EVALUATION OF ECOLOGICAL STATUS OF SHKODRA LAKE BASED ON BENTHIC DIATOMS AND MACROPHYTE INDEXES

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ABSTRACT

The evaluation of the trophic state of Shkodra Lake is based on biomonitoring, aquatic macrophytes, and diatoms, which are correlated with organic pollution and nutrient enrichment. Five sampling sites were selected in the Albanian portion of Shkodra Lake. In this study, we focused on the correlation between diatom and macrophyte indexes as bioindicators of lake water quality. Both significant organisms demonstrated a response to eutrophication gradients. The growth and distribution of submerged macrophytes are influenced by changes in the nutrient concentrations of their surrounding environment. Conversely, diatoms are capable of absorbing nutrients from both the sediment and the overlying water. Diatoms and macrophytes thus serve as integrators of environmental conditions to which they are subjected, rendering them suitable for use as long-term indicators with high spatial resolution. The Trophic Diatom Index (TIDIA), the Saprobic Index (SI) in accordance with the Macrophyte Index (MI), provides a link between ecological data and management decisions. The dominant species were rigid hornwort (*Ceratophyllum demersum*), (*Potamogeton perfoliatus*) and shining pondweed (*Potamogeton lucens*). These species are associated with moderate to very high nutrient enrichment. The data indicates that the levels of nutrient enrichment and trophic state, as well as the Macrophyte Index (MI), exhibited considerable variation between the Vraka and Shiroka sites. The MI (at Vraka) was recorded at 3.5, and TI_{DIA} value in this site is the highest at 2.5. The water quality oscillated from mesotroph (in Shterbeq), meso-eutroph (in Kompleski Hysaj, Shiroke and Zogaj) to eutroph (in Vraka). Despite the differing assessment approaches, a consensus was reached on the optimal implementation of the WFD to achieve a more favorable ecological status in the long term.

Keywords: Shkodra Lake, Biological monitoring, Diatom Index, Macrophytes Index, Saprobic Index, Nutrients, WFD.

