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Assessment of the ecological status of the water of Lake Lisi

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Abstract

The aim of the study was to assess the ecological condition of Lake Lisi water based on physicochemical, organoleptic, and microbiological indicators. The study was conducted seasonally throughout 2025 at two sampling zones of the lake: the pier-platform area and the reed-marsh zone. Water temperature, pH, dissolved oxygen, electrical conductivity, mineralization, turbidity, biological and chemical oxygen demand, biogenic elements, petroleum products, and microbiological parameters were investigated.

The results demonstrated that the ecological condition of Lake Lisi changes significantly according to seasonal variations. During the summer period, a decrease in dissolved oxygen and an increase in mineralization, BOD_5, COD, sulfates, phosphates, and petroleum products were observed, indicating increased organic and anthropogenic loading. Microbiological analyses revealed a significant increase in coliform bacteria and *E. coli*, particularly during summer and autumn.

The reed-marsh zone was identified as ecologically more vulnerable due to weak water circulation, accumulation of organic matter, and intensification of anaerobic processes. According to the recommendations of the European Union Water Framework Directive (WFD), the calculated pollution index indicated a high ecological risk in both study areas.

The obtained results emphasize the necessity of continuous ecological monitoring of Lake Lisi, control of recreational pressure, and implementation of effective ecological management measures for the shoreline and marshy zones.

Keywords: Lake Lisi, water quality, ecological condition, microbiological pollution, physicochemical indicators, anthropogenic impact.

Introduction

Water resources represent one of the most important factors in the social, economic, and ecological development of the modern world. Water is essential not only for public water supply, but also for agriculture, energy production, industry, and recreational activities. At the same time, the increasing anthropogenic impact on aquatic ecosystems remains a significant environmental issue. In particular, the assessment of the ecological condition of lakes and reservoirs is highly relevant, since they play an important role in the functioning of natural ecosystems and the preservation of biodiversity.

Aquatic ecosystems are affected by both natural and anthropogenic factors, including precipitation, surface runoff, livestock activity, sewage leakage points, and increased tourist pressure during summer [2;3;4]

The object of the study is Lake Lisi, located northwest of Tbilisi in a basin at an altitude of 624 m above sea level. The surface area of the lake is 0.47 km², the basin area is 16 km², the maximum depth is 4 m, and the water volume is 1.22 million m³. The catchment area covers 14.95 km², while the length of the largest tributary is approximately 5.6 km [1].

Lake Lisi is both a recreational and ecologically important water body. In recent years, the ecosystem of Lake Lisi has experienced increasing anthropogenic pressure associated with urbanization, infrastructure development, population growth, and intensified recreational activities.

The organoleptic, physicochemical, and microbiological parameters of Lake Lisi water were investigated. Pollution sources were identified, and the degree of contamination was determined.

Materials and Methods

The research methodology was developed to assess the hydrochemical and biological condition of Lake Lisi. The methods included proper sampling procedures and detailed laboratory-analytical processes, ensuring the accuracy, reproducibility, and reliability of the obtained data.

Samples were collected seasonally throughout 2025. Two sampling points were selected for the study: the pier-platform area and the Leliani-marsh zone near the beach. Sanitary-chemical and sanitary-bacteriological parameters of Lake Lisi water were investigated. Quality control indicators were selected and the research results were evaluated according to international normative documents.

The following parameters and instruments were used during the analyses: Temperature - measured using a digital thermometer; pH, electrical conductivity (μS/cm), and mineralization (ppm) - determined using a portable Milwaukee MW801 pH/EC/TDS Meter; Turbidity (NTU) -using a Turb 555 IR instrument. [1;5] The physical and organoleptic characteristics of Lake Lisi are given in Table 1.

Table 1. Physical and organoleptic characteristics of Lake Lisi

Dock-platform					
Indicator	**Spring**	**Summer**	**Autumn**	**Winter**	**MAC**
Temperature °C	16	28	12	9	
Smell- degrees	Odorless	Odorless	Odorless	Odorless	≤ 2
Color- degrees	Yellowish-turbid	Yellowish-turbid	Yellowish-turbid	Yellowish-turbid	≤15
Turbidity NTU	5,6	4,44	4,2	4,0	≤ 25
Electrical conductivity μS/cm	758	978	857	893	≤ 800
Mineralization ppm	800	1230	1200	1180	≤1000
Leliani					
Indicator	**Spring**	**Summer**	**Autumn**	**Winter**	
Temperature ˚C	16	28	12	9	
Smell- degrees	The strong smell of swamp	The strong smell of swamp	The strong smell of swamp	The strong smell of swamp	≤ 2
Color- degrees	Transparent	Transparent	Transparent	Transparent	≤15

Turbidity NTU	6,92	6, 48	6.42	6,40	≤25
Electrical conductivity μS/cm	761	978,4	877	898	≤ 800
Mineralization ppm	800	1230	1100	1225	≤1000

Chemical analyses were conducted in accordance with international standards recognized by ISO and the European Union. These analyses provide a detailed assessment of the chemical balance of Lake Lisi, which is critical for determining the level of eutrophication of the water [6] The results of the chemical analyses are presented in Table 2.

