Asia Pacific Academy of Science Pte. Ltd.

Pollution Study 2024, 5(2), 3076.
https://doi.org/10.54517/ps.v5i2.3076

Review

Methodology and results of surface water quality monitoring in Georgia

Nodar Elizbarashvili[1], Gela Sandodze[2,*]

[1] Ivane Javakhishvili Tbilisi State University, Tbilisi 0179, Georgia
[2] National Environmental Agency, Tbilisi 0112, Georgia
*** Corresponding author:** Gela Sandodze, Gela.sandodze@gmail.com

CITATION

Elizbarashvili N, Sandodze G. Methodology and results of surface water quality monitoring in Georgia. Pollution Study. 2024; 5(2): 3076. https://doi.org/10.54517/ps.v5i2.3076

ARTICLE INFO

Received: 18 November 2024
Accepted: 23 December 2024
Available online: 30 December 2024

Abstract: The article reviews the existing methodology and results of monitoring the quality of surface waters in Georgia. It also discusses improving the existing monitoring network and its approximation to the EU Water Framework Directive. The monitoring results are related to water quality indicators (chemical analysis) and pollution assessment. Georgia stands out worldwide for its biological and landscape diversity, features of an ecologically clean natural environment, water resources and a history of agricultural development of several thousand years. Despite this, the indicators of chemical and biological pollution of water bodies are still high. In Georgia, the quality of water bodies is monitored in several dozen locations (points). The monitoring results are the subject of constant attention and discussion. The importance of water quality monitoring is increasing even more against climate change trends when the demand for both water resources and their quality is constantly growing.

Keywords: Georgia; surface water; monitoring; water quality; pollution

1. Introduction

Georgia is distinguished by several features of the ecologically clean natural environment in Europe. Here, a relatively small part of the territory has a strong anthropogenic impact, which is 5–7 times higher than in many European countries (The United Kingdom, the Benelux countries, Denmark, Italy, Germany, Poland, etc.) [1].

The geographic features of Georgia's hydrographic network are determined by relief conditions, the diversity of geological structures, climate, landscape and vertical zonality of the soil and vegetation cover. Each of these impacts the resources and distribution of land waters [1].

Georgia, as part of the Caucasus, is included in:

1) Among the 34 most biologically rich and endangered "hotspots" of the world;
2) Among the 200 most sensitive, vulnerable ecoregions of the world, distinguished by high biodiversity;
3) In the habitat of endemic birds;
4) Among the world centres of agrobiodiversity;
5) In the "hotspot" of the distribution of large herbivores.

The rivers of Georgia belong to the basins of the Black (Atlantic Ocean) and Caspian (inland continental) seas. There are more than 26,000 rivers here, most of which (65%) flow into the Black Sea basin. The total length of the rivers is up to 60,000 km. The average frequency of the river network (the ratio of the total length of rivers to the area of a given territory) is 0.85 km/km^2. Approximately 60%–70% of the annual flow of Georgian rivers is formed by meltwater. Georgia's potential hydropower resources exceed 160 billion kWh. Their largest part (60%) is concentrated in five rivers (Rioni, Mtkvari, Enguri, Kodori, Bzipi) [2].

In the communal economy and industry, springs, river filtrates and groundwater are used. 90 water pipelines are involved in the communal economy, the total length of which is 6 thousand km. 175 head structures are presented here, the total capacity of which is 2 million m^3 per day. The average water consumption per citizen in Georgia is 600 litres per day, which is a very high indicator in the world. The household sector accounts for 20% of all water used, while 30%–35% goes to industry [2].

Maintaining water sanitation [3] is important for the safety of the population and agricultural products. The situation is currently very difficult. Treatment plants operate in only half of the cities of Georgia, and even here half of the water consumed is not purified.

