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# WATER QUALITY ASSESSMENT OF THE BLIDINJE SHALLOW HIGH MOUNTAIN LAKE IN BOSNIA AND HERZEGOVINA, BASED ON ITS BIOLOGICAL PROPERTIES

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Abstract

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Blidinje lake is the largest mountain lake in Bosnia and Herzegovina located at 1185 m a.s.l. and it is an integral part of the Nature Park Blidinje founded in 1995. This paper presents the qualitative composition of phytoplankton and phytobenthos of Blidinje lake and the population density of phytoplankton collected at five locations in the coastal region on its surface. The collection of phytoplankton material was carried out over a period of three months in 2008, while phytobenthos was taken once in September 2008. This paper also describes the environmental conditions in Blidinje lake relevant for phytoplankton and phytobenthos growth. The data presented here contributes baseline information concerning biological diversity essential for evaluation of environmental changes in the future. Conservation of karstic lakes is one way to preserve the overall biodiversity of karstic areas.

*Key words*: phytoplankton, phytobenthos, index saprobity, Blidinje lake

## Introduction

Blidinje lake is the largest mountain lake in Bosnia and Herzegovina located at 1185 m above sea level (Fig. 1).

According to Directive 2000/60/EC of the European Parliament and Council, (Directive 2000/60/EC of the European Parliament and of the Council Establishing a Framework for the Community action in the field of water policy) Blidinje lake is located in the fifth Ecoregion for Rivers and Lakes “Dinaric Western Balkan”.

Fig. 1. Blidinje lake.

The lake is very shallow with an average water depth of 0.3 to 1.9 m. The ratio of the surface of the lake during high-water to the surface of the lake during low-water level is 3.6 $km^2$: 2.5 $km^2$ (Spahić, 2001).

The Nature Park Blidinje is under the influence of a typical mountain climate. Summers are fresh and usually last from early June to September. The entire area of the Park is located on the border of the impact of the Mediterranean and continental climates. The limit of impact of the warm current of the Mediterranean is at an altitude of 900 m. The lake surface is usually frozen during the winter months, and although the duration of ice cover depends on weather conditions, on average it lasts from four to five months.

The only previous studies of phytoplankton, phytobenthos, zooplankton and zoobenthos in Blidinje lake were conducted in 2008. The saprobic index was 1.81 and the presence of indicator species in Blidinje lake indicates the degree of mesosaprobic saprobity and II bonitet class (Ćeric et al., 2008).

The lake fauna has not currently been systematically investigated. There is a Dalmatian barbelgudgeon (*Aulopyge huegelii* H e c k e l, 1841) endemic to the Adriatic, and sunbleak (*Leucaspius delineatus* H e c k e l, 1843) can still be found in the lake (Delić et al., 2005).

New species were introduced into the lake in the 1980's, and possibly earlier, so that today habitats can be found for chub (*Squalis cephalus* L i n n a e u s, 1758) and white chub (*Leu-*

*ciscus cephalus* L i n n a e u s, 1758) (Razdorov et al., 1990). Although there is no actual data concerning macrophytes in Blidinje lake it is evident that the lake is poor in macrophytes.

The present paper presents data on the phytoplankton and phytobenthos diversity in Blidinje lake, and the following physical and chemical properties of the lake's water: temperature, dissolved oxygen, oxygen saturation, pH, Secchi depth, suspended matter, total hardness, alkalinity, acidity, concentration of nitrites ($NO_2^-$) and nitrates ($NO_3^-$), amonia salts ($NH_4^+$), total nitrogen (TN), silica ($SiO_2$), phosphates ($PO_4^{3-}$) – SRP, total phosphorous (TP) and chlorophyll *a*.

## Material and methods

Over the three month period of June 4th to September 1st 2008, samples were taken from the surface at five locations located along the edge of the lake (Fig. 2), and phytobenthos samples were collected once on September 1st at the fifth location. Water sampling was adequate from the surface because water mixing is usual in shallow lakes, and there is no vertical stratification (Rocha et al., 2009).

