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Evaluating the Environmental State of Albanian Rivers: Findings from a One-Time Sampling Campaign

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Abstract- This study provides a one-time sampling-based assessment of the environmental state of selected rivers in Albania, focusing on key indicators of water quality and ecological health. Sampling was conducted at specific locations along the Osumi, Shkumbin, Ishmi and Erzen rivers to evaluate parameters such as pH, dissolved oxygen, nutrient levels, and presence of contaminants. The investigation also included observational data on visible pollution sources and riverbank conditions. Results reveal varying degrees of environmental stress across the sampled sites, with notable impacts from urban runoff, industrial discharge, and inadequate waste management practices. This snapshot offers valuable insight into the current condition of these river systems and serves as a baseline for future monitoring efforts, policy development, and targeted conservation initiatives aimed at restoring and protecting Albania's freshwater ecosystems.

***Keywords*:** Water quality; Albanian rivers; nutrients; Water Quality Index

1. Introduction

Human activities, especially urbanization, transform water supplies into economic benefits, while severely undermining the integrity of river ecosystems and biodiversity [1]. The extensive use of synthetic agrochemicals, irrigation of agricultural fields with untreated municipal and industrial effluents, improper disposal of industrial wastewater and waste residues, along with various other industrial activities, are the primary contributors to the accumulation of heavy metals and other pollutants in soil and rivers during urbanization [1, 2].

Several organic and inorganic pollutants produced by humans can last in the environment for prolonged periods. As these toxins disperse and degrade in groundwater and soil, they will negatively impact the aquatic ecosystems [3]. Contaminants can concurrently cause substantial harm to human health and biological populations. The primary pressures on surface water bodies include pollution from point sources (e.g., wastewater) and diffuse sources (e.g., agriculture), as well as various hydromorphological pressures such as barriers (dams) and low-flow or channelized rivers [4, 5]. The principal impacts are nutrient enrichment, chemical pollution, and habitat alterations resulting from morphological changes [4, 5].

The Water Framework Directive (WFD) requires from EU Member States to reach good status for all surface water and groundwater bodies [6]. Ecological status and potential are metrics used to evaluate the quality and function of surface water ecosystems. The ecological state is dependent on water quality, such as pollution, and habitat destruction, serving as indicators of the overall condition of water bodies [6].

The Albanian government prioritizes integrated water management. This goal is highlighted in the National Strategy for Development and Integration 2015-2020, sanctioned by Council of Ministers No. 348 on May 11, 2016 [7]. The water sector is crucial to the social and economic advancement of the nation. It is intricately connected to electrical generation, agricultural advancement, tourism, and recreation [6, 7].

In the context of European integration, attaining EU standards in the water industry is regarded as one of the most challenging and expensive endeavours. Law 111/2012 on "Integrated Water Resources Management" have approximated the Directive 2000/60/EC "Establishing a legal framework for community action in the field of water policy" from the European Parliament and Council of Europe, dated 23 October 2000; however, this legislation has not been augmented with the requisite legal acts to render its provisions fully enforceable [6, 8].

In Albania, a country rich in biodiversity and natural resources, the environmental state of major rivers such as the Erzeni, Ishmi, Semani, and Shkumbini warrants careful examination [9]. These rivers play a significant role in local agriculture, industry, and recreation, yet they face a myriad of anthropogenic pressures, including pollution and habitat degradation [9, 10]. Understanding the current ecological status of these waterways will not only highlight the challenges they encounter but also inform necessary policy interventions.

In this study are presented finding of a one-time sampling campaign on the environmental status of four rivers in Albania.

2. Material and methods

2.1. Location of sampling stations

In the present study, the water quality of four rivers in Albania during winter season was evaluated. Sampling was conducted during January-Ferbruary, 2025 respectively in Ishmi, Erzeni, Shkumbini and Osumi-Devolli-Semani rivers. The maps of sampling stations in each river are presented in Figure 1.

