J. Int. Environmental Application and Science, Vol. 20(3): 158-169 (2025)
Research Paper

Analysis of the Physico-Chemical and Microbiological Water Quality in the Protected Area of the Buna River, Shkoder Albania

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Received June 17, 2025; Accepted July 26, 2025

Abstract: Protected freshwater areas can be extremely important for preserving their biodiversity, as well as providing ecosystem services around them. Globally, there is an increasing need to reduce threats to freshwater resources in protected areas, as well as to recognise the associated issues and manage them to safeguard these resources. This study aimed to evaluate the physico-chemical and microbiological quality along the Buna River in the Shkodra region of Albania. The Buna River flows through both urban and rural areas of great interest in northern Albania. The surrounding area includes a mosaic of natural habitats with rich biodiversity and serves as an important destination for nature-based tourism. The assessment of Buna River's quality was carried out through a detailed analysis of the previously missing correlation between physico-chemical and microbiological parameters. This study aimed to take a new approach by analysing the correlation between these two aspects of water quality in this ecologically and touristically important protected area. Sampling in the Buna River was conducted monthly from June 2023 to September 2024 at six stations, resulting in a total of 600 analyses. For the evaluation of the correlation between the data obtained from the study areas, the statistical program SPSS was used, specifically the Pearson correlation. The study results provide a detailed overview of the state of the water and the impacts stemming from human activities such as pollution, agriculture, and tourism. The findings confirm that the majority of the stations were highly polluted in terms of microbiological and physico-chemical parameters. These data provide important recommendations for taking necessary measures and maintaining the ecological balance of this protected area of national and international importance.

Keywords: *Buna river, microbiological quality, physico-chemical analysis, protected areas*

Introduction

Shkodra region is the main destination for visitors to protected areas in Albania, accounting for 26% of total visitors during the first 8 months of 2024, with an increase of 2% compared to the same period in 2023, according to statistics from the Ministry of Tourism and Environment. The Blue Eye and Lake Shkodra are the most visited attractions, while the Buna River - Velipojë is the most frequented landscape among protected landscapes. Data on visitor numbers in natural reserves and parks show that during August 2023, the Blue Eye (34%) had the highest number of visitors, followed by Lake Shkodra (21%). The number of visitors to Albania's protected landscapes shows that the Buna river -Velipojë (56%) has been the destination of greatest interest, followed by Lake Pogradec (24%). In natural tourism, Shkodra leads the national ranking. (Ministry of Tourism and Environment 2024)

The Shkodra region is known for its biodiversity and unique natural landscapes, where the Buna River and Lake Shkodra are protected areas of international interest. The Buna River is a Category V protected landscape (IUCN), along with the Franz Josef Delta and Island, the

Velipoja Reserve, the Viluni Lagoon, the Baks-Rrjoll Beach, the Domni and the surrounding territories (Republic of Albania 2005). The Buna River is a short 44 km river with a natural delta, part of the EMERALD and IBA networks, and a habitat for many species of migratory fish and birds. Lake Shkodra represents the largest aquatic ecosystem and is the only area in Albania included in the RAMSAR Convention for habitats of ecological importance. It carries rare, endemic and threatened

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species, enriching the natural and environmental values of the region National (Environmental Agency. Protected Areas 2020)

Lake Shkodra, due to its high biodiversity and its ecological function as an important habitat for waterfowl and several other species of flora and fauna, was included on February 2, 2006, in the list of areas of international importance protected by the RAMSAR Convention (Regional Environmental Center Albania/RAMSAR. 2010)

Surface waters are an important part of the natural ecosystem. However, human activities are increasingly threatening these waters with pollution, which mainly comes from human activities themselves. These impacts jeopardise the ecological quality and natural function of water bodies (UNEP 2021). The impact of human activities, challenges and threats to protected areas are numerous, starting from pollution; the discharge of untreated wastewater, the use of chemical fertilizers such as pesticides in rural areas and their discharge into rivers, land use by cutting down trees without criteria, climate change and indiscriminate hunting and fishing during the breeding season in fauna. Sustainable management of water resources requires regular monitoring to identify anthropogenic impacts and protect aquatic biodiversity (EEA 2022)

The importance of physicochemical and microbiological analyses is essential for identifying sources of pollution and assessing the ecological status and sustainable conservation of water resources. Through physicochemical analyses of the Buna River, it is possible to identify sources of pollution mainly resulting from human activities. Parameters such as pH, nitrites, nitrates and phosphates play an important role in identifying urban discharges and agricultural activities such as the use of fertilisers and pesticides, as well as the discharge of untreated wastewater (WHO 2016; Małgorzata et al.,2024)

These indicators serve as indicators for assessing the risks of the aquatic ecosystem in protected areas. At the same time, the analysis of microbiological parameters such as faecal coliforms and fecal streptococcus constitutes a direct indicator of the risk of the occurrence and spread of infectious diseases. These indicators are important in recreational areas. The presence of these bacteria is also linked to the impact on biodiversity and aquatic ecosystems (EPA 2021; WHO 2023)

The purpose of the study of the Buna River is essential and important for assessing the ecological status of the most important waterway in Albania, as it directly affects the conservation of biodiversity and the ecological balance of protected areas. The detailed analysis of the Buna River through the assessment of microbiological, physical and chemical parameters provides important data that can contribute to improving water management. The data obtained are of particular importance for maintaining the quality of the aquatic ecosystem and the environment, ensuring optimal conditions for the survival and well-being of biodiversity in protected areas. The relationship between physical, chemical and microbiological indicators is a key factor for assessing the self-purification capacity of water bodies and their impact on aquatic life.