Water sampling for physical and-chemical analysis was carried out using standard methodology (APHA, 1998). Portable (HACH DR/2010) spectrophotometer was applied for all analyses except for the phosphates and total phosphorous which were determined using UV-VIS spectrophotometer (Shimatzu) at 690 nm wavelength.


Fig. 2. Marked sampling locations on Blidinje map with marked Blidinje lake position on the map of Bosnia and Herzegovina.

The total nitrogen was determined by Kjedahl (Gerhardt), while chlorophyll *a* content was established by the fluorimetric method (TURNER TD-700, Sunnyvale, CA) at 365 nm wavelength and using 90% acetone as the extracting solvent (Jeffrey et al., 1997).

The samples for phytoplankton cell density analysis were fixed in 4% neutralized formaldehyde. Sub-samples of 50–100 ml were permitted to settle for 24–48 hours in the counting chambers, and cells were subsequently counted with an Olympus IX 71 inverted microscope (Utermöhl, 1958), using phase-contrast at 600x. Cells covering the entire bottom of the chamber were counted, and results were expressed as cell density of phytoplankton (including cyanobacteria) per litre.

Each cell of filamentous algae (and cyanobacteria) was counted as a single cell. A 20-cm diameter, 53-μm mesh-size net with horizontal tows 50 cm beneath the surface was employed, and the netted phytoplankton samples were used in the qualitative analysis of plankton.

Diatoms were identified following standard techniques described by Battarbee (1986), and relevant references were used in the identification of algae (Hustedt, 1930; Lind, Brook, 1980; Ettl, 1983; Krammer, Lange-Bertalot, 1986, 1988, 1991a, b; Popovský, Pfiester, 1990; Canter-Lund, Lund, 1996). Cyanobacteria were identified using Geitler (1932), Komárek and Anagnostidis (1986) and Lenzenweger (1996, 1997, 1999, 2003), while the taxonomy of higher-level categories was adjusted according to Lee (1999). The indicator values of taxa are defined by Wegl (1983) and the saprobity index was estimated according to Pantle and Buckh (1955) and Zelinka and Marvan (1961) using the formula:

$$s = \frac{\sum_{i=1}^{n} (s_i \cdot h_i)}{\sum_{i=1}^{n} h_i},$$

where: $s_i$ is the indicator value of taxa, $h_i$ is the relative frequency of species and $s$ is the saprobity index.

Margalef's species richness index (Margalef, 1965) was used to characterize the species richness, so that :

$$D = \frac{S-1}{\log N},$$

where: *D* is the index; *S* is the number of species; and *N* is the total number of individuals. When only one species is present, *S-1* is zero and thus *D* is undefined. The similarity index of Jaccard (JI) (Jaccard, 1908), based on the presence/absence of a species, rather than on its actual number, was used to quantify species associations in the netted plankton samples. This is symbolized as *S* (not to be confused with *S* in the Margalef expression) and calculated as:

$$S = \frac{a}{a+b+c},$$

where: *a* is the number of species present in both sample pools; *b* is the number of species present in sample 1, but absent in sample 2; and *c* is the number of species present in sample 2, but absent in sample 1. Double absences were not considered.

## Results and discussion

### *Physical and chemical parameters*

Blidinje lake is a shallow mountain lake, with high turbidity which varies throughout the day depending on the wind direction and speed. Since there are different micro-conditions at different locations, it is possible to measure different values of the same indicators simultaneously. The European Water Framework Directive states that the indicative phytoplankton taxa and additional parameters are to be used for assessing the ecological status.

Nutrients here show large fluctuations, and concentrations of chlorophyll *a* were in the range of oligotrophic waters, according to OECD classification.

Water in Blidinje lake is mesotrophic-eutrophic in terms of total phosphorus content. The chlorophyll *a* content averaged 1.39 μg $L^{-1}$ which is very low, as often seen in oligotrophic water bodies which have very high transparencies at several metres depth. The low chlorophyll *a concentration* does not correspond to the relatively high content of total phosphorus, at 0.05–0.14 ug/L and a Secchi depth of 10–40 cm. It is assumed that dissolved reactive phosphorus was inhibited by suspended solids close to the surface, and this would also contribute to the poor transparency.

