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The influence of ecochemical and ecotoxicological factors on the water of the Kisishkevi River

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Abstract

This study examines the ecochemical and ecotoxicological conditions of the Kisishkevi River's water. The research was conducted in compliance with normative documents. For chemical analysis, both qualitative chemical experiments and mobile water quality analyzers, adhering to international standards, were employed. The results were evaluated in accordance with Georgia's environmental protection regulations. Parameters such as pH, mineralization, and dissolved oxygen were found to be within the permissible concentration limits for surface water, remaining within acceptable norms. However, in two seasons of the year, biological consumption of oxygen exceeded the standard levels for unpolluted waters. Notably, an increase in NO_3- (nitrate) pollution was observed, with organic pollution levels rising from 40.1 mg/l to 63.2 mg/l. To maintain the ecological health of small rivers like the Kisishkevi, regular water quality monitoring is recommended.

Keywords: River Water; Ecochemistry; Pollution; Health

1. Introduction

The primary sources of water body pollution include runoff from agricultural areas, household and industrial waste, landfills, and communal sewage. These pollutants introduce large quantities of biogenic substances into water bodies, leading to the accelerated growth of algae (eutrophication). This process can result in oxygen release in the water, ultimately disrupting and potentially destroying aquatic ecosystems. Pollutants such as household waste, industrial runoff, and rainwater affect both the chemical and bacteriological composition of water. The accumulation of chemical substances in water bodies contributes to significant ecological changes. Fortunately, water has a natural self-cleansing ability to some extent. [1,2]

Household wastewater, in particular, introduces fecal contamination into watercourses, fostering the growth of pathogenic microorganisms that can spread infectious diseases. In polluted rivers, the diversity of hydrobionts (aquatic organisms) may decrease, while organic and toxic substances are released. These pollutants affect organisms at all

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trophic levels of the ecological pyramid, potentially impacting the entire food chain. As illustrated, water pollution often leads to undesirable ecological and health consequences. [3,4]

The purpose of this research was to study the mineralization of the water in the Kisishkevi River, considering the geographical and socio-economic conditions of the village of Kisishkevi. Additionally, the study examined the river's ecochemical and ecotoxicological status.

1.1. Research Object and Methods

The object of this research is the Kisishkevi River, located in the Telavi municipality. The river originates on the northeastern slope of the Gombor Ridge, 1,755 meters above sea level, and joins the Alazani River from the right. It has a length of 37 km and a basin area of 142 km^2. The river is fed by rain, snow, and underground water.

On the left bank of the river lies the village of Kisishkevi, where the inhabitants use the river water for irrigation and bathing. The river is polluted by household sewage, runoff from animal stalls, and agrochemicals used in agriculture. It is important to note the significant anthropogenic impact on the Kisishkevi River, particularly due to the absence of a proper sewage system in the village. The sewage system is open, the river valley serves as a garbage dump, and the riverbank is a resting area for animals. Therefore, these factors play a major role in the pollution of the Kisishkevi River. Based on the issues outlined above, fieldwork was conducted on the river in the spring and summer of 2023. The analyses were performed using modern methods and equipment in accordance with European standards.

2. Research Methods

We conducted river water research in accordance with normative documents (General Requirements for Water Sampling SSM, No. 26.2014.03.01). Surface samples were taken at a depth of 10-15 cm from the water surface [5].

The main physical and chemical indicators of water quality were determined using a Horiba W22-7. Oxygen levels were monitored with a platinum electrode on a potentiometer. The processing of experimental data was carried out using both parametric and non-parametric statistical methods.

For chemical analysis, we employed qualitative chemical experiments and mobile water quality analyzer tools, including a pH Meter $^0C/^0F$-HI 98128 (Manufacturer: Company, Hanna Instruments, USA) and DREL/2400 (Manufacturer: Hach Company, USA), both of which conform to international standards. The obtained results were evaluated according to the environmental protection normative documents valid in Georgia.

The determination of suspended particles was performed using gravimetric analysis, following the ISO 11923:1997 standard, which is the most traditional and accurate method for such determinations [6]. This method involves separating the suspended particles from the sample through filtration and, after drying, weighing the precipitate on the filter until a constant weight is achieved.

3. Research Results and Discussion

To fully assess the ecological condition of the Kisishkevi River, we studied its mineralization process. Soil, climatic, and anthropogenic factors play a significant role in shaping the chemical composition of the river water.

Nine observation locations were marked along the entire length of the river, where water samples were taken, with the corresponding locations indicated. The pH of the water was measured at each water sampling site. Qualitative chemical analysis experiments were used to determine the organoleptic parameters of the water (see Table 1).

