Biological Water Quality of Lake Shkodra Based on the Diatoms and cyanobacteria Bioindicator Species

Marash Rakaj
Department of Biology-Chemistry, University of Shkodra "Luigj Gurakuqi"
Sheshi 2 Prilli, Shkoder, Albania

ABSTRACT

Diatom species have a narrow optima and tolerances for many environmental variances, which make them exceptionally useful in quantifying environmental characteristics to a high degree of certainty. Regarding to the trophy valences of the bioindicator species of the Lake Shkodra diatoms, the highest number of them belong to oligo-mesotrophic and tolerant groups, which show a good situation of lake for life.
Cyanobacteria are distributed in rich organic waters, wetlands and soils. In some shallower localities of the southern part of the Lake Shkodra, some large forms and water blooms filamentous of the cynobacteria species (Merismopedia, Microcystis, Oscillatoria) during summer were observed, but unpleasant odor or the harmful substances of Cyanobacteria during our investigation were not evidenced.
During last six years a list of Microalgae of Lake Shkodra was compiled, which included 214 genera with 1069 taxa, 98 of which belong to Cyanophyta/Cyanobacteria and 421 to Bacillariophyta.
In this paper phytoplankton diversity and biological water quality based on the bioindicator species of the Cyanobacteria and Diatoms for the Lake Shkodra is given.

Keywords: *Phytoplankton, diatoms, cyanobacteria, Lake Shkodra, bioindicator, trophy valences, water blooms.*

Introduction

Lake Shkodra is situated transboundary between Montenegro and Albania. The Lake is large, shallow (mean depth: 5.1m), with high oscillations of lake water level (4.4-9.8m), slightly alkaline, with the average temperature 14.9˚ C.
Diatoms are single-celled microscopic algae (*Bacillariophyta*) commonly distributed in different water ecosystems: oceans, lakes, rivers, wetlands and even soils. Diatoms species, both phytoplankton and periphyton communities have a narrow optima and tolerances for many environmental variances, which make them exceptionally useful in quantifying environmental characteristics to a high degree of certainty. Diatoms respond quickly to environmental change because they immigrate and replicate rapidly. Also, changes in diatom assemblages correspond closely to shifts in other biotic communities, such as other algae, zooplankton, aquatic macrophytes and fishes. This away, diatoms can be used as indicators of biological conditions and to accurately inter a variety of water chemistry and other limnological characteristics, including lake acidification, lake eutrophication and climatic change.
Cyanobacteria are colonial and filamentous photosynthetic organisms, distributed in rich organic waters, wetlands and soils. In the special conditions, such increased temperatures, summer stagnation and in rich organic waters, some large forms of cyanobacteria (*Merismopedia, Microcystis*) development quickly and may appear water – blooms or red – tides, sometimes with an unpleasant odour. Also, cyanobacteria could produce the harmful substances for zooplankton, molluscs, fishes and other aquatic organisms, as neurotoxic alkaloids (*Anabaena, Aphanizomenon* etc.) or hepatotoxic peptides (*Microcystis, Nodularia* etc.).
During last decades were published several data on the phytoplankton species composition, horizontal and vertical distribution and seasonal changes togather with some evaluation of the Lake Shkodra water quality (RAKAJ, HINDAK & HINDAKOVA 2000; RAKOCEVIC & RAKAJ 2001; RAKAJ, MIHO & KASHTA 2002; RAKOCEIC-NEDOVIC & HOLLERT 2005; RAKAJ 2002, 2008). Also a checklist of phytoplanbkton taxa of Lake Shkodra was compiled (RAKAJ, ALUSHI & DHORA 2007), included 214 genus with 1069 species and intraspecific taxa. The most of the taxa belong to two groups: 1. Archeoplastida with 478 taxa, composed by green algae (Chlorophyta 237, Charophyta 241) and 2. Chromalveolata with 476, mainly composed by diatoms (Bacillariophyta 421), while Cyanophyta/Cyanobacteria 98 taxa.