Physico-chemical parameters are shown in Table 1. In general, Secchi depth is very low; at from 10 to 40 cm, which is lower than typical depth for eutrophic/hypertrophic water. Dissolved oxygen and oxygen saturation are relatively high with a balanced pH, while the water hardness is very low at 37.5–67.5 mg $L^{-1}$, as also is alkalinity due to calcareous bedrocks in the catchments.

Some studies have shown that reactive silica concentrations at 0.5 mg $L^{-1}$ may limit the growth of some diatoms (Welch, 1980), and values in Blidinje lake were significantly below that limiting concentration, at 0 to 0.08 mg $L^{-1}$.

T a b l e 1. The main physico-chemical parameters of the water.

| Date | Jun 4th Location | | | | | Sep 1st Location | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parametre | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| **$NO_3^-$ ($mgL^{-1}$)** | 0.6 | 0.8 | 0.3 | 0.4 | 0.5 | 0.8 | 0.5 | 0 | 0 | 0 |
| **$NO_2^-$ ($mgL^{-1}$)** | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0 | 0 | 0.02 | 0.02 |
| **$NH_4^+$ ($mgL^{-1}$)** | 0.09 | 0.16 | 0.12 | 0.14 | 0.11 | 0.13 | 0.05 | 0.04 | 0.04 | 0.02 |
| **$SiO_2$ ($mgL^{-1}$)** | 0.04 | 0.04 | 0.05 | 0.02 | 0.06 | 0.04 | 0.08 | 0 | 0 | 0.01 |
| **TN ($mgL^{-1}$)** | 1.12 | 1.19 | 1.26 | 1.47 | 1.05 | 3.08 | 3.22 | 3.78 | 2.87 | 3.43 |
| **Secchi depth (cm)** | 25 | 25 | 40 | 40 | 30 | 15 | 10 | 20 | 20 | 10 |
| **Susp. matter ($mgL^{-1}$)** | 23 | 19 | 18 | 25 | 25 | 347 | 187 | 66 | 63 | 67 |
| **Temperature (°C)** | 23.1 | 24.1 | 23.5 | 23.2 | 23.8 | 23.1 | 25.5 | 24.6 | 24.4 | 23.2 |
| **Dissolved $O_2$ ($mgL^{-1}$)** | 8.05 | 7.3 | 7.8 | 8.4 | 8.3 | 7.48 | 7.13 | 7.22 | 7.31 | 7.39 |
| **Saturation $O_2$ (%)** | 105.7 | 102 | 96 | 103.2 | 113.5 | 102.7 | 95 | 85.9 | 86.9 | 95.1 |
| **pH** | 8.05 | 8.11 | 8.35 | 8.26 | 8.15 | 8.36 | 8.09 | 8.14 | 8.22 | 8.62 |
| **Hardness ($mgL^{-1}$)** | 57.5 | 37.5 | 52.5 | 67.5 | 67.5 | 67.5 | 65 | 65 | 62.5 | 60 |
| **Acidity ($mgL^{-1}$)** | 13.2 | 8.8 | 22 | 22 | 8.8 | 8.8 | 7.92 | 4.4 | 6.16 | 5.28 |
| **Alkalinity ($mgL^{-1}$)** | 128.1 | 134.2 | 134.2 | 183 | 183 | 79.3 | 85.4 | 82.35 | 88.45 | 91.5 |
| **$PO_4^{3-}$ (SRP) ($mgL^{-1}$)** | 0 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 |
| **TP ($mgL^{-1}$)** | 0.08 | 0.08 | 0.09 | 0.07 | 0.14 | 0.08 | 0.05 | 0.08 | 0.07 | 0.07 |
| **Chl *a* (μ$gL^{-1}$)** | 2.26 | 1.63 | 1.51 | 1.12 | 2.03 | 1.39 | 1.29 | 0.65 | 1.02 | 1.02 |

*Qualitative composition of phytoplankton and phytobenthos*

A total of 57 taxa were detected; 32 on June 4th and 45 on September 1st , and 21 of these were euplankton. The qualitative composition of phytoplankton is shown in Table 2, where the most abundant class was Bacillariophyceae with 23 taxa.

