MONITORAMENTO DA COMPOSIÇÃO QUÍMICA DO RIO IORI

MONITORING OF THE CHEMICAL COMPOSITION OF IORI RIVER

მდინარე იორის ქიმიური შედგენილობის მონიტორინგი

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RESUMO

O artigo examina a poluição química do rio Iori, um dos rios mais importantes da Geórgia. Além da Geórgia, este rio é presente no Azerbaijão. O estudo desse rio é crucial, pois a LLC *United Water Supply Company* da Geórgia organiza o abastecimento de água das grandes cidades e vilas da Geórgia através da água do Iori. Além disso, a população de duas grandes aldeias usa independentemente a água do rio para várias atividades domésticas: lavagem (lavanderia, produtos, louças), fornecimento de água para animais e irrigação. Não sendo utilizada diretamente como água potável. A água do rio Iori foi monitorada em duas seções: vila Sasadilo e vila Sartichala. No total, foram coletadas 24 amostras ao longo dos anos de 2018 e 2019. Alguma parte da pesquisa foi realizada no local através do instrumento HI83399-02 | Multiparâmetro para água e esgoto (com COD) Fotômetro e medidor de pH. Esses estudos incluíram pH, DBO e a temperatura foi medida diretamente durante a amostragem. O mesmo dispositivo foi usado para medir concentrações aproximadas de metais pesados. Na etapa seguinte do estudo, foi realizada uma pesquisa entre os habitantes para identificar seus conhecimentos sobre questões de limpeza e segurança ambiental. Como resultado do estudo, foi recomendado para a população abster-se ou restringir o uso de água do rio não tratada diretamente nas domesticidades. Os resultados da pesquisa mostraram que a população tem menos informações sobre a probabilidade de reter metais pesados no corpo e desenvolver doenças tumorais.

Palavras-chave: *Poluição da água, Contaminantes, Bacia hidrográfica, Produtos químicos tóxicos, pesquisa de habitantes.*

ABSTRACT

The article examines the chemical pollution of the Iori River, one of the most important rivers in Georgia. In addition to Georgia, this river is found in Azerbaijan. The study of this river is crucial as LLC *United Water Supply Company* of Georgia organizes the water supply of big cities and villages of Georgia through Iori water. Furthermore, the population of two big villages independently uses the river water for various household activities: washing (laundry, products, dishware), livestock watering, and irrigation. They do not use it as drinking water. The water of the Iori River was monitored in two sections: village Sasadilo and village Sartichala. In total, 24 samples were taken over the course of 2018 and 2019 years. Some part of the research was conducted on the site through HI83399-02 | Water & Wastewater Multiparameter (with COD) Photometer and pH meter device. These studies included pH, BOD, and the temperature was measured directly during sampling. The same device was used for measuring approximate concentrations of heavy metals. At the next stage of the study, an inhabitants survey was conducted to identify their knowledge of environmental cleanliness and safety concerns. As a result of the study, our recommendation to the population is to refrain or restrict the use of untreated river water directly in domesticities. The results of the survey showed that the population has less information about the likelihood of getting heavy metals in the body and developing tumor diseases.

Keywords: *Water pollution, Contaminants, River basin, Toxic chemicals, inhabitants survey.*

რეზიუმე

სტატიაში შესწავლილია საქართველოს ერთ-ერთი მნიშვნელოვანი მდინარის იორის ქიმიური დაბინძურების მონიტორინგი. ეს მდინარე საქართველოს გარდა აზერბაიჯანში გვხვდება. მისი კვლევა მნიშვნელოვანია, რადგან იორიდან შპს საქართველოს გაერთიანებული წყალმომარაგების კომპანია, ორგანიზებას უკეთებს დიდი ქალაქებისა და სოფლების მოსახლეობის წყალმომარაგებას. გარდა ამისა, ორი დიდი სოფლის მოსახლეობა დამოუკიდებლად იყენებს მდინარის წყალს სხვადასხვა საოჯახო საქმიანობისთვის: რეცხვისთვის (სარეცხი, პროდუქტი, ჭურჭელი), საქონლის დასარწყულებლად და მოსარწყავად. სასმელ წყლად არ იყენებენ. მდ. იორის წყალზე დაკვირვებას ვაწარმოებდით 2 კვეთზე: ს. სასადილო და ს. სართიჭალა. სულ აღებული იქნა 24 სინჯი, 2018 და 2019 წლის განმავლობაში. კვლევის ნაწილი შესრულდა ადგილზე HI83399-02 | წყლის და ჩამდინარე წყლების მულტიპარამეტრული ფოტომეტრული საზომი აპარატით და pH საზომით. ეს კვლევები იყო pH, ჟანგბადის ბიოლოგიური მოხმარება, ტემპერატურა უშუალოდ სინჯების აღების დროს გაიზომა. ამავე აპარატით გაიზომა მძიმე მეტალების სავარაუდო კონცენტრაციები. კვლევის შემდეგ ეტაპზე ჩატარდა მოსახლეობის გამოკითხვა, რომლის მიზანიც იყო გამოვლენილიყო მათი ცოდნა გარემოს სისუფთავის და სახფრთხეების შესახებ. კვლევის შედეგად, მოსახლეობისადმი ჩვენი რეკომენდაციაა, რომ გაწმენდის გარეშე თავი შეიკავონ ან შეზღუდონ მდინარის წყლის გამოყენება უშუალოდ ოჯახის საქმეებში. გამოკითხვის შედეგებმა აჩვენეს, რომ მოსახლეობას ნაკლები ინფორმაცია აქვს მძიმე მეტალების ორგანიზმში მოხვედრასა და სიმსივნური დაავადებების წარმოქმნის ალბათობის შესახებ.

