O 9. PERIPHYTON DIATOM DIVERSITY AND WATER QUALITY EVALUATION IN POJSKA TRANSECT, (OHRID LAKE)

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ABSTRACT: Aim of this paper is analysis of the composition for the periphyton communities on Macrophyte species (Chara) in Pojska transect (Ohrid Lake). The lake has underwater resources, which contribute to the creation of endemic species-specific habitats as they supply oxygen, nutrients, and create conditions for the development and growth of endemic species. Changes in diatom community structures suggest a change in environmental conditions such as, for example the deterioration of trophic status observed in Ohrid lakes. Estimation of diatom species based on two standards: EN 13946:2003 and EN 14407:2004, we calculate biodiversity variations (Shannon index) between different depths. The Saprobic Index fluctuated from oligosabrob to oligo- β-mesosaprob but Trophic Diatom Index (TIDIA) fluctuated from mesotroph to meso-eutroph. The structures of the diatom communities reflect real environmental changes.

***Keywords**: Periphyton diatom diversity, trophic status, Pojska transects, Ohrid Lake.*

1. INTRODUCTION

Watershed of Ohrid lake extends to an area of 966 km2 where only 273 km2 lie within the Albanian territory; the rest lies on the territory of Northern Macedonia. The total area of the Lake is 358 km2, with 111.4 km2 located within Albania. This lake is the deepest in the Balkans, with an average depth of 138 m (maximum 295 m). The lake has a relatively regular ellipsoid shape and forms a shoreline of 87 km and only 32 km is in the Albanian territory. 63 of this shoreline are generally rocky, high and steep; whereas the rest are flat, low shores of limnogenic and potamogenic origin (Pano, 2015), extending mainly in the northern part near the town of Ohrid, and in the southern part, near the town of Pogradec. The origin of the lake is tectonic, where karstic processes also operate (Qirjazi, 2019; Kabo, 1900-1991). In the watershed of Lake Pogradec, starting from northwest to south-east, chrome (Pojske), iron-nickel and coal mines (Gur i Kuq) have been active. These mines worked at full capacity until the early 1990, which in the past have affected the disruption of the ecological balance of the lake water discharging into the lake and the disruption of the tourist landscape of the area. Despite their closure, their several years' previous activity has affected the lake's aquatic environment. Lake Ohrid has a tectonic origin and has rich biodiversity in flora and fauna. A considerable space is occupied by macrophytes, which form several vegetation belts by depth, namely: *Cladophora, Phragmites, Potamogeton, Chara* (Talevska & Talevski, 2015; Osmani et al., 2012; Krog & Keçi, 2013). The high presence of macrophytes in the lake is associated with the influence of streams or rivers, but also by the slope of the shores; on the lower shores, the amount of deposited matter is higher and the chance of developing aquatic vegetation is better. But also, the relatively high amount of nutrients (nitrates, phosphates, etc.) leads to the development of macrophytes and diatoms, as well as the development of an entire food chain in the aquatic ecosystem.

Aim of this study was to identify silicate algae (diatoms) in perifiton communities at Pojska transects, at different depths from the lake shore, and to assess nutritional status based on the use of contemporary biomonitoring methods (EN13946: 2003; EN14407: 2004) which are implemented by many European countries. Microscopic algae (Diatoms) are used for assessing the nutritional status and quality of waters (Fott, 1971; Sladacek, 1986; Kelly & Whitton, 1995; John, 2002; Bellinger & Sigee, 2010; Miho, 2011). Biological monitoring (diatoms) has many advantages over chemicals, since it summarizes large-scale contamination biota data over time (Calow & Petts, 1994; John, 2002).

2. MATERIAL AND METHODS

Samples were collected as perifiton in macrophytes (*Chara*) at Pojska transect, at different depths from the lake shore (2 m; 3 m; 4.5 m; 6 m; 8 m; 11 m; 13 m; 15 m; 17 m; 18 m; 19 m), during July 2011.

These samples were collected with the help of a scraper fitted with a rope, which was released several times from the boat, at each depth. This is a rocky area near the Pojska Mine. All samples were conserved in 3-4% formaldehyde (Lenzi-Grillini, 1978; Sournia, 1986).

The cleaning of diatom frustules was done by boiling the material, first with HClcc and then, after washing, boiling them again with H_2SO_4cc, adding during the last procedure some crystals of KNO3, as described by Krammer & Lange-Bertalot 2001; Kupe, 2006.