T a b l e 2. Qualitative composition of phytoplankton.

| **Date**<br>**Total number of taxa** | **June 4th**<br>**32** | **September 1st**<br>**44** |
|---|---|---|
| **Taxa** | | |
| **Class: Cyanophyceae** | | |
| *Anabena* sp. | | + |
| *Chroococcus limneticus* Lemmermann | + | + |
| *Gomphosphaeria aponina* Kützing | | + |
| *Oscillatoria limosa* Agardh | + | |
| *Oscillatoria* sp. | | + |
| *Phormidium* sp. | + | |
| **Class: Chrysophyceae** | | |
| *Dinobryon divergens* Imhof | + | + |
| **Class: Dinophyceae** | | |
| *Ceratium hirundinella* (O.F. Müller) Bergh | | + |
| *Peridinium* sp. | + | |
| **Class: Bacillariophyceae** | | |
| *Achnanthes* sp. | | + |
| *Cyclotella ocellata* Pantocsek | + | |
| *Cyclotella* sp. (Kützing) Brébisson | + | + |
| *Cymbella* sp. | + | |
| *Cocconeis pediculus* Ehrenberg | | + |
| *Cocconeis* sp. | | + |
| *Diatoma vulgare* Bory | + | + |
| *Encyonema ventricosa* Kützing | | + |
| *Euontia* sp. | | + |
| *Fragilaria* sp. | + | |
| *Fragilaria ulna* (Nitzsch) Lange-Bertalot | | + |
| *Gomphonema* sp. | + | + |
| *Gyrosigma attenuatum* (Kützing) W. Smith | | + |
| *Melosira varians* C. Agardh | | + |
| *Navicula* sp. | + | + |
| *Neidium dubium* (Ehrenberg) Cleve | + | + |
| *Neidium* sp. | + | |
| *Nitzschia* sp. | + | + |
| *Pinnularia microstauron* (Ehrenberg) Cleve | + | + |
| *Rhoicosphaenia abreviata* (Agardh) Lange-Bertalot | | + |
| *Stephanodiscus hantzschii* Grunow | | + |

T a b l e 2. (Continued)

| | | |
|---|---|---|
| *Synedra danica* Kützing | + | + |
| *Fragilaria ulna* (Nitzsch) Ehrenberg | + | + |
| **Class: Chlorophyceae** | | |
| *Chlamydomonas* sp. Ehrenberg | | + |
| *Didymocystis inermis* (Fott) Fott | + | + |
| *Coleosphaerium naegelianum* Unger | | + |
| *Coleosphaerium* sp. | | + |
| *Crucigenia rectangularis* (Nägeli) Gay | | + |
| *Crucigenia tetrapedia* (Kirchner) Kuntze | | + |
| *Oedogonium* sp. | + | |
| *Scenedesmus quadricauda (S.communis)* Chodat | + | + |
| *Scenedesmus ecornis* (Ehrenb. ex Ralfs) Chodat | | + |
| *Scenedesmus spinosus* Chodat | + | + |
| *Tetraedron regulare* Kützing | + | + |
| **Class: Euglenophyceae** | | |
| *Trachaelomonas* sp. | + | + |
| **Class: Conjugatophyceae** | | |
| *Closterium* sp. | + | |
| *Closterium laeve* Kützing | | + |
| *Cosmarium* sp. | + | + |
| *Cosmarium heimerlii* West | | + |
| *Cosmarium* sp1. | + | |
| *Cosmarium botrytis* Meneghini | + | + |
| *Cosmarium reniforme* (Ralfs) W. Archer | + | + |
| *Cosmarium subprotumidum* Nordst | + | + |
| *Pleurotaenium ehrenbergii* (Brébisson) De Bary | + | |
| *Mougeotia* sp. | + | |
| *Penium margaritaceum* (Ehrenberg) Brébisson | | + |
| *Staurastrum punctulatum* Brébisson | | + |

When phytobenthos was sampled for the single time on September 1$^{st}$, 37 species were detected: 6 of these belong to Cyanphyceae class (16%), 10 Bacillariophyceae (27%), 4 Chlorophyceae (11%) and 17 Conjugatophiceae (46%). The qualitative composition of Blidinje lake phytobenthos is shown in Table 3.

