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RELATIONSHIP OF DIATOM COMMUNITIES TO CHEMICAL VARIABLES IN BUTRINTI LAGOON IN ALBANIA

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ABSTRACT

Lagoons are distinctive ecosystems where river and sea waters converge, supporting a distinctive biodiversity in the brackish waters. Like all aquatic ecosystems, lagoons are vulnerable to natural and anthropogenic factors that impact physicochemical variables and aquatic biota, particularly those that are environmentally sensitive, such as phytoplankton. Aquatic organisms that are susceptible to changes in water chemistry, pollution, and trophic state, like diatoms, are utilized for environmental assessment. The Butrinti lagoon is significant within the southern region of Albania. Consequently, this study was initiated with the objective of evaluating the water quality based on chemical variables and diatom assemblages. The chemical parameters and trophic index of the Butrinti lagoon waters indicate a trophic status ranging from mesotrophic to eutrophic. This finding aligns with the trophic classes of diatoms, which were observed to range from mesotrophic to eu-polytrophic. Additionally, the results revealed the presence of 42 distinct species of diatoms, comprising 15 genera of pennate diatoms and 3 genera of centric diatoms.

Key words: Butrinti lagoon, trophic status, chemical variables, diatom’s assemblages

INTRODUCTION

Lagoons represent a significant ecologically and economically valuable aquatic ecosystem, characterised by a diverse range of biological species. As with all aquatic ecosystems, lagoons are susceptible to natural and anthropogenic factors that affect physicochemical variables and aquatic biota, particularly those that are environmentally sensitive, such as phytoplankton. Biomonitoring techniques have been employed for over a century (Kupe et al., 2023) to evaluate the effects of diverse forms of contamination in freshwater ecosystems. The assessment of chemical substances and the monitoring of biological systems are two closely related processes that are employed in the evaluation of water ecosystems. Chemical monitoring enables the assessment of the current state of water ecosystems. However, biomonitoring offers several advantages over chemical monitoring, as it provides a comprehensive overview of the biota's response to a range of pollutants over time (Alikaj et. al, 2023).
The most useful tools for evaluating environmental and ecological change in this water ecosystem are modifications in their algal communities. Diatoms are employed for environmental assessments due to the fact that their siliceous valves can be preserved in sediments. Changes in their associations along stratigraphic sequences permit the assessment of the present condition of water ecosystems and their recent history (Caballero et. al., 2024; Kwon

et.al., 2021). Diatoms are more prevalent in freshwater and inhabit all water basins (Kupe et. al., 2008). They are essential organisms in ecological quality analyses of watercourses and have been used for over a decade in several European countries (Kupe et. al., 2023). Diatoms grow in a wide range of habitats, which could be oligotrophic or eutrophic, acidic or alkaline, fresh, brackish or marine, standing and flowing waters (A. M. Chia, 2011). The Butrinti lagoon, also known as Lake Butrint, is situated amidst forested hills and mountains, with saltwater and freshwater marshlands in its vicinity. The primary activities conducted in this area are fishing, mussel farming, stock raising, viticulture, and cultural tourism, with a particular focus on the southern part of Lake Butrint (Dedej & Bino, 2003). In view of the preceding activities and their implications for water ecosystems, it is of the utmost importance to obtain data regarding the current state of affairs. Accordingly, the present study was undertaken with the objective of assessing the quality of the lagoon water in terms of its chemical parameters and benthic diatom content.

MATERIAL AND METHODS

The study area

The study was realized in Butrinti lagoon. Butrinti lagoon with coordinates 39°47′0″N 20°12′0″E, has an area of 1600 ha, it has a maximum 7.1 km length and 3.3 km wide. The maximum depth is 21.4 m with an average of 11 m. It is surrounded by dense forested hills, rocky coast and complemented by saltwater and freshwater marshlands. The lake is known for its famous blue mussel, *Mytilus galloprovincialis*.