Research Hypothesis

Starting from the objectives of this study and based on the analysis of the theoretical and practical context, the research hypothesis has been formulated as follows: Considering the anthropogenic impacts on the aquatic ecosystem of the Buna river, we assume that there is a significant correlation between the physicochemical parameters and microbiological indicators of water, which varies according to the intensity of pollution and human activity at the monitoring stations, reflecting the ecological state of the river.

Materials and Methods

Location and study period

The study was conducted in the Shkodra region, Albania, during the period June 2023- September 2024. A total of six stations were included along the Buna River watershed, where microbiological, physical and chemical parameters were analysed for each of them. Samples were taken once a month for one year, covering all four seasons. Sample selection was carried out along the entire. Buna river, focusing mainly on protected areas with ecological and socio-economic importance that are frequented by the public for recreational water activities such as beaching, bathing, fishing, nature walks and animal observation. These areas also represent key areas for rural development and for the conservation of flora and fauna. At station S1-the plant is located near the area where the Buna river originates from Lake Shkodra and also near the water treatment plant. The study of this station can provide us with valuable information regarding the efficiency of the operation of the wastewater treatment plant. At station S2- the bridge Buna is an overpopulated area with numerous buildings and various functions, such as local businesses around, and above all, we have the discharge of wastewater from the city of Shkodra. At station S3-the confluence of the Buna River with the Drin River, where the interaction between the waters of the two rivers and their impact on water quality parameters will be studied. At station S4- Darragjat is characterized as a rural area inhabited by the population, where they are mainly engaged in agricultural activities and carry out various activities near the sources of the Buna River. At station S5- Reç i Ri is like that observed at station S4. At station S6- Pulaj was selected due to its position near the Buna delta as the last point before flowing into the sea, which serves as a spatial summary of the entire Buna River line from the beginning to the end. During the monitoring at six stations, 144 microbiological parameters, 288 physical parameters and 168 chemical parameters were assessed for each station. A complete analysis was performed for each station, including all these parameters, resulting in a total of 600 analyses.

Table 1. Geographic coordinates of the Buna River sampling stations

Code of stations	Sampling stations	Geographical coordinates
S1	Buna River-Plant	42°03'21.2"N 19°28'18.2"E
S2	Buna River-Buna Bridge	42°02'55.8"N 19°29'29.2"E
S3	The confluence of the Drin and Buna rivers	42°01'37.5"N 19°28'19.4"E
S4	Buna River-Darragjat	42°00'06.1"N 19°27'23.6"E
S5	Buna River-Reç i Ri	41°54'55.3"N 19°21'27.9"E
S6	Buna River-Pulaj	41°52'27.8"N 19°22'33.7"E

Water Sampling

Two samples were collected simultaneously—one for microbiological analysis and the other for physico-chemical analysis. The samples for microbiological analysis were placed in sterile glass bottles, and each bottle was labelled with the sampling date, sample number, location, and geographic coordinates. (ISO 19458: 2006). Samples intended for physico-chemical parameter analysis were placed in plastic bottles labelled with the sampling date, sample number, location, and geographic coordinates (ISO 5667–3:2024)

Sample Transport

The water samples were preserved and transported under controlled temperature conditions using a thermobox and were analysed on the same day (within 24 hours) from the time of collection from the Buna River (ISO 5667–3:2024)

Methods used for Physical Parameters

The analysis of the Buna River for physical parameters included a total of 288 analyses. Temperature as a physical parameter was studied according to the APHA 2550 A method, using the Aqualytic Al 15 (APHA 1998).

Turbidity was measured using the TURB 430 IR-WTW turbidimeter, following the ISO procedure. (ISO 7027-1:2016).

Electrical conductivity was measured using the Aqualytic Al 15 instrument. (EN 27888:2001)

Total dissolved solids were analysed in accordance with the APHA 2540 C method, gravimetric instrument (APHA 2540 C).

Methods used for chemical parameters

The analysis of the Buna River for chemical parameters included a total of 168 analyses. The chemical parameters evaluated were pH, ammonium, nitrites, nitrates, and phosphates.