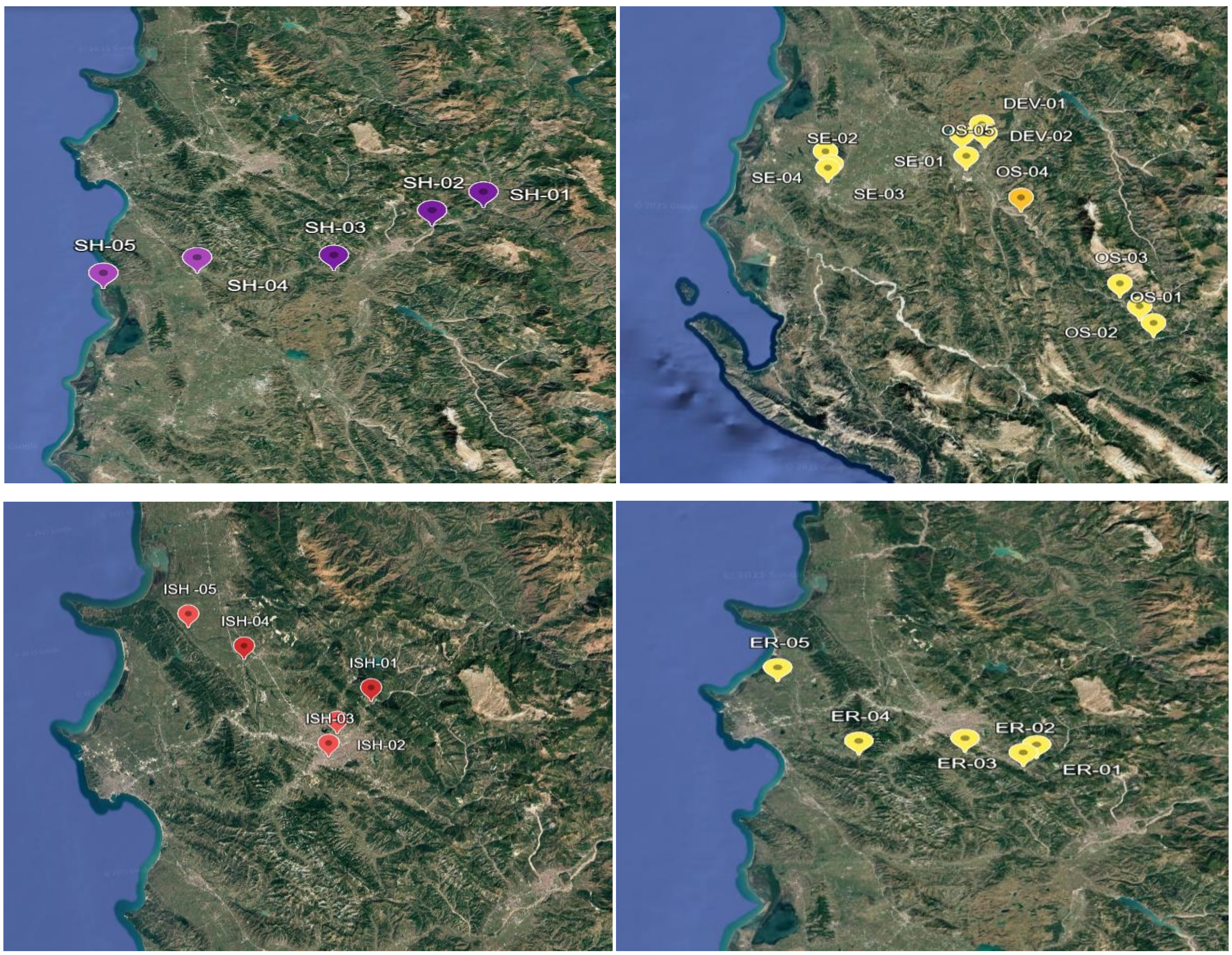

Figure 1. Maps of sampling stations. (Up-left-Shkumbini river; Up-right-Osumi-Devolli-Semani river
Down – left- Ishmi river; down right- Erzeni river.