Methodology Applied

The phytoplankton was sampled during spring – autumn 2009, monthly from 4 different stations: **1 – Zogaj, 2 – Kamica,** round 400m far from lakeside, **3 – Open water** dhe **4 – Shegan** (Figure 1). During sampling water temperature, pH, transparency and disolved oxygen were measeured (Table 1). Phytoplankton bottles and scrached samples were preserved with 4% formaldehyde or with 1% Lugol solution. Determination of species were performed with an optic microscope Leitz-Diaplan with immersion objective 63/1.4 Plan-APO

and inverse universal microscope. Taxa determination was made according to KOMAREK & ANAGNOSTIDIS (1999), KRAMMER & LANGE-BERTALOT (1986-1991a). The density was counted seasonally according to UTERMOHL (1958), while biological evaluation quality of water quality was done according to PANTLE & BUCK (1955), SLADECEK (1973), ROTT (1999).
Density was evaluated with 3 scales: 1 – rare, 3 – medium, 5 – high.
The lake water classification was done according to values of the parameters: diversity indices (MENHINICK 1964), pollution indices (BECK 1954), saprobic indices (PANTLE & BUCK 1955; SLADECEK. 1973) and index of relative purity (KNÖP 1954).

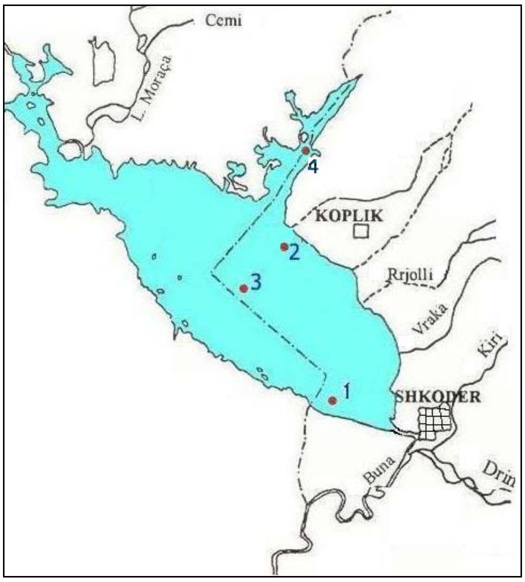

Figure 1. Sampling points of Lake Shkodra

Results Obtained

1.Cyanobacteria as bioindicator
Development of Cyanobacteria began with warming water, stable limnological conditions and increased quantity of the organic material at the time. The abundance peak of cyanobacteria occurred in summer.
The water – blooms or red – tides were not observed, but water-blooms species and genera with potential toxin-producing species of cyanobacteria such as: *Microcystis aeruginosa, M. wesenbergii, Plantolyngbbya limnetica, P. circumcreta, Nostoc coeruleum, Anabaena flos-aquae* (rarely), *Oscillatoria limosa* and *Aphanizomenon flos-aquae* near the inhabited villages (Zogaj, Kamice) were commonly found. The development of these cyanobacteria prevents all forms of aquaculture, apart from direct exploitation of the phytoplankton and zooplankton.

2. Diversity indices
About 72 genera with 340 species and infraspecific taxa of phytoplankton composed mostly by diatoms (*Bacillariophyceae* 296) and less cyanobacterial species (*Cyanophyceae* 44) were recorded.
High diversity, quantitatively dominated by diatoms composed by 24 taxa (8.1 %) centric diatoms (*Coscinodiscales*) and 272 (91.8 %) taxa pennates diatoms (*Naviculales*) was observed.
Among the diatoms, the Naviculales have the largest number of genera and species: *Navicula* with 67, *Nitzschia* 26, *Cymbella* with 21, *Fragillaria* 17, *Gomphonema* 19, *Acnanthes* 12 species etc.
The most occurring species were *Cyclotella ocellata* and *Aulacoseira ambigua*, *Asterionella formosa, Cyclotella distinguenda, Fragillaria ulna, F. capucina, F. elliptica, Diatoma ehrenbergii, Cymbella caespitosa, C. microcephala, Gomphonema angustatum, G. truncatum, Navicula scutelloides, N. radiosa* and *Nitzschia recta*, *Merismopedia glauca, Microcystis aeruginosa, Planktolyngbya limnetica, Radicystis aphanothecoides* and *Oscillatoria limosa*.
Diatoms assemblages of Lake were not uniform in horizontal distribution. Species composition differs in different sampling stations. More species were found in Zogaj and less in Shegan. Average cell number for liter water during Maj - Shtator at different stations rate from 1020 in Shegan (st. 4) to 92000 in Kamica (st. 2), while diversity indices rate from 0.42 to 1.20 (Table 2).
In the wintertime the hydrological and meteorological regimes are unstable and the diatoms and cyanobacteria were rather poorly developed. Species density was low (850 – 3700 ind/l).