Surface water quality monitoring in Georgia [4] is carried out at 237 sites, which fully cover the main rivers of the Caspian and Black Sea basins. Monitoring includes the collection of water samples and subsequent laboratory analysis. Sampling is carried out using the point method under Resolution No. 26 of the Government of Georgia [5].

This monitoring is carried out by the National Environmental Agency of Georgia. The purpose of the monitoring is to identify water pollutants that may harm aquatic organisms and, accordingly, harm the environment. Ultimately, the results of this monitoring should be used to determine the ecological status of water bodies. Monitoring is carried out on water bodies represented in 6 river basins of Georgia, which cover the largest part of the country.

In 2023, Georgia adopted the Law on Water Resources Management. Through it, the legal foundations for water resource management were created in the country, ensuring the implementation of a unified state policy in the field of water resource protection and use. The law regulates the right of citizens to access clean water, the creation of a safe environment for human health and life, and the protection and sustainable use of water resources under the principles of integrated management [6].

In Georgia also valid environmental standards, that set thresholds for some chemical parameters (heavy metals, chemical parameters, etc.).

Monitoring results are published in the form of monthly newsletters and yearbooks, which are published on the agency’s website (Nea.gov.ge).

Below are the characteristics of the water bodies whose research results are presented in the article.

The Mashavera River is located in the Kvemo Kartli region (eastern Georgia). Its length is 66 km, and the catchment area is 1390 km^2. The river is fed by snow, rain and groundwater. In the river, floods happen in spring, while water shortage in winter. In spring and summer, 70% of the annual runoff flows, the majority of which is used for irrigation [7].

The mining and processing plant is located in the Mashavera River basin. Since 1975, it has been engaged in the extraction of copper, barite, gold-silver quartzites and polymetallic ores, primary processing, enrichment and sale of mined copper and barite ores. Ore mining is carried out in an open way, for this reason, water bodies are intensively polluted and the natural landscape is degraded.

There are 5 irrigation systems on the Mashavera River, which irrigate 5.5 thousand hectares of agricultural land. These lands partially provide vegetables and garden crops to the population of Georgia's largest urban agglomeration Tbilisi-Rustavi, where almost 1.5 million people live.

It is known that such enterprises have a negative impact on both the surrounding area and the region's ecosystems. Due to the peculiarities of the ore mining method, the main technogenic (caused by human agricultural activity) load falls on the region's hydrographic network and, accordingly, on the irrigation systems. strong technogenic impacts in the form of copper and cadmium, as well as zinc and cadmium on the Mashavera River. pollution of the irrigation system in the river basin leads to soil pollution with heavy metals [8].

Kumisi Lake is located in eastern Georgia, in a semi-arid climate zone, at an altitude of 475 m sea level. The surface area of the lake is 5.4 km^2, the basin area is 97 km^2, and the maximum depth is 4 m. The lake is fed by rainwater and small streams [9]. Currently, it is supplied with river water through artificial canals and water pumps. The reservoir is used for irrigation. The bottom of the lake is covered with sulfide mud with healing properties. Lake's mud is actively used at the Tbilisi balneological resort.

The length of the Kvirila River is 140 km, and the area of the basin is 3598 km^2. The river has 2906 tributaries of different orders, with a total length of 5254 km. The Chiatura manganese deposit is located in the river basin, the extraction of which is of global importance. It has been developed for over 150 years. Manganese deposits here are distinguished by the high quality of ore, large industrial reserves and a convenient geographic location. The distance from the deposit to the processing plant is 28 km, so in recent decades, the ore has been transported by road. This type of transportation increases the dispersion of ore in the environment and the pollution of surface waters. In recent years, the environmental damage associated with the exploitation of the Chiatura manganese deposit has exceeded several tens of millions of US dollars.

2. Materials and methods

In the article uses field research methods, theoretical research methods, comparative and analytical methods. Field research included sampling and subsequent laboratory analyses.