2.2 Sampling and analysis methodology

Samples were collected using a horizontal PVC sample collector. The water samples were placed in 1L acid-washed polyethylene bottles and were stored at 4^{o}C. Water pH, temperature, conductivity, salinity and dissolved oxygen were measured in situ with a Multi meter model 3630 IDS water checker. All nutrients were determined by spectrophotometry using an UV-VIS Spectrophotometer.

The design and performance of the water sampling protocol and strategy were based on the following standards and guidelines [11].

ISO 5667-1:2023 Water quality - Sampling Part 1: Guidance on the design of sampling programmes and sampling techniques

ISO 5667-3:2024 Water quality - Sampling Part 3: Preservation and handling of water samples

ISO 5667-3:2012 Water quality - Sampling - Part 6: Guidance on sampling of rivers and streams

ISO 5667-14:2014 Water quality - Sampling - Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling

2.3 Calculation of water quality index (WQI)

Since its introduction by Horton in 1965, the Water Quality Index (WQI) has become a widely adopted tool for assessing water quality globally [12]. The WQI is calculated using multiple water quality parameters, with the specific parameters chosen based on the intended application of the evaluation. To determine the WQI, each parameter is first converted into a sub-index using recommended standard values. These sub-indices are then combined, typically through averaging, to produce an overall indicator of water quality. The water quality index WQI, was calculated by the Weighted Arithmetic Index, as below.

$$WQI = \frac{\sum WiQi}{\sum Wi}$$

Where W = unit weight, and Q = quality rating scale. W and Q were calculated using equations, respectively. The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(Vi - Vo)/(Si - Vo)$$

Where, Vi is estimated concentration of i^{th} parameter in the analysed water; Vo is the ideal value of this parameter in pure water Vo = 0 (except pH =7.0 and DO = 14.6 mg/l); Si is recommended standard value of i^{th} parameter. The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$\mathrm{Wi} = \frac{\mathrm{Ki}}{\mathrm{Si}} \qquad K = \frac{1}{\Sigma(\frac{1}{Si})}$$

2.4 Quality control of results

Quality control of the obtained results was provided by performing replicate analysis, blanks and the analysis of certified reference materials such as: NSI Lab Solution CRM 063 – simple nutrients; NSI Lab Solution CRM 064-complex nutrients; NSI Lab Solution CRM – 136 major ions;

Statistical treatment of results was provided by using the MINITAB 2023 statistical software.

3. Results and Discussions

Variations in the concentration of each parameter for selected samples were estimated by the use of Descriptive Statistics of the obtained results. All values were compared with respective recommended limits, according to European Directives, respectively Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 “On the quality of fresh waters needing protection or improvement in order to support fish life” and Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption [13, 14]. Results of Descriptive statistics are presented in Tables 1-3. Recommended values for each parameter are presented in Table 4.

Table 1. Descriptive statistics of Osumi River

	Mean	Median	Standard Deviation	Range	Minimum	Maximum	Confidence Level(95.0%)
Temp. (oC)	7.55	7.80	0.95	2.60	6.10	8.70	0.64
pH	8.36	8.40	0.51	1.78	7.26	8.85	0.34
Cond. (µS/cm)	530.82	501.00	139.64	494.00	434.00	928.00	93.81
TSS mg/L	96.98	44.70	116.91	324.86	7.54	332.40	78.54
Turb. NTU	52.83	16.50	68.51	164.38	3.62	168.00	46.02
DO (mg/L)	11.61	11.96	0.84	3.08	9.39	12.47	0.57
DO (%)	100.31	102.20	4.48	15.60	88.70	104.30	3.01
BOD_5 (mg O_2/L)	2.31	1.80	1.71	6.09	0.90	6.99	1.15
COD (mgO_2/L)	5.12	4.00	2.68	8.80	2.60	11.40	1.80
N-NO_3 (mg/L)	0.46	0.50	0.12	0.43	0.24	0.67	0.08
N-NO_2 (mg/L)	0.09	0.08	0.03	0.10	0.06	0.16	0.02
N-NH_4 (mg/L)	0.07	0.00	0.18	0.61	0.00	0.61	0.12
P-PO_4	0.05	0.01	0.06	0.16	0.00	0.16	0.04
TP	0.08	0.08	0.06	0.18	0.01	0.19	0.04
Ca	56.18	56.00	13.31	48.00	38.00	86.00	8.94
Mg	18.76	16.80	8.11	21.60	7.20	28.80	5.45
Cl^-	18.23	14.20	10.19	33.28	9.22	42.50	6.84
SO_4^{2-}	51.85	50.70	18.77	66.51	7.09	73.60	12.61