INTRODUCTION

The Water Framework Directive (WFD) introduced a statutory obligation for EU Member States to monitor and assess the ecological status of water bodies. The use of biomonitoring techniques has a long history, more than 100 years (Kolkwitz R.1908). These techniques have been employed to gain insight into the impact of polluted and fertilized agricultural waters on biota in freshwater ecosystems. To assess the ecological state of lakes, a method based on the analysis of aquatic plants has been developed. The former method must account for the lake's taxonomic composition and macrophyte abundance. Furthermore, five status classes (high, good, moderate, poor, and bad) must be defined in accordance with the normative definitions set in the directive. The present study examines the ecological state of Shkodra Lake in accordance with the requirements of the Water Framework Directive. The objective is to evaluate the water ecosystem of the lake using the correlation of macrophytes and diatoms indices. This is feasible in Shkodra Lake due to the availability of data on macrophyte sampling and distribution. It is imperative to assess the sensitivity of Phyto benthos (diatoms) and macrophytes to nutrients and acidification in freshwater. Despite this necessity, a significant number of studies have employed Phyto benthos to monitor water quality in Europe (Prygiel J. et al., 1999). Diatoms are the most abundant species and primary producers in a vast array of habitats, spanning from springs to connections in dense and freshwater environments (John J., 2003). They have a relatively short life cycle and can adapt rapidly to environmental changes. Their silicon cell walls facilitate sampling and preservation, thereby enabling the generation of a continuous record that can be used to analyze short- and long-term changes. It is evident from a few studies that diatom communities undergo changes in response to increases in the concentration of both organic and inorganic substances. As a result, they are the preferred group of organisms in laboratory biomonitoring studies in Europe, the USA, and Asia (John J., 2003; Kovacs et al., 2006). The variation of diatom population between regions and seasons was evaluated by calculating different indicators measuring their value for observing the relatively clean waters of Shkodra lake. To assess water quality conditions, a series of indices have been calculated based on the nutrient preferences and relative frequency of all current orders of diatom and macrophyte species. These include the Trophic Diatom Index (Round F.E, 1991; Kelly M. G, 1995; Rott et al., 1999), the Saprobic Index (Rott et al., 1997), the Shannon Index (H) (Shannon & Weaver, 1949), and the Macrophyte Index (MI) (Mezler A., 1998; 1993). These indices offer effective methods for monitoring alterations in the proportions of saprophyte and trophy populations within a lake (Round F.E, 1991, Prygiel J. et. al., 1999, Rott. et. al. 2003). The macrophyte index is based on the fact that certain species are most common at certain nutrient loads (Lund J.W.G et. al., 1958, Seele J. et. al.,2000, Carbiener R et al 1990). So far, nutrient values in lakes have been characterized by Trophic (Rott E et al, 1999), Saprofic (Rott et. al. 1997), Shannon (Shannon & Weaver 1949) and Macrophyte indices (Mezler A. 1998, Schnider 2020). The first attempts at applying a macrophyte index for eutrophication in the Western Balkans were made in Lake Ohrid (Kupe. et al. 2013), (Trajanovska. et al. 2014) and Lake Prespa (Trajanovska et. al., 2019). The "macrophyte index" (MI); Melzer 1999, Melzer & Schneider, 2001), developed in South Germany, was successfully applied, and produced meaningful results. However, the application of assessment methods across countries or ecoregions is not always straightforward. It has been demonstrated that the indicator values of macrophyte species for the assessment of eutrophication are largely comparable across Central Europe (Schneider, 2007). The Balkan Macrophyte Index, as employed by Schneider et al. (2020), has been adapted here to yield data for the present lake. The objective was thus to develop a macrophyte index for the assessment of lake eutrophication, specifically tailored to Shkodra Lake, with the aim of determining the pollution level of the lake. The calculations yielded a macrophyte index divided into five classes, each representing a distinct degree of nutrient enrichment. To facilitate a clear illustration of the results, distinct colors were assigned to each of the seven classes. The color scheme was as follows: very low nutrient enrichment (dark blue); moderate (green); moderate-immense (yellow); immense (orange); and massive (red) (Trajanovska et al. 2014, 2019).

MATERIAL AND METHODS

The Shkodra Lake is situated in a border region between Montenegro and Albania, and its ecosystem exerts a significant influence on the surrounding environment. The objective of this study is to examine the current condition of the lake and to provide insights that will contribute to the maintenance of a healthy habitat in the future. In accordance with the primary objectives of the Water Framework Directive, the predominant issue observed in the majority of lakes is the presence of highly eutrophic conditions, which can be attributed to a multitude of underlying causes. However, these conditions can be discerned through the analysis of biological and chemical parameters. Diatom and macrophyte samples were collected from 5 sampling points in the Albanian part of Shkodra Lake in December 2023 and May 2024. In total, we have collected 10 diatoms and macrophytes samples.