The pH value was measured directly in the field through “in situ” measurement using the AQUALYTIC AL 15 device (ISO 10523- 2008)

Ammonium levels were measured using the spectrophotometer DR 1900 following the ISO procedure (ISO 7150-1:1984). Nitrites levels were measured spectrophotometer DR 1900 (EPA- NERL :354.1 method 8507)

Nitrates were measured using the spectrophotometer DR 1900 following the ISO procedure. (ISO 7890-1:1986) and phosphates were determined using the DR 1900 Spectrophotometer (APHA 4500-P-E method 8048).

Methods used for microbiological parameters

The microbiological analysis of the Buna River included a total of 144 analyses. The microbiological parameters assessed were *Faecal coliforms* and *Faecal streptococci*. Identification and enumeration of these parameters were performed using the Most Probable Number (MPN) method. The MPN method was applied in three stages: presumptive test, confirmatory test, and completed test (APHA 1998)

For the analysis of *Faecal coliforms*: In the presumptive test, LB medium was use. (Bakare *et al.,* 2003). In the confirmatory test, ECB medium was applied (APHA 1998). For the completed test, EMB agar was used. (BAM Chapter 4., 2010). For the analysis of *Faecal streptococci*: In the presumptive test, Azide Dextrose Broth was used. (Mallmann *et al.,* 1950). In the confirmatory test, Ethyl Violet Azide Broth (EVA) was used. (Litsky et al., 1955). The enumeration of faecal coliforms and faecal streptococci was done using the statistical MPN index table (CNR-IRSA 2003)

Results and Discussions

By statistical processing with SPSS, Pearson correlation, we have analysed the correlation of physical, chemical and microbiological parameters as they influence the pollution of the Buna river in the six analysed stations, also using Excel, the graphic models for the parameters studied in detail have been presented.

In Figure 1, station S1 resulted of excellent quality, while the other five stations along the entire length of the Buna River are outside the norms, based on the new Directive 2006/7EC, classified as poor quality for the presence of *Fecal coliforms*, while for *Fecal streptococci* all analysed stations are within the norms and are classified as excellent quality. The ratio between the two microbiological parameters shows that the source of pollution is mainly from human activity such as the discharge of untreated wastewater from the city of Shkodra that flows directly into the river and waste deposited near the river.

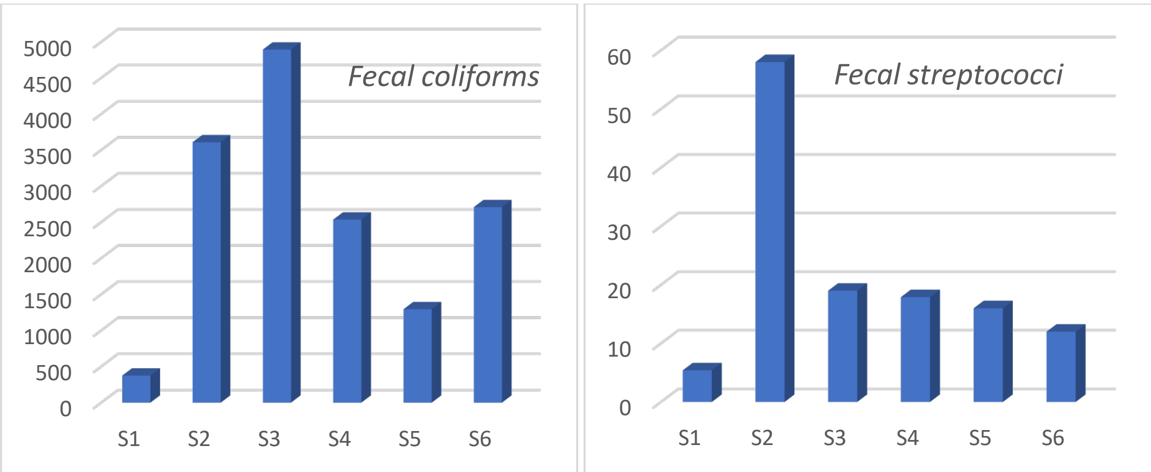

Figure 1. Distribution of *Faecal coliforms* and *Faecal streptococci* values according to stations

Figure 2 illustrates the classification of waters according to the criteria set by NIVA for water quality for phosphates, station S1 is classified in class III average quality, while station S2 and S4 are classified in class V very bad, while other stations such as S3 and S5 are classified in class I very good, while station S6 is classified in class II good. The high value of phosphate in S2 comes because of the discharge of untreated wastewater from the city of Shkodra, while in S5 it is an area where agriculture is developed, and the indiscriminate use of chemical fertilizers influences pollution. From the above, the differences in the classification of chemical parameters between stations highlight the crucial role of local pollution sources, as well as the importance of wastewater treatment for maintaining surface water quality. According to NIVA for chemical parameters for NO_3, station S1 is classified in class I very good, while the other five stations are classified in class II good quality.

