doi.org/10.36073/1512-0902-2025-136-152-156
UDC: 551.510.41:628.54

Determination of Water Quality Classification of Tskhenistskali and Lukhuni Rivers According to Hydrochemical Indicators

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Abstract. The paper discusses the physicochemical and hydrochemical characterisation of the waters of the rivers (Lukhuni and Tskhenistskali) in the areas adjacent to the arsenic processing enterprises of the Racha-Lechkhumi and Kvemo Svaneti region.
The paper summarises multi-year (2021-2024) data on the studied rivers. Based on the obtained results, the ecological condition of the rivers was assessed. Using the proposed equation and chemical indicators (Water Framework Directive-2000/60/EC), the river pollution index and river water quality were determined. According to the pollution index, both rivers were assigned water quality class 1 and belonged to the "clean" category.
Keywords: Rivers, hydrochemistry, pollution, pollution index, water quality.

Introduction. The region of Racha-Lechkhumi and Kvemo Svaneti is one of the mining regions of Georgia, where arsenic ores have been mined, processed, and arsenic-containing compounds produced for decades.
To this day, in the villages of Uravi and Tsana, in the territory of the former factory, large batches of toxic waste (more than 130 thousand tons of waste containing 4-9% white arsenic) left over from the production of arsenic from the Soviet period are stored [1,2]. Currently, both deposits are conserved, and no arsenic is produced.
The main mechanism for the spread of arsenic wastes is related to the leaching and transport of toxic wastes by atmospheric precipitation and flood waters. They accumulate in the soil, where soil contamination with arsenic significantly exceeds the norm [3-5]. In the oxidation zone, after some time, arsenic from waste sulfide ores and incinerators can be converted into a mobile (soluble) form [6,7], which is easily transported to rivers [3,4], plants [8-10] and living organisms.
Tskhenistskali River is a water-rich river of Western Georgia, which originates from the eternal snow on the southern slope of the Svaneti Caucasus and joins the Rioni River. The length of the Tskhenisksli River is 176 km.
The River Lukhuni, in the Ambrolauri municipality, is the right tributary of the river Rioni. It originates on the southern slope of the Lechkhumi ridge at an altitude of 2650 m above sea level, the length of which is 39 km, and the area of the basin is 239 km^2 [11].

Study area and methods. The paper presents the physicochemical and hydrochemical characterisation of the waters of the rivers (Lukhuni and Tskhenistskali) in the areas adjacent to the arsenic processing enterprises of the Racha-Lechkhumi and Kvemo Svaneti region. To solve the set tasks, river water sampling points were selected from the background and polluted areas in the Racha-Lechkhumi and Kvemo Svaneti region.
1. River Lukhuni - Upper Uravi;
2. River Lukhuni - 100 m below the sarcophagus;
3. River Tskhenistskali - Upper Tsana;
4. River Tskhenistskali - below Lentekhi.
The following physicochemical and hydrochemical parameters were determined in the water samples: pH, electrical conductivity, biogenic substances - NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, major ions, mineralization, a common form of arsenic, copper, zinc, and lead [12].
Analyses were carried out using modern methods and equipment that correspond to European standards:
1. Ion-chromatograph-IC-1000; ISO100304-1:2007
2. Spectrophotometric method - SPECORD 205; ISO 7150-1: 2010;
2. Plasma-emission spectrometer - ICP-OES; EPA method 200.8;
4. Field portable equipment - Hanna Combo pH/EC/TDS/PPM Tester HI98129;
5. pH meter - Milwaukee 150.

Analysis of results. Focusing on the rivers we studied is not accidental, because the Lukhuni and Tskhenistskali rivers are tributaries of the Rioni River, the main source of drinking water for the city of Kutaisi. They are also used for irrigation, so the hydrochemical study of the research rivers of the region is of great importance.
Among the biogenic compounds, it is worth noting the inorganic nitrogen compounds that can be formed in water by the decomposition of nitrogen-containing organic compounds. They can also get into surface waters through atmospheric pre-

cipitation, leaching of fertilizers from the soil, and industrial and household wastewater. To ensure a safe environment for health, it is important to study the distribution of nitrogen-containing substances in river waters and to evaluate the quality of water.

As can be seen from Table 1 and Fig. 1, the average content of ammonium ions in the research rivers changes from 0.322 to 0.391 in the Tskhenistskkali River and in the Lukhuni River 0.365-0.576 mg/l. In both rivers, the content of nitrites varies from 0.057 to 0.176, nitrates from 0.480 to 0.583 mg/l, and in no case does it exceed the maximum allowable concentration. However, it should be noted that in some cases their high content was recorded, and in the case of mediation, these indicators decreased.

Of the heavy metals, attention is focused on copper, lead, zinc, and arsenic. Their content in the river water is within the norm, which is due to the dilution and self-cleaning processes of the river water.