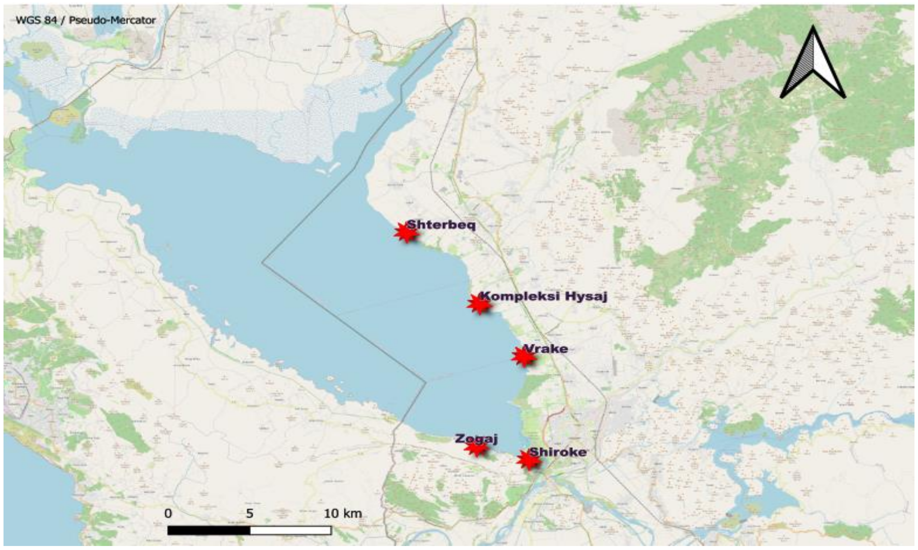

Figure 1. Sampling sites in Shkodra Lake

The samples of diatoms in the Shkodra Lake were taken in parallel with the samples of macrophytes. Sampling was carried out in the period of December 2023 and May 2024, where 5 sampling points were taken: Shterbeq (Sh1), Kompleksi Hysaj (Sh2), Vrake (Sh3), Shiroke (Sh4), Zogaj (Sh5).

The collected material was identified to species level, using different floras and keys for vascular macrophytes. For each plant association, the name of present species and its abundances were estimated using Braun-Blanquet scale (Braun-Blanquet, 1928). Based on the data we have gathered, the macrophyte index was calculated according to the formula described by Melzer (1999). Where:

$$BMI = \frac{\sum_{i=1}^{n} Qi * IVi}{\sum_{i=1}^{n} Qi}$$

The BMI (Balkan Macrophyte Index) was calculated using the estimated plant abundances at each site and the species-specific indicator values. In the field, plant abundances were estimated on a scale of 1 (very rare) to 5 (abundant and predominant). To calculate the BMI, the cubed abundance categories (termed "plant quantities") were employed, as this method better reflects the true differences between rare and abundant species (Melzer & Schneider, 2001). In other words, plant quantities 1, 8, 27, 64, and 125 were used in lieu of the estimated abundance categories 1, 2, 3, 4, and 5 for the calculation of the BMI. With BMI = Balkan Macrophyte Index, Qi represents the plant quantity (1, 8, 27, 64, 125) of a given species., n = Total number of species with an indicator value.

The diatom community are collected like epiphytes in different macrophytes in different depths from shoreline; the resulting suspensions collected in small bottles and preserved in 4% formaldehyde (Kelly et.al., 1998; Prygiel et. al., 2002; Kupe L., 2006; Kupe et. al., 2013). The cleaning of diatom frustules was done boiling the material, first with HClcc and then, after washing, boiling them again with H_2SO_4 cc, adding during the last procedure some crystals of KNO_3, as described by Krammer & Lange-Bertalot1996-2001. The whole procedure was carried out in the Laboratory of the Department of Environment and Natural Resources in Agricultural University of Tirana (AUT). About 500 valves per slide were counted using 100 oil immersions, yielding a 95% confidence for the data on species composition (Lund et al., 1958; Kelly et al., 1998; Prygel et al.,2002). Diatoms were identified using standard literature (Cleve – Euler 1955; Pascher 1976; Krammer& Lange Bertalot 1996-2001). Additionally, the following indices were calculated:

$$TI_{DIA} = \frac{\sum_{i=1}^{n} TW_i G_i H_i}{\sum_{i=1}^{n} G_i H_i}$$

Where: TI_{DIA}, trophic index for diatoms; TW_i, trophic (saprobic) value of i species (1-3); G_i, indicative weight of i species (1-5); H_i, relative frequency of i species (%); n, total number of species. Respective values of TW_i and G_i, as well as trophic classes were taken after Rott et al.

$$SI = \frac{\sum_{i=1}^{n} S_i G_i H_i}{\sum_{i=1}^{n} G_i H_i}$$

Where: *SI*, Saprobic index for diatoms; S_i, saprobic value of *i* species (1-3); G_i, indicative weight of *i* species (1-5); H_i, relative frequency of *i* species (%); *n*, total number of species. Respective values of TW_i and G_i, as well as trophic classes were taken after Rott *et al*.

$$H^{'} = -\sum_{i=1}^{n} p_i \log_2 p_i$$

Where: H', is the indicator of variability and pi, shows the frequency of the amount of each type to the entire population.