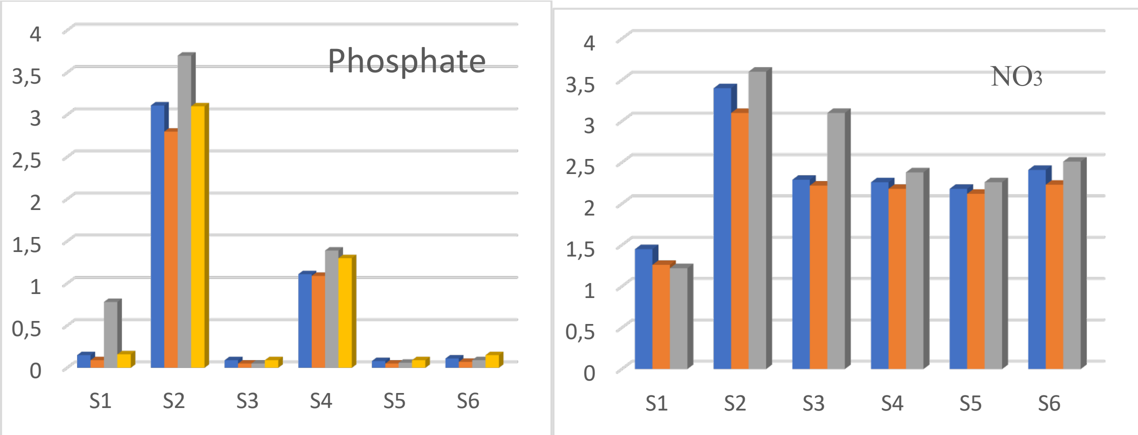

Figure 2. Distribution of phosphate and nitrate values according to stations

Figure 3 illustrates the classification of waters according to the criteria set by NIVA for ammonium, where S2 is classified as class III average, while the other stations are classified as class I very good. Around station S2, untreated city wastewater is mainly discharged, which influences the classification of ammonium. According to NIVA, for the chemical parameter NO2, all stations are classified as class I very good.