საკვანძო სიტყვები: წყლის დაბინძურება, დამაბინძურებლები, მდინარის აუზი, მომწამლავი აგენტები, მაცხოვრებელთა გამოკითხვა.

1. INTRODUCTION:

Recent developments have made it clear that human health, the stability of the country, and the stability of the world may be threatened by various epidemics. The cleanliness of water resources is of particular importance in terms of the spread of various poisonous contaminants. Even if a disease-causing agent is transmitted by airborne droplets, frequent hand washing is recommended according to the recommendations issued by the World Health Organization, 2017. Moreover, for this, clean water is needed (Matthew, Freeman, 2017; Sharma, Bhattacharya, 2017; Daughton, 2004).

Added to this is the growing shortage of freshwater on the planet. Increased demand for global water threatens biodiversity and water supply for food production, other vital human needs. Water scarcity already exists in many regions of the world, with more than one million people left without drinking water (Lomsadze, Makharadze, 2016; Sammons, Maceina, 2009; Danyer, Arda, 2018). Also, 90% of infectious diseases in developing countries are transmitted by water, because in some cases, contaminated water is used for drinking and washing. Sometimes the problem is that people do not have complete information about the dangers of polluted water and they use it.

Consequently, the cleanliness and monitoring of the country's surface waters, i.e., rivers and lakes, take on enormous importance. Especially if the river water is used by inhabitants (Kupatadze, Kiziloz, 2019; Kupatadze, 2018; Abhijit, Ranju, 2012).

Georgia is rich in rivers and lakes, the water of which is used by the population to drink, prepare food, wash products, do housework, and irrigate. See the list of the main rivers of Georgia in Table 1.

This time, the purpose of our research was to study the chemical composition and the degree of water pollution in the Iori River.

Currently, LLC United Water Supply Company of Georgia (<http://water.gov.ge/eng/>) operates all over the area of Alazani and Iori, organizing water supply for large cities and villages.

Surface and underground waters are used for water supply. However, their quantity is not enough for the population today. Therefore, in near-by medium-sized villages, water obtained directly from the river, the so-called Rural Water, though not for drinking, is used for all the rest needs. It is used for washing dishes, fruits, vegetables, and other food products, as well as for irrigation.

For this very reason, monitoring of the degree of pollution is essential.

Iori (Fig.1) is the river flowing in Georgia and Azerbaijani. It originates on the southern slope of the Caucasus, near the peak Borbalo, at an altitude of 2600 m above sea level. In the upstream, it flows into the gorge, in the middle, it crosses the Samgori Cave, ultimately joining the Mingachevir reservoir. In the past, Iori used to join the Alazani River on the right side. It is fed from snow and rain waters. Iori has South-East direction. In the beginning, Iori Valley has the shape of a narrow and deep mountain valley, then it passes into Tianeti Valley, with two tributaries flowing into it, ending in the Zion Valley, where the Sioni Reservoir is located. Iori River divides Iori Plateau into two parts: Iori-Alazani and Iori-Mtkvari. On the left bank of the Iori River, humus-sulfate, and saline soils are widespread (Pistric, Klaus, 1989; William, David, 1971).

There is a regulating Sioni Reservoir constructed on the Iori River. Tbilisi Reservoir or "Tbilisi Sea" was formed by Iori water. Dali Mountain Reservoir is constructed in the downstream of the Iori River, with a water volume of 140.0 km³. More than 90 thousand hectares are irrigated by the Iori River on the Iori plateau. Several irrigation systems have been built on the river, central of which are the upper and lower water mains.

