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EVALUATION OF ENVIRONMENTAL SITUATION IN NARTA LAGOON, VLORA, ALBANIA

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Abstract

Narta Lagoon is one of the biggest Lagoons in Albania. It is situated in the southern part of the Vjosa River delta. Two canals in the northwest and southwest parts of the lagoon connect it to the Adriatic Sea. These artificial canals enable the water exchange process with the sea during tidal flow. Vjose - Narta area is considered a Protected Landscape, so environmental monitoring is important. Setting and design: Water samples were taken monthly, at six evenly distributed sample stations. The study was conducted from January – to December 2018. Materials and methods: The assessment of microbial contamination was performed with the MPN method. Total coliform, fecal coliform, and fecal streptococci were tested as fecal contamination indicators. PH and salinity were the physicochemical parameters analyzed. Conclusions: the cleanest sampling station is the one near contact with the seawater. The most polluted stations are stations 2, 4, and 6. Temperature values range from 5 ^oC in January to 33 ^oC in August. Lagoon pollution is caused by an anthropogenic factor as well as a lack of appropriate cleaning strategies.

Keywords

Water Quality, Pollution, Fecal contamination, Physic-Chemical Parameters, Narta Lagoon

1. Introduction

The Narta Lagoon is Albania's second-largest coastal lagoon. It is separated by a narrow littoral cordon. Due to its position between the land and the sea, it is a highly productive coastal ecosystem. Narta Lagoon serves as a refuge and food area for many continental and marine species.

The categorization of coastal lagoons as transitional areas defined by shallow waters is a typical feature. They have low hydrodynamics, high productivity, and a high sedimentation rate (Viaroli et al. 2001). These lagoons are easily affected by atmospheric phenomena such as evaporation, precipitation, winds, cyclones, and tidal currents, which can cause biogeochemical changes. Most coastal lagoons are shallow, which helps to enhance the effect of forces between land, sea, and atmosphere (such as winds, tides, and relative sea level), which can easily result in rapid changes in lagoon biogeochemistry (Viaroli et al. 2001). As a result, these ecosystems are described as complex and delicately balanced.

Significant anthropogenic pollutants from both point and non-point sources are present in coastal lagoons (Davutluoglu et al. 2010). They are also subject to high anthropogenic pressures that come as a result of increased human activity, urbanization, and industrialization. Factors such as waste discharges from various sources, such as: agricultural runoff, domestic and industrial runoff, industrial waste, untreated wastewater, various wastes during boat ballast, and uncontrolled fishing, are responsible for alterations in the microbial ecology of water in these places. These types of factors have an influence also in the deterioration of chemical and biological factors (Fiandrino et al. 2003; Mansilha et al. 2009; Cabral 2010; Fiandrino et al. 2003; Bakaj et al., 2017; Bakaj A., Ruçi E., Kalaja J., 2017).

Increased concentrations of microbial fecal contamination indicators emanating from many sources could indicate a higher risk, such as the presence of additional pathogenic microorganisms, pathogenic bacteria, enteric viruses, or even parasites (Anastasi et al. 2012; Steele et al. 2018; Vega et al. 2021). This water can consequently lead to the transmission of pathogens and water-borne diseases (Savichtcheva & Okabe 2006). Therefore, it is critical to comprehend the scope of fecal contamination (Sugumar et al. 2008).

Continuous monitoring of microbiological indicators such as total coliform (TC) and fecal coliform (FC) bacteria is critical because they provide insight into the sanitary status of recreational waterways and fisheries. (Sugumar et al. 2008). In addition to anthropogenic origins (e.g., sewage, agricultural, and urban waters), feces from a wide variety of warm-blooded species, including waterfowl from coastal coastlines and wetlands, must be considered a source of fecal bacteria (Evanson & Ambrose 2006; Bakaj A., Kiçaj H., and Ferati A. 2019). Consequently, land runoff caused by rivers, streams, or drainage canals, wildlife, sewage runoff, animal farm runoff, and damaged septic systems should be considered significant sources of water microbial contamination. (Bakaj and Dalipaj, 2020; Chigbu et al., 2005; Viau et al., 2011).