Based on the characterization and impact assessment carried out by Article 5 and Annex II of the EU Water Framework Directive (WFD), the following monitoring programmes can be defined for the period of the River Basin Management Plan (RBMP) [10]:

- Surveillance monitoring programme;
- Operational monitoring programme;
- If necessary, an investigative monitoring programme.

Currently, Operational and Surveillance monitoring is carried out in Georgia.

Surveillance monitoring is carried out monthly, i.e., 12 times a year, and operational monitoring is carried out 6 times a year (See **Figures 1** and **2**).

Monitoring of the study water bodies was conducted monthly from January to December 2023.

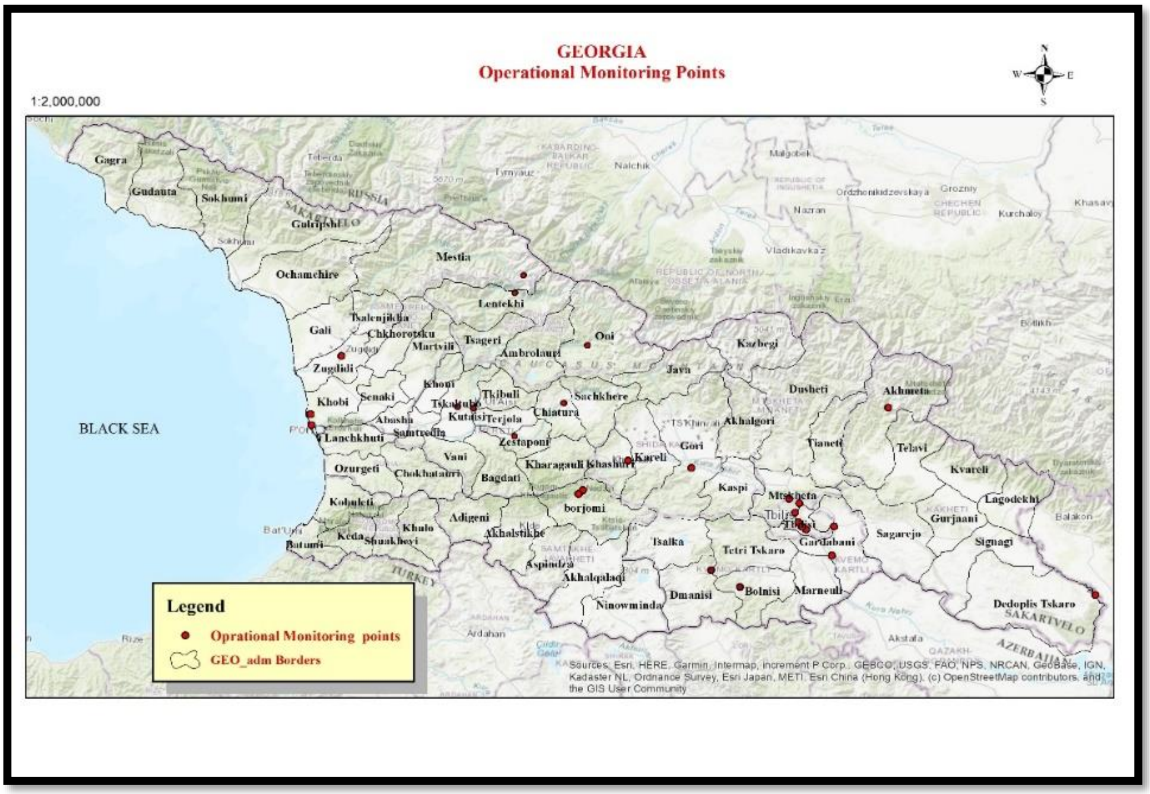

Figure 1. Operational surface water monitoring points of Georgia (Nea.gov.ge).

