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Research Article

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Assessment of the anthropogenic impact on the quality of the surface waters of Lake Shkodra (Albanian Part)

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Abstract

The purpose of this study was to evaluate the quality of Shkodra lake waters in terms of physical-chemical and microbiological parameters, knowing that many people frequent this water lake to bath in spring and summer. Lake Shkodra is the largest freshwater body on the Balkan Peninsula. It covers an area of about 370-600 km^2 and is shared between Montenegro and Albania. Evaluation of Lake Shkodra was realized during the period October 2021-June 2022 for Albanian Part. The study was carried out in six stations of the Lake Shkodra based on the anthropogenic impact in some different points of Lake Shkodra. The physical-chemical parameters are: temperature, pH, turbidity and conductivity. The analyzed microbiological parameters are: *heterotrophic bacteria, Intestinal Enterococci, Escherichia coli.* The results showed that most physical-chemical and microbiological parameters are within the limited values allowed by the WHO and Directive 2006/7/EC for surface water with some exceptions in few points.

Keywords: pH, turbidity, conductivity, temperature, heterotrophic bacteria, Escherichia coli, Intestinal enterococci etc.

1. Introduction

Lake Shkodra is the largest freshwater body on the Balkan Peninsula. The drainage area of the lake is about 5,500 km ^{2} (4,470 km^2 in Montenegro and 1,030 km^2 in Albania). Because of its specific hydrological characteristics, exposure to Mediterranean climate, close connection to Adriatic Sea via Buna River, diverse shoreline, and physical-chemical water quality it is home to myriads of animal and plant species, many of which are endemic to the lake or region (GIZ, 2017). The lake water trophy has a considerable impact on the outflow of wastewater containing organic matter for decomposition, as well as phosphorous detergents and agricultural chemical

fertilizers, which drain to the lake from the basin. Sewage is a major source of pollution, especially when it comes to decomposing organic waste, which results in higher levels of water saprobes, particularly along shorelines (Dhora, 2012). Most pollutants for surface Shkodra Lake's water, groundwater, soil and air originate from Podgorica, situated on the Morača River terraces in the Zeta Plain. On the Albanian side the main polluter is the City of Shkodra with its solid waste and wastewater (Strategic Action Plan, 2007). Assessments about physical-chemical and microbiological analysis for the lake began in the mid-1960s in Montenegro, which were conducted by the Institute of Hydrometeorology and the Institute of Public Health (Ristanovic, 1981), which worked to identify psychrophilic, mesophilic and heterophilic bacteria of Lake Shkodra. The assessment of physical-chemical and microbiological parameters of Lake Shkodra have been the object of the study of many scientists from Albania and foreign scientists (Beka, 1994; Bekteshi, 1997; Kashta, 1999: Rakaj, 2001; Dhora, 2005; Filipovic, 1981; Mijovic et al. 2006; Neziri, 2009; Rakaj, 2009; Bekteshi, 2007; Bekteshi, 2000; Petrovic, 1981; Dhora, 2012; Nedeljkovic, 1959; TDA, 2006). The lake Shkodra waters have a pH of approximately 8 (7.3-8.4), which varies slightly horizontally. The slightly alkaline pH of the lake's water is due to the carbonate-bicarbonate buffer system. The oxygen level of freshwater varies throughout the year, ranging from 7 to 12 mg/l in the winter and 5 to 12 mg/l in the summer. Dissolved oxygen levels are affected by atmospheric conditions, aquatic plant photosynthesis, and metabolic processes in the lake (Bekteshi, 2000). Montenegro's pH ranges from 7.2 to 8.5 (Petrovic, 1981). Groundwater, agricultural water, municipal wastewater and rainfall all have varying conductivity levels (Dhora, 2012). On the surface, temperature fluctuations range from 17.2°C to 25°C vertically. In July, the temperature fluctuates from 24°C to 29.5°C. Temperatures in the winter do not fall below 5° C and do not rise above 30°C in the summer (Nedeljkovic, 1959). Lake water has a turbidity of 0.6-10.4 NTU or 5-45 mg SiO_2/l (TDA, 2006). Water pollution is one of the challenges for society, especially for industries working in the water sector. With rapid urbanization, population, and industrial growth, there is a serious threat to water management (Rekha, 2022). Water has played a crucial role in the spread of diseases to humans in the past. Coastal environments are favorable for the growth of a wide range of bacteria and algae (Cabral, 2010). Sewage discharges into freshwater and marine waters are a significant source of fecal bacteria, including pathogens that cause disease. *Escherichia coli* can enter streams, rivers, lakes, and groundwater during rainfall, snowmelt, and other events. The presence of *Escherichia coli* in water is a strong indicator of pollution from sewage and warm-blooded organisms (Alam, 2006). In urban wastewater, *fecal streptococcus* is present in concentrations 10-100 times higher than *fecal coliforms* (Sinton, 1998). Humans have a high prevalence of *enterococci,* whereas animals have a high prevalence of *streptococci* (Wilson, 2005).