Table 2. Descriptive statistics of Shkumbini River

	Mean	Median	Standard Deviation	Range	Minimum	Maximum	Confidence Level(95.0%)
Temp. (oC)	10.70	11.40	1.06	2.10	9.40	11.50	1.31
pH	8.22	8.04	0.31	0.69	7.98	8.67	0.38
Cond. (µS/cm)	346.00	367.00	53.11	108.00	287.00	395.00	65.95
TSS mg/L	105.06	97.20	82.93	211.20	29.20	240.40	102.97
Turb. NTU	114.04	70.60	99.63	252.80	21.20	274.00	123.70
DO (mg/L)	11.58	11.37	0.39	0.83	11.18	12.01	0.48
DO (%)	104.58	104.10	1.50	3.40	102.90	106.30	1.86
BOD_5 (mg O_2/L)	2.71	2.70	0.31	0.87	2.28	3.15	0.39
COD (mgO_2/L)	3.04	3.10	0.50	1.20	2.50	3.70	0.62
N-NO_3 (mg/L)	0.51	0.55	0.10	0.25	0.33	0.58	0.13
N-NO_2 (mg/L)	0.08	0.09	0.02	0.05	0.06	0.11	0.02
N-NH_4 (mg/L)	0.05	0.03	0.05	0.10	0.00	0.11	0.06
P-PO_4	0.01	0.01	0.01	0.02	0.00	0.02	0.01
TP	0.03	0.02	0.02	0.05	0.01	0.06	0.03
Ca	41.80	44.00	4.60	11.00	36.00	47.00	5.72
Mg	18.96	19.20	4.83	12.00	12.00	24.00	6.00
Cl^-	11.03	10.60	2.42	5.78	8.40	14.18	3.00
SO_4^{2-}	24.74	27.90	9.99	22.00	13.90	35.90	12.40

Table 3. Descriptive statistics of Ishmi and Erzeni Rivers

	Mean	Median	St. Dev.	Range	Minimum	Maximum	Confidence Level(95.0%)
Temp. (oC)	9.49	9.6	1.9	6.1	7.3	13.4	1.33
pH	7.66	7.715	0.2	0.57	7.29	7.86	0.13
Cond. (µS/cm)	546.9	549.5	140.2	444	401	845	100.30
TSS mg/L	910.6	786	923.1	2486.8	27.2	2514	660.36
Turb. NTU	387.0	342.85	364.8	848.8	23.2	872	261.00
DO (mg/L)	9.84	11.02	3.2	10.2	2	12.2	2.27
DO (%)	84.6	98.2	26.4	80.5	19.8	100.3	18.90
BOD_5 (mg O_2/L)	275.7	5.82	778.9	2488.7	1.3	2490	557.20
COD (mgO_2/L)	9.90	6.6	14.1	47.3	2.2	49.5	10.10
N-NO_3 (mg/L)	0.39	0.34	0.3	0.76	0.05	0.81	0.18
N-NO_2 (mg/L)	0.39	0.12	0.6	2.06	0.04	2.1	0.44
N-NH_4 (mg/L)	2.78	0.489	7.3	23.5	0.0263	23.5	5.22
P-PO_4	0.23	0.007	0.6	1.93	0.001	1.93	0.43
TP	0.33	0.02275	0.9	2.74	0.009	2.75	0.61
Ca	60.2	58	8.8	24	50	74	6.29
Mg	17.2	16.2	5.3	15.6	12	27.6	3.77
Cl^-	14.8	15.25	4.4	13.8	8.23	22	3.16
SO_4^{2-}	49.2	49.6	18.8	55	25.7	80.7	13.50