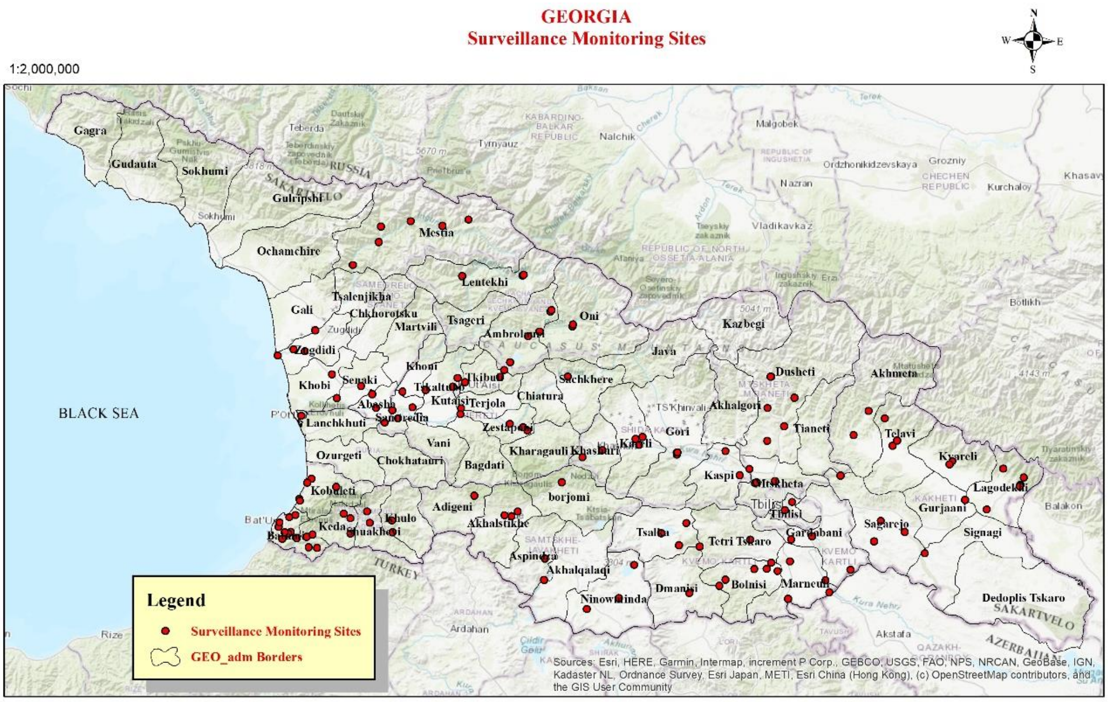

Figure 2. Surveillance surface water monitoring points of Georgia (Nea.gov.ge).

The ecological status and potential of water are determined at the monitoring site (points). Ecological status is related to biological quality elements, including phytoplankton, macrophytes and phytobenthos, macroinvertebrates and fish fauna.

The supporting elements for determining biological quality are:

- Physico-chemical parameters;

- Specific pollutants;
- Priority substances;
- hydro morphological quality elements (morphology and hydrological regime).

In Georgia, chemical parameters are determined for most rivers and microbiological parameters for several rivers.

During the field survey, five physico-chemical parameters are determined on-site using a portable water device WTW 3630: Dissolved oxygen, pH, salinity, water temperature and electrical conductivity (See **Figure 3**).

Figure 3. Field survey process of sampling (Nea.gov.ge).

Water samples are transported to the National Environmental Agency's atmospheric air, water and soil analysis laboratory, which is accredited. Refrigerated containers and water-freezing elements are used for transportation. Under the existing procedure, the maximum transportation period for a chemical sample is 24 h, and for a microbiological sample 4–5 h [5].

In the laboratory, determine the chemical parameters of the water composition: Ammonium nitrogen, cadmium, iron, manganese, mineralization, sulphates, and chlorides.

3. Results and discussion

In 2023, monitoring was carried out in all major rivers of the Caspian and Black Sea basins. We highlighted those rivers and lakes where the maximum indicators of chemical and biological pollution are observed. These include the Mashavera River and Lake Kumisi in eastern Georgia and the Kvirila River in Western Georgia. All the results presented in the article exceed the threshold.