2. Experimental

Research area

Shkodra Lake lies in the Northwest part of Albania, the largest in the Balkan Peninsula. The lake is located in the border area between Albania and Montenegro.

Sampling period

The monitoring of water samples from the surface waters of Lake Shkodra was carried out from October 2021 - June 2022 in six stations selected based on the anthropogenic impact in east and west sides of Shkodra lake from Albanian part (Fig.1) based on the standard ISO 5667-4:1987. Water samples for microbiological parameters were taken with 250 ml sterile bottles by means of a Telescopic sampler with a depth from 30 cm while water samples for physico-chemical parameters were taken with high density polyethylene bottles. The water samples were analyzed within 24 hours.

Analyzing process

Standard methods for the examination of different parameters described in (APHA, AWWA, WEF 1995), were carried out at the Center for Microbiological Diagnostication "Wolfdieter Sixl" in Shkodra University "Luigj Gurakuqi".

Measured paramethers

Physico-chemical parameters were analyzed based on the ISO 5667-6 standard at University of Shkodra "Luigj Gurakuqi". The physico-chemical parameters analyzed were:

i) pH, temperature and conductivity were measured "in situ" with Aqualytic system:
ii) turbidity was measured using Turb 430 IR/T. Standards used for physical-chemical parameters were: APHA 2550-1992, ISO 10523:2008, ISO 7027-1:2016.

The microbiological parameters analyzed were:

i) Heterotrophic bacteria were analyzed in yeast agar media by 37 ºC for two days,
ii) *Escherichia coli* and *Intestinal Enterococci* were analyzed based on European recommendations and standard analyses: ISO/DIS 8199 (1986), ISO 5667-2 (1991), ISO 7704 (1985), ISO 9308-1 (2000) [ISO/DIS 8199 (1986); ISO 5667-2 (1991); ISO 7704 (1985); ISO 9308-1 (2000)]. Based on ISO Standards 9308-1 (2000) the recommended use of membrane filtration, where the incubation temperature was 37ºC/44º C and incubation time was 48 hours. An appropriate volume of water sample (100 mL water) was filtered through a 0.45 μm pore size with nitrocellulose membrane filter that retains the bacteria present in the sample. *Escherichia coli* was cultivated in the Endo-Agar medium for 24 hours at a temperature of 44ºC, while in the Slanetz-Bartley medium for *Intestinal Enterococci* 44ºC for 48 hours.

Figure 1. Map of Shkodra Lake with sampling stations

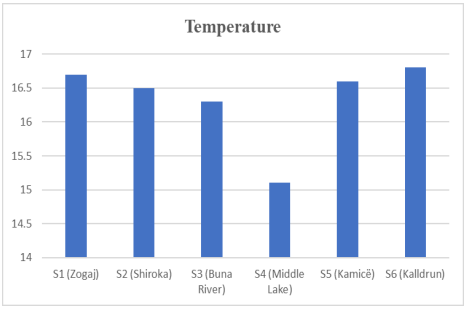
Table 1. Sampling locations on the Albanian side of Shkodra Lake

Station No.	Station description	Coordinates
S1 (Zogaj)	Shkodra Lake, littoral in Zogaj, 50 m from the lakeshore	(N 42º07'04.81", E 19º41'05.96")
S2 (Shiroka)	Shkodra Lake, littoral in Shirokë, 50 m from the lakeshore	(N 42º06'23.25", E 19º44'42.41")
S3 (Buna River)	Mouth of the river	(N 42º05'54.43", E 19º48'02.90")
S4 (Middle Lake)	Shkodra Lake, Open water, middle of the Lake	(N 42º17'05.60", E 19º.34'77.68")
S5 (Kamicë)	East Part of the lake, littoral of the lake	(N 42º21'86.34, E 19º35'66.94")
S6 (Kalldrun)	East Part of the lake, littoral of the lake	(N 42º19'82.90", E 19º38'81.08")