Table 4. Recommended values according to Directives 2006/24/EC and Council Directive 98/83/EC

Parameter	Recommended value
Temp. (oC)	na
pH	6.0-9.0
Cond. (µS/cm)	2500
TSS mg/L	25
Turb. NTU	na
DO (mg/L)	≥5.0
DO (%)	Class A1 - ≥70; Class A2 - ≥50; Class A3 - ≥30
BOD_5 (mg O_2/L)	3.0 (S); 6.0 (C)
COD (mgO_2/L)	Class A1, A2 - n.a.; Class A3 - 30
NO_3 (mg/L)	Class A-1: 25 Guidance, 50 Imperative; Class A2, A3 - 50
NO_2 (mg/L)	0.01 (S); 0.03 (C)
NH_4 (mg/L)	0.04 (S); 0.2 (C)
P-PO_4 (mg/L)	Class A1 - 0.17; Class A2, A3 – 0.30
TP (mg/L)	na
Ca (mg/L)	200
Mg (mg/L)	50
Cl^- (mg/L)	250
SO_4^{2-} (mg/L)	250

Note: Class A1 - need only simple physical treatment (filtration) and disinfection; Class A2 - Normal physical treatment, chemical treatment and disinfection, e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination). Class A3- Intensive physical and chemical treatment, further treatment and disinfection, e.g. chlorination to the breaking point (the point where *we have residual free chlorine), coagulation, flocculation, decantation, filtration, absorption (activated carbon), disinfection (ozone, final chlorination).*

4. Discussions

The highest variation in the concentration of the determined parameters were more evident for conductivity, TSS, Turbidity and BOD_5, COD and less evident for pH, nitrogen and phosphorus compounds.

Temperature in waters of the selected rivers ranged between 6.1 (in Osumi River to 13.4 in Erzeni-Ishmi River. River water temperature tends to follow the ambient air temperature.

pH values ranged between: 7.26-8.85, both values registered in water of Osumi River. All measured pH values fall within the recommended limits set for surface water, respectively Directives 2006/24/EC and Council Directive 98/83/EC.

Conductivity and major ions content in all selected stations were below the threshold limits according to Directives 2006/24/EC and Council Directive 98/83/EC. Water hardness in the rivers varied 161 to 330 mg/L $CaCO_3$, being classified as hard and very hard water.

NH_4^+: Among the nitrogen compounds, ammonia (NH_4^+) comprised the main portion in samples of Ishmi-Erzeni rivers. It is generally present in natural waters as a result of microbiological activity which causes the reduction of nitrogen-containing compounds. Obtained results revealed that the highest content of ammonia was observed in sample ISH-03-Lana, (23.6 mg/L) followed by ISH-04 and ISH-05 (1.25 and 1.13 mg/l respectively). Lana River is considered one of the most polluted rivers, which flows through Tirana city, collecting a wide range of domestic and waste water of the city. It is then discharged in Ishmi River.

In contrast, concentration of ammonia in stations ISH-01; ISH-02; OS-01 to OS-04; DE-01 and DE-02; SE-02 and SE-04; ER-01, ER-02 and ER-05 resulted to be lower than the limit 0.04 mg/l, recommended by the Directive 24/2006 EC for salmonid waters.

NO_3^-. The presence of nitrogen in the form of nitrates indicates older events of pollution [1, 2]. In selected samples**,** samples ER-05 and ER-04 exhibited the highest content of nitrates, (3.59 and 3.10 mg/l). Even though all values have resulted lower than the recommended value (25 mg/l NO_3^-) presence of nitrates indicate old contamination, probably mainly from the use of the fertilisers in the areas where the river flow.

NO_2^-. Nitrite exists normally in very low concentrations, even in waste treatment plant effluents, principally because the nitrogen will tend to exist in the more reduced (ammonia; NH_3) or oxidised (nitrate; NO_3) forms. High nitrite levels would indicate a more recent pollution as it is an intermediate stage in the ammonia-to-nitrate oxidation. The highest concentrations of nitrites in this investigation were evident for samples of Ishmi river suggesting instant pollution being present in the time of sample collection.