The goal of this research is to evaluate the state of the Narta lagoon's ecosystem, as well as the impact of anthropogenic activity, using a thorough analysis that includes values for microbiological indicators and physical-chemical parameters of lagoon water.

2. Literature Review

Narta Lagoon is considered one of the most important wetland areas of Albania for its biodiversity and the number of habitats. Narta's natural ecosystem is an important part of the natural potential of Europe and a complex of international importance.

This lagoon system is more or less threatened in the long term by sedimentation, siltation of the channels connecting them to the sea, episodes of hypertrophic anoxia, and domestic and industrial pollution (Peja et al., 1996).

Anthropogenic activities have a great impact on Narta Lagoon water system and Albania do not have a regional or international program for pollution monitoring, over the years are only made some different studies which suggest continuous monitoring of the area due to the levels of pollution detected in the water (Pano et al., 2005) (Kotori et al., 2015).

The nutrients content in the water samples collected in Narta Lagoon were found at higher levels and the sources of nutrients could be the urban wastes discharged from the surrounding areas and agricultural and livestock wastes (Kotori et al., 2015; Kane et al., 2015).

1.1. Case Study

Referring to previous studies about the pollution of this lagoon, we wanted to verify the level of water pollution and evaluate the state of the Narta lagoon's ecosystem using a thorough analysis that included data for microbiological parameters as total coliform (TC) and fecal coliform (FC) bacteria, and physic-chemical parameters. Moreover, the goal of this research was the determination of the anthropogenic activity impact on the quality of lagoon water.

2. Material and Methods

This research took place over the course of a year (2017-2018) and water samples were taken at 4 different seasons on seven distinct sampling stations. Samples were collected from the surface water (10–30 cm) at each site and total and fecal coliform were determined using MPN techniques and EC media in a combination of 3 - 3 - 3 tubes.

2.1. Study Area

Narta Lagoon has a stroke of 45 km^2. It is a shallow lagoon with an average depth of 1.2 m. It is located in the north of Vlora city. The lagoon is bordered on the north by the saline through a dam, on the southern part, it is bordered by land, while on the west by the Adriatic Sea. There is a littoral cordon between the lagoon and the sea mostly covered by a pine forest (Figure 1).

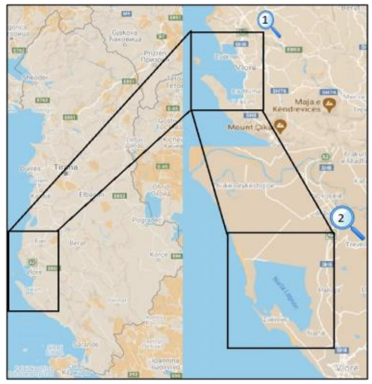

Figure 1: *Study area zoomed in from Albania (1) and Vlora region (2)*
*(**Source**: Google maps modified by Bakaj et al., 2021)*

Communication with the sea is realized through the southern and northern canals, which are often blocked due to sediment filling. The southern canal is 200 m long, while the northern canal is 800 m long and has a flow of 2.2–4.3 m^3 / s. The water regime of the lagoon depends on the tide. The water in the lagoon is somewhat alkaline (pH 8.4-8.8). Dissolved oxygen concentrations ranging from 5 to 10 mg/l (Miho et al. 2013; FEIA 2003)

2.1.1. Sampling Points

This research took place over the course of a year, from December 2017 to November 2018. During this time, we examined the lagoon water in four seasons: winter (December 2017 to February 2018), spring (March to May), summer (June to August), and autumn (September to October) (from September to November).

Water samples were taken at seven distinct sampling stations located throughout the lagoon's perimeter, beginning from the first connection point with the sea (S1, S2, S3, S4, S5, S6, and S7) (Figure 2, Table 1).

S1 sampling station is the first connection point with the sea. S2 sampling station is the second connection point with the sea. S3 sampling station is located near Zvernec Monastery. S4 sampling station is situated on the northeast of Narta village, near the irrigation canal that flows into Narta lagoon (Figure 2, Table 1).

