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PHYSICO-CHEMICAL AND HYDROCHEMICAL STUDIES OF THE WATERS OF THE KVIRILA RIVER AND SPRING WATERS IN CHIATURA MUNICIPALITY

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Abstract*. The paper discusses the physicochemical and hydrochemical state of the Kvirila River waters in the areas surrounding the manganese processing plants of Chiatura Municipality. Determining the purity of the Kvirila River water is necessary because the Kvirila River water is used to wash the mined ore, after which the wastewater flows into the river and pollutes it.*

Key words*: Kvirila River, bottom sediments, spring waters, manganese, pollution.*

Introduction

In terms of environmental pollution, the negative impact of the mining industry in Chiatura Municipality is very significant, especially when developing deposits using the open-pit (open-cast) method. The latter is naturally much more profitable compared to underground ore processing. At the same time, labor productivity increases by 3–5 times, and the cost of production decreases by almost the same amount. It should also be noted that the soil, natural, and cultural vegetation that have developed over centuries on the site of the open pits are destroyed, and the areas around the pits often become hotbeds of erosion, landslides, and pollution of wastewater, drinking water, as well as the atmosphere [1–3].

In Chiatura Municipality, the company "Georgian Manganese" carries out mining of manganese concentrate using the shaft method, but licenses have also been issued to small private companies. There are approximately 20 deposits in the municipality, of which 9 are shaft-type and 11 are open-careers type. Ore processing began in 1879 [https://socialjustice.org.ge].

Manganese mining in Chiatura is causing significant damage to the hydrographic network, in particular the Rgani Gorge and the Kvirila River. The Kvirila River joins the Rioni River and carries pollutants to the Black Sea, causing significant damage to the irrigation network and agricultural fields of the Zestaponi district. In Chiatura Municipality, the Kvirila River flows into a ravine, so it is not used in the irrigation system, as the location of the villages and the river makes this process difficult.

Manganese is an important element for humans and animals. The human body contains about 10 mg of manganese, which is mainly accumulated in the liver and kidneys. Manganese is also part of the composition of bones. Manganese is contained in small concentrations in almost all human organs. Manganese participates in the blood-forming functions of humans and animals, in the process of bone growth, affects the functions of the reproductive organs, and the metabolism of proteins, carbohydrates, and fats. It is one of the main components of many enzymes and endocrine glands.

Manganese does not cause acute poisoning. It is a cumulative poison and causes the following occupational diseases: manganism, coniogenic bronchitis, bronchial asthma, manganoconiosis, eczema, and allergic dermatitis [4].

Research area and methods

The paper provides a physicochemical and hydrochemical characterization of the waters of the Kvirila River in the areas surrounding the manganese processing plants of Chiatura Municipality. Determining the purity of the Kvirila River water is necessary because the Kvirila River water is used to wash mined ore, after which the wastewater flows into the river and pollutes it.

To solve the set tasks, spring waters and samples of the Kvirila River water were taken, both background and downstream of the pollution source. As well as suspended solid and bottom sediments of the Kvirila River.

The following parameters were determined in the collected water samples: physicochemical and hydrochemical parameters, namely: pH, electrical conductivity, biogenic substances – NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, main ions, mineralization, heavy metals: Cu, Zn, Pb, Cd, Ni, Co and total manganese [5] and microbiological parameters: E-coli, total coliforms, fecal streptococci [6].

The analyses were carried out using modern methods and equipment that meet and comply with European standards, namely:

1. Ion chromatograph-IC-1000; ISO100304-1:2007
2. Spectrophotometric method – SPECORD 205; ISO 7150-1: 2010;
3. Plasma emission spectrometer – ICP-OES; Epa method 200.8;
4. Field portable equipment – Hanna Combo pH/EC/TDS/PPM Tester HI98129;
5. IDEX-apparatus
6. pH-meter – Milwaukee-Mi 150.

In Table 1. Hydrochemical and microbiological data of the Kvirila River and Spring waters are shown. As can be seen from Table 1, below Kvirila-Ltd "Andro" and Kvirila-Ltd "Jruchula", a deviation of pH in the alkaline direction is observed and amounts to 7.9 – 8.1. In the river Kvirila, below the enterprises, the content of ammonium ions is increased and amounts to 0.772 (2.0 MPC) and 0.523 mg/l (1.3 MPC), respectively. The content of nitrites and nitrates is within the norm. It is noteworthy that the content of almost all ingredients is much higher below Kvirila-Ltd "Andro", compared to Kvirila-Ltd "Jruchula" and especially to the background. The sum of hydrocarbonates, sodium and potassium, calcium, and magnesium are high. The mineralization of Kvirila water at the mentioned enterprises is moderate-696.82 and average-318.15 mg/l, respectively, while the mineralization of the river Kvirila at the background point is average mineralized-241.84 mg/l [7].