Figure 1. Iori river

2. MATERIALS AND METHODS:

The water of the Iori River was monitored at 2 sections: village Sasadilo and village Sartichala. In total, 24 samples were taken over the course of 2018 and 2019 years. Some part of the research was conducted on the site through HI83399-02 Water & Wastewater Multiparameter (with COD) Photometer and pH meter device. These studies included pH, BOD, and the temperature was measured directly during

sampling. The same device with special analytical reagents (HI-93746-03, HR-HI-93709-01HR, HI-93721-01, HI-93731-01, HI-93737-03) was used for measuring approximate concentrations of heavy metals (Pb, Mn, Fe, Zn, Cu).

It is very convenient to use the above-mentioned equipment to do the analysis directly from the source of research material (directly from the river in our case). This photometer features an innovative optical system that uses LEDs, narrow band interference filters, focusing lens, and both a silicon photodetector for absorbance measurement and a reference detector to maintain a consistent light source ensures accurate and repeatable photometric readings every time. Selecting the pH measurement mode allows for the photometer to be used as a professional pH meter with many features, including temperature compensated measurements, automatic two-point calibration.

Analysis for defining the ammonium nitrogen were also performed with HI83399-02 | Water & Wastewater Multiparameter using appropriate reagents. Analysis of total alkalinity and acidity, cations, and anions were performed in the laboratory of Ilia State University. Their protocols are based on the methodology of analytical chemistry, mainly on qualitative (colorimetric) and quantitative analysis (titrimetric).

Alkalinity is a measure of a river's "buffering capacity" or its ability to neutralize acids. Alkaline compounds in the water, such as bicarbonates, carbonates, and hydroxides, remove H⁺ ions and lower the acidity of the water (which means increased pH). This is usually done by combining with the H⁺ ions to make new compounds. Without this acid-neutralizing capacity, any acid added to a river would cause an immediate change in the pH. Measuring alkalinity is important to determine a river's ability to neutralize acidic pollution (as measured by pH) from rainfall or snowmelt. It's one of the best measures of the sensitivity of the river to acid inputs. Alkalinity comes from rocks and soils, salts, certain plant activities, and certain industrial wastewater discharges. The result is reported as milligrams per liter (mg/l) of calcium carbonate.

Acidity is the quantitative expression of water's capacity to neutralize a strong base to a designated pH and an indicator of how corrosive water is. Acidity can be caused by weak organic acids, such as acetic and tannic acids, and strong mineral acids, including sulfuric and hydrochloric acids; however, the most common source of acidity in unpolluted water is carbon dioxide in the

form of carbonic acid. Standard Methods for the Examination of Water and Wastewater (Standard Methods) recommends titration with sodium hydroxide to an endpoint pH of 3.7 to determine mineral acidity. Titrate to pH 8.3 to determine total acidity (Bhatia, 2013; Lopes, 2017; VanLoon, 2011; Sutton, 2008; Rawn, 2004).

In general, the existence of an ecologically educated population is vital (Lui, 2009; Cross, 2007; Henjum, Barikkmo, 2010). Therefore, in parallel with sampling and analysis, we conducted the inhabitant survey. See the questions in Table 2.

3. RESULTS AND DISCUSSION:

In general, the oxygen content in the samples taken was satisfactory. BOD varied within 0.64 – 1.83 mg/l. The nitrogen content of ammonium ranged from 0.016 to 1.672 mg N/l and exceeded the maximum allowable value in five samples. Its average annual concentration was 0.348 mg N/l. The maximum value of 1.672 mg N/l (4.3 maximum allowable concentration (MAC) was observed in January 2019). Mineralization ranged from 203.34–429.65 mg/l. The maximum value 429.65 mg/l was registered in Sartichala. The maximum concentrations of iron and manganese in just one sample exceeded the allowable value. Iron levels ranged from 0.0455 to 4.1684 mg/l. Its average annual concentration amounted to 0.8106 mg/l (2.1 MAC). The maximum value 4.1684 mg/l (13.9 MAC) was registered in September of 2019 by village Sartichala.

It should also be noted that iron (II) compounds are mainly found in groundwater. They are found in water as a result of iron-containing rocks washed out by acids. These acids may be carbonic dioxide or humic acid.

Iron (III) compounds are present in surface waters, however, not in large quantities. They are formed by hydrolysis of salts. Iron ions in water are mainly composed of complexes formed with humic acid, and such water is slightly brown if the content of iron ions exceeds 0.3 mg/l, the water tastes of iron.