3.1. River Mashavera

Table 1 presents the results of the analysis of 4 chemical parameters of the Mashavera River, which were conducted in the laboratory. All indicators presented in the table exceed the threshold.

Table 1. The highest concentrations of the Mashavera River [11].

month	parameters			
	Ammonium nitrogen (mgN/l)	**Iron (mg/l)**	**Cadmium (mg/l)**	**Manganese (mg/l)**
January	0.684		0.0145	1.1459
February	0.892		0.0073	0.6973
March	0.602		0.004	0.4885
April	0.448	0.3606		0.235
May	1.046	0.5795		
June	0.77		0.0019	0.1249
July	0.555			
August				
September	0.925			
October	0.538			0.2495
November			0.001	0.4872
December	2,432		0.0012	0.2077
Threshold	0.39	0.005	0.001	0.01

Pollution levels in the Mashavera River reach their maximum during the winter months (January–March) when the river is in a period of low water levels and heavy precipitation. As precipitation increases, the concentration of chemical compounds decreases, which is explained by the increased volume of water.

3.2. Kumisi Lake

Table 2 presents the results of the analysis of 4 chemical parameters of the Kumisi Lake, which were conducted in the laboratory. All indicators presented in the table exceed the threshold.

Table 2. The highest concentrations of Kumisi Lake [11].

month	parameters			
	Mineralisation (mg/l)	**Ammonium nitrogen (mgN/l)**	**Sulphates (mg/l)**	**Chlorides (mg/l)**
January	21,849.25		13,021.33	1621.723
February	19,169.59	3.879	11,524.61	1468.61
March	21,401.36	6.263	12,647.29	1584.18
April	10,530.25	4.001	13,097.45	1194.83
May	23,485.43	6.287	13,468.2	2265.02
June	21,403.78		14,312.01	935.92
July	11,756.75		5423.34	668.75
August	1771.05	0.868		734.04
September	18,905.98	2.968	600.82	526
October	22,978.13	6.525	1621.76	1063.74
November	7862.16	4.74	3617.85	1461.43
December	6822.02	6.09	3412.81	1073.44
Threshold	1000	0.39	500	300

The maximum concentrations of chemical composition in the lake are in the autumn-winter and early spring periods, which is associated with an intensive decrease in atmospheric precipitation.

Also, marsh vegetation is widespread in the lakeshore wetland. During the period of water shortage (winter and summer), the intensity of eutrophication processes increases. The small amount of precipitation (550 mm) and intensive evaporation (900–950 mm), as well as the intensive use of lake water resources for irrigation, lead to a periodic reduction in the area of the lake. Against climate change, a tendency to decrease in precipitation is observed, which further increases the intensity of eutrophication processes and the concentration of minerals.

3.3. River Kvirila

Table 3 presents the results of the analysis of 3 chemical parameters of the Kvirila River, which were conducted in the laboratory. All indicators presented in the table exceed the threshold.

Table 3. The highest concentrations of the Kvirila River [11].

month	**parameters**		
	Ammonium nitrogen (mgN/l)	**Iron (mg/l)**	**Manganese (mg/l)**
January	0.64	0.77	0.9114
February		0.31	0.3248
March	0.49		0.2899
April		0.31	0.275
May	0.49	0.35	
June	0.61	0.31	0.2196
July	0.41	0.62	0.4331
August	0.41	0.32	0.4399
September	0.49		0.4726
October			0.6021
November			0.1384
December			0.1102
Threshold	0.39	0.005	0.01

Pollution levels in the Kvirila River reach their maximum in the spring and autumn months (April–June, September–October), which is associated, on the one hand, with intensive melting of snow cover (spring), and on the other hand, with atmospheric precipitation (autumn). In both cases, a large amount of manganese is transported by surface waters, which affects the degree of chemical pollution of the Kvirila River.

