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Assessment of Water Pollution in the Erzeni River: Major Sources, Environmental Impacts, and Sustainable Solutions

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Abstract - This study aims to characterize water pollution of the Erzen River in Albania, by analyzing the main sources of pollution and their environmental impacts. For this study, water samples were collected along the river impacted by human settlements, human activity and agricultural activities at four points, during three expedites (April June, July 2023) analyzing of physico- chemical parameters, and some nutrients. All analytical methods used for parameter analysis were standard methods, recommended by the contemporary international literature as so as APHA, DIN, ISO/EN which are considered official water analysis methods in the USA and Germany. For chemical analysis, the calibration curve, sensitivity, working range and measurement range have also been evaluated. Statistical analysis was performed to assess variations and relative pollution levels across stations. The results indicate high levels of pollution, especially in the urban and downstream segments, with significant consequences for biodiversity and human health. The study proposes a set of measures aimed at improving water quality and restoring the river ecosystem in line with principles of sustainable development.

Keywords: Water pollution, Erzen river, pollution sources, sustainable management

Introduction

The addition of material or energy forms to a water body that modifies the character of the water body is referred to as water pollution. [1]- [2]- [3]- [4]- [5]-[6]- [7]

Water is considered polluted if it contains substances or conditions that prevent it from being used for a certain purpose, example the water is no longer appropriate for bathing, cooking, drinking. [8]

Water resources are necessary for sustaining human life and life of other living organisms, assuring manufacturing and agriculture. However, anthropogenic factors, natural geochemical and biological processes, climate change processes lead to disruptions of water ecosystems, worsening water quality and decreasing volumes of fresh water.

High quality water reserves are shrinking, and this limits opportunities for preserving public health, biodiversity, nature's aesthetic and recreational potential. Water scarcity directly affects over 40% of the world population in water stressed regions of every continent. It also has severe repercussions for the neighboring countries and represent a growing global problem for humanity. The United Nations project that by 2050 one in four people or more will be affected by repeated water shortages. Integrated (sustainable) water resources management and pollution treatment should be applied in order to address the global water challenges. [9]

Natural surface waters are an extraordinary asset in our country; therefore, their qualitative assessment is of particular importance.

The Erzeni River originates from Mali me Gropa, 25 km east of Tirana, near Shengjergji, and flows into the Bay of Lalezit north of the city of Durrës. The watershed discharges into the main Erzeni River, with quite large feeder branches formed by the rivers. The watershed area is 760 km², with a length of 109 km. The main tributaries of this river are the Zalli, Zhullimed and Peze branches, with respective drainage areas of 79.8 km², 132 km² and 74.3 km². The assessment of the annual flow regime of the Erzeni River basin takes into account observations at hydrometric stations, where water and flow levels are measured and where the flow-level ratio is determined. This study aims to characterize water pollution of the Erzeni River in Albania, by analyzing the main sources of pollution and their environmental impacts. The study proposes a set of measures aimed at improving water quality and restoring the river ecosystem in line with principles of sustainable development.

Materials and Methods
Sampling Sites

Water samples were collected along the river impacted by human settlements, human activity and agricultural activities at four points, during three expedites (April June, July 2023). Figure 1 gives a map of the water sampling stations: E1 at 'Théatre Kame' E2 at 'Illumination'; E3 at near the "Sharre" Landfill; E4 was taken at 'Beshiri Bridge"

Fig 1. The water sampling stations

Sampling, preservation and conservation at river stations was carried out in accordance with the recommended standard methods. [10]-[11]-[12]-[13]-[14]

All standard analytical methods used, are recommended by APHA [15], DIN [16]- [17]-[18] and [19], and EN/ISO standard methods, [19]-[20]. All nutrients were determined by UV- VIS, spectrophotometry technique [15]-[16]-[17]-[18]- [19]-[20].

Very important during the analysis of surface water pollution is the evaluation of the analytical performance of the methods used for the analysis. For chemical analyses, the calibration curve, sensitivity, working range and measurement range have also been evaluated. [15]

Results and Discussions

The results obtained during this study after statistical processing with the descriptive statistics method are presented in Tables [1]-[2]- [3]- [4]-[5]- [6]- [7]- [8]. The discussions are divided into two groups: physico-chemical parameters and nutrients.