Sample collection and preparation

In Decembre 2023, five sampling points (B1, B2, B3, B4, B5) were identified within the lagoon, and water samples were collected from each point in 1.5 L polyethylene bottles (Figure 1). The samples were collected from a depth of 50 cm below the water surface and were transported to the laboratory, in refrigerated containers at a controlled temperature of 4°C and were subsequently analysed within 24 hours. The laboratory responsible was accredited and belonged to the Department of Environment and Natural Resources at the Agricultural University of Tirana. Physic-Chemical parameters like pH, salinity, conductivity, ammonium, nitrite, nitrates and phosphates were analysed, using ISO standard methods and were compared against the WFD standard.

At the same sampling point were collected diatoms samples. Diatom algae material was obtained by gently scraping the upper surface of selected rocks from the lagoon using a toothbrush or from the collection of macrophytes. The resulting suspensions were collected and preserved in 4% formaldehyde (Kupe et. al., 2013; Kupe & Alikaj, 2020, Vidakovic et. al., 2020). Diatom frustules from organic and inorganic sources were purified by boiling the material. Initially, the material was treated with HClcc and then, after washing, boiled again with H_2SO_4cc. During the final procedure, some crystals of KNO_3 were added to whiten the sample as described by (Krammer and Lange-Bertalot, 2001). Biological analysis for diatoms, were performed at Botany laboratory of Agronomic Sciences Department. Diatoms were identified using standard literature (Levkov, Kristic, Metzelin, Nakov (2007); Krammer & Bertalot 1996-2001).

Assessment of trophic status of the lagoon

The trophic status of the Butrinti lagoon was determined through the application of Carlson and (Kratzer and Brezonik, 1981) equations for the calculation of trophic indexes, with a particular focus on total phosphorus and total nitrogen as followed:

$$TSI(TN) = 54.45+14.43 \ln (TN) \text{ mg/l}$$

$$TSI(TP) = 14.42 \ln (TP) + 4.15 \ \mu\text{g/l}$$

Additionally, trophic classes were assigned to each station through the calculation of the Trophic Diatom Index (TI_{DIA}) for diatom algae.

Figure 1. Waters and diatoms sampling points at Butrinti lagoon

RESULTS AND DISSCUSIONS

Physic chemical parameters assessment.

The chemical parameters analysed in the water of the Butrinti lagoon demonstrated a temperature of approximately 13°C and a pH value of 8.304 on average values, indicating an alkaline condition within this ecosystem. The salinity was determined to be 11.7 ppt (1.17%) and the waters exhibited a high conductivity, with a range of 24,400 µs/cm to 38,100 µs/cm. The nutrient levels of nitrogen and phosphorus indicate that the Butrinti lagoon waters are in a favourable condition (Table 1). The concentration of nitrogen-ammonium in the water samples ranged from 0.2 mg/L to 0.4 mg/L. In accordance with the WFD and the assessment of the eutrophication process, the level of ammonium is classified as level I and II. The concentration of nitrogen-nitrites in the lagoon waters ranges from 0.01 to 0.03 mg/l, indicating that the quality of these waters falls within the I and II classes as defined by the WFD. Similarly, the values of nitrogen-nitrates manifest in this context. This parameter ranges from 0.95 mg/l to 1.86 mg/l, indicating that the waters are of first class and between first and second. The concentration of phosphorusphosphate in the Butrinti lagoon ranges from 0.02 to 0.04 mg/l. While phosphorus is an essential nutrient for plant growth, elevated levels of this element can lead to the eutrophication of the water ecosystem. In this context, the phosphates in the Butrinti lagoon fall within the first class of quality (0.05 mg/l), which represents the background values for this element.

Table 1. Physic - chemical parameters of water in Butrinti lagoon.