Table 1. Hydrochemical and microbiological data of the Kvirila River and Spring waters, June 2025

N	Ingredients	Kvirila-below "Andro" Ltd	Kvirila-below "Jruchula" Ltd	Kvirila-background	Spring water-1	Spring water-2	MPC *	MPC **
1	pH	7.9	8.0	8.1	8.1	8.0	6-9	6.5-8.5
2	Electrical conductivity μsms/cm	860	334	233	425	975		
3	BOD_5, mg/l	3.64	3.04	1.32	3.05	2.25	6.0	6.0
4	Hardness, mg.seq./l	6.78	2.99	4.55	4.15	6.12	7-10	
5	Ammonium, mgN/l	0.772/2.0	0.523/1.3	0.383	0.235	0.222	0.39	0.39
6	Nitrites, mgN/l	0.623	0.014	0.029	0.111	0.125	0.2	3.3
7	Nitrates, mgN/l	1.552	0.361	0.269	8.55	9.15	50	45
8	Phosphates, mg/l	0.120	0.098	0.050	0.115	0.156	3.5	3.5
9	Sulfates, mg/l	337.28	44.94	14.55	80.65	450.25/1.8	250	500
10	Chlorides, mg/l	14.25	3.40	7.78	7.15	7.12	250	350
11	Bromine, mg/l	0.006	0.010	0.107	0.012	0.095		
12	Fluoride, mg/l	0.170	0.112	0.036	0.085	0.143	0.7	
13	Hydrocarbons, mg/l	161.04	163.48	159.82	212.60	214.23		
14	Potassium, mg/l	85.75	31.50	14.25	20.14	102.32		
15	Sodium, mg/l							
16	Calcium, mg/l	86.17	44.29	34.69	45.23	95.33		
17	Magnesium, mg/l	30.15	9.48	9.94	16.82	14.42		
18	Mineralization, mg/l	696.82	318.15	241.84	435.47	985.13	1000-1500	
19	E-Coli, in 250 ml				N.D	N.D	not allowed	
20	Total coliforms in 250 ml				N.D	N.D		
21	Fecal streptococci, in 300 ml				N.D	N.D		
22	Manganese, mg/l	23.800/238.0	9.892/98.9	0.0527	0.0025	0.0055	0.4	0.1
23	Copper, mg/l	0.0379	0.0355	0.0036	0.0009	0.0011	2.0	1.0
24	Zinc, mg/l	0.0454	0.0518	0.0050	0.0022	0.0042	3.0	1.0
25	Lead, mg/l	0.0082	0.0037	0.0015	0.0015	0.0027	0.01	0.03

26	Cadmium, mg/l	0.0007	0.0002	0.0001	<0.0001	<0.0001	0.003	0.001
27	Nickel, mg/l	0.0201	0.0467	0.0028	0.0008	0.0010	0.07	0.1
28	Cobalt, mg/l	0.0130	0.0097	<0.0001	0.0007	0.0005		0.1

**** – MPC** – maximum permissible concentrations according to Technical Regulations for Drinking Water (Decree №58 of the Georgian government as of 15th January 2014, Tbilisi) [10]*
***** – MPC** – maximum permissible concentrations according to Technical Regulations for Surface Water (Decree №425 of the Georgian government as of 31st December 2013, Tbilisi) [11].*

Fig.1 shows the manganese content in the surface waters of the rivers and springs of Kvirila as of June 2025.

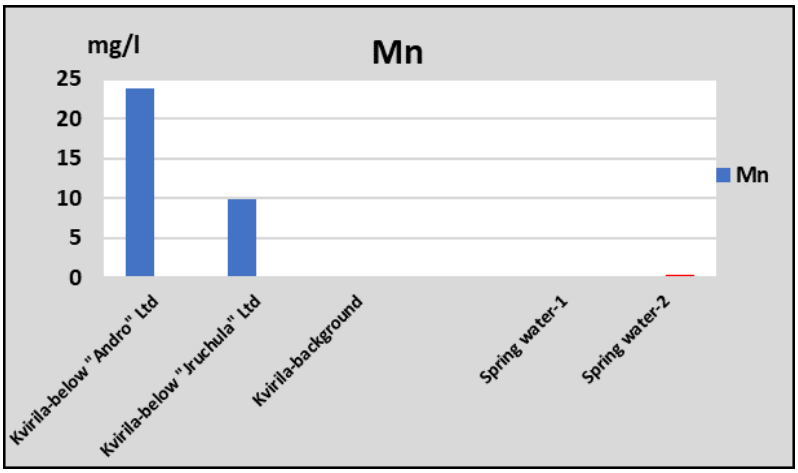

Fig. 1. Manganese content in the Kvirila rivers and spring waters, June 2025.