Figure 2: *Sampling stations along the perimeter of Narta lagoon, Albania*
*(**Source**: Google maps modified by Bakaj et al.,2021)*

Sample station S5 is situated on the northeastern part of the lagoon, located near the highway. S6 and S7 sampling stations are situated in the northern part of the lagoon, along the lagoon barrier with the Skrofotina saline. Sample station S6 is situated near the highway, while S7 is near the pine forest (Figure 2, Table 1).

Table 1: *Geographic coordinates of sampling stations evaluated with GPS device.*

Sta.	Altitude	Longitude
S_1	19° 38.904’	40° 54.277’
S_2	19° 39.144’	40° 52.365’
S_3	19° 24.100’	40° 32.246’
S_4	19° 23.966’	40° 31.329’
S_5	19° 27’ 070’	40° 30’ 217’
S_6	19° 27.145’	40° 31.128’
S_7	19° 27.115’	40° 31.113’

*(**Source**: Data by Bakaj et al., 2021)*

2.1.2. Physic–Chemical Characteristics of Lagoon Water

Despite microbiological analysis of water samples, this study was performed also some basic physic-chemical analysis using standard methods as described by APHA-AWWA-WEF (APHA-AWWA-WEF 2005). Temperature, pH, and salinity were the physic-chemical parameters analyzed. A thermometer was placed at a depth of 10 cm to take the water temperature in situ. In the lab, the pH and salinity were determined.

2.1.3. Sampling Techniques for Microbiological Analyses.

A liter sterilized glass bottle was used to collect samples from the surface water (10–30 cm) at each site. Within 2 hours, the collected water samples were transferred to the laboratory in a thermal box.

Lab work was performed based on standards at the Microbiological Laboratory of Biology Department, University of Vlora (Bakaj & Dalipaj 2020; WHO 1995; Borrel Fontelles &Winkler, 2006). The exact day and time of the sampling, as well as the water temperature and other weather-related data, were documented. Water samples were analyzed and treated bacteriologically in accordance with legislation and norms (ISO 1991; Borrel Fontelles &Winkler, 2006). During the monitoring period, 336 water samples were collected and evaluated based on the most likely number (FDA 1998; APHA 2005).

2.1.4. Microbiological Examination

The microbiological tests were carried out at the University Ismail Qemali of Vlora's Microbiological Lab of the Biology Department. International Standards Techniques were referred to for these analyses (CEC 1978; WHO 1984; UNECE 1994; ISO 1986; ISO 1990; ISO 1999; Camper et al. 1996). Total and fecal coliform were determined using MPN techniques and EC media in a combination of 3 - 3 - 3 tubes (Bakaj et al., 2017; Bakaj A., Ruçi E., Kalaja J., 2017). Diluted samples were incubated for 24-48 hours at 35°C for the preliminary test and 44°C for the confirmation test. In the confirmation test, Bromocresol Azide Purple broth (Merck 3032, Darmstadt, Germany) was utilized. The numbers of organisms per 100 mL (MPN 100 ml^{-1}) were used to represent the results statistically.

2.1.5. Analytical Statistics

Box plots and mean plots of FC distribution revealed seasonal changes in bacterial numbers and environmental conditions between collection locations. A one-way analysis of variance was used to compare FC levels at different stations and months (ANOVA). A Tukey's pairwise comparison test was used when there was a significant difference for the main effect (p 0.01). Spearman's correlation analysis in SPSS was used to determine the relationship between the bacterial levels and the variables. For differences between the components, the significance threshold was set at 0.01.

3. Results and Discussion

The goal of our research was to assess the quality of lagoon water using a thorough analysis that included data for microbiological parameters and physic-chemical variables. We studied 7 separate sampling points that were eventually distributed along the lagoon border for a comprehensive pattern.

A statistical description of the given data at all of the studied sites is presented in table 2. For the first three sampling stations, it is noted that the skewness values are (2) and the kurtosis coefficient is positive. In all sampling stations, values are stable and have a minimal variance, indicating a modest environmental impact.