Thus, atmospheric precipitation (climatic factor) is a direct form of natural impact on water bodies. Against climate change, the amount of precipitation in Georgia is decreasing, which negatively affects both the quantitative characteristics and the qualitative state of rivers and lakes.

4. Discussion

Thus, pollution levels in the Mashavera River reach their maximum during the winter months (January–March) when the river is in a period of low water levels and heavy precipitation. As precipitation increases, the concentration of chemical compounds decreases, which is explained by the increased volume of water.

The maximum concentrations of chemical composition in Kumisi Lake are in the autumn-winter and early spring periods, which is associated with an intensive decrease in atmospheric precipitation.

Also, marsh vegetation is widespread in the lakeshore wetland. During the period of water shortage (winter and summer), the intensity of eutrophication processes increases. The small amount of precipitation (550 mm) and intensive evaporation (900–950 mm), as well as the intensive use of lake water resources for irrigation, lead to a periodic reduction in the area of the lake. Against climate change, a tendency to decrease in precipitation is observed, which further increases the intensity of eutrophication processes and the concentration of minerals.

Pollution levels in the Kvirila River reach their maximum in the spring and autumn months (April–June, September–October), which is associated, on the one hand, with intensive melting of snow cover (spring), and on the other hand, with atmospheric precipitation (autumn). In both cases, a large amount of manganese is transported by surface waters, which affects the degree of chemical pollution of the Kvirila River.

Thus, atmospheric precipitation (climatic factor) is a direct form of natural impact on water bodies. Against climate change, the amount of precipitation in Georgia is decreasing, which negatively affects both the quantitative characteristics and the qualitative state of rivers and lakes.

Chemical monitoring is a key tool in assessing the status of water bodies. It also plays an important role in identifying anthropogenic pressures that may affect water quality. The chemical substances subject to monitoring should be reviewed and adjusted regularly to ensure the best possible assessment of surface waters.

According to the EU Water Framework Directive [12], the ecological status is defined as high, good, moderate, poor and very poor. For the overall ecological assessment, quality elements such as hydrobiological, hydromorphological and physicochemical elements are taken into account. It is important to note that biological quality elements play a decisive role in determining the ecological status of surface water bodies. Physicochemical and hydromorphological parameters are used to determine biological quality elements. At this stage, the ecological status of rivers in Georgia has not been established. Therefore, it is necessary to expand the monitoring network and increase its intensity, which should be in compliance with the EU Water Framework Directive.

Thus, the number of research parameters in the mentioned research objects exceeded the maximum permissible norm, and this is mainly related to the activities taking place in the regions. It is also worth noting the connection between the amount of precipitation and the increase in concentrations.

The results showed that research and geographical analysis in this direction are important promising issues for future studies. It is also necessary to strengthen chemical monitoring and analyze more parameters, this is necessary to determine the ecological status of water.

Monitoring surface water quality is an important issue in terms of water resources. Studies similar to ours have been conducted in many countries, which emphasizes its relevance. For example, some of the parameters and approaches we investigated are similar to those of the Liao River in China [13] and the Mekong River in Vietnam [14]. The results of the study show that the increase in the concentration of some parameters is caused by both natural and anthropogenic factors. The articles discuss parameters such as heavy metals, ammonium, etc.

The articles also emphasize the importance of monitoring, increasing the frequency and linking it to best practices. It should be noted that by increasing the use of best practices, scientific approaches and research priority parameters, it is possible to investigate all sources of pollution and achieve the desired result.

5. Conclusion

As a result of the research, the chemical parameters of the studied water bodies were compared with the Technical Regulations on the Protection of Surface Waters from Pollution in Georgia [15]. The results obtained show that intensive (monthly) pollution is presented by those water bodies whose catchment basins contain mineral resource deposits and irrigation systems.