In order to have a complete picture, these results were interpreted and compared, with European Standards and Allowed Norms:

Environmental Quality Criteria the Classification of the Norwegian Institute for Water Research. [21]

European Community Directive (CEE/CEEA/CE 78/659) regarding "Quality of fresh waters supporting fish life" [22]

The Water Quality Classification According to UNECE. [23] - [24]

Temperature is a significant parameter for a river system, affecting photosynthesis process of aquatic plants, but also the solubility of salts, content of DO, biodegradation of organic compounds and other physic-chemical parameters [25]

The results of this study show that the water samples analyzed had variable temperatures depending on the month in which they were taken. The lowest temperature of 12.4°C was found in April at the Kame Theater sampling site, while the highest temperature of 30.2°C was found in July at the Ura e Beshirit sampling site. It is also worth noting that in the river studied, the temperature increases gradually from the upper to the lower reaches.

Table 1.

Temperatura				
	E1	E2	E3	E4
Mean	18.5	20.7	23.2	23.8

Median	18.9	21.6	25.6	23.9
Standard Deviation	5.46	5.56	7.49	6.45
Minimum	12.8	14.7	14.8	17.3
Maximum	23.7	25.7	29.2	30.2

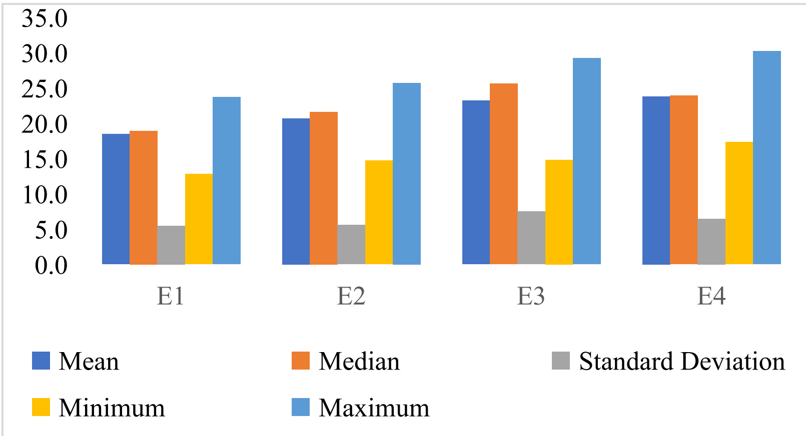

Fig 2. Temperature values trend for each station

pH

Table 2. pH values for each station

	E1	*E2*	*E3*	*E4*
MEAN	8.180	8.069	8.078	7.831
MEDIAN	8.176	8.085	8.077	7.831
STANDARD DEVIATION	0.122	0.041	0.379	0.086
MINIMUM	8.061	8.022	7.7	7.77
MAXIMUM	8.304	8.1	8.457	7.892

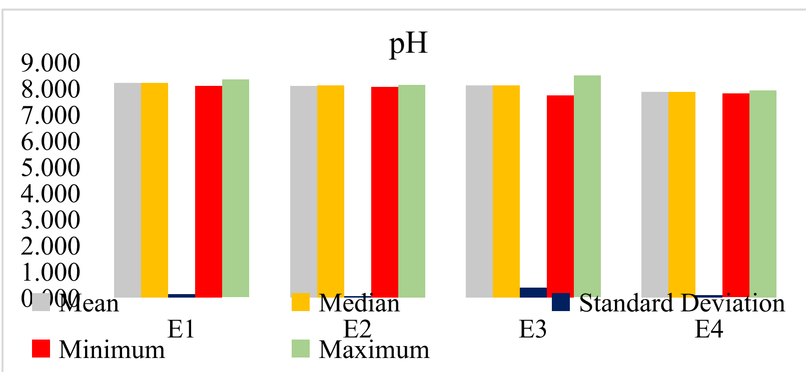

Fig 3. pH values trend for each station

The results obtained for the study show mean pH values ranging from 7.831 - 8.180. These values are normal values for European norms (pH >6) and show that these waters are suitable for fish farming and according to NIVA norms, they belong to class I of environmental quality, (pH > 6.5).