Table 2: *All sampling stations' descriptive statistics (MPN 100 ml^{-1}) are listed in the table*

Statistics								
		S_1	S_2	S_3	S_4	S_5	S_6	S_7
N	Valid	48	48	48	48	48	48	48
	Missing	0	0	0	0	0	0	0
Mean		34.250	26.250	248.333	457.813	255.188	248.354	273.417
Median		23.000	23.000	120.000	225.000	75.000	93.000	93.000
Mode		23.0	23.0	23.0	23.0[a]	43.0	23.0	43.0
Std. Deviation		21.7495	15.4967	323.2796	679.7251	520.3892	451.7853	518.4906
Variance		473.043	240.149	104509.7	462026.15	270804.92	204109.97	268832.46
Skewness		1.214	1.589	1.922	2.072	3.349	3.081	3.284
Kurtosis		.829	2.907	2.739	3.430	11.274	10.795	10.975
a. Multiple modes exist. The smallest value is shown								

*(**Source**: Data by Bakaj et al., 2021)*

According to our findings, two of the stations, S4 and S5, have higher coliform bacteria levels. Due to the presence of a significant anthropogenic source, this high degree of pollution is to be expected. During the assessment of the S4 study area, a discharge channel with active urban wastewater was discovered.

Our data sets are somewhat skewed right and tend to have heavy tails since the data gathered from 4 to 7 sample stations has a high coefficient of skewness (>2) and positive coefficients of kurtosis. Based on the above assessment, fecal pollution indicators are influenced by the time conditions of sampling. The total number of coliform bacteria is largest in sampling stations S4, S5, S6, and S 7, with a minimum value of 23 MPN 100 ml^{-1} in winter and a maximum of 2.4 10^3 MPN 100 ml^{-1} in summer, according to a clear depiction of the data acquired.

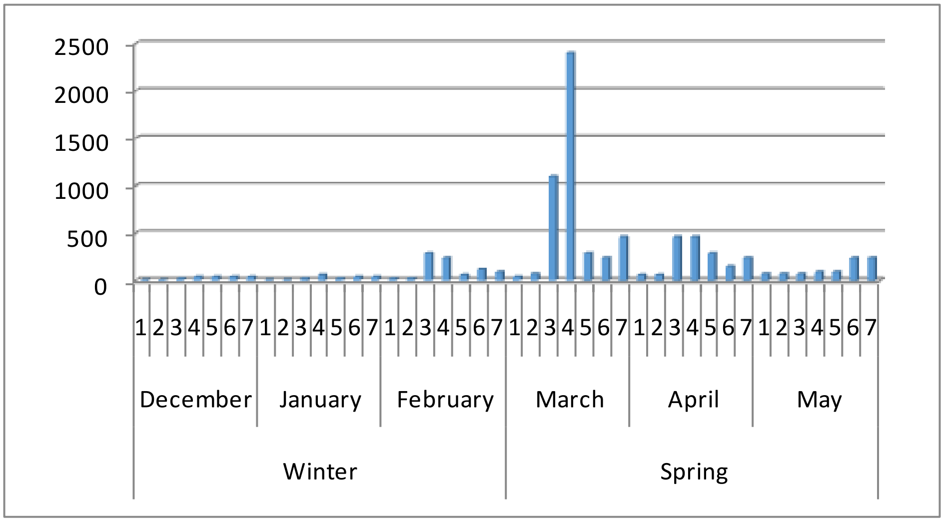

Figure 3: *Fecal coliform bacteria value in winter and spring (MPN 100 ml^{-1})*
*(**Source**: Data by Bakaj et al., 2021)*

Figure 3 shows a higher coliform bacteria concentration from February to April (during springtime). The greatest level of total coliform bacteria in water was recorded in March, which is likely due to the warm temperatures and rainy weather. This result is similar to observations made by other authors (Sugumar et al. 2008; Bakaj et al. 2019; Bakaj and Dalipaj 2020).