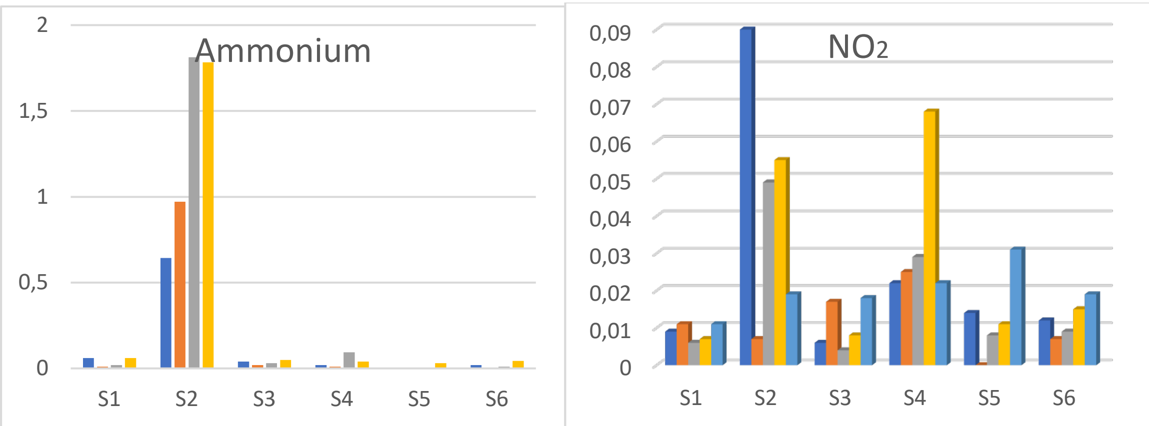

Figure 3. Distribution of ammonium and nitrite values according to stations

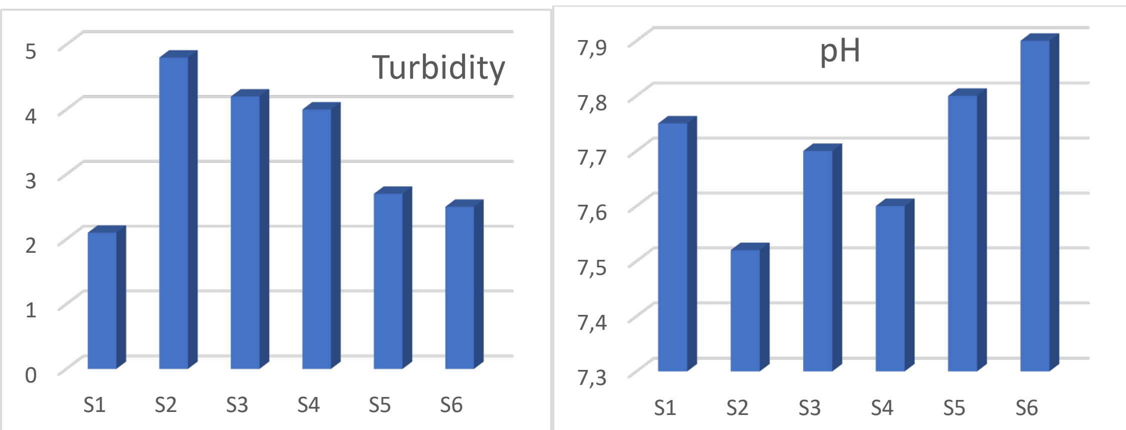

Figure 4. Distribution of turbidity and pH values according to stations

Figure 4 illustrates the classification of waters according to the criteria set by NIVA for turbidity; all stations are classified in class V very bad. High turbidity is an indicator that shows that in these studied stations there is pollution or degradation of water quality. At station S6, a slightly higher increase in pH value is observed than in other stations, but it is within the established norms. High turbidity values highlight an urgent need for protective measures and rehabilitation interventions, while pH values indicate a relative stability of chemical parameters, despite small local deviations.

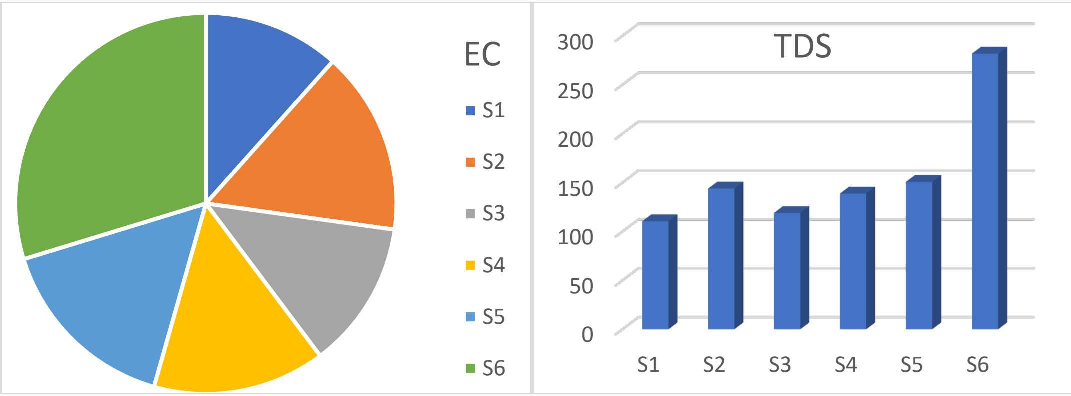

Figure 5. Distribution of electrical conductivity and TDS values according to stations

In Figure 5 we have illustrated the electrical conductivity and TDS where both stations S4 and S6 have higher values than the other stations as a result of the position where S1 we have pollution as a result of the discharge of untreated wastewater, while at S6 we have pollution mainly from agriculture where waste is discharged directly into rivers.

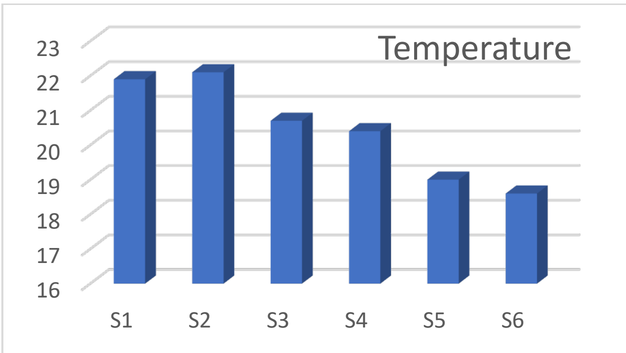

Figure 6. Distribution of temperature values according to stations

The lowest temperature of the studied stations is station S6. Using SPSS, we used Pearson's correlation to observe how the pollution of the Buna River along its line influences the parameters with each other. The results of the correlation analysis show that there is a perfect positive and significant correlation between EC and TDS a very strong relationship between each other. (r=1).

Table 2. Table of correlation of Buna River – Plant of electrical conductivity with TDS

Correlations		Buna River-Plant EC	Buna River-Plant TDS
Buna River-Plant EC	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		0.000
	N	15	15
Buna River-Plant TDS	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	0.000	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

At the Bune Bridge station, a negative correlation is observed between temperature and EC (r= -0.794) and temperature with TDS (r= -0.510). EC with TDS positive correlation, a very high relationship between each other (r= -0.8). The pH parameter with NO_2 has a very high positive correlation with each other (r= -0.884), while the pH parameter with fecal coliforms has a negative correlation (r= -0.625)