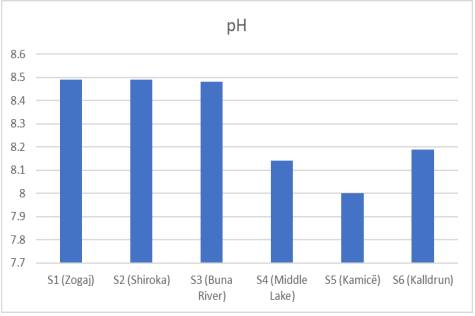
3. Results and discussion

The mean values of physical-chemical and microbiological parameters for the investigation period are given at table 1 and figure 2 (a-d). The average temperature varied from 15.1-16.8ºC, pH ranged from 8.00-8.49, turbidity varies from 0.415-9.95 NTU/FNU, conductivity varied from 210-413 µS/cm. Conductivity values at Kamica point (S5) result with 413 µS/cm. *Heterotrophic bacteria* varied from 200 CFU/100 ml at Middle Lake (S4) until 26100 CFU/100 ml at Kamica point (S5), *Escherichia coli* varied from 0-630 CFU/100 ml and *Intestinal enterococci* varied from 0-478 CFU/100 ml. The

hotspot point in terms of *Escherichia coli* and *Intestinal enterococci* loading is (S1) point which represent Zogaj, which has a large number of restaurants and bars illegally built at the lake Shkodra, which discharges sewages without any preliminary treatment directly into the lake. *Escherichia coli* in this point has a bacterial loading from 630 CFU/100 ml, while *Intestinal enterococci* have a bacterial loading from 478 CFU/100 ml. Based on the directive 2006/7/EC (table. 3) (S1) Zogaj point is classified with sufficient quality (C) for two microbiological parameters. The sufficient quality of Zogaj point for *Escherichia coli* and *Intestinal enterococci* is linked with sewage waters of Zogaj village, which affect directly the quality of surface water since sewage waters are being discharged directly into the lake water without being processed before. Here it is also worth noting the lack of a sewage treatment plant for the village of Zogaj, which missed and brings problems for the quality of the surface waters of Shkodra Lake. Meanwhile at the Shiroka area, the Sewage Treatment Plant in Shiroka built up in 2011 has significantly reduced the negative impact that these business entities have had through the discharge of sewages in the lake area before 2011. The temperature in summer probably influence also to the high microbial loading. Kalldrun point (S6) on the East side of Lake Shkodra which has a higher bacterial loading for *Intestinal enterococci* with 285 CFU/100 ml, which classified this point with a sufficient surface water quality based on the Directive 2006/7/EC. *Escherichia coli* at Kalldrun point (S6) result with 176 CFU/ml. Regarding the bacterial load the waters of Lake Shkodra in stations (S2) Shiroka, (S3) Buna river, (S4) Middle lake, (S5) Kamicë, (table 2), content of *Escherichia coli* ranged from 0-192 CFU/100 ml and content of *Intestinal enterococci* ranged from 0-140 CFU/100 ml, these stations were classified of excellent quality in Class (A) based on the Directive 2006/7/EC, table 3. The cleanliness stations result the point (S4) Middle Lake, which presents an excellent point from the hygienic point of view with 0 CFU/100 ml.



a.



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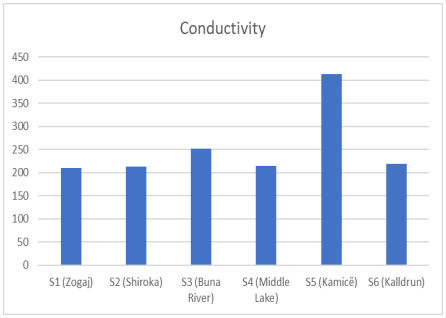

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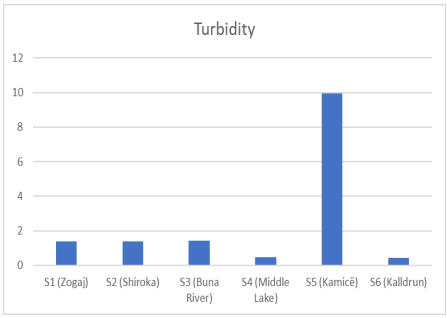


d.

Figure 2 a-d (a, b, c, d) Mean values of physical-chemical parameters of Shkodra lake

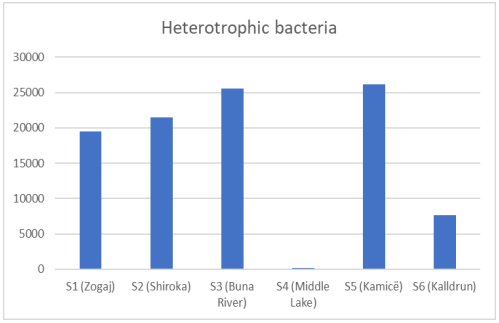
Table 2. Mean values of physical-chemical and microbiological parameters at sampling stations of Lake Shkodra surface waters for October 2021-June 2022.