Seasonal rainfall and the surrounding environment, including the numerous tributaries of the Vjosa River, we believe, affect not only the TC and FC levels in the lagoon directly (Evanson and Ambrose 2006), but also indirectly through the physic-chemical parameters variation of water in the lagoon (Evanson and Ambrose 2006). Other researchers have similarly detected high amounts of FC and TC in surface water in the spring (Chigbu et al. 2005 and Sivri et al. 2010).

As a result of poor fecal organic matter filtering (Bahri and Saibi 2012), coastal lagoons may have high levels of fecal contamination. A number of other wetland pollutants such as untreated domestic, agricultural water discharges, urban runoff, resuscitation of sediments, also birds and wildlife should also be assessed (An et al., 2002; Kirschner et al., 2004, Chigbu et al., 2005; Zhu et al., 2011, Kacar 2011; Saibi et al. 2013).

We note that the highest levels of bacterial cargo contamination are recorded in the summer season and exactly in July – August (Figure 4). Based on the box plot of microbial distribution in different months (Figure 5, B), we can say that the highest values of FC are in July – August, as they display variation in samples (Ghasemi and Zahediasl 2012; Barton and Peat 2014; Baghban et al 2013). The highest bacterial cargo during this season may be due to high temperatures, lack of rainfall, and falling water levels in the lagoon (Bakaj & Dalipaj 2020).

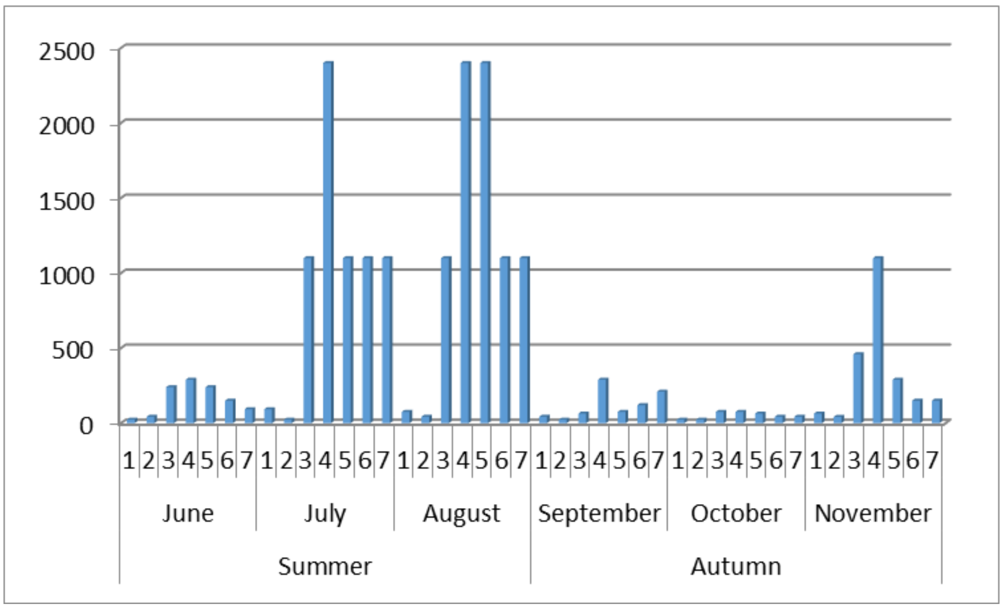

Figure 4: *Fecal coliform bacteria value in spring and summer (MPN 100 ml^{-1})*
*(**Source**: Data by Bakaj et al., 2021)*

Based on the box plot of microbial distribution in different sampling stations (Figure 5, A), as well as in different months (Figure 5, B), we can say that there are many outliers present in our data set, especially in sampling stations 4, 5, 6, and 7.

We may notice that the outliers in S_4 have 2.4 10^3 MPN 100 ml^{-1} value exactly in March, July, and August, while in other stations S_5, S_6, and S_7 these outliers are recorded in July and August.