Table 3. Table of correlation of Buna bridge

Correlations		Buna Bridge Temp	Buna Bridge pH	Buna Bridge EC	Buna Bridge TDS	Buna Bridge NO2	Buna Bridge FC
Buna Bridge Temp	Pearson Correlation	1	0.098	-0.794**	-0.510	0.318	0.017
	Sig. (2-tailed)		0.729	0.000	0.052	0.603	0.953
	N	15	15	15	15	5	15
Buna Bridge pH	Pearson Correlation	0.098	1	-0.239	0.049	0.884*	-0.625*
	Sig. (2-tailed)	0.729		0.391	0.862	0.046	0.013
	N	15	15	15	15	5	15
Buna Bridge EC	Pearson Correlation	-0.794**	-0.239	1	0.800**	-0.158	0.158
	Sig. (2-tailed)	.000	.391		0.000	0.800	0.574
	N	15	15	15	15	5	15
Buna Bridge TDS	Pearson Correlation	-0.510	0.049	0.800**	1	-0.158	0.188
	Sig. (2-tailed)	0.052	0.862	0.000		0.800	0.503
	N	15	15	15	15	5	15
Buna Bridge NO2	Pearson Correlation	0.318	0.884*	-0.158	-0.158	1	0.825
	Sig. (2-tailed)	0.603	0.046	0.800	0.800		0.086
	N	5	5	5	5	5	5
Buna Bridge FC	Pearson Correlation	0.017	-0.625*	0.158	0.188	0.825	1
	Sig. (2-tailed)	0.953	0.013	0.574	0.503	0.086	
	N	15	15	15	15	5	15

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

At the station of the studied point where the Buna river joins the Drini river, we have a negative correlation between temperature values and NO_3 (r= - -1) but for the TDS and EC parameters, we have a very high positive correlation (r= -0.998), EC with streptococcus has a significant real positive correlation (r= 0.5), PO_4 and coliforms have a very high positive correlation (r= 0.984), TDS and streptococcus have a significant real positive correlation (r= 0.563)

Table 4. Table of correlation of Drin and Buna river

Correlations		The confluence of the Drin and Buna rivers. TDS	The confluence of the Drin and Buna rivers. PO4	The confluence of the Drin and Buna river. FC	The confluence of the Drin and Buna rivers. FS	The confluence of the Drin and Buna rivers. NO3
The confluence of the Drin and Buna rivers. Temp	Pearson Correlation	-0.455	-0.456	0.237	-0.365	-1.000*
	Sig. (2-tailed)	0.088	0.544	0.395	0.180	0.012
	N	15	4	15	15	3
The confluence of the Drin and Buna rivers.EC	Pearson Correlation	0.998**	0.421	-0.126	0.533*	0.938
	Sig. (2-tailed)	0.000	0.579	0.654	0.041	0.225
	N	15	4	15	15	3
The confluence of the Drin and Buna rivers.TDS	Pearson Correlation	1	0.421	-0.115	0.563*	0.938
	Sig. (2-tailed)		0.579	0.682	0.029	0.225
	N	15	4	15	15	3
The confluence of the Drin and Buna rivers.PO4	Pearson Correlation	0.421	1	0.984*	0.311	-0.437
	Sig. (2-tailed)	0.579		0.016	0.689	0.712
	N	4	4	4	4	3

The confluence of the Drin and Buna rivers. FC	Pearson Correlation	-0.115	0.984*	1	-0.014	-0.475
	Sig. (2-tailed)	0.682	0.016		0.960	0.685
	N	15	4	15	15	3
The confluence of the Drin and Buna rivers. FS	Pearson Correlation	0.563*	0.311	-0.014	1	0.726
	Sig. (2-tailed)	0.029	0.689	0.960		0.483
	N	15	4	15	15	3
The confluence of the Drin and Buna rivers. NO_3	Pearson Correlation	0.938	-0.437	-0.475	0.726	1
	Sig. (2-tailed)	0.225	0.712	0.685	0.483	
	N	3	3	3	3	3

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2- tailed)

At the Darragjat station, temperature along with TDS and EC, pH with coliforms and EC with coliforms have a negative correlation, while EC with TDS has a positive perfect correlation with each other (r= 1). EC with fecal streptococcus (r= 0.551) and TDS with fecal streptococcus (r=0.551) have a real positive correlation, while TDS with coliforms have a negative correlation (r= - 0.522).

Table 5. Table of correlation of Darragjat station

Correlations		DarragjatTemp	Darragjat pH	Darragjat EC	Darragjat TDS	Darragjat FC	Darragjat FS
Darragjat. Temp	Pearson Correlation	1	0.155	-0.743**	-0.743**	0.405	-0.417
	Sig. (2-tailed)		0.582	0.002	0.002	0.135	0.122
	N	15	15	15	15	15	15
Darragjat pH	Pearson Correlation	0.155	1	-0.008	-0.008	-0.576*	0.065
	Sig. (2-tailed)	0.582		0.976	0.976	0.025	0.817
	N	15	15	15	15	15	15
Darragjat EC	Pearson Correlation	-0.743**	-0.008	1	1.000**	-0.522*	0.551*
	Sig. (2-tailed)	0.002	0.976		0.000	0.046	0.033
	N	15	15	15	15	15	15
Darragjat TDS	Pearson Correlation	-0.743**	-0.008	1.000**	1	-0.522*	0.551*
	Sig. (2-tailed)	0.002	0.976	0.000		0.046	0.033
	N	15	15	15	15	15	15
Darragjat FC	Pearson Correlation	0.405	-0.576*	-0.522*	-0.522*	1	-0.251
	Sig. (2-tailed)	0.135	0.025	0.046	0.046		0.367
	N	15	15	15	15	15	15
Darragjat FS	Pearson Correlation	-0.417	0.065	0.551*	0.551*	-0.251	1
	Sig. (2-tailed)	0.122	0.817	0.033	0.033	0.367	
	N	15	15	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