Code	pH	Temp	Salinity	EC	$N\text{-}NO_3^-$	$N\text{-}NO_2^-$	$N\text{-}NH_4^+$	$P\text{-}PO_4^{3-}$	TSI (TN)	TSI(TP)
Unit	pH unit	(ºC)	ppt	μs/cm	mg/L	mg/L	mg/L	mg/L		
B1	8,27	13,7	11,7	32500	0,95	0,02	0,3	0,04	57,76	56,062
B2	8,17	13,7	11,6	24400	1,86	0,01	0,4	0,02	66,14	47,41
B3	8,34	13,4	11,7	38100	1,49	0,01	0,2	0,04	62,09	56,062
B4	8,61	13,3	11,7	37900	1,3	0,01	0,3	0,03	61,22	53,18
B5	8,13	13,4	11,6	24600	1,02	0,03	0,3	0,04	58,78	56,062
Average	8,304	13,5	11,66	31500	1,324	0,016	0,3	0,034		
Max	8,61	13,7	11,7	38100	1,86	0,03	0,4	0,04		
Min	8,13	13,3	11,6	24400	0,95	0,01	0,2	0,02		

Based on Carlson equations for nitrogen and phosphor are calculated trophic state index for Butrinti lagoon. Total nitrogen is calculated as sum of nitrogen nutrients and the total phosphorus as phosphorus- phosphates. From the results is evident that the values of trophic index show the trophic status that is mostly eutrophic for total phosphorus (table 1 and 2) and except in B2 station which is mesotrophic. For total nitrogen the situation of Butrinti lagoon is totally eutrophic with trophic index that range from 57.76 to 66.14. Despite the fact that nutrients according to WFD demonstrate a situation of first and second class of quality, these values are significant for the eutrophy of waters in the lagoon. The deterioration of the Butrinti lagoon can be attributed to the discharge of waters from surrounding areas and the increase of nutrients resulting from the application of fertilizers and pesticides in agricultural activities.

Table 2. Trophic state index and trophic status classification.

Trophic State Index	Phosphorus (μg/L)	Trophic Class
< 30—40	0—12	Oligotrophic or hipotrophic
40—50	12—24	Mesotrophic
50—70	24—96	Eutrophic
70—100+	96—384+	Hypertrophic

The assessment of Diatoms flora

Table 3 presents a list of the diatom species identified in the Butrinti lagoon. A total of 42 species of diatoms were identified, distributed among three genera of centric diatoms and 15 genera of pennate diatoms. The study of taxon abundance demonstrated that the genera *Cyclotella, Achnanthes, Bacillaria, Fragilaria,* and *Nitzschia* occupied a significant position in diatom communities, representing 80% to 100% of the total. These species were present in all sampling stations. One species of *Cyclotella*, namely *Cyclotella ocellata*, was identified. This species is dominant in Algerian lakes with salinity levels above 0.7 ‰, whereas (Van Dam et al. 1994; Ludes and Coste 1996) have reported it in sites with lower salinity levels (below 0.2 ‰). This indicates that the species is capable of withstanding or adapting to fluctuations in salinity. *C. ocellata* constitutes a significant element of the diatom community in eutrophic lakes (Schelegel and Scheffler, 1999; El Haouati, 2015). From our result is evident that *Cyclotella* can support 1.17 % of salinity in lagoon waters. At the other hand *Achnanthes* was presented with 3 species like *Achnanthes brevipes C. Agardh, Achnanthes brevipes* var. *Intermedia*, *Achnanthes coarctata*. The only species identified at all stations was *Achnanthes brevipes* var. *intermedia,* while two others were observed exclusively at station B1. The genus *Fragilaria* was represented by three species: *Fragilaria acus, Fragilaria tenera,* and *Fragilaria fasciculata*. However, only the latter was present at all stations. The *Navicula* genus was identified in the lagoon, with five distinct species.

However, only *Navicula splendicula* was observed at three distinct stations, while the remaining species were exclusively present at station B4. Additionally, *Navicula* is a euryhaline species, occurring in waters with a salinity of at least 0.9%. In this context, the Butrinti lagoon represents an optimal habitat for this species. The genus *Nitzschia* is the most prevalent, comprising ten species. *Nitzschia constricta* and *Nitzschia dissipata* were present in all sampling stations, with a 100% occurrence. The remaining species were predominantly found in B4. The majority of *Nitzschia* species are known to thrive in polluted waters, particularly in the presence of elevated organic matter concentrations, as observed by (Krammer & Lange-Bertalot 1986) and (El Haouati 2015). *Nitzschia palea*, a species commonly associated with such environments, was exclusively identified in the B4 station.

