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Spatial and Temporal Assessment of Physicochemical Water Quality Parameters in Selected Rivers of Georgia

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ABSTRACT

This study presents a comprehensive assessment of the water quality of several rivers in Western Georgia, namely the Pichori, Enguri, Mtkvari, and Tskhenistskali Rivers, based on organoleptic, physicochemical, elemental, biogenic, and sanitary-bacteriological parameters. The results revealed significant differences among the studied rivers in terms of mineralization, oxidizability, elemental composition, and microbiological status. The Enguri River exhibited relatively high concentrations of organic matter and biogenic nutrients, as well as the presence of total coliform bacteria and *Escherichia coli*. The Pichori River was characterized by elevated aluminum concentrations and microbiological contamination. In contrast, the Mtkvari and Tskhenistskali Rivers demonstrated comparatively favorable ecological conditions, reflected by lower pollution levels and bacteriological safety. Most heavy metals were either not detected in the analyzed samples or were present within environmentally acceptable limits. The obtained results indicate distinct spatial variations in river water quality across Western Georgia and emphasize the importance of regular monitoring for sustainable water resource management and ecosystem protection.

KEYWORDS: River water, water quality, sanitary-bacteriological analysis, Western Georgia

Relevance of the Study. Rivers represent one of the most important freshwater resources and are widely used for drinking water supply, agriculture, energy production, recreation, and the maintenance of ecological balance. Under current conditions, climate change, urbanization, industrial activities, and agricultural practices exert significant pressure on the quality of surface waters [1]. The rivers of Western Georgia are characterized by high hydrological and ecological significance; however, available information on their water quality is often fragmented and insufficient. Therefore, a comprehensive assessment of organoleptic, physicochemical, microelement, biogenic, and microbiological parameters of river water is of considerable scientific and practical importance. The obtained results are essential for water resource monitoring, environmental status assessment, and the development of effective environmental protection measures [2, 8].

Aim of the Study. The aim of the study was to assess the water quality of selected rivers in Western Georgia through a comprehensive investigation, compare the obtained results with environmental standards, and determine the ecological status of the studied water bodies.

Study Area and Research Objects. The study was conducted on water samples collected from four rivers in Western Georgia: the Pichori River (near Poti), the Enguri River (near the Enguri Hydropower Plant), the Mtkvari River (Tashiskari section), and the Tskhenistskali River (near the Vartsikhe Hydropower Plant, Baghdati Municipality). The collected samples were analyzed to determine their qualitative characteristics and ecological condition.

Research Methods. The following analytical methods were employed in the study: titrimetric methods [3, 4, 6], photometric methods [5], and inductively coupled plasma optical emission spectrometry (ICP-OES) [7]. These methods enabled the determination of key physicochemical parameters, biogenic compounds, and elemental composition of the water samples.

Material and Technical Base. The research was carried out at the Institute of Agrarian and Membrane Technologies of Batumi Shota Rustaveli State University (BSU), utilizing its laboratory facilities and analytical equipment.

I. ORGANOLEPTIC AND SELECTED PHYSICOCHEMICAL PARAMETERS OF RIVER WATERS (FIELD MEASUREMENTS)

According to the organoleptic assessment, the highest visual water quality was observed in the Enguri River, whose water was colorless, whereas the waters of the Pichori, Mtkvari, and Tskhenistskali Rivers exhibited a slightly yellowish or yellowish-green coloration (Table 1). No suspended particles were observed in the Pichori and Tskhenistskali Rivers, while their presence was detected in the Enguri and Mtkvari Rivers. In addition, the waters of the Enguri, Mtkvari, and Tskhenistskali Rivers were slightly turbid, which may be associated with the presence of suspended particulate matter.