Table 1. Tskhenistskali and Lukhuni Rivers' average multi-year data (2021-2024)

N	Ingredient	Rivers			
		Tskhenistskali (Tsana upper)	Tskhenistskali (Tsana below)	Lukhuni (Uravi upper)	Lukhuni (Uravi below)
1	pH	7.5	7.6	7.8	7.7
2	Ammonium, mgN/l	0.322	0.391	0.576	0.365
3	Nitrites, mg/l	0.057	0.060	0.081	0.176
4	Nitrates, mg/l	0.515	0.583	0.480	0.576
5	Phosphates, mg/l	0.020	0.024	0.036	0.038
6	Calcium, mg/l	52.39	49.85	28.63	24.64
7	Magnesium, mg/l	8.98	11.80	6.61	7.39
8	Mineralization, mg/l	300.23	304.58	180.75	169.05
9	Arsenic, mg/l	0.0059	0.0033	0.0028	0.0042
10	Copper, mg/l	0.0084	0.0064	0.0068	0.0085
11	Zinc, mg/l	0.0432	0.0244	0.0118	0.0105
12	Lead, mg/l	0.0040	0.0032	0.0021	0.0037

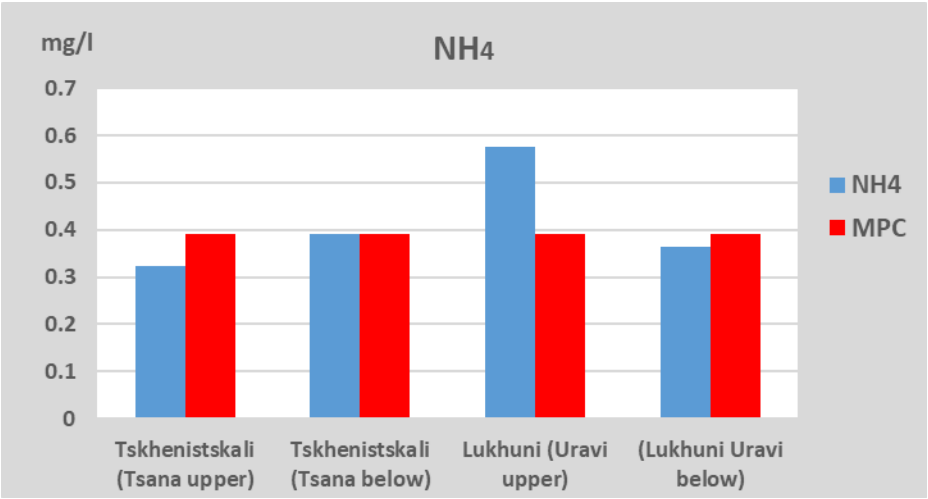

Figure 1. The average content of ammonium ions in the rivers Tskhenistskali and Lukhuni (2021-2024)

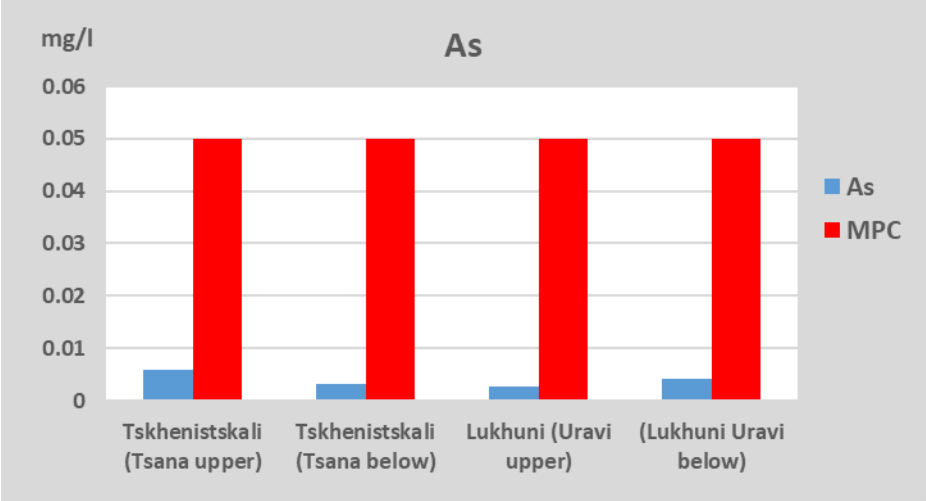

Figure 2. The average content of arsenic in the rivers Tskhenistskali and Lukhuni (2021-2024)

According to the recommendations of the Water Framework Directives of the European Union countries (2000/60/EC), the water pollution index (S) was calculated for assigning the classification of surface waters, for the calculation of which at least 6 or 7 hydrochemical indicators (indicators) are required. In our case, the average multi-year data of 9 hydrochemical and physicochemical indicators were used in the calculations.
The pollution index was calculated according to equation 1 [13]:

$$S = \sum_{i=1}^{N} \frac{Ci/MAC}{N} \qquad (1)$$

Ci is the concentration of the hydrochemical indicator;
MAC - Maximum Allowable Concentration of hydrochemical component;
N is the number of indicators used in calculations.

