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Evaluation of heavy metal contamination in selected rivers of Kakheti

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Abstract

Water pollution is a significant ecotoxicological problem for the environment. Various toxic compounds discharged into water bodies disrupt the ecosystem's balance, reduce or completely destroy the self-cleaning ability of rivers, and decrease biodiversity. Priority pollutants include heavy metals, whose increased presence in the environment is particularly dangerous to human health.

The paper presents the ecochemical condition of two rivers in Georgia: the Turdo River and the Didkhevi River. Water analyses were performed using modern methods and equipment that meet European standards. Based on the results of hydrochemical analyses, it was concluded that the levels of heavy metals—specifically cadmium and copper—have increased to their maximum permissible concentrations in these natural waters. The Didkhevi River was found to be more polluted, with recorded cadmium levels at 0.005 mg/l and copper levels at 4.01 mg/l. In comparison, the Turdo River had slightly lower levels of these pollutants, with cadmium content observed at 0.0023 mg/l and copper at 2.15 mg/l.

Keywords: River; Pollution; Heavy metals; Copper; Cadmium.

1. Introduction

Water is a crucial factor in the formation of the physical and chemical environment, climate, and in maintaining life on Earth. It is an essential component in virtually all processes, both in agriculture and industry. [1]

Water pollution is a significant ecotoxicological problem for the environment. Due to anthropogenic impact, various biogenic or toxic compounds enter water bodies, disrupting the ecosystem's balance. This disruption decreases or completely destroys the self-cleaning ability of water bodies, reduces biodiversity, and impacts the variety of life forms (plants, animals, and microorganisms) on Earth. The deterioration of water quality, a global issue, is particularly pressing for Georgia. Recently, the nature and intensity of anthropogenic impact on Georgia's ecosystems have increased significantly. Ecochemical monitoring of natural waters is essential for assessing the current ecological condition of these environments. One of the main sources of chemical pollution in Georgia is ore and sand-gravel mining enterprises, which pose a significant risk to ecosystems, especially surface and underground waters. Main pollutants

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include heavy metals, whose increased presence in environmental elements and impact on food products are particularly dangerous to human health. [2,3]

2. Material and Methods

The aim of our research was to study the ecochemical condition of the Didkhevi and Turdo rivers in Eastern Georgia. The research focused on the Didkhevi River, a right tributary of the Lopota River, and the Turdo River, a right tributary of the Alazani River. The Didkhevi River originates on the southern slope of the Caucasus in Kakheti. It has a length of 19 km and a basin area of 94.6 km^2. The river is fed by snow, rain, and underground water, experiencing floods in the spring, short floods in the fall, and low water levels in the winter and summer. The average annual flow at the estuary is 2.84 m^3/s. The Turdo River originates on the eastern slope of Gombori Mountain and joins the Alazani River. It has a length of 32 km and a basin area of 114 km^2, and is fed by snow and rainwater.

We selected these rivers because in the village of Artana in the Telavi district, located on the right bank of the Didkhevi River, a copper processing point and a wood processing plant have been operating for years. Additionally, sand and gravel have been mined from the Turdo River for several decades. [4,5]

Fieldwork was carried out in the spring of 2023 to address the research objectives. Analyses were performed using modern methods and equipment that meet European standards. River water research was conducted in accordance with normative documents (General requirements for water sampling, Legislative Herald of Georgia, No 26.2014.03.01). Surface samples were taken at a depth of 10-15 cm from the water surface, and when necessary, samples near the bottom were taken at a height of 30-50 cm from the bottom. In reservoirs with a depth of at least 0.5 m, samples were taken using a sterile bathometer and sterile containers. The bathometer was sterilized by flambéing before each sample when taking multiple samples. The vessel was opened immediately before sampling, and after filling, it was closed with a sterile stopper. Water samples were acidified with HNO_3 and $HClO_4$ solution, dried, and then re-acidified with dilute nitric acid. [6] The concentration of heavy metals was determined using the atomic absorption method (Spectrometer type - AAnalyst 800 Perkin Elmer).