*Phytoplankton abundance*

Maximum phytoplankton abundance of 9.134x10$^6$ cells L$^{-1}$ was recorded on September 1$^{st}$ at the fifth location. Most abundant taxon was *Crucigenia rectangularis* (N ä g e l i) G a y with 8.482x10$^6$ cells L$^{-1}$ and the minimum phytoplankton abundance of 1.08x10$^5$ cells L$^{-1}$ was recorded on June 4$^{th}$ at the second location (Fig. 3).

T a b l e 3. Qualitative composition of phytobenthos.

| **Total number of taxa**<br>**Taxa** | **September 1st**<br>**37** |
|---|---|
| **Class: Cyanophyceae** | |
| *Anabaena constricta* (Szafer) Geitler | + |
| *Lyngbya martensiana* Meneghini ex Gomont | + |
| *Oscillatoria irrigua* Kützing ex Gomont | + |
| *Oscillatoria limos* Agardh | + |
| *Oscillatoria probiscidea* Gomont | + |
| *Plectonema radiosum* (Schidermayer) Gomont | + |
| **Class: Bacillariophyceae** | |
| *Achnanthes* sp. | + |
| *Caloneis silicula* (Ehrenberg) Cleve | + |
| *Cocconeis pediculus* Ehrenberg | + |
| *Cymbella* sp. | + |
| *Diatoma vulgare var.capitulatum* Grunow | + |
| *Fragilaria ulna* (Nitzsch) Lange-Bertalot | + |
| *Gyrosigma* sp. | + |
| *Melosira varians* Agardh | + |
| *Navicula* sp. | + |
| *Pinnularia microstauron* (Ehrenberg) Cleve | + |
| **Class: Chlorophyceae** | |
| *Bulbochaete* sp. Agardh | + |
| *Coelosphaerium kützingianum* Naegeli | + |
| *Oedogonium* sp. Link | + |
| *Scenedesmus quadricauda* (Turpin) Brébisson | + |
| **Class: Conjugatophyceae** | |
| *Closterium* sp. | + |
| *Closterium acerosum* (Schrank) Ehrenberg ex Ralfs | + |
| *Closterium angustatum* Kützing | + |
| *Cosmarium botrytus* Menegh ex Ralfs | + |
| *Cosmarium cymatopleurum* Nordst | + |
| *Cosmarium granatum* Brébisson | + |
| *Cosmarium humile* (Gay) Nordst | + |
| *Cosmarium laeve* Rabenhorst | + |
| *Cosmarium naegelianum* Brébisson | + |
| *Cosmarium punctulatum* Brébisson | + |
| *Cosmarium subprotumidum* Nordst | + |
| *Cosmarium tumens* Nordst | + |
| *Docidium baccatum* Brébisson | + |
| *Penium margaritaceum* (Ehrenberg) Brébisson | + |
| *Spirogyra* sp. | + |
| *Staurastrum muticum* Brébisson | + |
| *Zygnema* sp. | + |