Conductivity

The electrical conductivity of water indicates the overall presence of chemical compounds and is an indicator of water pollution. The higher the conductivity of natural water, the more polluted it will be. The following table show the conductivity values for this study.

Table 3. The conductivity values

	E1	E2	E3	E4
Mean	409	405	438	454
Median	423	422	455	450
Standard Deviation	36.7	45.9	45.4	45.1
Minimum	367	353	387	411
Maximum	436	440	473	501

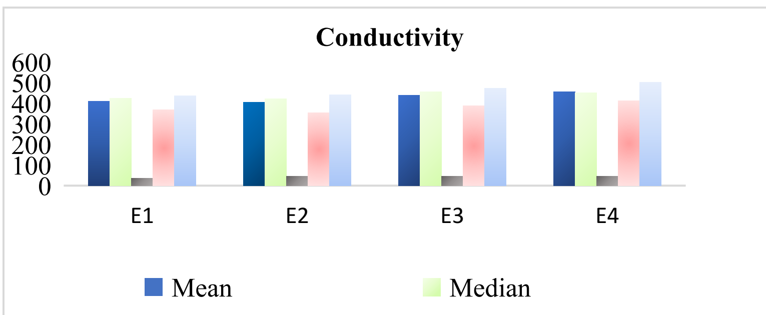

Fig 4. The value of electrical conductivity

The highest average value of electrical conductivity was recorded at station E4 (Beshir Bridge) and the lowest value at station E1 (Kame Theater). It is noted that the value of electrical conductivity is increasing at the stations belonging to the lower parts of the studied river – urban areas. This is due to the increase in discharges into the river.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a very important quality parameter that indicates the health of the aquatic environment. The concentration of DO in water depends mainly on temperature, dissolved salts, wind speed, pollution load, photosynthetic activity and respiration rate. The lack of oxygen is fatal for many aquatic animals such as fish. The presence of oxygen can be equally fatal for many types of anaerobic bacteria.

Table 4 Variation of DO values by stations

The results of our study show that the mean DO values range from 7.183 mg/L at sampling site E3 to 9.287mg/L at sampling site E1. The minimum DO value (5.88) was recorded at station E3 in June and the highest value,

	E1	E2	E3	E4
Mean	9.287	9.070	7.183	8.260
Median	9.04	9.23	7.3	8.04
Standard Deviation	1.130	0.753	1.249	0.407
Minimum	8.3	8.25	5.88	8.01
Maximum	10.52	9.73	8.37	8.73

10.52, was recorded at station E1 in April. These results are explainable (stations with the lowest DO values are stations in urban areas affected by anthropogenic activity).

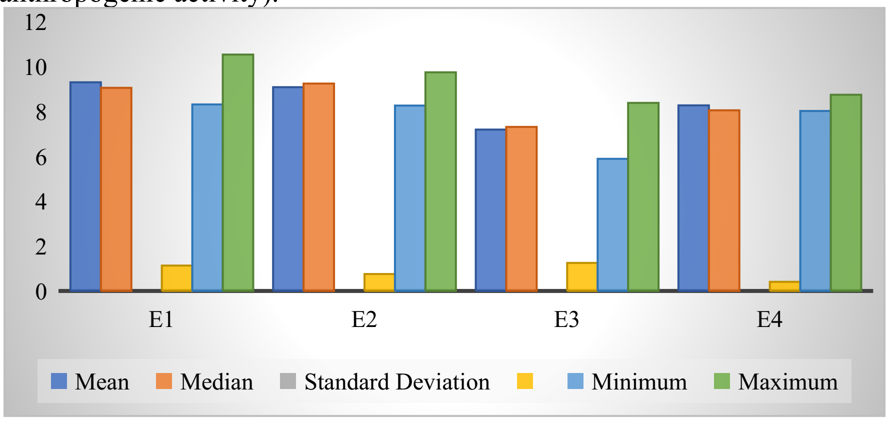

Fig 6. Variation of DO values by stations

Based on the classifications according to standards (NIVA > 9 mg/l O_2, UNECE > 7 mg/l O_2 and EC Directive > 9 mg/l O_2), we can evaluate the studied waters in the following way:

The waters of station E1, E2, are classified in class I, “good” according to NIVA, according to UNECE they are classified in environmental class I and according to the European Directive they are suitable for fish farming;

The waters of station E3, E4, referring to the average DO values recorded during the study, are classified in class II - “good” according to UNECE and NIVA, but are not suitable for fish farming.

Biochemical oxygen demand (COD)

Chemical oxygen demand (COD) is a critical water quality parameter that represents the degree of organic pollution in water bodies. This is an important issue for the characterization of water bodies, urban and industrial liquid discharges.

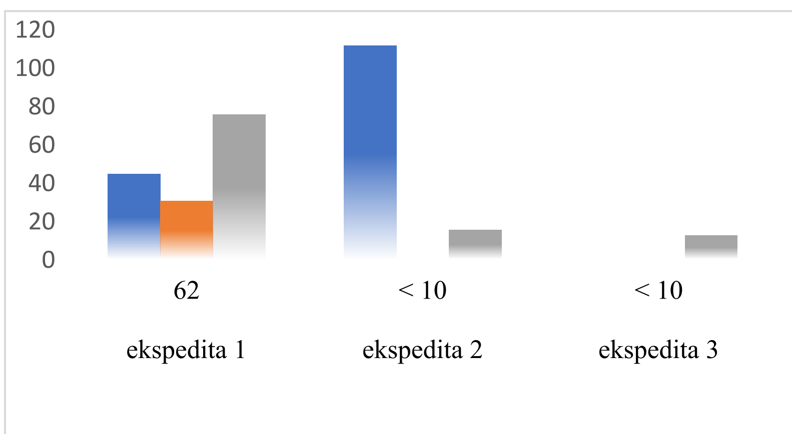

Fig 7. Variation of COD values by stations

Based on Figure 7, we see that the highest average COD values were recorded at station E2, followed by station E3. These values can be explained by the fact that in these river segments the majority of the discharges of restaurants and urban collectors of the city are collected. Comparing the average COD values with the values recommended by international standards, we say that, according to UNECE and according to the NIVA classification, the studied waters belong to class V with a very poor environmental quality.

Suspended solids (TSS)

The concentration of suspended solids affects the water balance in the cells of aquatic organisms. Higher concentrations of suspended solids can serve as carriers for toxic substances, which easily attach to suspended particles. This is most noticeable when pesticides are used. High concentrations of suspended solids reduce the passage of light through the water, thus slowing photosynthesis by aquatic plants. Sources of suspended solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion.

Table 4 Variation of TSS values by stations

	E1	E2	E3	E4
Mean	0.132	0.328	0.596	0.689
Median	0.087	0.1462	0.2604	0.3146
Standard Deviation	0.157	0.447	0.816	0.931
Minimum	0.003	0.0004	0.0014	0.00315
Maximum	0.307	0.837	1.526	1.749

Figure 8 shows the mean, median, minimum, and maximum TSS values.

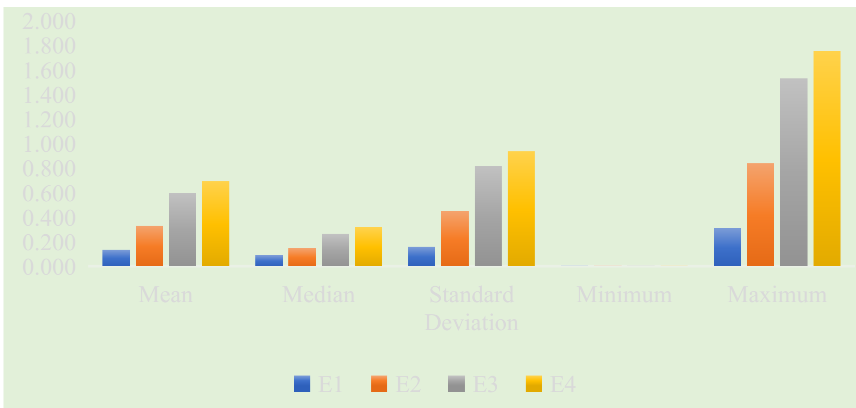

Fig.8. The results of the statistical processing of the TSS parameter in the waters of the Erzeni River