3. Results and Discussion

One of the main sources of soil, groundwater, and surface water pollution is the use of organic and inorganic fertilizers on farms. The Didkhevi River belongs to the weakly mineralized waters of the calcium carbonate group. Its hydrochemical regime is influenced by the proportion of atmospheric waters in the river balance. The Didkhevi River was polluted due to copper mining operations, while the Turdo River was polluted from sand-gravel mining activities. Additionally, pesticides and fertilizers used in agriculture contribute to the pollution of these rivers.

Table 1 Concentrations of copper and cadmium in the River Didkhevi water 2023

Cadmium (Cd) mg/L			
Didkhevi River			
Points located near the quarry	Upper side of vlg. Artan	Caucasus Slope	Middle of vlg. Artan
	0,005±0.00	0,0041±0.001	0,0032±0.001
A point located far from the quarry	Lower side of vlg. Artan	Upper side of vlg. Lechuri	Lower side of vlg. Lechuri
	0,0029±0.001	0,0021±0.001	0,0015±0.001
Control Point MPC 0,001mg/L			
Mg/L copper (Cu) content			
Points located near the quarry	Upper side of vlg. Artan	Caucasus Slope	Middle of vlg. Artan
	4,06 ±0.001	4,08 ± .001	
A point located far from the quarry	Lower side of vlg. Artan	Upper side of vlg. Lechuri	Lower side of vlg. Lechuri
	3,33 ± 0.001	2,26 ± 0.001	2,1± 0.001
Control Point MPC 1.0 mg/L			

*MPC – Maximum Permissible Concentration

Table 2 Concentrations of copper and cadmium in the river River Turdo Water 2023

Cadmium (Cd) mg/L			
Turdo River			
Points located near the quarry	Nearby area of vlg. Vardisubani	Upper side of vlg. Gulgula	Middle of vlg. Gulgula
	0,0023±0.001	0,0021±0.001	0,0019
A point located far from the quarry	Boundary of vlg. Vardisubani	Vlg. Mere	Shuamta
	0,0021±0.001	0,003±0.001	0,0012±0.001
Control Point MPC 0,001mg/L			
Mg/L copper (Cu) content			
Points located near the quarry	Nearby area of vlg. Vardisubani	Upper side of vlg. Gulgula	Middle of vlg. Gulgula
	2,15 ±0.001	2,11 ± .001	2,09 ±0.001
A point located far from the quarry	Boundary of vlg. Vardisubani	Vlg. Mere	Shuamta
	2,01 ± 0.001	1,27 ± 0.001	1,21± 0.001
Control Point MPC 1.0 mg/L			

Based on the obtained results of hydrochemical analyses of the studied natural waters, the following conclusions can be made:

In natural waters, an increase in the content of heavy metals—cadmium and copper—was observed at levels approaching the maximum permissible concentration.

Rivers contaminated with heavy metals show more significant pollution in the Didkhevi River, where cadmium levels were reported at 0.005 mg/L (0.001 mg/L permissible) in May 2023, and copper levels were at 4.01 mg/L (1.0 mg/L permissible).

In comparison, the Turdo River is slightly less polluted, with cadmium levels at 0.0023 mg/L (0.001 mg/L permissible) and copper levels at 2.15 mg/L (1.0 mg/L permissible).

4. Conclusion

The risk of high cadmium levels is associated with areas where minerals are extracted or processed. When cadmium enters the human body, it can damage the lungs, kidneys, central nervous system, cardiovascular system, and bones. Excessive concentrations of copper in the body affect the liver, kidneys, reproductive system, nervous system, musculoskeletal system, endocrine system, and respiratory organs. Therefore, additional research on vegetables, milk and meat products is also necessary. [7]

Regarding the impact of sand-gravel extraction enterprises, the formation of deep pits from their activities leads to the loss of valuable agricultural plants. Additionally, sand-gravel extraction can increase riverbank erosion, thereby reducing the area of land available for agricultural use.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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