The diatoms were identified using standart literature: mainly the volumes of the Central European Freshwater Flora series (Süßwasserflora von Mitteleuropa; Krammer & Lange-Bertalot, 1986-2001), as well as the publication of Levkov et al. (2007). Scientific names have been consistently consulted with websites, especially AlgaeBase (Guiry & Guiry, 2020) and DiatomBase (Kociolek et al., 2020).

About 500 valves per slide were counted using 100 oil immersions; the calculated value in% of species is error ± 10, with 95% reliability (Lund et al., 1958; Kupe, 2006).

We calculate the Diversity Index (H'), (Shannon & Weaver, 1949); Trophic and Saprobic indices may be used to make a rought estimate of lake's condition and to determinate a water quality. For this purpose, we calculated TI DIA and SI using the formula of Zelinka & Marvan (1961) by Root et al., 1999 and 1997.

3. RESULTS AND DISCUSSION

In this paper we focused on identifying microscopic algae (diatoms) as well as assessing the trophic state of the water at Pojska transect, near which the chrome mine was operational prior to the 1990, which although not functioning today, again has its effects on the waters of this lake and precisely at the Pojska transect. The influence of nutrients affects the structure of the biodiversity. About 11 diatoms have been identified in the Pojska transect in 11 samples, 2 diatoms belong central diatoms represented by *Cyclotella ocellata* (TW = 1.5 which indicates oligo-mesotrophic states) and *C. fotti* with a limited distribution and 100 diatom species, belong order pennate, which was classified as the most dominant species in eight samples.

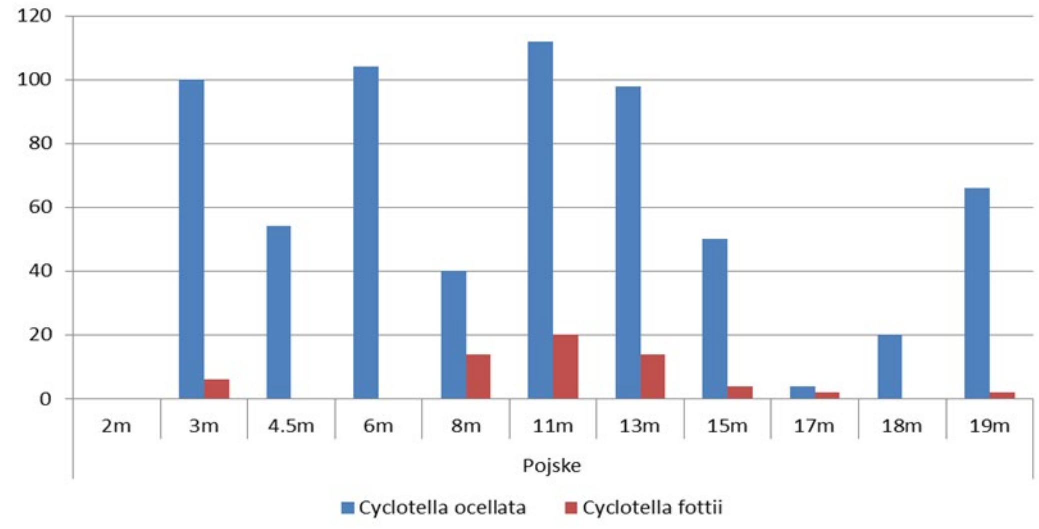

Figure 1. Distribution of centric diatom in Pojska transect

We have identified many endemic species. Underwater resources contribute to the creation of endemic species-specific habitats as they supply oxygen, nutrients, and create conditions for the development and growth of endemic species in Lake Ohrid (Stankovic, 1960; Matzinger et al., 2007; Albrecht & Wilke, 2008; Hauffe et al., 2010; Trajanovski et al., 2010).

Cyclotella ocellata is widespread in all depth of Pojska transect (especially 2m depth) approximately 91% of frequency the maximum valves number of *Cyclotella ocellata* were counted in 11m, 6m, 3m, 13m (Tab.1).