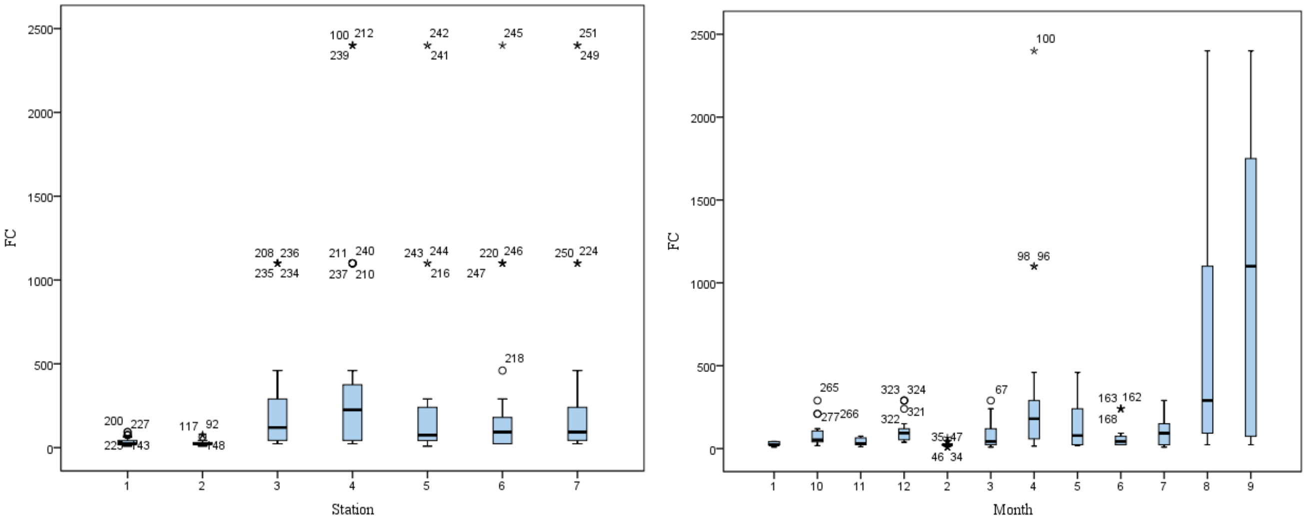

Figure 5: *Box plot of microbial distribution in different sampling stations (A) and in different months (B),*

*(**Source**: Data by Bakaj et al., 2021)*

Fecal contamination is determined also at sample station 3 (Figure 6, A) which is located near Zvernec Monastery, contamination is especially evident during summertime.

Zvernec Monastery is an impressive object of significant cultural and religious value that attracts tourists mainly in summertime, causing an increase in human impact on the lagoon during these months (Fig. 5. A, B).