Sampling stations	Temperature °C	pH	Conductivity microsiemens/cm	Turbidity NTU/FNU	*Escherichia coli CFU/100 mL*	*Intestinales enterococci CFU/100mL*	*Heterotrophic bacteria CFU/100mL*
S1 (Zogaj)	16.7	8.49	210	1.385	630	478	19500
S2 (Shiroka)	16.5	8.49	213	1.395	180	65	21500
S3 (Buna River)	16.3	8.48	252	1.435	192	140	25500
S4 (Middle Lake)	15.1	8.14	215	0.475	0	0	200
S5 (Kamicë)	16.6	8.00	413	9.95	90	56	26100
S6 (Kalldrun)	16.8	8.19	219	0.415	176	285	7600

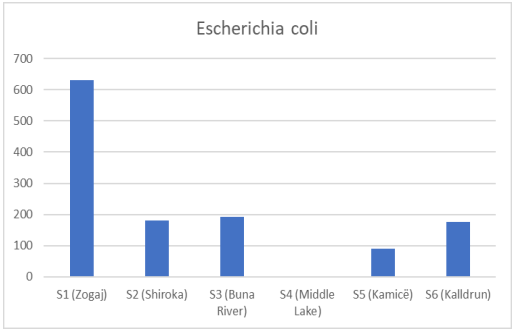
Table 3: Directive 2006/7/EC on surface water

Parameter	Excellent quality [b] (cfu[a] 100 ml^{-1})	Good quality [b] (cfu 100 ml^{-1})	Sufficient quality[c] (cfu 100 ml^{-1})
Escherichia coli (cfu/100ml)	500	1000	900
Intestinal Enterococci (cfu/100ml)	200	400	330

a CFU: colony forming units.
b Based upon a 95 th-percentile evaluation
c Based upon a 90 th-percentile evaluation



e.



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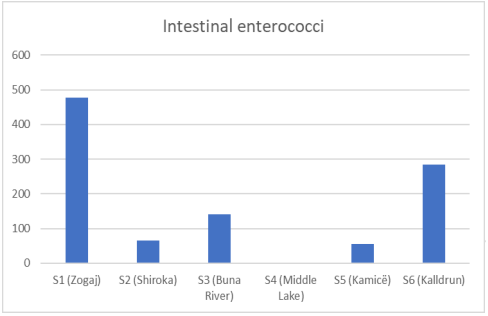

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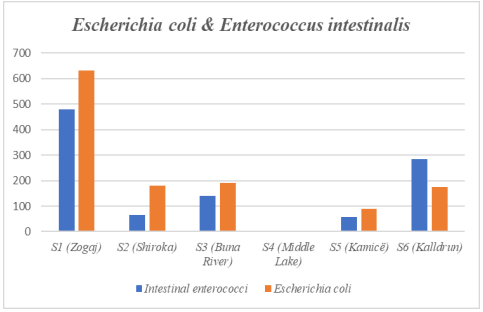

h.

Figure 2 e-h (e,f,g,h) Mean values of microbiological parameters of Shkodra Lake

4. Conclusion

Anthropogenic activity has a considerable impact on the Shkoder Lake ecosystem, either directly (irrigation, drainage, poaching, overfishing) or indirectly (poor waste water management, illegal landfills). Agriculture-related pollution has an impact mostly in the eutrophication process of the lake. Population increases in areas near the lake with insufficient urban waste and wastewater management has led to increases in both water demand and pollution. This study aims at providing evaluations for period October 2021-June 2022 of water quality for physical-chemical and microbiological parameters of different stations of East and West side of Shkodra Lake (Albanian Part). Directive 2006/7/EC quality of bathing water from inland waters in four stations were met. Middle lake and three stations taken in Shkodra lake for microbial content resulted with excellent quality, meanwhile Zogaj as hotspot was classified with sufficient quality for two microbiological parameters *Escherichia coli* and *Intestinal enterococci* and Kalldrun was classified for *Intestinal enterococci* as sufficient quality based on Directive 2006/7/EC. The conductivity resulted in higher values compared to the normal parameters of Lake Shkodra for the East part of the lake in connection with the diary industry production.

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