Table 1. Organoleptic Characteristics of River Water Samples

Parameter	Location	Description	Standard
Color	*Pichori*	Yellowish-green	*Water should be visually clear and colorless, or exhibit only a very slight yellowish tint.*
	Enguri	Colorless	
	Mtkvari	Slightly yellowish	
	Tskhenistskali	Slightly yellowish	
Odor	*Pichori*	1	*0–2 points*
	Enguri	0	
	Mtkvari	1	
	Tskhenistskali	0	
Appearance	*Pichori*	No suspended particles observed	*Free from suspended particles, sediment, oily films, foam, and foreign impurities*
	Enguri	Suspended particles observed	
	Mtkvari	Suspended particles observed	
	Tskhenistskali	No suspended particles observed	
Transparency	*Pichori*	Clear	*Water should remain transparent to a depth of 0–20 cm from the surface*
	Enguri	Slightly turbid	
	Mtkvari	Slightly turbid	
	Tskhenistskali	Slightly turbid	

The pH values ranged from 6.0 to 8.3, which, in most cases, fall within the range typical of natural waters in Georgia (Table 2). The Enguri River was distinguished by the highest electrical conductivity and total dissolved solids (TDS) values (975 µS/cm and 350 mg/L, respectively), indicating a relatively higher degree of mineralization. The lowest concentration of dissolved oxygen was recorded in the Enguri River (3.12 mg/L), whereas the highest concentration was observed in the Tskhenistskali River (5.7 mg/L), suggesting a more favorable ecological condition of the latter.

Table 2. Physicochemical Characteristics of River Water Samples Determined under Field Conditions

Location	pH	Temperature (°C)	Air Pressure (mbar)	Electrical Conductivity (µS/cm)	Total Dissolved Solids (TDS, mg/L)	Dissolved Oxygen (mg/L)
Pichori	6.9	18.5	1015	263	140	4.74
Enguri	6.0	25.4	995	975	350	3.12
Mtkvari	8.3	21.4	942	282	150	4.56
Tskhenistskali	7.45	16.5	994.3*	245	130	5.70
Background Ecological Ranges	6.5–8.5	—	—	—	≤ 1 g/L	≥ 4 mg/L

II. PHYSICAL-CHEMICAL PARAMETERS OF RIVER WATERS (LABORATORY STUDIES)

Laboratory analyses showed that chloride content in all samples is significantly below the permissible limits, indicating the absence of anthropogenic saline pollution (Table 3). Water hardness was highest in the Tskhenistskali River (2.3 mg-eq/L) and the Mtkvari River (1.9 mg-eq/L). Notably, the oxidation index reached 10.4 mg O_2/L in the Enguri River, substantially exceeding the background ecological value. This result indicates a certain level of organic pollution in the water. In contrast, oxidation values in the Pichori, Mtkvari, and Tskhenistskali rivers are considerably lower, reflecting a better ecological condition.

Table 3. Physico-Chemical Parameters of River Waters

Location	pH	Cl^- (mg/L)	Hardness (mg-eq/L)	Oxidation (mg O_2/L)	F^- (mg/L)
Pichori	7.05	19.4	0.6	3.0	0.12
Enguri	6.0	5.35	0.63	10.4	0.25
Mtkvari	8.3	3.85	1.9	3.36	0.10
Tskhenistskali	7.5	1.90	2.3	2.4	0.06
Background ecological ranges	6.5–8.5	250	7–10 mg-eq/L	≤ 3.0 mg O_2/L	0.7

III. MULTI-ELEMENT ANALYSIS OF WATERS

The highest concentrations of calcium and magnesium were recorded in the Tskhenistskali River, which can be explained by the influence of carbonate rocks within the river's drainage basin (Table 4). The Mtkvari River was characterized by the highest sodium concentration (49.6 mg/L), while in the Enguri River, phosphorus levels exceeded the background ecological range, which may indicate increased nutrient loading and a potential risk of eutrophication.

Table 4. Macroelements (mg/L)

Location	Ca	Mg	Na	K	P
Pichori	6.0	3.6	9.05	2.13	0.0812
Enguri	7.35	3.12	0.0876	1,76	3.682
Mtkvari	9.28	2.75	49.6	1.63	0.259
Tskhenistskali	26.7	6.58	1.3	0.0689	0,056
Background ecological ranges	140	85	200	20	3.5

In the assessment of microelements, particular attention is drawn to the elevated aluminum concentration in all samples, especially in the Pichori River (13.7 mg/L), which significantly exceeds background values (Table 5). The Enguri River showed increased levels of iron (2.78 mg/L) and manganese (0.0638 mg/L). These data may be associated with both geological factors and anthropogenic impacts within the catchment area.