Table 1 Mineralogical characteristics of the Kisishkevi River – 2023

Water Physical Chemical Indicators/ Sample No.	Sampling time	Smell	Coloration	Transparency	PH	Biological consumption of oxygen mg/l	Oxidation mg/l	Dissolved oxygenmg/l		Substances that been treatedmg/l	Chemical consumption of oxigen mg/l	
Sample №1	Spring 9^0 C			0	10	7.8	7,1	2,3	2,5	7,9	65	1.6
	Summer -13^0 C			0	10	7.9	7,5	2,1	2,2	7,0	63	1.3
Sample №2	Spring - 9^0 C			0	10	7.8	7,7	2,4	2.5	7,7	63	1.9
	Summer - 13^0 C			0	10	7.6	7,9	2,1	2,.3	7,1	61	2.2
Sample №3	Spring - 9^0 C			0	10	7.8	8,1	2.3	3,.5	6,9	65	2.1
	Summer -13^0 C			0	20	7.9	7,9	1.9	3,1	6,7	64	2.3
Sample №4	Spring- 9^0 C			0	20	7,9	8,0	2,5	3.7	6,5	67	1.8
	Summer- 13^0 C			0	20	7.9	7,7	2,1	3.,2	6.3	73	2.2
Sample №5	Spring- 9^0 C			0	20	7.9	8,3	2,7	3,3	7,3	73	2.1
	Summer - 13^0 C			0	20	7.9	8.2	2,3	3,1	7,1	69	2.5
Sample №6	Spring- 9^0 C			0	20	7.9	8,7	1,5	2.1	7.5	77	1.7
	Summer -13^0 C			0	20	7.8	8,5	1,2	1,5	7,3	75	1.9
Sample №7	Spring - 9^0 C			0	20	7.9	8,5	1,2	2,1	8,5	79	1.9
	Summer -13^0 C			0	20	7.8	8,3	1,1	1,7	8,1	76	2.1
Sample №8	Spring- 9^0 C			0	20	7.6	8,6	1,4	2,1	8,9	78	2.2
	Summer-13^0 C			0	20	7.8	8,4	1,3	1,7	8,7	77	2.5
Sample №9	Spring - 9^0 C			0	20	7.9	8,2	1,6	2,5	7,2	80	1.7
	Summer-13^0 C			0	20	7,9	8,1	1,3	2,.3	6,9	77	11.9
MPC*				-	10	-	6,5-8,5	6,0	5.0	-	75	30

MPC* - Maximum permissible concentrations

As the research has shown, the river is characterized by moderate mineralization, with values ranging from 165-188 mg/l. Various floating impurities were observed on the surface of the river water, which hinder aeration, impede self-cleaning processes, and reduce the intensity of photosynthesis.

The Kisishkevi River is slightly polluted with ammonium (Ammonium ion). According to the technical regulation for surface water pollution protection in Georgia [7], a high level of ammonium ions in water—ranging from 0.41 mg/l to 0.49 mg/l—indicates the presence of organic compounds, most of which originate from untreated sewage waste. The discharge of large amounts of wastewater containing microorganisms and organic matter into the river leads to a deterioration of the chemical and biological quality of the river water.

Ammonium ions enter surface water through several pathways, including the biochemical degradation of proteins, deamination of amino acids, decomposition of urea, and the action of creatinine. Consequently, an increase in ammonium ion concentration is often observed during periods of organismal death, especially in areas where organisms congregate. High concentrations of nitrates, nitrites, and phosphates in water bodies contribute to the excessive growth of algae, leading to eutrophication.

The level of organic matter in water is measured by biological oxygen demand (BOD), which indicates whether there is a sufficient level of oxygen in the water after the decomposition of organic matter. According to Georgia's surface water pollution protection regulation [7], the BOD for unpolluted rivers is either 3 mg/l or 6 mg/l, depending on the category of the water body. In unpolluted rivers, the BOD is typically less than 1 mg/l. In our study, the maximum BOD value observed was 2.7 mg/l (5th sample), and no location had a BOD value of 1 mg/l or less (the lowest was 1.1 mg/l in the 7th sample), indicating moderate pollution of the river.

Table 2 Content of anions in the Kisishevi River water (mg/l) - 2023 (spring)

Sample number	NH_4^+ Ammonium mg/l	NO_2^- Nitrites mg/l	NO_3^- Nitrates mg/l	PO_4^{3-} Phosphates mg/l
Sample №1	0.19	0.00	40.1	0.01
Sample №2	0.23	0.00	41.3	0.01
Sample №3	0.31	0.00	42.5	0.01
Sample №4	0.31	0.00	43.0	0.02
Sample №5	0.35	0.00	44.4	0.02
Sample №6	0.39	0.00	49.7	0.01
Sample №7	0.41	0.00	63.0	0.01
Sample №8	0.40	0.00	58.8	0.01
Sample №9	0.49	0.00	63.2	0.021
MPC	0,39	0,08	40	3.5

Nitrates, nitrites, and phosphates primarily enter water bodies due to nutrient runoff from fertilized agricultural fields and municipal and industrial wastewater discharges. In our research, nitrate levels exceeded the norm, with concentrations of 42.0 mg/l (4th sample) and 63.2 mg/l (9th sample) (see Table N2), indicating a concerning level of river pollution [7]. Nitrates are especially toxic to humans. When the river water, used by the local population for irrigation, contaminates vegetable crops with excess nitrates, it poses a significant health risk. High nitrate intake in humans can lead to the transformation of hemoglobin into methemoglobin, which impairs the ability of red blood cells to transport oxygen from the lungs to other tissues

4. Conclusion

Based on the analyzed water quality indicators, the water in the studied sections of the Kisishkevi River falls into the category of moderately mineralized waters in the spring and highly mineralized waters in the summer. The results for pH, mineralization, and dissolved oxygen are within the permissible concentration limits for surface waters and do not exceed the standards. However, it is noteworthy that in all nine samples, across both seasons, the BOD values are slightly higher than those of unpolluted waters, which is significant.

As is often the case, pollution is lower at the river's headwaters and upper reaches, increasing downstream. Our research confirmed this pattern in the Kisishkevi River. The increase in organic parameters, particularly the NO_3^- (nitrate) levels, is alarming, as the nitrate concentrations in all nine samples exceed the acceptable norms.

Potential sources of pollution in the Kisishkevi River include untreated wastewater from household and communal complexes, as well as runoff from the village landfill, which is located near the riverbank.

To maintain a healthy ecological status, regular monitoring of small rivers is essential, as water quality and practical suitability are influenced by many interrelated factors. The study of natural water quality will continue to be a priority in future research.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

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