RESULTS AND DISCUSSIONS

Macrophyte diversity

The percentage composition of each category of aquatic macrophytes exhibited seasonal variation. Submerged vegetation was observed to comprise 50% of the total flora during the rainy season. The rainy season exhibited the greatest abundance of the three categories of macrophytes observed. The species frequencies indicate that *Ceratophyllum demersum* and *Potamogeton pectinatus* were more prevalent across all seasons under investigation.

Our study revealed the presence of eight distinct species of submerged aquatic macrophytes in the coastal areas of Shkodra Lake.We performed a quantitative analysis of the five species recorded seasonally at the stations. In addition to the submerged macrophytes, the study also recorded the aquatic vegetation in the coastal area of Shkodra Lake (see Table 1). The composition of submerged macrophytes differed significantly between seasons and stations during the study period. During the winter period, no submerged macrophyte species were encountered. There was a positive correlation between temperature and macrophyte variables during the spring, with an increase in the number of *Potamogeton lucens* and *Ceratophyllum demersum*. In the summer, there was a notable increase in the number of *Potamogeton perfoliatus* and *Phragmites australis*. Meanwhile, the species *Naja major* was very rare.

Table 1. Growth forms of aquatic macrophytes, recorded in Shkodra Lake (the species indicated with an asterisk are those evaluated quantitatively at the interlace stations).

	Family	Species
Submerged macrophytes	Haloragaceae	*Myriophillum spicatum* L., *
	Ceratophyllaceae	*Ceratophyllum demersum*L., *
	Najadaceae	*Najas major* L.,
	Potamogetonaceae	*Potamogeton perfoliatus*L., *
		*Potamogeton lucens*L., *
		*Potamogeton crispus*L.,
		*Potamogeton pectinatus*L.,
		*Vallisneria spiralis*L.,
Floating	Lemnaceae	*Lemna minor* L.,

macrophytes	Nymphaeaceae	*Nymphaea alba* L.,
		Nuphar lutea (L.) Smith.,
	Lythraceae	*Trapa natans*L.,
Emerged macrophytes	Typhaceae	*Typha angustipholia*L.,
	Poaceae	*Phragmites australis* (Cav.) Trin. *
		Phragmites communis (Trin)
	Cyperaceae	*Heleocharis pallustris*(L.) R.
		Scirpus lacuster(L.),

Macrophytes play a significant role in numerous aquatic ecosystems, influencing the abundance and diversity of other organisms, including phytoplankton, zooplankton, and macroinvertebrates. This is a well-established phenomenon. Macrophytes compete with phytoplankton for nutrients and light.
The presence of macrophytes in shallow lakes leads to a shift from phytoplankton-dominated lakes to macrophyte-dominated lakes with lower phytoplankton biomass (Scheffer et al., 1993).
An increase in structural heterogeneity within macrophytes has been associated with an increase in zooplankton and macroinvertebrate density and diversity (Thomaz & Cunha, 2010). Macrophyte studies have been a primary focus of our research due to their essential role in maintaining water-bodied health, particularly in lakes. In conjunction with diatom analysis, this approach allows us to assess water body status and inform sustainable management practices soon. The diversity of macrophytes present in the water ecosystem are the best indicator in the water quality.

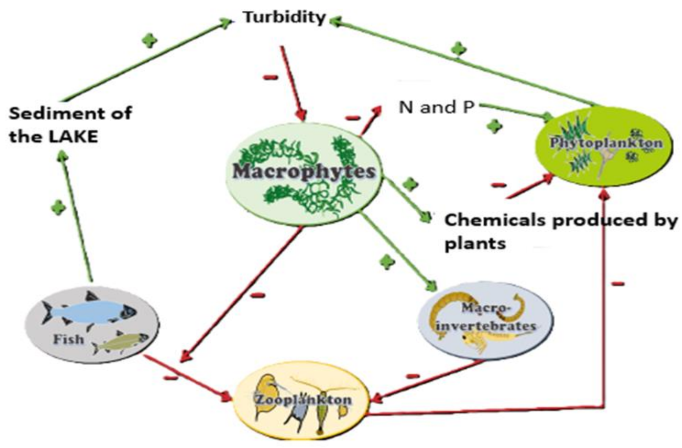

Figure 2. Schematic representation mechanisms mediated by habitat complexity affecting species assemblages associated with macrophytes and interactions between other aquatic species, (Thomaz and Cunha 2010).