The manganese content ranged from 0.0032–0.5974 mg/l. Its average annual concentration amounted 0.1057 mg/l (1.1 MAC). The maximum value of 0.5974 mg / l (6.0 MAC) was observed in September 2019. Concentrations of nitrite and nitrate nitrogen, phosphates, sulfates, chlorides, lead zinc, and copper did not exceed the maximum allowable concentrations.

A total of 12 samples were taken from the lori River, in Sartichala village (Table 3). The oxygen content was satisfactory. BOD varied within 0.64–1.83 mg/l. The nitrogen content of ammonium ranged from 0.047 to 1.672 mg N/l. Its average annual concentration reached 0.445 mg N/l (1.1 MAC). The maximum value of 1.672 mg N/l (4.3 MAC) was observed in January. Mineralization ranged from 231.01–429.65 mg/l. The maximum value was 429.65 mg/l in May. Iron content ranged from 0.0901–4.1684 mg/l. Its average annual concentration was 1.4976 mg/l (5.0 MAC). The maximum value of 4.1684 mg/l (14 MAC) was observed in September. The manganese content ranged from 0.0086–0.5974 mg/l. Its average annual concentration was 0.2068 mg/l (2.1 MAC). The maximum value of 0.5974 mg/l (6.0 MAC) was observed in September. Concentrations of nitrite and nitrate nitrogen, phosphates, sulfates, chlorides, lead, zinc, and copper did not exceed the maximum allowable concentrations.

In total, 12 samples were taken from the lori River in Sasadilo village (Table 4). The oxygen content was satisfactory. BOD varied within 0.72–1.51 mg/l. The nitrogen content of ammonium ranged from 0.016 to 0.505 mg N/l. Its average annual concentration was 0.250 mg N/l. The maximum value of 0.505 mg N / l (1.3 MAC) was observed in March, and it exceeded the limit only once. Mineralization ranged within 203.34–332.32 mg/l. The maximum value was 332.32 mg / l in May. Concentrations of nitrite and nitrate nitrogen, phosphates, sulfates, chlorides, iron, lead, zinc, copper, and manganese did not exceed the maximum allowable concentrations.

As can be seen from the data, heavy metals are present in the water, albeit within the permissible norm.

According to the study (Kiziloz, 2018; Kupatadze, Kiziloz, 2019), the possible impact of heavy metals on human health can be calculated by using equation (1).

$$ADIW_{ing} = C \times IR \times EF \times ED / BW \times AT \quad (Eq.1)$$

Where, $ADIW_{ing}$ is the average daily intake of heavy metals ingested from water (mg/kg-day), C is the heavy metal concentration in water ($\mu\text{g/L}$). IR is the daily intake of water, approx. 2l/day. ED is the exposure duration, approx. 80 years. EF is the exposure frequency, 365 days/year. AT is the period over which the dose is averaged, $365 \times 80 = 29.200$ days. BW is the bodyweight of the exposed individual (75kg approx.).

At the same time, by Equation 2, e.g., "Hazard quotient" (HQ) can also be calculated.

$$HQ=ADI/RfD \quad (Eq.2)$$

Were, ADI is the value obtained from the previous equation. RfD is chronic reference dose values are generally calculated.

For the studied water samples, the values calculated through Equation 1 and 2 are given in Tables 5 and 6.

Table 5. ADIW and HQ values for some hazardous metals in lori water Sasadilo

Ions of heavy metals	ADIWing		HQ	
	2018	2019	2018	2019
Pb	34.66	57.1	3.46	5.71
Mn	15.024	15.93	0.3004	0.3186
Fe	107.8	111.1	539	555.7
Zn	26.66	27.2	26.66	27.2
Cu	320	293	3.2	2.93

Table 6. ADIW and HQ values for some hazardous metals in lori water Sartichala

Ions of heavy metals	ADIWing		HQ	
	2018	2019	2018	2019
Pb	34,6	74.6	3.46	7.46
Mn	14.17	15.93	0.2834	0.3186
Fe	107.7	111,1	538	555.7
Zn	26.66	27.2	26.66	27.2
Cu	293	373	2.93	3.73

Inhabitant survey

At the second stage of the study, we conducted the inhabitant survey, wondering what they knew about water intake rules and clean water, what information they had about water-borne diseases, or the likelihood of causing such an incurable disease as a malignant tumor. According to the Statistics Office of Georgia, 8731 cases were registered in Georgia in 2018 and 10402 new cases - in 2019.