Table 3. List of diatoms species with the ratio of the amount of each type to the total population (p%) and percentage (%) of species in each sampling sites in Butrinti lagoon.

Table of species	Butrinti_B1	Butrinti_B2	Butrinti_B3	Butrinti_B4	Butrinti_B5	%
	p%	p%	p%	p%	p%	%
Centric						
Campylodiscus sp				0,7		20
Cyclotella ocellata Pantocsek	0,4	2,3	9,6	2,1	0,0	100
Melosira moniliformis (O.F.Müller) C.Agardh		13,5		28,9		40
Melosira nummuloides C.Agardh 1824				4,1		20
Melosira varians Agardh	7,8					20
Pennate						
Achnanthes brevipes C.Agardh	1,1					20
Achnanthes brevipes var. intermedia (Kützing)	26,6	26,2	16,0	14,8	1,8	100
Achnanthesc coarctata (Brébisson ex W.Smith) Grunow	1,1					20
Amphora aequalis Krammer		6,9				20
Amphora veneta Kützing 1844					2,5	20
Bacillaria paradoxa J.F.Gmelin		5,8	17,3	3,3	8,5	80
Cocconeis placentula var. lineata (Ehrenberg) Van Heurck		10,4		0,0	4,2	60
Cocconeis scutellum Ehrenberg	1,8				14,1	40
Diploneis didyma (Ehrenberg) Ehrenberg,			4,5			20
Eunotia paladusa var. paladusa			3,8			20
Entomoneis alata Ehrenberg					4,2	20
Ellerbeckia arenaria (D.Moore ex Ralfs)				0,4		20
Fragilaria acus(Kützing) Lange-Bertalot		5,8		6,2		40
Fragilaria tenera (W.Smith) Lange-Bertalot		4,6				20
Fragilaria fasciculata (C.Agardh) Lange-Bert	4,9	16,2	12,8	3,7	4,2	100
Gyrosigma acuminatum (Kützing) Rabenhorst			5,1	0,6		40
Gyrosigma balticum (Ehrenberg) Rabenhorst		3,1				20
Gyrosigma scalproides (Rabenhorst) Cleve 1894: 118)				1,0		20
Navicula capitatoradiata Germain					3,9	20
Navicula cryptotenella Lange-Bertalot				0,2		20
Navicula halophila (Grunow) Cleve 1894: 109				1,0		20
Navicula splendicula VanLandingham			1,9	0,7	4,2	60
Navicula tripunctata (O.F.MŸller) Bory				0,6		20
Nitzschia constricta (Gregory) Grunow,	17,1	2,7	17,3	9,1	13,0	100
Nitzschia dissipata (Kützing)	2,2	0,8	4,5	3,5	1,8	100

Nitzschia palea (Kützing) W.Smith				6,4		20
Nitzschia gracilis Hantzsch	0,4					20
*Nitzschia incognita*Legler & Krasske 1940: 343				1,0		20
Nitzschia vermicularis(Kützing)Hantzsch				1,1		20
Nitzschia pellucida Grunow	14,4	0,8		3,1		60
Nitzschia perminuta Grunow	16,6	1,2	1,9			60
Nitzschia subacicularis Hustedt				4,3	4,2	40
Nitzschia scalpelliformis Grunow			5,1	3,1	10,6	60
Pleurosigma salinarum (Grunow) Grunow					5,3	20
Rhoicospheniaa bbreviata (C.Agardh) Lange-Bertalot	5,5				17,6	40
Surirella gemma Ehrenberg			4,5	0,4		40
Surirella splendida Legler & Krasske 1940					4,2	20

In order to conduct an ecological assessment of the Butrinti lagoon waters based on diatoms, it was necessary to calculate the trophic index of diatoms and determine the trophic classes. The trophic index of diatoms is of great importance in ascertaining the degree of eutrophication of an ecosystem on the basis of nutrient levels. In this instance, the Butrinti lagoon index ranged from 1.6 at B2 to 2.9 at B1 and B5 (Table 4). This indicates that the eutrophication level of the lagoon ranges from mesotrophic to eu-polytroph. A comparison of the trophic status of the lagoon based on chemical parameters and trophic classes based on diatoms indicates that the situation in Butrinti lagoon is similar.

