecological indicators of the surface waters. As we can see from the data of Tables 1 and 2 provided upon the studies of the Environmental Monitoring and Information Center, the values of electrical conductivity in the Sotk and Masrik Rivers grow up for the period of December-March as compared to those observed for the period of Spring-Autumn. The mentioned data testify that in the winter hydrological period the river flow appears from the feeding of ground and underground waters and their hydrochemical quality is formed under hydrochemical influence of just the mentioned waters. Considering that unlike the river waters, the values of electrocunductivity in the waters of cellar pits practically stay unchanged in that period and have 2-2.5 times higher values than those recorded in the river waters, it can be stated that in the period of December-March the hydrochemical composition in the waters of the Sotk river is affected also by the drainage waters of the mining site and cellar pits.

Table 3. Content of individual chemical elements in the waters of the Sotk River by dates*

N/N	Name of the chemical elements	Measuring unit	October-November, 2010			October-November, 2015			November, 2019			
			Above the Sotk community	Opposite the Sotk community	River mouth	Above the Sotk community	Opposite the Sotk community	River mouth	Above the Sotk community	Opposite the Sotk community	River mouth	After interflowing of the Sotk and Masrik Rivers
1.	*Ca*	mg/L	35.09	40.07	50.97	37.91	21.87	28.15	20.35	23.02	46.04	34.32
2.	*Mg*	mg/L	33.63	39.91	29.26	42.14	31.12	30.72	32.56	41.09	19.70	30.39
3.	*K*	mg/L	1.18	1.68	5.49	2.77	0.52	5.47	0.48	0.93	2.07	2.45
4.	*Na*	mg/L	3.06	6.07	11.38	3.83	2.68	10.86	2.72	6.35	7.58	11.70
5.	*Al*	mg/L	0.06	0.03	0.04	0.06	0.02	0.56	0.02	0.02	0.12	0.14
6.	*Se*	mg/L	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	<0.00	0.00
7.	*S*/Sulphur/	mg/L	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01

Table 4. Content of individual chemical elements in the waters of the Masrik River by dates*

N/N	Name of the chemical elements	Measuring unit	October-November, 2010			October-November, 2015			November, 2019			
			1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	1.5 km above the community of V. Shorzha	1.5 km below the community of V. Shorzha	River mouth	After interflowing of the Sotk and Masrik rivers
1.	*Ca*	mg/L	32.43	28.4	26.42	31.96	30.89	30.89	16.45	30.03	28.75	29.36
2.	*Mg*	mg/L	6.61	8.40	9.16	5.82	8.86	8.86	2.31	6.78	7.55	11.22
3.	*K*	mg/L	2.29	3.00	3.30	4.42	4.46	4.46	0.64	2.60	2.95	4.48
4.	*Na*	mg/L	9.04	9.11	9.11	7.86	9.89	9.89	3.33	10.46	5.36	11.92
5.	*Al*	mg/L	0.01	0.03	0.04	0.79	0.06	0.06	0.13	0.11	0.15	0.23
6.	*Se*	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	*S* (Sulphur)	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*Composed by the authors.

The results of the laboratory studies show that in the waters of left-bank tributary of the Sotk and Masrik Rivers, the feeding of which hardly has any relation with the Sotk mine, the average value of electrocunductivity is lower in 2-4 times than the values generally recorded in the waters of the mentioned rivers. For comparison the values of the electrocoductivity in waters of the Karchaghbyur river mouth (frith) have been also studied, which don't have any seasonal variabilities and are 2 times lower than the average electroconductivity value observed in the waters of the Masrik River mouth.

The investigated waters are equivalent to the alkaline waters regarding the values of their hydrogenic indicators (*pH*). Thus, *pH* in the Sotk River mouth (frith) makes 8.78, in the water sample taken from 1.0 km above the Sotk community it makes 8.43, while in the Masrik River mouth it is 8.38 and in the samples taken from the same river, 1.5 km above V. Shorzha community, it makes 8.21. This circumstance is related to the chemical composition of the environmental mountain ores, where the alkaline chemical elements (*Ca, K, Na, Mg,* etc.) are prevailing, the content of which has always been high both in the period of 2010-2018 and in the period of our investigations.

Waters of the Sotk River contain averagely 30.2 mg *Ca,* 1.3 mg *K*, 5.5 mg *Na* and 31.6 mg *Mg* per liter of water, while in waters of the Masrik River the mentioned indices have made 22.5, 2.0, 6.3 and 5.4 mg/L respectively. The content of *Ca* has made 26.00 mg/L, *K* – 2.60, *Na* – 6.45 and *Mg* – 5.20 mg/L (Tables 3 and 4); the mineralization degree in the waters (total amount of the inorganic compounds) doesn't exceed 1g/L and, per the average data of the previous 10 years, it makes 129.8 mg/L in the waters of the Masrik River and 263.4 mg/L in the waters of the Sotk River, while for the period of our investigations (November, 2019) the mentioned index in waters of the Masrik River has made averagely 146.9-182.0 mg/L and in the waters of the Sotk River it makes 230.8-253.5 mg/L, besides, 95 %-96 % are hydrocarbons; 4-5 % are sulphates, while Se and Al make very little amount. As to the content of nitrate, nitrite and ammonium ions it is clear from the table data that upon the results of the investigations conducted in the previous years and upon the laboratory investigations on the water samples conducted in November 2019, they hardly exceed the standards set upon the decision N 75 on the surface waters assessment, taken on January 27. 2011, by the RA Government, which are as follows: NO_3^- – 45, NO_2^- – 3.3, NH^+ – 2 mg/L and NO_3^- – 0.02-1.5, NO_2^- – 0.001-0.04, NH_4^+ – 0.03-0.7 mg/L respectively.