From the graph presented in this figure it can be seen that the average values range from 0.132 mg/L E1 to 0.68mg/L E4 station. The minimum TSS value was recorded at E3 station during the third expedition and the maximum TSS value was recorded at E4 station during the first expedition. This is explained by the fact that this expedition was carried out in April during which there was heavy rainfall and the flows of the rivers under study were large and influenced by anthropogenic activities. If we compare the results, referring to the average TSS values (mg/L), with the European standards we say that:

According to the NIVA classification, for the V quality class, the TSS limit is 10 mg/L. The average TSS values for the studied stations result in quality I. According to the EU Directive, the recommended level for TSS is below 25 mg/L. So, this shows that the studied waters are suitable for fish farming

Alkalinity

The capacity of water to accept H+ ions (protons) is called alkalinity. Alkalinity is important in water treatment in the chemistry and biology of natural waters. Natural water typically has an alkalinity of

$1.00*10^{-3}$ equivalents of liter (eq/L), meaning that the alkalinity dissolved in 1 liter of water will neutralize $1.00*10^{-3}$ mol. of acid. The contributions of different species to alkalinity depend on pH. Highly alkaline water often has a high pH and generally contains high levels of dissolved solids.

Table 5 Variation of Alkalinity values by stations

	E1	E2	E3	E4

Mean	7.933	11.667	7.967	6.300
Median	11	16	10	0.7
Standard Deviation	6.198	9.292	6.301	10.136
Minimum	0.8	1	0.9	0.2
Maximum	12	18	13	18

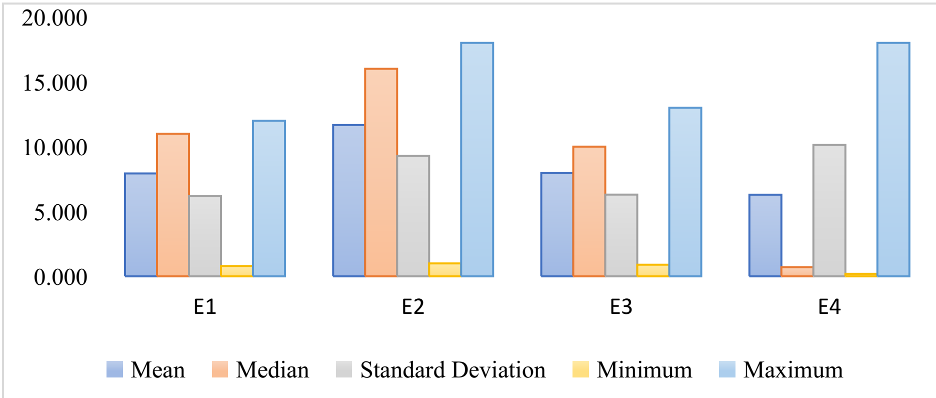

Fig 9. Variation of alkalinity values by stations

The average alkalinity values in this study range from 6.3 mg/L to 11.667 mg $CaCO_3$/L or from 0.0063 mmol/L to 0.1166 mmol/L (table 5, fig. 9). These values are recommended from 100 - 200 mg/L of the "good" class and > 200 mg/L, of the "very good" class, according to the UNECEF norms, so that the buffer capacity of the water is very good, or in the range > 0.2 mmol/L of the "very good" water quality class, and 0.05-0.2 mmol/L of the "good" water quality class according to the NIVA norms, classifying them as good waters.

Hardness

The total hardness of water is a very important parameter of water quality that affects its use in many branches of industry and production. Water hardness is the total concentration of calcium and magnesium ions in a water sample and is expressed as the concentration of calcium carbonate.