Table 2 provides a list of hydrochemical and physicochemical indicators, which, in our opinion, more or less characterize the water quality of the selected rivers and which will be used in the subsequent calculations.

Table 2. Tskhenistskali and Lukhuni rivers' water quality indicators

	Indicators	MAC*
1	pH	6,5-8,5
2	Ammonium, mgN/l	0.39
3	Nitrites, mg/l	3.3
4	Nitrates, mg/l	45
5	Phosphates, mg/l	3.5
6	Arsenic, mg/l	0.05
7	Copper, mg/l	1.0
8	Zinc, mg/l	1.0
9	Lead, mg/l	0.03

MAC* - The maximum allowable concentration of surface water by the technical regulations (Decree of the Government of Georgia N 425, December 31, 2013, Tbilisi) [14]

Based on the obtained results, river classifications (pollution quality class) were evaluated according to the values given in Table 3, proposed by the European Directive.

Table 3. Water quality classification assessment of pollution using indexes

Surface water	Pollution index	Water quality class
clean	0.2 - 1.0	1
moderately contaminated	1.0 - 2.0	2
contaminated	2.0 - 4.0	3
dirty	4.0 - 6.0	4
very dirty	>6.0	5

As a result of entering the given values from Table 2 into Equation 1, the pollution index of the river itself was obtained (Table 4), based on which they were assigned the appropriate water quality class.

Table 4. Water quality classifications are assigned according to pollution indices Tskhenistskali and Lukhuni rivers

River		Pollution index	Water quality class
1	Tskhenistskali (Tsana upper)	0.2	1
2	Tskhenistskali (Tsana below)	0.3	1
3	Lukhuni (Uravi upper)	0.3	1
4	Lukhuni (Uravi below)	0.3	1

According to the data, the studied rivers - Tskhenistskali and Lukhuni were classified according to the pollution index in the "clean" category and belong to the first class of water quality.

Conclusion

1. Tskhenistskali and Lukhuni rivers were chosen as research objects since they represent the main water arteries of the Racha-Lechkhumi and Kvemo-Svaneti region, which are under a certain anthropogenic load;
2. The paper summarises the multi-year (2021-2024) results of the environmental assessment of these rivers. Physico-chemical and hydrochemical indicators were determined in the water samples.
3. River pollution rate and river water quality were determined (Water Framework Directive-2000/60/EC);
4. It was established that both rivers were assigned water quality class 1 according to the pollution index and belonged to the "clean" category.

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უაკ: 551.510.41:628.54

მდ. ცხენისწყალი და ლუხუნის წყლის ხარისხის კლასიფიკაციის დადგენა ჰიდროქიმიური ინდიკატორების მიხედვით. შავლიაშვილი ლ., კუჭავა გ., ტაბატაძე მ., შუბლაძე ე. სტუ-ის ჰმი-ის შრომათა კრებული-2025.-ტ.136.-გვ.152-156. -ქართ., რეზ. ქართ., ინგლ., რუს.

ნაშრომში განხილულია რაჭა-ლეჩხუმის და ქვემო სვანეთის რეგიონის დარიშხანის გადამამუშავებელი საწარმოების მიმდებარე ტერიტორიებზე არსებული მდინარეების (ლუხუნი და ცხენისწყალი) წყლების ფიზიკურ-ქიმიური და ჰიდროქიმიური დახასიათება.

ნაშრომში შეჯამებულია საკვლევი მდინარეების მრავალწლიური (2021-2024) მონაცემები. მიღებული შედეგების საფუძველზე შეფასდა მდინარეების ეკოლოგიური მდგომარეობა. შემოთავაზებული განტოლებისა და ქიმიური მაჩვენებლების გამოყენებით განისაზღვრა მდინარეების დაბინძურების ინდექსი და შეფასდა მდინარის წყლის ხარისხი. ორივე მდინარეს დაბინძურების ინდექსის მიხედით მიენიჭა წყლის ხარისხის 1 კლასი და მიეკუთვნა ,,სუფთა“ კატეგორიას.

УДК: 551.510.41:628.54

Определение классификации качества воды рек Цхенисцкали и Лухуни по гидрохимическим показателям. Шавлиашвили Л., Кучава Г., Табатадзе М., Шубладзе Е. Сб. Трудов ИГМ ГТУ. - 2025. – том 136. - с. 152-156. - Груз.; Рез: Груз., Англ., Рус.

В статье рассматривается физико-химическая и гидрохимическая характеристика вод рек (Лухуни и Цхенисцкали) на территориях, прилегающих к предприятиям по переработке мышьяка региона Рача-Лечхуми и Квемо Сванети.

В статье обобщены многолетние (2021-2024 гг.) данные по исследованным рекам. На основании полученных результатов дана оценка экологического состояния рек. С использованием предложенного уравнения и химических индикаторов (Рамочная водная директива 2000/60/EC) были определены индекс загрязнения реки и качество речной воды. По индексу загрязнения обеим рекам присвоен 1 класс качества воды и они относятся к категории «чистые».