The situation is alarming regarding the manganese content in the Kvirila River below Ltd "Andro", where the manganese concentration reaches 23.800 mg/l, which is equivalent to 238.0 times the maximum permissible concentration (MPC). In the section of the Kvirila River near Ltd "Jruchula", the manganese concentration is 9.8920 mg/l, or 98.9 MPC. This elevated pollution level is caused by the discharge of wastewater into the Kvirila River during the washing of mined ore (Fig. 1).

The water of the second spring is notable for its high levels of certain components compared to other spring waters. The sulfate content is 450.25 mg/l, which is 1.8 times higher than the maximum permissible concentration. Its mineralization level is 985.13 mg/l, classifying it as moderately mineralized water. The manganese content in the water of both springs remains within the permissible limits.

Among the identified heavy metals, aside from manganese, none were found in concentrations exceeding the maximum permissible levels, and the spring waters showed no contamination according to the determined microbiological parameters.

According to Table 2, the manganese content in suspended particles and bottom sediments of the Kvirila River is higher downstream of Ltd "Andro" than it is below Ltd "Jruchula", at 41.5 and 19.7 mg/kg, respectively. The manganese content in the bottom sediments is higher than in the suspended particles, measuring 54.3 mg/kg below Ltd "Jruchula" and 46.1 mg/kg below Ltd "Andro". It should also be noted that the color of the Kvirila River water is black in the vicinity of the enterprises, which is due to the high content of sediments and suspended particles.

Table 2. Manganese content of suspended solids and sediments of the Kvirila River, June, 2025

N	Sampling location	Coordinates	Results	
	Suspended solid		**mg/kg**	**%**
1	Kvirila-below "Andro" Ltd	X-363027 Y-4686103	41.5	4.15
2	Kvirila-below "Jruchula" Ltd	X-363791 Y-4686878	19.7	1.97
	Sediments		**g/kg**	
1	Kvirila-below "Andro" Ltd	X-363027 Y-4686103	46.1	4.61
2	Kvirila-below "Jruchula" Ltd	X-363791 Y-4686878	54.3	5.43

Conclusion

The study of the Kvirila River and nearby spring waters reveals several key findings:

- The pH of the Kvirila River ranges from 7.9 to 8.0, while the spring waters show slightly higher values, between 8.0 and 8.1, indicating generally neutral to slightly alkaline conditions.
- The major cations and anions in the Kvirila River, both upstream and downstream of pollution sources, remain within the maximum permissible concentrations (MPC), confirming that the river water is generally medium to moderately mineralized. However, elevated ammonium ion levels were observed downstream of Ltd "Andro" and Ltd "Jruchula", with concentrations of 0.772 mg/l (2.0 MPC) and 0.523 mg/l (1.3 MPC), respectively, while nitrite and nitrate levels stayed within safe limits.
- Manganese contamination is of particular concern: its concentration in the river downstream of Ltd "Andro" reaches 23.800 mg/l (238.0 MPC) and 9.892 mg/l (98.9 MPC) below Ltd "Jruchula". This significant increase is attributed to wastewater discharge from ore washing activities.
- Additionally, the total manganese content in suspended particles and bottom sediments of the river is notably high, indicating the potential for long-term accumulation in the aquatic environment.
- Other heavy metals were detected at levels within the acceptable standards, with no exceedances of MPCs except for manganese.
- In the analyzed spring waters, sulfate concentrations are elevated in Spring 2, reaching 450.25 mg/l (1.8 MPC), classifying it as moderately mineralized. However, the manganese content in both springs remains within the permissible limits.
- The manganese content in the water of both springs is within the norm;
- Microbiological analysis of the spring waters did not reveal any signs of contamination.

Overall, the findings highlight that while the general water chemistry of the Kvirila River and springs is within acceptable ranges for most parameters, targeted measures are urgently needed to address the excessive manganese pollution and localized increases in ammonium ions, particularly downstream of mining operations. Continuous monitoring and stricter wastewater

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