Table 6 Variation of Hardness values by stations

Hardness	E1	E2	E3	E4
Mean	78.3	87.1	67.9	114.5
Median	42	78	60	84
Standard Deviation	94.9	79.6	54.5	119.3
Minimum	6.9	12.4	17.8	13.4
Maximum	186	170.8	126	246

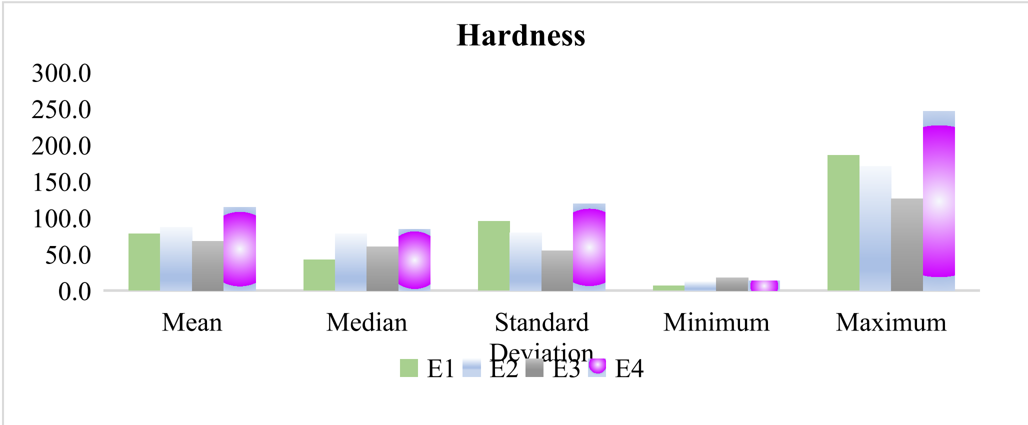

Fig10. The mean values of total hardness

From the graph given in Figure 10 it is noted that the average values of total hardness in the studied waters range from 67.9 mg$CaCO_3$/L for station E3 to 114.5 mg$CaCO_3$/L for station E4. The minimum value of total hardness resulted in station E1 of 6.7mg/L and the maximum value resulted in station E4 of 246mg/L $CaCO_3$. Based on these results, it can be said that these waters are relatively classified as moderately soft - moderately hard waters.

Nutrients

Orthophosphates

Phosphorus is a nutrient for living organisms, but it is a pollutant if it is present in high concentrations under specific environmental conditions. The addition of phosphorus as phosphate ion to natural waters is one of the most serious environmental problems due to its contribution to the processes of artificial eutrophication of waters.

In natural waters and wastewater, phosphorus is present almost exclusively in the form of phosphates, which can be dissolved and as insoluble compounds (mainly with iron, aluminum and calcium) in solid particles and sediments.

Table 7 presents the results obtained from the statistical processing of the orthophosphate parameter in the waters of the Erzen river

Table 7. The results of the statistical processing of the PO_4^{3-} - P(mg/L) parameter in the waters of the Erzeni river

	E1	E2	E3	E4
Mean	0.0736	0.0905	0.2783	0.1777
Median	0.0493	0.1051	0.3731	0.2459
Standard Deviation	0.0739	0.0252	0.1642	0.1180
Minimum	0.0149	0.0615	0.0886	0.0414
Maximum	0.1565	0.1051	0.3731	0.2459

Figure 11 shows the average values of orthophosphate concentration as PO_4^{3-} - P and the minimum and maximum values for each station.