TP, P-PO_4^{3-}. Run-off and sewage discharges are important contributors of phosphorus to surface waters. Phosphorus along with nitrate, promotes the growth of algae and other plants in the water. Usually total phosphorus is the most complete determination of the element phosphorus, irrespective of the compounds in which it is actually present in the water. The limit 0.17 mg/l, set by the Directive 24/2006/EC was exceeded only in station ISH -03 (Lana river).

BOD_5, COD. Can be found naturally or from introduced organic matter in the water. No direct health implications were observed for this parameters, but are considered important indicators of overall water quality. The highest concentration was observed in samples of Ishmi river, especially station of Lana River, (2490 mg/l O_2), exceeding the limit recommended by the Directive 24/2006/EC by approximately 1000 times.

Water Quality Index (WQI). The overall water quality of the selected water samples was estimated by means of the WQI. In the graphs of Figure 2 are presented WQI values obtained for all selected stations of respective rivers

WQI values ranged between 10.5 to 6900 respectively in station SE-02 and ISH-03. Samples collected at the mouth of the rivers, such are: SE-02 SH-01; SH-02; OS-01; OS-02; ISH-01; ER-03 and ER-04 have exhibited excellent water quality (WQI <25).

Water quality in stations ISH-02; ISH-03; ISH-04; ISH-05 have resulted to be very poor. Also, stations like SE-01; SE-03 and SE-04 have exhibited very poor water quality.

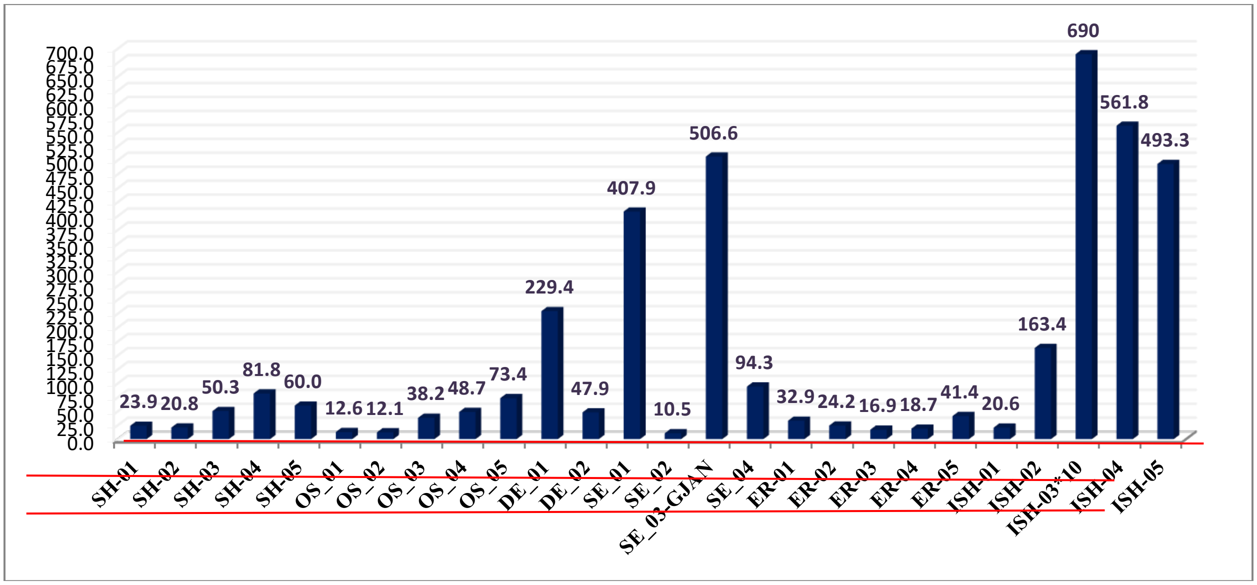

Figure 2. Water Quality Indexes of selected stations

4.2 Principal Component Analysis

In this study, Principal Component Analysis (PCA) was employed to analyze the multivariate water quality data collected from various sampling sites. Given the complexity and high dimensionality of the dataset, PCA was used to reduce the number of variables while retaining the majority of the information. Results of parameters analyzed in all rivers selected in this study are presented in Figure 3.