Macrophytes and diatoms in the littoral zones of the lakes exhibit two fundamental properties that render them useful as limnological indicators. Firstly, they react slowly and progressively to changes in nutrient conditions (Melzer, 1999), and secondly, the littoral zone may exhibit patterns of nutrient (and pollutant) concentrations resulting from natural or artificial inflows, in addition to diffuse, non-point sources (Melzer, 1999).

Table 2. Presence (+) and absence (-) of macrophytes in the five stations during sampling.

Species	Sterbeq	Kompleksi Hysaj	Vraka	Shiroka	Zogaj
Phragmites australis (Cav).,	+	-	-	-	-
*Phragmites communis*Trin.,	+	-	-	-	-
*Typha angust*ipholia L.,	+ +	-	-	-	+ +
Nymphaea alba L.,	-	-	+	-	-
Nuphar lutea L.,	-	-	+	-	+
*Trapa natans*L.,	+	-	+	-	+
Potamogeton natans L.,	-	-	+ +	-	-

Lemna minor L.,	-	-	-	-	-
Potamogeton perfoliatus L.,	-	-	-	-	-
Potamogeton lucens L.,	-	+ +	-	-	-
Potamogeton crispus L.,	-	-	-	+	-
Potamogeton pectinatus L.,	-	-	-	+ +	-
Myriophillum spicatum L.,	-	-	+	+ +	-
Ceratophyllum demersum L.,	-	+ + +	-	+ +	-
Vallisneria spiralis L.,	-	-	-	+	-
Najas major L.,	+	-	-	-	-
Heleocharis pallustris (L.) R.	+ +	-	-	-	+

Rooted submerged macrophytes may serve as a reflection of this patchiness. It can be reasonably concluded that both organisms serve as important structural components and sensitive bioindicators of the long-term trophic state of freshwater lakes (Melzer, 1999). Bioindicators can be utilized at various levels, from the microhabitat to the ecosystem, to evaluate the condition of a specific ecosystem. They integrate data from the biological and physicochemical composition of all aquatic ecosystems, including aspects such as population density and ecosystem processes. They are of value in reflecting the concept of biological sustainability in the context of water management.The highest relative abundance was observed in *Typha angustipholia* and *Ceratophyllum demersum*, which are species that are indigenous to eutrophic water bodies. Subsequently, *Potamogeton* and *Myriophyllum* species were observed to flourish in shallow water bodies with muddy substrates. The distribution of macrophytes was significantly influenced by the presence of pollutants. In the present study it was observed that plants like *Typha angustifolia* survive till early summer and again rejuvenate after the summer is over. The submerged plants were found throughout the year as they were much affected by the changes in the abiotic factors. Emergent amphibious hydrophytes and wetland hydrophytes like *Scripus* and *Typha* were found growing as indicating the pollution tolerance. The excessive growth of *Ceratophyllum demersum*, may be due to eutrophication this is typical that requires high inorganic level in the lake. Seventeen aquatic macrophyte species were recorded at the five sites. The highest diversity of species was observed at Zogaj and Shiroka. Eight of the species recorded were macrophyte indicators according to Melzer and Schneider (2001), their indicator values ranging from 2.5 (minimum) to 5.0 (maximum). The dominant species were rigid hornwort (*Ceratophyllum demersum*), (*Potamogeton perfoliatus*) and shining pondweed (*Potamogeton lucens*). These species are associated with moderate to very high nutrient enrichment. The Macrophyte Index (MI) varied between 2.8 at Shterbeq and 4 at Vraka *(Tab. 3),* This corresponds to mesotrophic to eutrophic conditions at all sites. The growth of *Myriophyllum spicatum* is significantly correlated with nutrient rich, highly productive plant growth in Vraka where the MI and TI_{DIA} are higher. Studies, carried out by Schneider and Melzer (2004) showed that the growth of *M. spicatum* was positively correlated with high water ammonia concentrations or highest amount of plant and algal productivity. *Ceratophyllum*-dominated lakes showed typical trophic conditions which enable their development under high phytoplankton biomass. In the study of *Ceratophyllum*-dominated lakes, we observed a significant effect of total phosphorus. In *Potamogeton*-dominated stations, we observed the lowest biomass of macrophytes and low species diversity. *Potamogetons* are an indicator of eutrophication (Nichols and Shaw, 1986) and are best suited to nutrient-rich water.