Table 2. Chemical indicators of Lake Lisi

Dock-platform				
Indicator	**Spring**	**Summer**	**Autumn**	**Winter**
pH	6,5	9,18	8,2	7,6
Dissolved oxygen mgO_2/l	4,8	3,64	4,2	4,18
Chemical oxygen demand mg/l COD	2,48	2,96	2,12	1,78
Biological oxygen demand mg/l BOD_5	4,0	4,58	3,4	3,36
Calcium mg/l	96	108	120	116
Total hardness mg./l	420	538	480	460
NH_4^+ mg/l	0,200	0,198	0.260	0.286
NO_2^- mg/l	0,214	0,154	0,166	0.148
SO_4^{-2} mg/l	800	980	920	900

PO_4^{-3} mg/l	0,038	0,018	0, 054	0,054
Cl^- mg/l	650,80	870,60	850	780
H_2S mg/l	0,0	0,02	0,026	0,02
Petroleum products mg/l	0,10	0,08	0,078	0,074
Leliani				
Indicator	**Spring**	**Summer**	**Autumn**	**Winter**
pH	6,5	5.5	5,8	6,0
Dissolved oxygen mgO_2/l	2,6	3,95	4,18	4,12
Chemical oxygen demand mg/l COD	3,1	3,24	2,98	2,45
Biological oxygen demand mg/l BOD_5	3,18	4,22	4,0	2,24
Calcium mg/l	96	110	120.2	118
Total hardness mg./l	420,2	540	481	462
NH_4^+ mg/l	0,238	0,210	0,218	0,290
NO_2^- mg/l	0,218	0,198	0,200	0,178
SO_4^{-2} mg/l	760	925	916	798
PO_4^{-3} mg/l	0,038	0,022	0, 066	0,074
Cl^- mg/l	652	970,83	850,4	760,2
H_2S mg/l	0,0	0,02	0,024	0,02
Petroleum products mg/l	0,11	0,078	0,08	0,078

In order to assess the biological safety of the lake, microbiological indicators important for the sanitary and hygienic condition of the water were determined. The results of the microbiological research analysis are given in Table 3.

Table 3. Results of bacteriological research of Lake Lisi

		Dock - platform			
Research parameters		**Spring**	**Summer**	**Autumn**	**Winter**
	Significance of indicators in relation to ND	Actual value of indicators CFU			
Mesophilic aerobes and facultative anaerobes in 1 ml	$37^0C \leq 20$	120	105	100	96
			188	190	240
	$22^0C \leq 100$	130			
Total coliform bacteria, per 300 ml	Not allowed	30	72	2827,2 MPN	960
E.coli, in 300 ml	Not allowed	30	72	8,2	22
Faecal streptococci (Faecalis), in 250 ml	Not allowed	Not found	Not found	23,8	59
	Leliani				
Research parameters		Spring	Summer	Autumn	Winter
	Significance of indicators	Actual value of indicators CFU			

	in relation to ND				
Mesophilic aerobes and facultative anaerobesin 1 ml	$37^0C \leq 20$ $22^0C \leq 100$	98 104	144 150	130 170	82 184
Total coliform bacteria, per 300 ml	Not allowed	30	66	1034,4	640
E.coli, in 300 ml	Not allowed	30	66	6,2	15
Faecal streptococci (Faecalis), in 250 ml	Not allowed	Not found	Not found	21,6	47

Results

Based on the conducted studies, the ecological condition of Lake Lisi was assessed in 2025 according to seasonal physicochemical, organoleptic, and microbiological indicators at two analytical points: the pier-platform area and the Leliani-marsh zone.

The obtained results showed that the ecological condition of the lake changes significantly according to seasonal variations; however, the nature and intensity of these changes differ between the studied zones.

It is particularly important to note that the reed-marsh zone is naturally richer in organic matter and less characterized by water circulation, whereas the pier area represents a more open and aerated section.

Seasonal analysis of the 2025 results demonstrated that physicochemical indicators in the pier-platform section remained relatively stable. The increase in temperature from spring to summer (from 16°C to 28°C) caused a decrease in dissolved oxygen from 4.8 mg/L to 3.64 mg/L, which is a typical phenomenon for lake ecosystems. As water temperature rises, oxygen solubility decreases, while microbial metabolic activity and oxygen consumption increase.