At the Reç i Ri station, temperature along with TDS, EC, NO2, coliforms, ammonium and coliforms have a negative correlation with each other. While the EC parameter in relation to TDS has a perfect positive correlation (r= 1), EC with coliforms has a real positive correlation (r= 0.662) and EC with streptococcus has a real positive correlation with each other (r= 0.568). TDS with coliforms and streptococcus has a real positive correlation (r= 0.568).

Table 6. Table of correlation of Reç i Ri station.

Correlations		Reç Temp	Reç EC	Reç TDS	Reç NH4	Reç FC	Reç FS	Reç NO2
Reç Temp	Pearson Correlation	1	-0.535*	-0.535*	-0.960*	-0.569*	0.055	-0.912*
	Sig. (2-tailed)		0.040	0.040	0.040	0.027	0.847	0.031
	N	15	15	15	4	15	15	5
Reç EC	Pearson Correlation	-0.535*	1	1.000**	0.641	0.662**	0.568*	0.276
	Sig. (2-tailed)	0.040		0.000	0.359	0.007	0.027	0.653
	N	15	15	15	4	15	15	5
Reç TDS	Pearson Correlation	-0.535*	1.000**	1	0.641	0.662**	0.568*	0.276
	Sig. (2-tailed)	0.040	0.000		0.359	0.007	0.027	0.653
	N	15	15	15	4	15	15	5
Reç NH4	Pearson Correlation	-0.960*	0.641	0.641	1	.c	0.333	0.305
	Sig. (2-tailed)	0.040	0.359	0.359		0.000	0.667	0.695
	N	4	4	4	4	4	4	4
Reç FC	Pearson Correlation	-0.569*	0.662**	0.662**	.c	1	0.278	.c
	Sig. (2-tailed)	0.027	0.007	0.007	0.000		0.315	0.000
	N	15	15	15	4	15	15	5
Reç FS	Pearson Correlation	0.055	0.568*	0.568*	0.333	0.278	1	-0.265
	Sig. (2-tailed)	0.847	0.027	0.027	0.667	0.315		0.667
	N	15	15	15	4	15	15	5
Reç NO2	Pearson Correlation	-0.912*	0.276	0.276	0.305	.c	-0.265	1
	Sig. (2-tailed)	0.031	0.653	0.653	0.695	0.000	0.667	
	N	5	5	5	4	5	5	5

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

At the Pulaj station, the temperature parameter with turbidity has a negative correlation (r= -0.547) as well as temperature with NO2 (r= -0.947). The pH values with NH4 and pH with PO4 have a negative correlation. EC with coliforms and TDS with coliforms have a significant positive correlation (r= 0.537). NO_2 with NH4 (r= 0.982) and NO_2 with PO_4 (r= 0.990) and NH4 with PO4 (r= 0.999) have a very high positive correlation. Faecal coliforms and faecal streptococci have a significant positive correlation (r= 0.520).

Correlation data at the Pulaj station indicate significant pollution from nutrients and pathogenic microorganisms, closely linked to anthropogenic impact. Very strong positive correlations between ammonia, nitrites and phosphates suggest a unified source of pollution, while positive correlations between microbiological and chemical parameters highlight the complex interaction that affects the deterioration of water quality. These results indicate the need for protective measures and continuous monitoring, as well as for more effective treatment of polluted waters to protect the coastal area from further pollution.

Table 7. Table of correlation of Pulaj station.

		Pulaj Turb	Pulaj NO_2^-	Pulaj NH_4	Pulaj NO_3^-	Pulaj PO_4^-	Pulaj FC	Pulaj FS
Pulaj Temp	Pearson Correlation	-.547*	-0.947*	-0.864	0.091	-0.870	0.188	-0.434
	Sig. (2-tailed)	0.035	0.015	0.136	0.942	0.130	0.503	0.106
	N	15	5	4	3	4	15	15
Pulaj pH	Pearson Correlation	-0.271	-0.792	-0.973*	-0.705	-0.960*	0.352	-0.027
	Sig. (2-tailed	0.329	0.110	0.027	0.502	0.040	0.198	0.924
	N	15	5	4	3	4	15	15
Pulaj Turbidity	Pearson Correlation	1	0.644	0.612	0.419	0.582	-0.462	-0.148
	Sig. (2-tailed		0.241	0.388	0.725	0.418	0.083	0.599
	N	15	5	4	3	4	15	15
Pulaj EC	Pearson Correlation	-0.310	-0.854	-0.877	0.994	-0.852	0.537*	0.101
	Sig. (2-tailed	0.261	0.065	0.123	0.067	0.148	0.039	0.720
	N	15	5	4	3	4	15	15
	Pearson Correlation	-0.310	-0.854	-0.877	0.994	-0.852	0.537*	0.101