Among the pennate species (Tab. 1, Fig. 2) are the most widespread and abundant in the Pojska transect: *Amphora ohridana* (endemic species), *Cocconeis placentula* var. *lineata* (TW = 2.6 (eutroph);

S = 1.8 (α-mesotroph), *Cocconeis robusta* (endemic species), *Epithemia ohridana* (endemic species), *Gomphonema pumilum* (TW= 1.1 (Oligotroph); S = 1.6 (oligo –α- mesotroph), *Navicula cryptotenella* (TW = 2.3 (eutroph); S = 1.5 (oligo – α- mesotroph), N. subalpine, *Denticula tennuis* etj. In Ohrid lake more diatom species may be considered rare, endemic, or tertiary relicts, such as, *Epithemia goeppertiana*, *Navicula oligotraphenta*, *N. mediocostata*, *N. praeterita* etc.

Also, the diatom communities are good indicators to respond changes in nutrient and to evaluation long-term changes in ecosystem. The climate has influence in community of diatoms and is normal to evaluate the status of Lake one/year.

The number of species in the Pojska transect fluctuates from 8 at 2 m depth to 41 species at 11 m depth (Tab. 1; Fig. 2), which coincides with the maximum found at this station. As the depth increases, the number of species found increases except for depths of 15 m to 18 m; perhaps this is due to the low concentration of nutrients, or by the greater development of macrophytes.

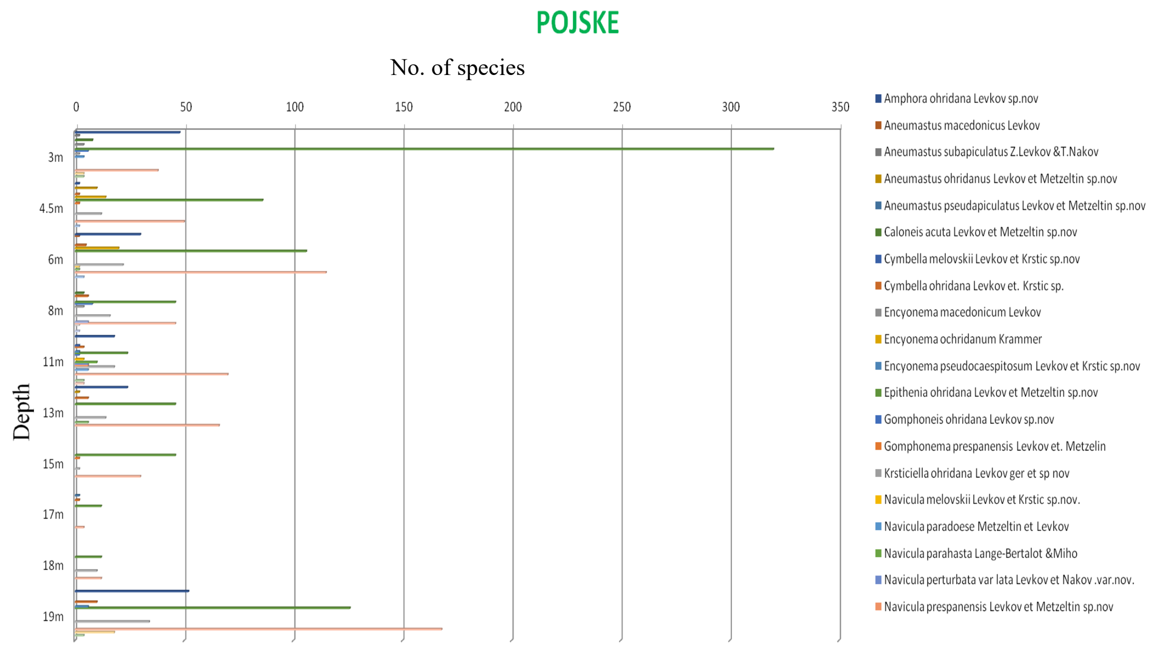

Figure 2: Distribution of pennate diatom in Pojska transect

Table 1. Check list of diatoms in Pojska transect, Ohrid Lake

Name of species / Depth, m	2	3	4.5	6	8	11	13	15	17	18	19	*Frequency, %*
Centricae												
Cyclotella fotii Hustedt		*0.2*			*2.1*	*1.9*	*1.5*	*0.6*	*1.0*		*0.1*	64
Cyclotella ocellata Pantocsek		*4.0*	*7.3*	*9.7*	*6.1*	*10.9*	*10.3*	*8.1*	*2.0*	*6.6*	*3.0*	91
Pennatae												
Achnanthes minutissima Kützing *agg.*						*0.2*						9
Amphora ohridana Levkov		*1.9*	*0.3*	*2.8*		*1.8*		*1.6*	*2.0*			55
Amphora pediculus (Kützing) Grunow					*2.8*		*1.1*	*0.6*				27
Amphora sp.		*0.4*										9
Aneumastus macedonicus Levkov				*0.2*								9
Aneumastus ohridanus Levkov et Metzelin			*1.4*				*0.2*					18
Aneumastus subapiculatus Levkov & Nakov		*0.1*										9
Aneumastus pseudapiculatus Levkov & Metzeltin									*1.0*			9
Caloneis acuta Levkov & Metzeltin		*0.3*			*0.6*							18
Caloneis tenuis (W.Gregory) Krammer			*0.3*	*0.2*								18