The results of the Principal Component Analysis (PCA) revealed that the first two principal components (PC1; PC2) accounted for the majority of the variance in the water quality dataset, indicating that these components effectively summarize the key patterns in the data. Parameters such as nitrites, phosphates, ammonia, total phosphorus, chemical and biochemical demand, showed strong positive loadings on the first principal component, PC1 indicating their association with instant waste discharges, mainly form untreated waste water or the solid wastes.

Parameters like dissolved oxygen and pH showed strong positive loadings on the PC2, whereas NO_3 showed negative loading to PC1 and PC2. It is known the fact that nitrates originate mainly by the use of fertilizers and also in oxygenated water nitrogen exists mainly in the NO_3^- state. In this case a negative correlation was found between oxygen and nitrates concentration assuming that it can be inputted to the rivers due to external sources rather than due to oxidation of nitrites and ammonia ions.

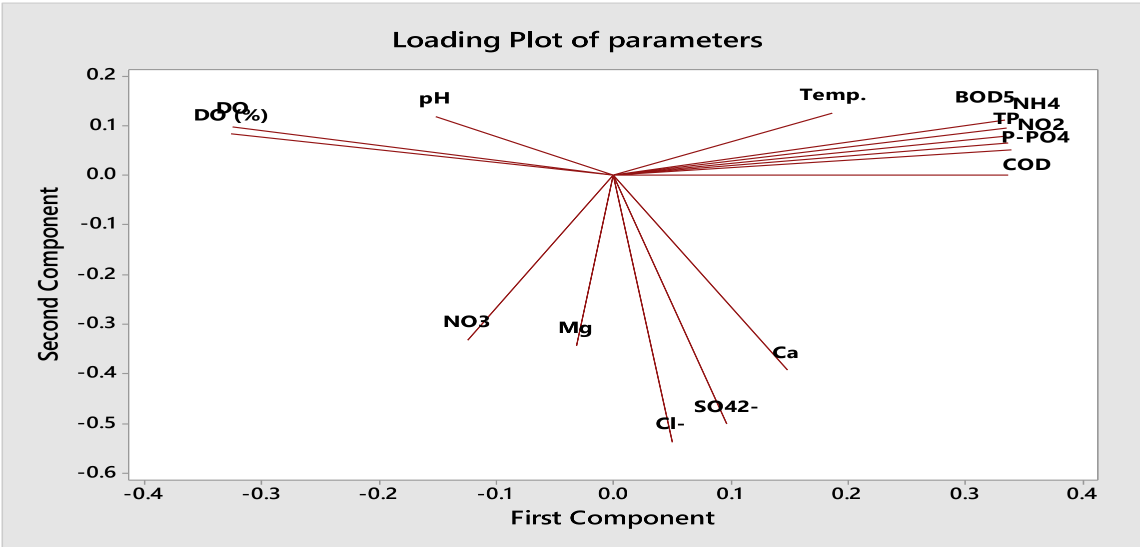

Figure 3. PCA of selected physic-chemical parameters

5. Conclussions

The study revealed substantial variability in key water quality parameters, particularly conductivity, TSS, turbidity, BOD_5, and COD, indicating different levels of anthropogenic impact across the sampled rivers. Extremely high concentrations of ammonium in the Lana River (up to 23.6 mg/L) highlight severe local pollution, likely resulting from untreated domestic and urban wastewater. This supports the classification of the Lana River as one of the most polluted in the region.

Water hardness values ranged from 161 to 330 mg/L $CaCO_3$, classifying the rivers as having hard to very hard water, which can have ecological and technical implications for water use and treatment.

The presence of high ammonium levels in urban rivers underscores the urgent need for improved wastewater treatment infrastructure and enforcement of environmental regulations, particularly in urban centers like Tirana.

Overall, this study provides valuable insights into the current status of the river's water quality, serving as a baseline for future monitoring and conservation efforts to ensure sustainable water resource management.

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