The results of the survey were included in

Table 7.

The survey clearly showed that the population of Sasadilo and Sartichala villages have little idea that the use of water contaminated by heavy metals, even for irrigation or washing, is linked to the development of malignant tumors.

They are more or less aware of the importance of drinking water and the daily norm of water intake. Only 20% know that water containing chlorine ions cannot be boiled twice. That is, if the water is boiled once to make tea or other hot beverages, the residual water should not be boiled again, because chlorine ions form carcinogen with chromium, which is likely to be present in water, and may trigger cancer in the body over the years.

If the water contains chlorine or the chlorine is used for water disinfection, can it still be boiled for hot drinks after boiling.

4. CONCLUSIONS:

Thus, the chemical composition of the water of lori River was monitored in two villages.

The study showed that the main contaminants are: ammonium nitrogen, heavy metals. They do not go far beyond the standard. However, according to the values obtained through the relevant formula, the use of such untreated water in household activities is not recommended.

Also, the overall acidity, alkalinity, and mineralization range within the expected conditions.

Our recommendation to the population is: not to drink water (so-called rural water) entering the yards directly from the river without filtration.

The inhabitants survey showed that the population still needs a lot of educational work to make each of them environmentally educated.

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Table 1. River of Georgia

Rivers	Length of river, km	Space of water collecting basin, km
Alazani	366/362 (The total length of river/ length on Georgian territory)	1180
Mtkvari	1515/351 (The total length of river/ length on Georgian territory)	188000
Iori	320	4650
Ktsia-Khrami	205/201 (The total length of river/ length on Georgian territory)	8340
Algeti	118	763
DidiLiakhvi	98	2440
Ksani	84	885
Faravani	74	2350
Aragvi	66	2740
Mashavera	66	1300
PataraLiakhvi	63	513
tethami	51	404

Table 2. Survey questions

Questions
Do you think water is important for health?
How much water should we get during a day
If the water contains chlorine or is disinfected with chlorine, can it still be boiled for hot drinks after boiling?
What's the connection is between heavy metals in water and the probability of getting cancer?

Table 3. The Results from Sartichala village

Sartichala	Unit	Stan dard	2018		2019	
			Max	Min	Max	Min
BOD			1.930	0.78	1.730	0.69
pH	-	6-9	6.2	7.4	7.1	6.32
mineralization	Mg/l		429.65	231.01	412.00	215.9
Fe	mg/L	0.2	4.0423	0.0455	4.1684	0.0901
Mn	µg/L	50	0.5314	0.0042	0.5974	0.0086
Ammonia Nitrogen (NH ₃ -N)	mg/L	0.2	1.672	0.047	1.668	0.045
Cu	mg/L	100	11	1,7	14	1.567
Zn	mg/L	1	1	0.01	1,02	0,07
Pb	µg/L	10	1.3	0.43	2.8	1.04
Alkalinity	mg/L	<200	3,46	2,31	3,05	1,86
Acidity	mg/L	<300	0,5	0,32	0,73	0,22
Cl	mg/L	250	3.0	5.7	3.8	11.9

Table 4. The Results from Sasadilo village

Sasadilo	Unit	Standart	2018		2019	
			Max	Min	Max	Min
BOD			1.830	0.64	1.810	0.58
pH	-	6-9	6-9	7.8	7.9	6.1
mineralization	Mg/l		332.32	203.34	342.01	198.1
Ammonia Nitrogen (NH ₃ -N)	mg/L	0.2	1.672	0.047	1.668	0.045
Fe	mg/L	0.2	4.0423	0.0455	4.1684	0.0338
Mn	µg/L	50	0.5634	0.0032	0.5974	0.123
Cu	mg/L	100	12	0	11	0.5974
Zn	mg/L	1	1	0.01	1	0,01
Pb	mg/L	10	2.3	0.5	2	0.34
Alkalinity	mg/L	<200	3,85	2,01	3,5	1,97
Acidity	mg/L	<300	0,7	0,54	0,67	0,53
Cl	mg/L	250	5.0	4.0	23.8	15.9

Table 7. The survey results

Questions	Answers		
	yes	No	No idea
In your opinion water is important for the health?	96%	2%	2%
If the water contains chlorine or disinfected with chlorine, can it still be boiled for the second time after boiling?	20%	80%	---
	2 liter	1 liter	It's up to you
How much water should we drink during the day	89%	5%	4%
	Can cause cancer	No lincage	No idea
What is the connection between heavy metals in water and the likelihood of cancer	25%	35%	30 %