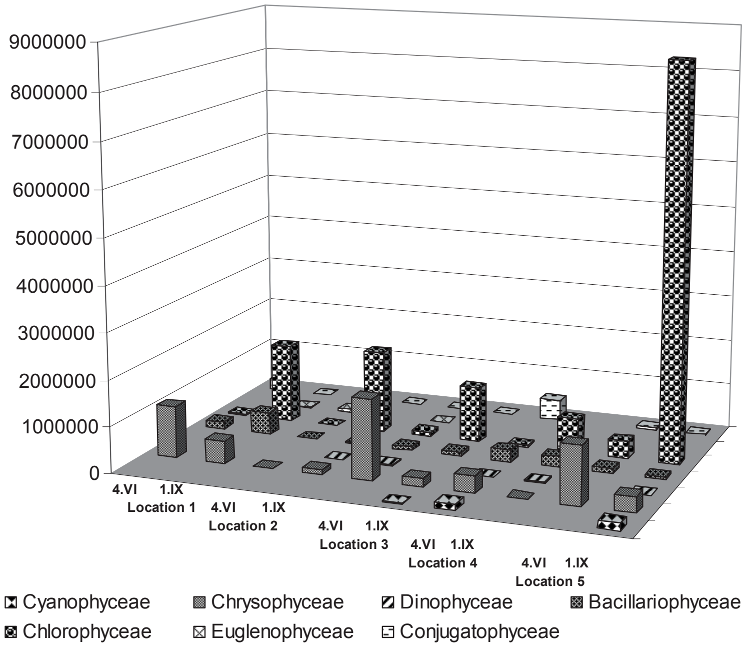


Fig. 3. Phytoplankton population density.

Species abundance varied from 24 to 44 per sample. In comparison, the research of Boračko lake (Blagojevic et al., 1983; Hafner, Kapetanovic, 2003) recorded relatively low phytoplankton community diversity at 16 taxa. Boračko lake is a natural mountain lake in the Neretva river basin within the Adriatic basin as is Blidinje lake. A poor composition of phytoplankton was also found in the reservoir on the Neretva, with 21 taxa in Jablaničko lake and 27 taxa in both Grabovica and Salakovac lakes, (Hafner et al., 1986).

The dominance of the *Dinobryon divergens* I m h o f taxa class Chrysophyceae with $1.128x10^6$ cells $L^{-1}$ (72.49%) was established at the first location on June 4th, while Conjugatophyceae comprised 15.55% ( the best represented taxon *Closterium* sp. had $1.8x10^6$ cells $L^{-1}$) and Bacillariophyceae 10.28% of population density. Maximum population abundance at this location was established on September 1st with $2.541x10^6$ cells $L^{-1}$. *Dinobryon divergens* I m h o f (Chrysophyceae) was present with $4.86x10^5$ cells $L^{-1}$ (18%), *Melosira varians* C. A g a r d h (Bacillariophyceae) with $2.64x10^5$ cells $L^{-1\ (6.3}$%) and the most abundant was *Didymocystis inermis* (F o t t) F o t t *(Chlorophyceae)* with *1.68* $10^5$ cells $L^{-1}$ ( 66.1%).

*D. inermis* (Fo t t ) Fo t t was detected for the very first time in Bosnia and Hercegovina, and the occurrence of these taxa is highlighted in Fig. 4.

Maximum phytoplankton abundance at the second location was determined on the 1st of September at $1.92x10^6$ cells $L^{-1.}$ Similar to the first location, this was dominated by *D. inermis* (Fo t t) F o t t (Chlorophyceae) with $1.784x10^6$ cells $L^{-1}$ (92.9%). The first sampling at this sta-

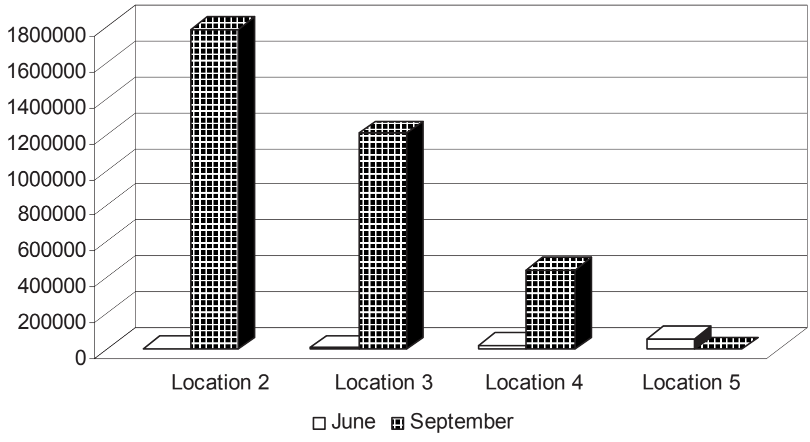


Fig. 4. The appearance of taxa *Didymocystis inermis* (Fott) Fott in Blidinje lake.