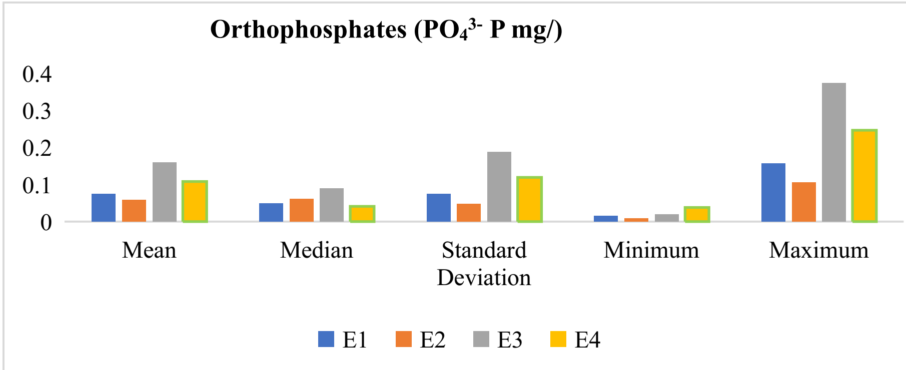

Fig 11. Variation of orthophosphates concentration by stations (PO_4^{3-} - P mg/L)

It is noted that the highest phosphate concentration values were measured at station E3. These high values are also followed by station E4.

Compared to international standards European Directive, the mandatory level of orthophosphates as phosphorus for salmonid waters is 0.2 mg/L and for cyprinid waters is 0.4mg/L.

From the stations taken in the study, it is noted that the resulting values of orthophosphates as phosphorus concentrations were within the permitted norms for cyprinid waters and the waters of stations E3 and E4 exceed the norms for salmonid waters of this directive.

Total Phosphorus

Table 8 presents the results obtained from the statistical processing of the total phosphorus parameter in the waters of the Erzeni river.

Table 8. The results of the statistical processing of the total P (PO_4^{3-} - P mg/L) parameter in the waters of the Erzeni river

	E1	*E2*	*E3*	*E4*
Mean	0.169	0.232	0.346	0.296
Median	0.072	0.108	0.391	0.304
Standard Deviation	0.215	0.300	0.305	0.028
Minimum	0.019	0.014	0.021	0.265
Maximum	0.416	0.573	0.626	0.320

Figure 12 shows the variability of total phosphorus concentration (PO_4^{3-} - P mg/L) from station to station.

From the graph it can be seen that the total phosphorus concentration values are higher for stations E2, E3, and the average values range from 0.169 mg/L phosphorus for station E1 to 0.346mg/L at station E3. These concentration values have the same trend as the orthophosphate concentrations.

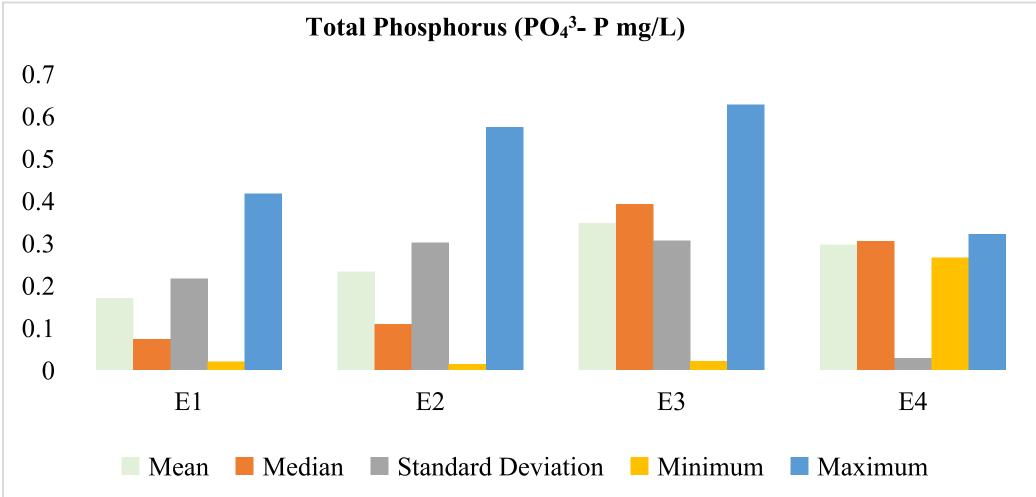

Fig12. Variation of total phosphorous concentration by stations (PO_4^{3-} - P mg/L)

Compared to European standards:

Based on the classification according to NIVA, all stations taken into the study belong to environmental quality class V (very bad), resulting in highly polluted, in terms of total phosphorus concentration.