Name of species / Depth, m	2	3	4.5	6	8	11	13	15	17	18	19	*Frequency, %*
Caloneis sp.			*0.5*									9
Campylodiscus levanderi Hustedt											*0.1*	9
Campylodiscus marginatus var.tenuis Jurilj				*0.6*								9
Cavinula scutelloides (W.Smith) Lange-Bertalot											*0.1*	9
*Cocconeis placentula var. lineata (*Ehrenberg) Van Heurck	*76.2*	*18.0*	*10.8*	*9.1*	*2.8*	*25.8*	*6.3*	*12.3*	*3.1*	*26.5*	*9.5*	100
Cocconeis placentula Ehrenberg *agg.*						*1.9*	*1.3*					18
Cocconeis pseudolineata (Geitler) Lange-Bertalot						*0.4*						9
Cocconeis robusta Jurilj		*3.0*	*2.7*	*1.9*	*7.1*	*9.7*	*6.9*	*7.5*	*7.1*		*2.8*	82
Craticula cuspidata (Kützing) D.G Mann											*0.4*	9
Cymatopleura solea (Brebisson) W. Smith											*0.1*	9
Cymbella exigua Krammer					*0.6*	*0.2*						
Cymbella lange-bertalotti Krammer		*1.6*	*2.2*	*1.9*	*0.3*	*0.2*	*1.9*	*0.6*			*0.5*	73
Cymbella melovskii Levkov et Krstic *sp.nov*						*0.2*						9
Cymbella ohridana Levkov et. Krstic sp.			*0.3*	*0.5*	*0.9*	*0.4*	*0.6*		*1.0*		*0.5*	64
Cymbella tumida (Brebisson) Van Heurck		*0.6*	*0.3*	*0.2*								27
Denticula tenuis Agarth		*13.8*	*14.6*	*11.2*	*9.8*	*0.8*	*4.4*	*6.5*	*5.1*	*9.9*	*6.9*	91
Diatoma densicostata Levkov		*0.1*										9
Diatoma tenuis Agardh		*0.1*	*0.3*									18
Diploneis elliptica (Kützing) Cleve			*0.3*			*0.4*						18
Encyonema minutum (Hilse) D.G.Mann		*0.4*			*1.2*	*6.0*	*2.9*	*3.9*	*2.0*	*1.3*	*1.3*	73
Encyonema macedonicum Levkov		*0.2*										9
Encyonema ohridanum Krammer			*1.9*	*1.9*								18
*Encyonema L*ange-Bertalotii		*0.5*	*0.8*	*1.9*	*0.6*	*2.1*	*1.7*	*1.9*		*2.6*		73
Encyonema pseudocaespitosum Levkov et Krstic *sp.nov*						*0.2*					*0.3*	18
Epithemia lunata Jurilj		*1.3*	*0.5*	*0.7*			*0.2*			*0.7*		45
Epithemia goeppertiana Hilse		*0.1*		*0.4*								18
Epithemia adnata (Kutziing) Brebisson		*1.6*	*0.3*	*0.4*							*0.1*	36
Epithemia sorex Kützing		*0.1*										9
Epithemia ohridana Levkov		*12.8*	*11.7*	*9.9*	*7.1*	*2.3*	*4.8*	*7.5*	*6.1*	*4.0*	*5.7*	91
Fragilaria acus Kützing								*0.3*				9
Gomphoneis ohridana Levkov		*0.2*			*1.2*	*0.2*						27
Gomphonema angustum Agardh	*4.8*											9
Gomphonema clavatum Ehrenberg		*0.3*	*3.3*	*0.2*			*0.2*					36
Gomphonema irroratum Hustedt		*0.1*										9
Gomphonema olivaceum (Hornemann) Brebisson *gr.*		*2.6*	*3.5*	*5.2*	*3.1*	*2.3*	*5.3*	*1.9*	*3.1*	*0.7*	*3.2*	91
Gomphonema olivaceolacuum Lange-Bertalot							*0.2*					9
Gomphonema olivaceum var. calcareum Cleve			*0.5*						*1.0*			18
Gomphonema parvulum Kützing *agg.*	*9.5*			*0.0*			*0.1*					27
Gomphonema pratense Lange-Bertalot		*1.2*	*0.8*		*2.1*					*2.6*	*1.2*	45
Gomphonema prespanensis			*0.3*					*0.3*				18