Diatom diversity

In ten samples from the Shkodra Lake, we identified about 90 diatom species. Diatoms can be identified at the species level by microscopic examination and are good indicators for assessing eutrophication of waters (Hall et al., 1999). Each species has its own specific preferences that are developed in each habitat (Lund et al., 1958). Diatoms, the most important group of microscopic algae, can indicate the state of the environment in which sampling is carried out. Nutrient enrichment has also been shown to cause readily observable changes in diatom assemblages at the species level (Neiderhauser & Schanz, 1993). *Cyclotella ocellata* from the centric diatoms is represented in all samples during Decembre 2023, respectively In Shterbeq 84 species, in Kompleksi Hysaj (94 species), in Vraka (33 species), in Shiroka (244 species) and in Zogaj (107 species). For *Cyclotella ocellata*, the highest relative abundance was calculated at Shterbeq (about 210.0) and the lowest was calculated in Vraka (about 8.5). Another species with high relaitive abundance in all samples of Shkodra Lake was *Cymbella affinis* Kützing agg., in Shterbeq (22.4), in Kompleksi Hysaj (7.9), in Vraka (5.9), in Shiroka (3.1) and in Zogaj (4.4) and *Gomphonema truncatum* Ehr., respectively (55.0 in Shterbeq), 11.5 in Kompleksi Hysaj, 8.2 In Vraka, 4.6 in Shiroka and 4.4 in Zogaj. The relative abundance is reflected in the water quality. A pennate diatom was classified as the most dominant species in eight samples; we identified many species which classified the water from mesotroph to meso-eutroph.

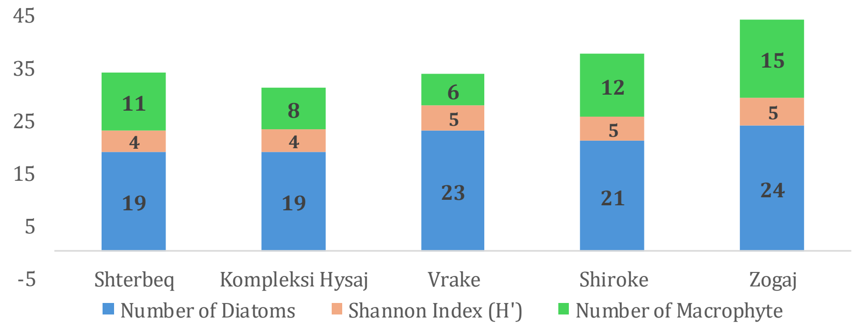

Figure 3. Average value of: number of Diatom species, number of macrophyte species and Shannon Diversity Index (H') during December 2023 and May 2024.

The average high number of Diatom species was in Zogaj (respectively 24) and the low number of diatom species was calculated in Shterbeq and Kompleksi Hysaj (about 19). Also, the high number of macrophyte was in Zogaj respectively 15 species and the low number of macrophyte was calculated in Shterbeq and Kompleksi Hysaj (4 species). As we know, we have a significance in the number of species of diatoms and macrophytes (Fig. 3). The ESMI evaluates the taxonomic composition and abundance of macrophyte communities. The index values range from 0 to 1, where 1 denotes the reference conditions, and values decrease as the quality of the ecosystem deteriorates. The ESMI responds satisfactorily to eutrophication pressure.