The qualitative condition of the presented water bodies is unsatisfactory, which is mainly related to the anthropogenic factor. The results of the study show that specific actions should be planned to improve the condition of water bodies, which will be related to scientific, technical, economic and infrastructural activities. The need for this is clearly related to the trends of climate change, the consequences of which will lead to an ecological disaster for the considered water bodies.

Thus, the current monitoring in Georgia is being implemented and its goal is to meet the requirements of the European Union Water Framework Directive. The existing monitoring network is certainly imperfect, requiring the addition of stations, an increase in the frequency of monitoring and priority research parameters. As we have already mentioned, the results of chemical monitoring are needed to determine the ecological status of water, which is also mandatory according to the existing legislation in Georgia. Of course, a scientific approach is needed in this process. For example, we presented the relationship between the increase in concentrations and the amount of precipitation. Such a scientific approach (inter-component relationships) is necessary to obtain realistic results.

Conflict of interest: The authors declare no conflict of interest.

References

1. Elizbarashvili N, Meladze G, Khoetsyan A, et al. Sustainable development of Mountain regions and resource management. Dani; 2018. pp. 304.
2. Elizbarashvili N, Davitashvili Z, Sichinava D, et al. Public Geography of Georgia Textbook for students of higher education institutions. Ivane Javakhishvili Tbilisi State University Press; 2021. pp.334.
3. WHO. Drinking-water. Available online: https://www.who.int/news-room/fact-sheets/detail/drinking-water (accessed on 17 November 2024).

4. Coraggio E, Han D, Tryfonas T. Smart cities and hydroinformatics. Handbook of Hydroinformatics. 2023; 2: 341-355. doi: 10.1016/b978-0-12-821961-4.00029-4
5. Order of the Minister on Sanitary Rules for Water Sampling. Available online: https://www.matsne.gov.ge/ka/document/view/57166 (accessed on 17 November 2024).
6. Law of Georgia on Water Resources Management. Available online: https://matsne.gov.ge/ka/document/view/5846594?publication=0 (accessed on 17 November 2024).
7. EU Water Initiative Plus for the Eastern Partnership Countries (EUWI+), Development of the Khrami-Debeda River Basin Management Plan in Georgia, 2020. Available online: https://www.euwipluseast.eu/images/2021/05/PDF/Khrami-Debeda-RBMP-GE__29012021.pdf (accessed on 17 November 2024).
8. Available online: https://old.tsu.ge/science/?leng=ge&cat=jurnal&jnomeri=6&tid=3 (accessed on 17 November 2024).
9. Available online: https://georgiantravelguide.com/ka/kumisis-tba (accessed on 17 November 2024).
10. Guidance on surface water chemical monitoring under the water framework directive: Guidance Document No.19. Available online: https://op.europa.eu/en/publication-detail/-/publication/91d313f0-2cc7-4874-b101-a7dba97401b0 (accessed on 17 November 2024).
11. National Environmental Agency's Brief Overview of Environmental Pollution in Georgia Newsletter, 2023, N1-12. Available online: https://nea.gov.ge/Ge/Departments/Polution/Biulettins?year=2023 (accessed on 17 November 2024).
12. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Available online: https://eur-lex.europa.eu/eli/dir/2000/60/oj (accessed on 17 November 2024).
13. Zhang L. Different methods for the evaluation of surface water quality: The Case of the Liao River, Liaoning Province, China. International review for spatial planning and sustainable development. 2017; 5(4): 4-18. doi: 10.14246/irspsd.5.4_4
14. Nguyen TG, Huynh THN. Assessment of surface water quality and monitoring in southern Vietnam using multicriteria statistical approaches. Sustainable Environment Research. 2022; 32(1). doi: 10.1186/s42834-022-00133-y
15. Technical Regulations for the Protection of Surface Waters of Georgia from Pollution. Available online: https://www.matsne.gov.ge/ka/document/view/4207689 (accessed on 17 November 2024).