Table 5. Microelements (mg/L)

Location	Al	B	Fe	Mn	Mo	Si	Co
Pichori	13.7	0.005	0.0321	0.0009	-	4.62	-
Enguri	4.47	0.0112	2.78	0.0638 L	0.0039	14.1	0.0008
Mtkvari	2.259	0.0002 L	-	-	0.0061 L	0.0637	-
Tskhenistskali	8.56	0.0094	-	-	-	2.25	-
Background ecological ranges	0.5	0.5-1.0	0.3	0.05	0.07	10.0	0.1

The analysis of toxic elements showed that the concentrations of As, Ba, Li, and V in most cases do not exceed the background ecological ranges (Table 6). No Cd, Hg, Sb, Se, Be, Ni, Cu, or Zn were detected in the samples, indicating a low risk of heavy metal contamination.

Table 6. Toxic Elements (mg/L)

Location	As	Ba	Li	V	Ti
Pichori	-	0.268	0.0353	0.0073 L	-
Enguri	0.0083 L	0.268	0.0353	0.00112	0.205
Mtkvari	–	0.286 L	0.037.0	-	-
Tskhenistskali	0.0026 L	-	0.241	0.0027 L	-
Background ecological ranges	0.01	0.7 – 1.0	0.001 – 0.01	0.001	No regulatory limit has been established.

IV. BIOGENIC NUTRIENTS AND SANITARY-BACTERIOLOGICAL PARAMETERS

In the Pichori and Enguri rivers, the concentrations of ammonium and phosphates exceed background values. Notably, nitrite levels are particularly high in the Enguri River (0.60 mg/L), which may indicate contamination of domestic or agricultural origin (Table 7). Sulfate concentrations in all samples are significantly below the permissible limit values.

Table 7. Concentrations of Biogenic Nutrients (mg/L)

Location	NH_4^+	NO_2^-	NO_3^-	SO_4^{2-}	PO_4^{3-}
Pichori	0.30	0.09	0.05	60.12	0.30
Enguri	0.29	0.60	4.15	35.45	0.341
Mtkvari	0.049	0,28	1,15	8,33	0,15
Tskhenistskali	0.038	0.18	-	28.0	0.03
Background ecological ranges	0.05 – 0.2	0.2	45-50	250	0.1

Total coliform bacteria and *Escherichia coli* were detected in the Pichori and Enguri river waters, whereas these microorganisms were not found in the Mtkvari and Tskhenistskali samples (Table 8). Since current regulatory standards prohibit their presence in 300 mL of water, these results indicate microbiological contamination of the Pichori and Enguri rivers and highlight the need for additional monitoring and preventive measures.

Table 8. Selected Sanitary-Bacteriological Parameters of River Waters

Location	Total coliform bacteria	Escherichia coli
Pichori	Detected in 300 mL	Detected in 300 mL
Enguri	Detected in 300 mL	Detected in 300 mL
Mtkvari	Not detected in 300 mL	Not detected in 300 mL
Tskhenistskali	Not detected in 300 mL	Not detected in 300 mL
Standards	Not permitted in 300 mL	Not permitted in 300 mL

CONCLUSION

The conducted study demonstrated that the water quality of rivers in western Georgia is characterized by pronounced spatial variability, reflected in organoleptic, physico-chemical, multi-element, biogenic, and microbiological parameters. The Tskhenistskali and Mtkvari rivers show comparatively better ecological conditions, whereas signs of organic pollution, elevated biogenic nutrient levels, and microbiological contamination were detected in the Pichori River and especially in the Enguri River. These differences confirm the importance of spatial assessment of water quality for determining the ecological status of rivers. The obtained data also provide a basis for temporal evaluation of river water parameters, as water quality significantly changes over time under the influence of seasonal, climatic, and hydrological factors. Accordingly, for sustainable water resource management and timely identification of ecological risks, it is essential to implement multi-seasonal and multi-year monitoring, which would enable a comprehensive assessment of the spatial-temporal dynamics of water quality and the identification of long-term trends in its variation.

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