The data of EMIC testify that for the winter-spring period in the waters of all observation points the concentration of nitrates grow up parallel to the intensification of water flow as well. In the waters of cellar pits, unlike in those of the rivers, the concentration of the nitrate almost stays the same and it is 2-4 times lower; hence, the effect of the drainage waters in the cellar pits is insignificant, while there are more considerable factors forming the content of nitrates in the river waters, which are mostly related to the anthropogenic factors and to the fluctuation of the temperature. The increase of the nitrate content is mainly conditioned by the intensive agricultural activities implemented in the given areas, particularly in the riverine land areas, as well as, most likely, by the development of the livestock sector. As a result of the single mineral fertilization with nitrogen, some part of the nitrogen is leached and moved into the river mingling with the river waters. At the same time, some part of the cattle manure and liquid manure is imbibed into the soil and the other part is leached with the atmospheric precipitations, then gets mixed with the river waters increasing the nitrate content.

Similar pattern is observed in case of the concentration dynamics in the sulphate ion, which also grows up. Unlike in the river waters, in those of the cellar pits, the sulphate concentration practically stays the same and is 2-3 times lower. So, the recorded sulphate content in the waters of the Sotk and Masrik Rivers is formed under the influence of the Sotk mine exploitation, under the impact of pressure factors existing near the zone of the mining site along the south-eastern part of the Areguni mountain chain, as well as under the influence of the waters in the zone of the seepage flow (internal stream) of the Sotk and Masrik Rivers, particularly under the significant impact of right-bank ground and artesian (underground) waters of the catchment basin. While in the lower parts of the rivers the increase of the sulphate ion content is mainly related to the application of various agrochemicals during agricultural farming, as well as to the vaccines administered throughout cattle breeding, the residuals of which are poured into the rivers flowing through the mentioned territories increasing the amount of the mentioned ions. The most concerning issues of the environmental pollution are related to the surface waters, which come forth as a transition medium, being carriers and conveyors of the chemical elements (technogenic pollutants) (Saet and Revich, 1990). In this respect the research results conducted on the chemical composition of the investigated waters are of utmost significance and purposeful, especially when they are viewed and compared with the Maximum Permissible Concentration Limits (MPCL) determined for the studied elements in drinking and domestic waters, which are as follows: *Hg* – 0. 0005, *Cd* – 0.001, *Pb* – 0.03, *Be* – 0.0002, *Co* – 0.01, *Cu* – 1, *Zn* – 5, Cr^{+6} – 0.05, *Ni, Ba, Mn* – up to 0.1 mg/L (Yagodin, 1987, Guideline on the Chemical Analysis of Terrestrial Surface Waters, 1977, Ghalachyan and Asatryan, 2012).

The research results have indicated that the content of the chemical elements in the Sotk and Masrik Rivers is significantly low or are in line with the MPCL as to the data gained upon the investigations conducted in November, 2019 and during the previous 10 years. Besides, we'll get a more comprehensive view of the above-discussed issue, if we put forward the circumstance that within the study period the total intensity of the geochemical flow of the chemical elements in the waters of the mentioned rivers significantly fluctuates and varies depending on the exploitation of the Sotk mining site and on the changes of the mining ore volumes.

Conclusion

Summing up the conducted investigations we can draw the following main conclusions:

1. Along with the increase of the mining dimesions in the Sotk gold mine and with the increase of the amounts of rock dumps, the organoeptic and chemical indicators in the waters of the Sotk and Masrik Rivers also grow up. The quantity of the suspension particles has increased by about 210 %-317.0 % as compared to the same indices obtained for the last 10 years (2010); in the waters of the Sotk River the increase has amounted to 32.1 mg/L, while in those of the Masrik River it makes 13.2 mg/L.

2. Increasing tendencies have been also observed in the mentioned waters regarding the values in the indices of nitrate, sulphate and hydrogenic ions, which are mainly related to the chemical composition of the ore mines, where the alkaline chemicals (*Ca, K, Na, Mg,* etc.) mainly predominate, and to the intensive agricultural activities carried out in the specific areas, particularly in the riverine land areas, as well as to the application of the single nitrogenous fertilization system

and, most likely, to the development of the livestock sector.

3. The total intensity of the geochemical flow of the chemical elements into the Sotk and Masrik Rivers considerably fluctuates and varies depending on the exploitation of the Sotk mining site, changes of volumes in the ore mine and the spring river floods resulted from the snowmelt.

4. Considering the fact that the waters of the mentioned rivers are used also for the irrigation purposes and that their constituent chemical elements are endowed with great ability to accumulate in the soils (deposited), besides, their mobility is extremely reduced in the base (alkaline) medium, especially when the environmental reaction (*pH*) equals to 9, it is recommended that the managerial body of the mining industry should constantly increase the amount of lime (*CaO*) in the acidic drainage of the mining site provided that the water pH will hold up minimum within the range of 9.

Meanwhile, taking into account that individual heavy metals (tungsten, vanadium, molybdenum. etc.) are more active in the base environment, it is necessary to install filters for their refining.

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Accepted on 27.07.2020
Reviewed on 14.09.2020