Table 4. Trophic index, trophic classes and water quality (by Rott et.al., 1999) based on diatoms community.

Sampling station	Trophic Diatom Index (TIDIA)	Trophic Classes	Water Quality
Butrinti_B1	2,9	Eu-politroph	Very bad
Butrinti_B2	1,6	Mesotroph	Moderate
Butrinti_B3	1,9	Meso-eutroph	Moderate
Butrinti_B4	2,2	Meso-eutroph	Moderate
Butrinti_B5	2,9	Eu-politroph	Very bad

Relationship between TI_{DIA} e PO_4^{3-} (figure 2) shows a correlation between the trophic index of diatoms and phosphates. Station B2 and B5 are characterized by the same TI_{DIA} and PO_4^{3-} respectively 2.9 and 0.004, which are characterized by a eu-polytrophic state, with high amounts of nutrients. The same situation is given for stations B3 and B4, which are characterized by Meso-eutrophic conditions. While station B2 is characterized by a mesotrophic state, respectively in lower values of TI_{DIA} (1.6) and PO_4^{3-} (0.02).

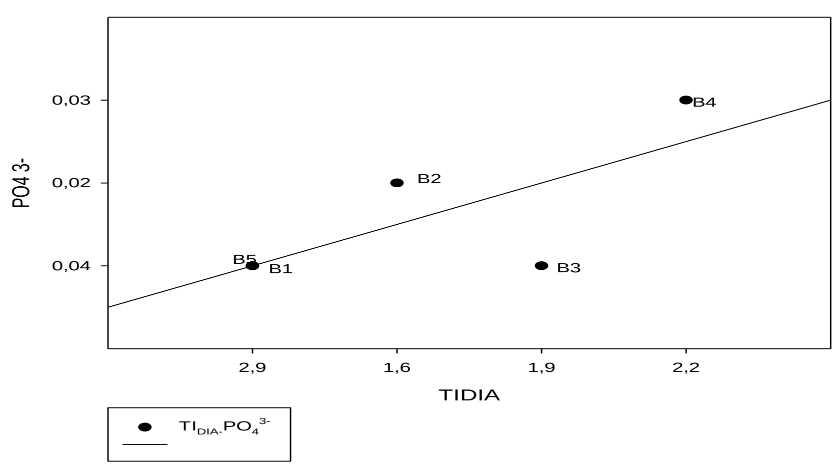

Figure 2. Correlation between Trophic Diatom Index (TI_{DIA}) and P-PO_4^{3-}

CONCLUSIONS

- The findings of this study clearly confirm the eutrophic status of the Butrinti lagoon. The waters of the lagoon were alkaline, and the nutrients N and P played an important role in the eutrophication of the lagoon. The presence of nutrients N and P exhibit the first and second class of water quality. The trophic status demonstrated a range from mesotrophic to eutrophic for total phosphorus and only eutrophic for total nitrogen. To obtain the most accurate assessment of the ecosystem at the time, our research was based on the analysis of diatom assemblages and the trophic diatom index. 42 species of diatoms were identified in the lagoon and the most evident were species of genus *Cyclotella, Achnanthes, Bacillaria, Fragilaria, Navicula* and *Nitzschia.*
- The diatoms display a considerable diversity in the lagoon. This diversity constitutes an important element in the indices of phytoplankton which are used for the evaluation of trophic status of this ecosystem. In this context, the trophic status of the lagoon is evaluated based on the range of diatom species present, which indicates a mesotrophic to eu-polytrophic status. It can thus be concluded that the situation in the lagoon, as indicated by chemical parameters and diatom analysis, is consistent. However, further investigation across different seasons is essential to ensure the most accurate and comprehensive results.

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