Pulaj TDS	Sig. (2-tailed	0.261	0.065	0.123	0.067	0.148	0.039	0.720
	N	15	5	4	3	4	15	15
Pulaj NO2	Pearson Correlation	0.644	1	0.982*	0.541	0.990*	-0.075	-0.113
	Sig. (2-tailed	0.241		0.018	0.636	0.010	0.905	0.857
	N	5	5	4	3	4	5	5
Pulaj NH4	Pearson Correlation	0.612	0.982*	1	0.634	0.999**	-0.036	-0.155
	Sig. (2-tailed	0.388	0.018		0.563	0.001	0.964	0.845
	N	4	4	4	3	4	4	4
Pulaj NO3	Pearson Correlation	0.419	0.541	0.634	1	0.634	0.163	0.163
	Sig. (2-tailed	0.725	0.636	0.563		0.563	0.896	0.896
	N	3	3	3	3	3	3	3
Pulaj PO4	Pearson Correlation	0.582	0.990*	0.999**	0.634	1	0.009	-0.110
	Sig. (2-tailed	0.418	0.010	0.001	0.563		0.991	0.890
	N	4	4	4	3	4	4	4
Pulaj FC	Pearson Correlation	-0.462	-0.075	-0.036	0.163	0.009	1	0.520*
	Sig. (2-tailed	0.083	0.905	0.964	0.896	0.991		0.047
	N	15	5	4	3	4	15	15
Pulaj FS	Pearson Correlation	-0.148	-0.113	-0.155	0.163	-0.110	0.520*	1
	Sig. (2-tailed	0.599	0.857	0.845	0.896	0.890	0.047	
	N	15	5	4	3	4	15	15

Conclusion

Due to human activities and lack of adequate attention from responsible institutions, protected areas are at risk of being destroyed, putting mass tourism at risk. Based on the results, fecal coliforms and faecal streptococci, the ratio between them indicates that the pollution is mainly human.

The poor quality of surface waters used for recreation, bathing, beach making and land irrigation brings problems to public health, and consequently, the treatment of diseases has a higher cost than the removal of pollution from pathogens of water origin. A strong positive correlation was found between TDS and electrical conductivity reflecting a high content of dissolved ions in water. At the Buna river station near the bridge, the correlation of pH with fecal coliforms is negative, this indicates that pH is a limiting factor for the growth of fecal bacteria in unsuitable conditions. At the station where the Buna river joins the Drini River, we have a significant positive correlation between EC with fecal streptococcus and with PO4 parameters with fecal coliforms which indicates a common source of pollution. Also, at the Darragjat station, EC with streptococcus have a positive correlation At the Pulaj station many parameters such as: EC with coliforms and TDS with coliforms, NO2 with NH4, NO2 with PO4 and NH4 with PO4 have a positive correlation because of a common source of pollution. Being a station where agriculture prevails, we have agricultural runoff, organic pollution and untreated wastewater discharges which influence these ratios.

The comparison of the results of this study with the data published by the European Environment Agency (EEA 2024) for Albania shows a clear alignment regarding the poor quality of bathing waters. According to the EEA report, Albania ranks last in Europe for bathing water quality, with only 16% of monitored sites classified as having excellent quality and 22.7% as having poor quality. The monitoring results conducted as part of this study in the Buna river support this assessment out of six monitored stations, only one was classified as having excellent quality, while the other five stations were assessed as having poor quality due to exceeding the limits for microbiological pollutants. This comparison indicates that microbiological contamination remains a serious issue in the surface waters of the studied area and reflects the national situation reported by the EEA.

The construction of a wastewater treatment plant for the city of Shkodra, aiming to create a modern infrastructure that meets environmental and sanitary standards, not dumping wastewater into rivers, would influence the quality of the Buna River. The Buna River Nature Reserve in Velipojë must be preserved and protected, as well as reforested, as these forests protect the soil from erosion, limit the flow into the lake and play a role in increasing the quality of the rich air. Also, forests act as a natural barrier that stops excess water.

Acknowledgment: *We thank the Faculty of Natural Sciences for the important contributions to this study.*
Compliance with Ethical Standards Ethical responsibilities of Authors: *The author has read, understood, and complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors".*
Conflict of Interest: *The authors declare that they do not have any conflict of interest.*
Change of Authorship: *The author has read, understood, and complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors and is aware that with minor exceptions, no changes can be made to authorship once the paper is submitted.*

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