tion recorded the total number of cells at 1.08x$10^5$, which is only 5.63% of the number of cells established on September 1st. *Dinobryion divergens* I m h o f, *Cyclotella ocellata* P a n t o c s e k and *Didymocystis inermis* (F o t t) F o t t appeared in spring and autumn samplings.

Maximum phytoplankton abundance at the third location was determined on June 4th at 1.946x$10^6$ cells $L^{-1}$, with dominant taxa *Dinobryion divergens* I m h o f 1.754x$10^6$ cells $L^{-1}$ (90.1%). In September, *Didymocystis inermis* (F o t t) F o t t dominated with 1.206x$10^6$ cells $L^{-1}$ at 82.6% of the total 1.46x$10^6$ cells $L^{-1}$. These two species mentioned above, together with *Navicula* sp. (Bacillariophyceae) and *Cosmarium subprotumidum* N o r d s t (Conjugatophyceae), were also recorded in June and September sampling.

Maximum phytoplankton abundance at the fourth location was determined on June 4th 1.23x$10^6$ cells $L^{-1}$, 10.73% Cyanophyceae, 29.91% taxa *Dinobryion divergens* I m h o f (Chrysophyceae), with 19.34% Bacillariophyceae, 3.41% Chlorophyceae and 36.42% Conjugatophyceae. In addition, 9.4x$10^5$ cells $L^{-1}$ were determined on September 1st. *D. divergens* I m h o f (Chrisophyceae), *Peridinium* sp. (Dinophyta), *Diatoma vulgare* B o r y, *Gomphonema* sp., *Neidium dubium* (E h r e n b e r g) C l e v e, *Nitzschia* sp., *Fragilaria ulna* (N i t z s ch) L a n g e - B e r t a l o t (Bacillariophyceae), *Didymocystis inermis* (F o t t) F o t t and *Scenedesmus quadricauda* C h o d a t (Chlorophyceae) were all present in the June and September samplings.

Maximum phytoplankton abundance at the fifth location was recorded on September 1st at 9.134x$10^6$ cells $L^{-1}$, and this was the general maximum population density. At this location in June 1.6866x$10^6$ cells $L^{-1}$ were present, and these mostly comprised the *Dinobryion divergens* I m h o f taxa with 74.62%.

According to Welch (1980), the limiting factor for diatom growth is silica concentration of 0.5 mg $L^{-1}$. However, the silica In Blidinje lake is present in a quantity significantly lower than that necessary for the growth of some diatoms, such as *Asterionella formosa* H a s s a l l.

Phytoplankton population density analysis showed that Bacillariophyceae were present at each location in each sampling, but this group, however, did not dominate quantitatively..

Desmidiales are considered to be environmentally very sensitive organisms that inhabit poorly productive oligo-mesotrophic waters, and their optimum habitat conditions are in places with lower concentrations of hydrogen ions. The richest communities are found in low conductivity and alkalinity areas, where there are spatial and temporal variations (Coesel, 1983). Although Conjugatophyceae are qualitatively very well represented in Blidinje at 47%, with17 species, the quantity accounted for only a small percentage, perhaps due to low conductivity and the slight alkalinity of 8.05 to 8.62 registered there.

*Biological analysis of water*

From 57 detected species of phytoplankton in Blidinje lake, 32 taxa were saprobity indicators, 14 were oligsaprobic indicators, 27 were oligo-beta-mesosaprobic, 6 beta-meso-saprobic, 1 beta-alfa-meso-saprobic and 2 alfa-meso-saprobic indicators.