Name of species / Depth, m	2	3	4.5	6	8	11	13	15	17	18	19	*Frequency, %*
Gomphonema pseudotenellum Lange-Bertalot					*0.3*							9
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	*9.5*	*26.0*	*22.8*	*14.6*	*27.3*	*11.9*	*28.4*	*23.1*	*56.1*	*23.2*	*40.2*	100
Gomphonema subclavatum (Grunow) Grunow								*0.6*				9
Gyrosigma sciotoense (Sullivant et Wormley) Cleve					*0.3*						*0.1*	18
Hippodonta costulaiformis Lange-Bertalot				*0.2*		*0.8*					*0.6*	27
Hippodonta lueneburgensis Lange-Bertalotii												0
Krsticiella ohridana Levkov					*0.6*							9
Meridion circulaire (Grewille) Agardh				*4.3*								9
Meridion circulaire (Grewille)var *constrictum*					*3.7*	*1.9*	*1.7*	*5.2*		*5.3*	*7.5*	55
Navicula ambigua Ehrenberg							*0.2*			*2.0*		18
Navicula capitatoradiata Germain				*1.5*	*0.9*	*0.4*	*5.8*	*7.1*	*5.1*	*2.6*	*0.5*	73
Navicula cari Ehrenberg					*0.6*		*0.2*					18
Navicula caterva Hohn & Hellerman		*0.1*										9
Nacicula cuspidata Kützing			*0.5*									9
Navicula cryptocephala Kützing					*0.6*						*0.7*	18
Navicula cryptotenella Lange-Bertalot		*2.4*	*2.7*	*7.3*	*7.4*	*3.9*	*6.3*	*3.2*	*3.1*	*4.6*	*5.2*	91
Navicula cryptotenelloides Lange-Bertalot						*0.4*						9
Navicula cf.*antonii* Lange -Bertalot						*0.2*						9
Navicula melovskii Levkov & Krstic						*0.4*						9
Navicula paraobesa Metzeltin & Levkov		*0.2*										9
Navicula parahastata Lange-Bertalot &Miho						*1.0*						9
Navicula perturbata Jurilj						*0.6*						9
Navicula prespanensis Levkov et Metzeltin						*0.6*						9
Navicula radiosa Kützing			*1.6*	*2.0*	*2.5*	*1.8*	*1.5*	*0.3*		*3.3*	*1.5*	73
Navicula rakowskae Lange-Bertalot				*0.2*								9
Navicula sancti-naumii Levkov & Metzeltin						*0.6*						9
Navicula stankoviccii Hustedt					*0.9*							9
Navicula subalpina Reichardt		*1.5*	*6.8*	*10.7*	*7.1*	*6.8*	*6.9*	*4.9*	*2.0*	*4.0*	*7.6*	91
Navicula saprophila Lange-Bertalot			*0.3*					*1.0*				18
Navicula tripunctata (O. F. Müller) Bory				*0.4*		*0.6*		*0.3*			*0.2*	36
Neidium binodis (Ehrenberg) Hustedt			*0.3*									9
Neidium dubium var. constricta Hustedt		*0.1*										9
Neidium majus (Jurilj) Levkov					*0.6*							9
Nitzschia angustata (W.Smith) Grunow											*0.1*	9
Nitzschia communis Rabenhorst											*0.3*	9
Nitzschia denticula Grunow		*4.3*										9
Nitzschia sigmoidea (Nitzsch) W.Smith						*0.4*						9
Pinnularia viridis (Nitzsch) Ehrenberg		*0.1*			*0.3*	*0.2*						27
Placoneis gastrum (Ehrenberg) Mereschkowsky						*1.2*						9
Placoneis tumidula Levkov			*0.3*	*0.4*								18