Stations	N-NO3 mg/L	Water quality	P-PO4 mg/L	Water quality	TI_{DIA}	Trophic classes	Water Quality	Macrophyte Index (MI)	Trophic classes	Water Quality	Saprobic index (SI)	Saprobic classes	Water quality
Shterbeq	1.56	Good	<0.005	Very good	1,7	*mesotroph*	Moderate	2,8	mesotroph 1	Moderate	1,5	Oligosaprob deri ß-mesosaprob	Very good
Kompleksi Hysaj	1.9	Good	<0.005	Very good	2	*meso-eutroph*	Moderate	3	mesotroph 2	Moderate	1,5	Oligosaprob deri ß-mesosaprob	Very good
Vraka	1.46	Good	<0.005	Very good	2.5	*eutroph*	Poor	3.5	eutroph 1	Poor	1,9	b-mesosaprob	Good
Shiroka	0.81	Very good	<0.005	Very good	2,2	*meso-eutroph*	Moderate	3.3	eutroph 2	Moderate	2.1	b-mesosaprob	Good
Zogaj	1.98	Good	<0.005	Very good	1.9	*meso-eutroph*	Moderate	3	mesotroph 2	Moderate	1.8	b-mesosaprob	Good

Figure 4. Mean value of Nitrates (NO_3-mg/L) (WFD, 2000), Phosphates (PO_4-mg/L) and water quality, Trophic diatom index (TI_{DIA}), trophic classes and Water quality (Rott. et. al., 1999), Saprobic Index (SI), saprobic classes and Water quality (Rott et. al., 1997), Macrophyte index (MI), trophic classes and water quality (Susane Schneider, 2004).

The Macrophyte index evaluates the taxonomic composition and abundance of macrophyte in Shkodra Lake. The macrophytes index values oscillated from 2.8 in Shterbeq to 3.5 in Vraka, that responds satisfactorily to moderate pressure, (*Tab. 4*). In order to gain a more comprehensive understanding of the extent of nutrient pollution in shallow waters, we calculated the macrophyte index for each zone. In shallow waters, the macrophyte index indicates a significant degree of pollution. The values calculated vary considerably, from moderate to poor water quality, which gives rise to concerns about the trophic state and the formulation of potential solutions. Nevertheless, the pollution originates from the shoreline, as evidenced by the consistently higher macrophyte indices in shallow waters compared to those in deeper waters at the same site. It can be reasonably assumed that a portion of the nutrients are incorporated into the plant biomass or stored in the sediment. The primary source of nutrient pollution in Shkodra Lake is the wastewater from households that has not undergone the necessary purification process. In addition, the tributaries are additional source of pollution, including river Buna, the river's inflows are also pointed out as a high pollutant of the lake, and as "hot spots" for the pollution generation. Based on our research we conclude that Shkodra Lake along its course is a subject to many anthropogenic pressures that alter the quality of water and the composition and distribution of macrophytes in the lake. Macrophytes flourish in the presence of water pollution, providing nutrients that facilitate growth. Therefore, it is strongly recommended that they be utilized as biological indicators for water quality classification in all water bodies in Albania and beyond, as they fully satisfy the criteria set by the Water Framework Directive for biological indicators in the assessment and classification of ecological status. It can be concluded that the implementation of the WFD for lake basin assessment provides a great deal of information that should be used by the state authorities to develop a regular system of monitoring and management of the lakes in Albania.

Macrophytes and diatoms play a significant role in the littoral system of lakes. They serve as reliable indicators of eutrophication and are highly susceptible to acidification. The indices of diatoms and macroscopic algae indicate that the lake system is adequately assessed. A typology of Shkodra Lake, an analysis of the impact of human activity on the reference sites, and a mapping of the macroalgae and diatoms are essential for an accurate assessment of the ecological quality of the lake. Our experience indicates that integrating data from two indexes allows for the fulfillment of scientific demands while also meeting the criteria for applicability.