From 37 detected species of phytobenthos in Blidinje lake, 22 taxa were saprobity indicators, 5 were oligo-saprobic indicators, 4 were oligo-beta-mesosaprobic, 10 beta-meso-saprobic, 1 beta-alfa-meso-saprobic, 1 alfa-meso-saprobic and 1 poly-saprobic.

T a b l e 4. Assessment of water quality effect on phytoplankton species.

| Parametre Sampling | Location 1 | | Location 2 | | Location 3 | | Location 4 | | Location 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jun 4th | Sep 1st | Jun 4th | Sep 1st | Jun 4th | Sep 1st | Jun 4th | Sep 1st | Jun 4th | Sep 1st |
| No. taxa indicators saprobity | 17 | 12 | 5 | 6 | 10 | 11 | 16 | 16 | 9 | 10 |
| Index saprobity | 1.75 | 1.77 | 1.8 | 1.85 | 1.74 | 1.93 | 1.75 | 2 | 2 | 2.38 |
| Saprobity degree | o–β | o–β | o–β | β | o–β | β | o–β | β | β | β–α |
| Bonitet class | I–II | I–II | I–II | II | I–II | II | I–II | II | II | II–III |

Notes: o–β – oligo-beta-saprobic, β – beta-mesosaprobic, β–α – beta-alfamesosaprobic

The saprobity index was 1.74 to 2.38, with an average of 1.897, corresponding to the beta-mesosaprobic degree or II bonitet class (Table 4). The highest saprobity index was recorded at location number. 5 in September and this was 2.38, corresponding to II–III bonitet class, while the lowest saprobity index was 1.74 at location number 3 in June, with I–II class capability.

*Margalef's species richness index*

Margalef's species richness index is presented in Table 5. Highest Margalef's species richness index was recorded at the fourth location in September at 2.85, while the lowest was at a different location also in September at 0.95.

T a b l e 5. Margalef's species richness index.

| Date of sampling | Loc 1 | Loc 2 | Loc 3 | Loc 4 | Loc 5 |
|---|---|---|---|---|---|
| June 4$^{th}$ | 1.13 | 1.17 | 1.75 | 2.79 | 1.77 |
| September 1$^{st}$ | 2.50 | 0.95 | 1.95 | 2.85 | 1.76 |

*The similarity index of Jaccard (JI)*

The similarity index of Jaccard (JI) is presented in Table 6, and it recorded the relatively low range of 0.111–0.444 between different locations.

The differences in plankton flora at different lake locations may be explained, at least in part, by wind and other abiotic factors influence, plus the origin and dynamics of the lake's water.

T a b l e 6. The similarity index of Jaccard (JI) between different locations (on June 4$^{th}$ – upper triangle and on September 1$^{st}$ – lower triangle).

| | Loc 1 | Loc 2 | Loc 3 | Loc 4 | Loc 5 |
|---|---|---|---|---|---|
| Loc 1 | ------- | 0.444 | 0.267 | 0.182 | 0.111 |
| Loc 2 | 0.200 | ------ | 0.133 | 0.150 | 0.214 |
| Loc 3 | 0.208 | 0.176 | ------- | 0.200 | 0.210 |
| Loc 4 | 0.129 | 0.316 | 0.192 | -------- | 0.304 |
| Loc 5 | 0.185 | 0.222 | 0.217 | 0.138 | -------- |

## Conclusion

The saprobity index average of 1.897 corresponds to the beta-meso-saprobic degree or II bonitet class.

The eutrophication process in some zones of Blidinje lake reached a mesotrophic level, as recognized at location 5 in September 2008. Since the trophic status of the lake had not been previously examined, it is not certainly established whether this eutrophication is an ongoing trend, or just a temporary excess phenomenon. This, therefore, must be seriously considered whenever further action is planned for Blidinje lake.

It was exciting and rewarding to report that the *Didymocystis inermis* (F o t t) F o t t taxa was detected for the first time in Bosnia and Hercegovina.

Although further phytoplankton studies are required to increase prediction accuracy, the data presented herein establishes the baseline information essential for the long-term evaluation of the karstic environs of the Blidinje Nature Park.

*Translated by the authors*
*English corrected by R. Marshall*

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