Name of species / Depth, m	2	3	4.5	6	8	11	13	15	17	18	19	*Frequency, %*
Placoneis macedonica Levkov					*0.3*							9
Placoneis ohridana Levkov et Metzeltin		*0.2*										9
Planothidium dubium (Grunow) Round & Bukhtiyarova						*0.2*	*0.2*					18
Planothidium lanceolatum (Brebsson) Lange-Bertalot							*0.2*					9
Roicosphaenia abreviata (Agarth) Lange-Bertalot					*0.3*	*0.2*		*1.0*				27
Rhoicosphaenia macedoniva Levkov		*0.2*				*0.4*					*0.2*	27
Sellaphora macedonica Levkov & Metzeltin					*0.3*							9
Sellaphora ohridana Levkov & Krstic						*0.4*						9
Staurosira sp.L											*0.3*	9
Staurosiriella pinnata Ehrenberg				*0.2*	*0.3*	*0.2*		*0.3*			*0.6*	45
Staurosirella sp.		*0.1*		*0.4*		*0.2*						27

Table 2. Diversity Index (H'); number of species (N); Trophic Index of Diatom, TIDIA), trophic classes, Trophic saprobic (SI), Saprobic classes in Pojska transect

Name of station	Pojska										
Depth (m)	**2**	**3**	**4.5**	**6**	**8**	**11**	**13**	**15**	**17**	**18**	**19**
Number of species, N:	4	34	31	30	31	39	27	23	15	16	28
Diversity Index (Shannon Index), H':	1.15	3.41	3.69	3.89	3.85	3.85	3.67	3.50	2.55	3.26	3.19
Trophic Diatom Index, TIDIA:	2.2	1.8	1.9	2.1	1.9	2.3	2.2	2.2	1.8	2.0	1.7
Trophic classes	Meso-eutroph	Mesotroph	Mesotroph	Meso-eutroph	Meso-eutroph	Mesotroph	Meso-eutroph	Meso-eutroph	Mesotroph	Mesotroph	Mesotroph
Saprobic Index, SI	1.6	1.5	1.4	1.4	1.5	1.4	1.6	1.6	1.6	1.4	1.5
Saprobic classes	Oligo-β-mesosaprob	Oligosaprob	Oligosaprob	Oligosaprob	Oligosaprob	Oligosaprob	Oligo-β-mesosaprob	Oligo-β-mesosaprob	Oligo-β-mesosaprob	Oligosaprob	Oligosaprob

To determine the waters ecology near this transect, depending on the types of diatoms and their numbers, we calculated the ecological values of the nutrient indicator (which is closely related to the inorganic matter accumulated in macrophytes and in water) and the saprobic indicator (which is related to the presence of organic matter). According to Shannon & Weaver 1949, the variability index fluctuates from 1.15 (2 m) to 3.89 (6 m). Almost all other H 'depths fluctuate around the value of 3, (Tab. 2). Based on inorganic matter in water, responsible index is TIDIA, which oscillated from mesotroph (1.7) in 19m depth to meso-eutroph (2.3) in other depths.

About the presence of organic matter in water, SI oscillated from oligossaprob (1.4) to Oligo-β-mesosaprob (1.6). As we show, the presence of organic matter is in the moderate value (grade II quality) compare with inorganic matter. Eutrophic habitats dominated Diatom species, in conditions by *Amphora pediculus, Cocconeis placentula* var. *lineata, Encyonema minutum, Navicula cryptotenella, Nitzschia dissipata* etc.

4. CONCLUSION

The diatom communities are good indicators to respond changes in nutrient and to evaluation long-term changes in ecosystem. *Cyclotella ocellata* as centric diatom is more widespread in all depth of

Pojska transect because centric diatoms float in water and the sampling is conducted from macrophyte. Most of pennate diatoms are present in all depth of sampling sites like epiphyte in macrophytes. Diatom communities in the Ohrid Lake were characterized by a high diversity, which is in accordance with other studies carried out in tectonic Ohrid Lake. The relative abundance is reflected in the water quality. Most of the species in Pojska transect are endemic like: *Amphora ohridana Levkovsp.nov; Encyonema macedonicum Levkov; Encyonema ochridanum Krammer; Encyonema pseudocaespitosum Levkov et Krsticsp. nov; Gomphoneis ohridana Levkov* sp. *nov;* etc., Endemic species are evaluated only on taxonomic aspects because until now don't have ecological status. The trophic classes oscillated from mesotroph (1.7) to meso-eutroph (2.3). Saprobic classes oscillated from oligosaprob (1.4) to Oligo-β-mesosaprob (1.6).

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