Based on figure 4, we see almost the same values between the trophic diatoms and the trophic index of macrophytes. The value of the trophic index varies from 1.7 (in Shterbeq), which indicates a mesotrophic state of the waters and normally a moderate quality, to 2.5 (in Vraka), which indicates a eutrophic state of the waters and normally a bad quality waters, rich in nutrients in the form of nitrates. The same situation has been evaluated by the index of macrophytes based on *Schnieder, 2004*. MI values vary from 2.8 in Shterbeq, corresponding to a *mesotrophic state 1* with moderate water quality, to 3.5, corresponding to a *eutrophic state 1*, with poor water quality. of waters rich in nutrients in the form of nitrates. Meanwhile, regarding the saprobic index, SI values range from *oligosaprobic -β-mesosaprobic* to *β-mesosaprobic*, respectively from a very good quality of the waters to their good quality. This shows that the influence of organic matter is almost negligible. It is worth noting that inorganic substances in the form of nitrates or nitrites have an impact on the state of the water quality of Lake Shkodra.

The highest value is recorded at Vraka station, respectively (TI_{DIA} 2.5 and MI 3.5), which correlates with the macrophyte index values. The correlation patterns of macrophytes and diatoms were more consistent across the number of species and their disturbance. Unfortunately, the data collected showed general trends in response to eutrophication pressure. This might be partly since the total number of macrophyte collected was few in most cases and these vegetation types showed that the majority of these types are significantly affected by physics chemical parameters indicative of higher levels of eutrophication. Aquatic plant communities could be utilized in eutrophication indices to broaden the assessment of the ecological status of freshwater lakes. Comparison of these two indicators shows that; In general, the trophic diatom index agrees with the macrophyte index variables due to sampling series. The diatom index is advantageous as a short-term marker, so samples can be easily collected for comparison with macrophytes. This is also an advantage for the macrophyte index.

The macrophyte index (MI) at the studied sites and transects in the lake varied from moderate to massive nutrient pollution *(Fig. 4)*. *Vraka* site was most polluted site and *Shterbeq* has good status. Phytoplankton abundance indicated oligotrophic conditions at *Shterbeq* and mesotrophic in *Kompleksi Hysaj* and *Zogaj*. We obviously checked the medium amount of nutrients in these sites. Based on the data from the MI and TI_{DIA} indexes, the trophic assessment for the Skadar lake range to be mesotrophic.

CONCLUSIONS

Our research findings indicate that Shkodra Lake, throughout its course, is subjected to a multitude of anthropogenic pressures that result in alterations to the quality of the water and the composition and distribution of the macrophytes present within the lake. Macrophytes and Diatoms flourish in the presence of water pollution, providing nutrients that facilitate growth. It is therefore strongly recommended that they be utilized as biological indicators for water quality classification in all water bodies in Albania and beyond, as they fully satisfy the criteria set by the Water Framework Directive for biological indicators in the assessment and classification of ecological status. The value of the trophic index varies from 1.7 (in Shterbeq), which indicates a mesotrophic state to 2.5 (in Vraka), which indicates a eutrophic state, rich in nutrients in the form of nitrates. The same situation has been evaluated by the index of macrophytes based on *Schnieder, 2004*. MI values vary from 2.8 in Shterbeq, corresponding to a *mesotrophic state 1*, to 3.5, corresponding to a *eutrophic state 1*, with poor water quality, rich in nutrients. Meanwhile, regarding the saprobic index, SI values range from *oligosaprobic -β-mesosaprobic* to *β-mesosaprobic*, respectively from a very good quality of the waters to their good quality. This shows that the influence of organic matter is almost negligible. It can be concluded that the implementation of the WFD for lake basin assessment provides a great deal of information that should be used by the state authorities to develop a regular system of monitoring and management of the lakes in Albania.

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