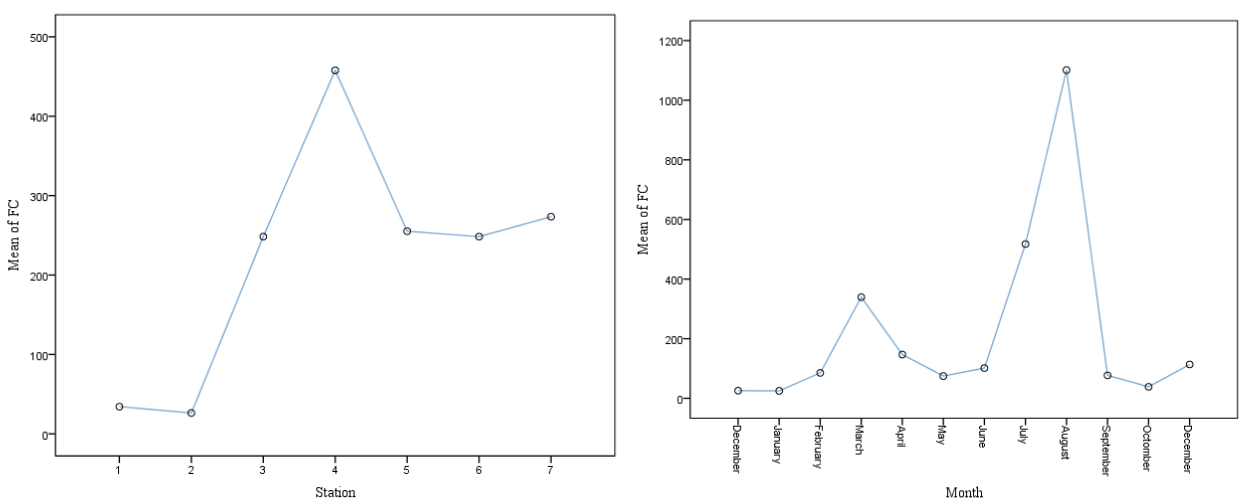

Figure 6. *Mean plot of microbial distribution in different sampling stations (A) and in different months (B),*

*(**Source**: Data by Bakaj et al., 2021)*

We can see a completely different situation at station 4, throughout the FC mean plot (Figure 6, A & B). This station is located in the northeast of Narta village, near the drainage canal which flows into the lagoon. The irrigation canal has a big influence on the fecal contamination of the lagoon (Figure 5, A; 6. A & B).

Sample stations S_5 and S_6 are situated on the northeastern part of the lagoon, located near sampling station 4 is exposed to discharges coming from the drainage channel. Sample station 7 is the farthest northeast point near the pine forest, which does not have a good water circulation (Figure 5. A; 6. A & B).

As previously mentioned, sites 1 and 2 are the two points of communication with the sea. Lower temperatures, varying salinity and pH, precipitation, water flows, and reduced human activity may all be factors in the absence of microorganisms. (Figure 5. A &B; 6. A & B).

Furthermore, there was a statistically significant difference in TC and FC between stations, as well as between months. The ANOVA results demonstrated that there were statistically significant differences in FC levels across sampling sites (F=5,736, p 0.001), as well as between months (F=8,233, p 0.001). Post hoc Tukey's HSD, SNK, and Duncan tests were used to confirm this finding. The high levels of contamination observed in sampling station 4 near the drainage channel cause this difference. FC counts were shown to be strongly connected to the stations after a post hoc analysis (p 0.001).

Table 3: *Table of Spearman's correlation coefficient*

FC		Month	Temperature
	Correlation Coefficient	$.285^{**}$	$.431^{**}$
	N	336	336
		1.000	1.000
****. At the 0.01 level, the correlation is significant.**			

*(**Source**: Data by Bakaj et al., 2021)*

Furthermore, Spearman's correlation coefficient matrices for FC, month, and temperature were constructed. Because FC counts are influenced by a variety of environmental conditions, a statistical analysis of the correlations between physical parameters and coliform levels was conducted.

Temperature, raised pH, greater DO levels, and a lack of salinity all accelerate the rate of die-off (An et al. 2002; Evanson & Ambrose2006; Chigbu et al. 2005; Kirschner et al. 2004). FC was found to be associated ($p>0.01$) with temperature, pH, and salinity in the study (Sugumar et al. 2008; Kacar 2011).

4. Conclusion

In this study, we focused on the lagoon water quality expressed by indicator bacteria and physic-chemical parameters concentration levels. We selected the sampling stations in order to cover all the hydrodynamical characteristics of the lagoon.

The human impact on the quality of Narta lagoon water was more than evident. Based on our data, the most polluted sample station was station 4 as it is located near the drainage channel. Stations 5 and 6 also appear polluted as they are located near station 4.

Narta Lagoon is a lagoon of high ecological and economic importance, due to the biological diversity it presents. Being under the constant influence of urban runoff, agricultural runoff, fishing activity, and increased human activity leads to altered levels of pollution affecting so humans and aquatic life in the future.

Therefore, we suggest that periodic studies of the environmental condition of the lagoon should be carried out.

This study represents the quality of Narta lagoon water, for only a year (4 seasons), continuous monitoring of microbiological indicators such as total coliform (TC) and fecal coliform (FC) bacteria, should be carried out because these parameters provide insight into the sanitary status of the lagoon.

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