According to UNECE all stations belong to class V resulting in the environmental class "very bad"

Nitrites

This parameter is also considered an indicator of surface water quality, as it has stronger toxic properties than nitrates in humans and animals. For this reason, limit values for its presence in waters have been determined and based on its content, we can also classify their quality. The content of nitrites in groundwater and surface waters is very low, usually < 0.01 mg to 0.03 mg NO_2^-/L. The high concentration of nitrites in river waters is due to wastewater discharges or industrial discharges. Table 9 presents the results obtained from the statistical processing of the nitrite parameter in the waters of the Erzeni river.

Table 9. The results of the statistical processing of the NO_2^- - N (mg/L) parameter in the waters of the Erzeni river

	E1	E2	E3	E4
Mean	0.0033	0.0063	0.0430	0.0157
Median	0.003	0.007	0.059	0.015
Standard Deviation	0.001	0.003	0.028	0.002
Minimum	0.002	0.003	0.010	0.014
Maximum	0.004	0.009	0.060	0.018

The graph in the figure below shows the mean, median, standard deviation, minimum and maximum nitrite concentrations.

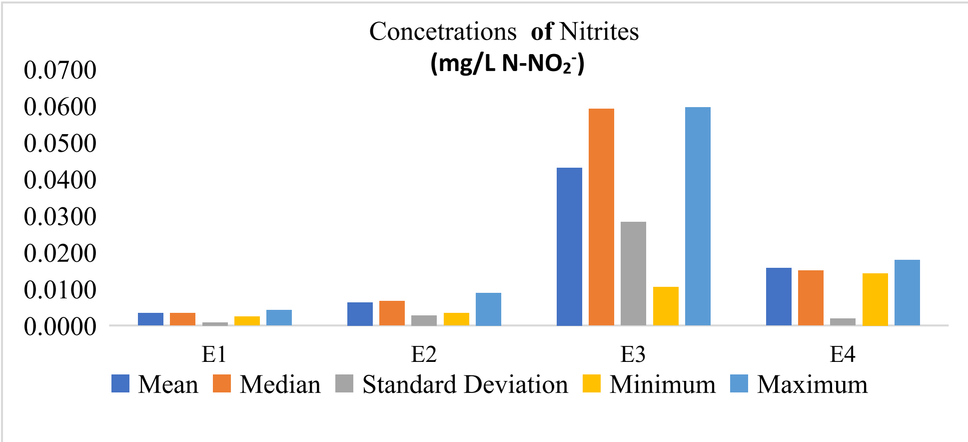

Figure 13. Variation of nitrite concentration by stations NO_2^- - N (mg/L))

From the results of statistical processing, it is noted that the average value of the nitrite concentration varies from 0.0033mg/L at station E1 to 0.0157mg/L at station E4. The concentration of nitrite is higher at stations where there are urban, industrial and agricultural discharges.

According to the European Directive, the recommended level for salmonid waters is <0.01 mg/l, while for cyprinid waters it is <0.03 mg/l. Compared to the European Directive, of the waters studied, only the waters of stations E1 and E2 meet these conditions. The waters of other stations do not meet these conditions. Therefore, they are not suitable for fish farming.

Conclusions

The average results of the study show a significant and sustainable impact of urban and industrial discharges on the quality of the studied waters. The Erzeni River is under significant environmental stress, particularly in its lower sections. (sampling sites E3 -Sharre and E 4 - Beshiri Bridge).

Pollution stems primarily from urban discharge and agricultural runoff, with major consequences for water quality, biodiversity, and human health. Urgent and coordinated actions are necessary to reverse degradation and restore the ecological integrity of the river through sustainable policies and investments. Based on this result we recommend: Development of treatment plants in urban areas along the river, especially in the outskirts of Tirana; Rigorous implementation of environmental legislation and punishment of repeat polluters; Awareness campaign with the local community to ban waste dumping in the river.

Continuous monitoring and transparency in the publication of water quality data by state institutions; Inter-institutional cooperation projects and with international organizations, to finance and implement sustainable water management practices.

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