The increase in pH to 9.18 during summer indicates intensive photosynthetic processes associated with the active development of algae and phytoplankton. Under such conditions, active absorption of CO_2 occurs, resulting in a more alkaline reaction of the water.

The increase in electrical conductivity and mineralization during summer is likely caused by intensified evaporation, reduced water volume, and increased concentration of dissolved salts.

During the same period, COD, BOD_5, sulfates, and chlorides also increased, indicating higher organic and mineral loading. The presence of petroleum products may be related to recreational activities, transport movement, and contamination caused by surface runoff.

From autumn to winter, partial improvement of the ecological condition was observed, including lower temperatures, slight increases in dissolved oxygen, reductions in COD and BOD_5, and stabilization of pH toward neutral conditions. This is associated with reduced algal activity and improved mixing of water masses.

Microbiological studies showed that the number of coliform bacteria and E. coli increased sharply during summer and autumn. Coliform bacteria levels were especially high during autumn. This may be caused by increased recreational pressure, shoreline pollution, bird and animal excrement, and accumulation of organic waste.

The Leliani-marsh zone was found to be ecologically more vulnerable. This zone consistently exhibited a strong marsh odor, relatively high turbidity, low oxygen concentration, and increased organic loading.

The specific characteristics of the reed-marsh zone are associated with restricted water circulation, which leads to accumulation of organic matter, decomposition of plant residues, and activation of anaerobic processes.

In spring, dissolved oxygen levels were only 2.6 mg/L, which is considered a very low value and indicates an unfavorable ecological condition of the water.

During summer, pH decreased to 5.5, indicating a shift toward acidic conditions. This is likely caused by decomposition of organic substances, formation of humic acids, and intensification of marsh processes.

The increase in phosphate concentrations during autumn and winter indicates mineralization of organic sediments and accumulation of biogenic elements.

Microbiological contamination was also observed in the reed-marsh zone, although in some cases the values were lower than those recorded at the pier area. This can be explained by lower anthropogenic pressure and relatively lower recreational activity. However, the presence of fecal streptococci during autumn and winter indicates organic contamination.

According to the recommendations of the European Union Water Framework Directive (WFD), a water pollution index was calculated to classify the ecological condition of Lake Lisi [6].

For ecological assessment and water classification, the following six indicators were selected:BOD_5; Dissolved oxygen; Petroleum products; Nitrites; Phosphates; Sulfates.

The total pollution index was 4.238 at the pier area and 4.38 at the reed-marsh zone.

The ecological assessment of the lake water quality according to color-coded classification revealed the following:

Table 4. Assessment of ecological status with color codes

Dock-platform

Season	Pollution Index	Color	Rating
Spring	1.201	🟡	Moderate pollution
Summer	0.995	🟢	Relatively stable condition
Autumn	1.038	🟡	Moderate pollution
Winter	1.004	🟡	Moderate pollution
Annual assessment	4.238	🟣	High ecological risk

Leliani

Season	Pollution Index	Color	Rating
Spring	1.136	🟡	Moderate pollution
Summer	1.062	🟡	Moderate load
Autumn	1.144	🟠	Increased ecological load
Winter	1.038	🟡	Moderate pollution
Annual assessment	4.38	🟣	High ecological risk

Conclusion

The physicochemical, chemical, and microbiological studies conducted to evaluate the ecological condition of Lake Lisi demonstrated that the water quality significantly depends on seasonal changes and the ecological characteristics of the studied locations.

The research was carried out at two different zones — the Dock-platform area and the Leliani-marsh zone — which enabled a comparative assessment of different ecological conditions within the lake.

According to the obtained results, the summer season was identified as the most critical period at both sampling points. High temperatures caused a decrease in dissolved oxygen, intensified decomposition of organic substances, and increased microbiological contamination.

During this period, biological oxygen demand (BOD_5), nitrite, phosphate, and petroleum product concentrations increased, indicating deterioration of the ecological condition of the water.

Particular attention should be paid to the reed-marsh zone, where low oxygen concentration, marsh-specific odor, accumulation of organic matter, and signs of eutrophication were recorded.

This section is characterized by weak water circulation and intensive accumulation of organic mass, which promotes the development of anaerobic processes. As a result, the degree of pollution in the reed-marsh zone was higher than in the pier-platform area.

Lake Lisi represents an important source of ventilation and ecological balance for the city of Tbilisi. It also performs a significant recreational function within the urban environment.

The territory is actively used for recreation, sports activities, and ecotourism, which increases its social and ecological importance.Therefore, continuous monitoring of Lake Lisi, control of recreational pressure, ecological management of the shoreline, and periodic cleaning of marshy areas are essential to preserve the ecological sustainability and recreational function of the lake.

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