Table 1. The average values of the physico-chemical parameters

Stations	Temperture (ºC)	pH	DO (mg/l)
1	20.7-26.8	8.1	8.0
2	20.3-26.3	7.6	7.5
3	19-26.2	7.8	8.3
4	10.1- 11.6	7.2	10.6

Table 2. Diversity indices of analized diatoms

Stations	Number of species	Density (Cell/l)	Diversity indices
1	246	54000	1.16
2	220	92000	0.82
3	236	46000	1.20
4	18	1020	0.42

In spring, with the approach of more stable water conditions, decreasing of the lake level and increasing of water temperature, the number of species and density of diatoms increased. The peaks of diatoms in abundance usually occurred in the early spring and fall.
The geochemichal preferences for majority of diatoms (96 species) found are cosmopolitan and alkalophilic, which corresponds well with the physical and chemical conditions for lake (pH 7.4 – 8.5, alkalinity:1.5 – 4.2 mval/l etc.)

3. Pollution indices

Data about the valences of 148 indicator species were performed according to ROTT (1999). The values of pollution indices rated from 6 to 8 for the three first stations, which indicate that water of lake are slightly polluted by organic matters especially the littoral waters (st. 1 and 2), while value of pollution indices 4 at Shegan (st. 4) indicates that water is not polluted (Table 3).

Table 3. Trophic valences of the indicator species

Trophic valences	Ot	Ot-βmt	Ot-αmt	Amt-eu	Tol	Eu	Sap	Pollution indices
Station: 1	4	7	6	23	20	25	2	7
2	6	9	8	28	32	36	3	8
3	3	6	5	21	25	20	2	6
4	2	2	1	1	5	0	1	4

The most of analized diatoms belonged to oligo-mesotrophic and tolerant groups (round 110 species): *Cyclotella ocellata, Asterionella formosa, Fragillaria capucina* etc., but also a high number of benthic species of the eutrophic group (36 species) were found in the littoral zone (st. 2 Kamica): *Fragillaria ulna, F. construens, Gymphonema acuminata*, *Navicula capitatoradiata, N. reichardtiana, N. trivialis, N. cryptotenella, N. menisculus, Nitzschia recta, Cocconeis placentula* etc.
We have found more euplanktonic taxa from the open water then in stations with development aquatic macrophytes (Kamica) or in station of karstic spring (Shegan). The east and north-east sides of Lake are characterized by much developed aquatic macrophytes, namely species of the genera *Nymphea, Nuphar, Najas, Potamogeton, Valisneria, Trapa, Myriophyllum, Scirpus* and *Phragmites*, which are preferred substrates for epiphytes. The most of the pennate diatoms which belong to epiphytic species: *Gomphonema, Acnanthes, Cymbella, Navicula* and *Fragillaria* (round 180 species) were found on aquatic macrophytes and in detritial base.

4. Saprobic indices

Data about saprobity classes, saprobic valences and saprobic indices of the 148 indicator diatom species for different stations (Table 4) are calculated according to STREBLE & KRAUTER (2002).

Table 4. Saprobity Classes of the lake waters

Sabrobity Classes	I	I-II	II	II-III	III	III-IV	IV
Saprobic Valences	Os	Os/β-ms	β-ms	β-ms/α-ms	α-ms	α-ms/psb	psb
DO (mg/l)	>6	>5	>4	>3	>2	>1	>0.1
Saprobic indices	1-1.5	1.5-1.8	1.8-2.3	2.3-2.7	2.7-3.2	3.2-3.5	3.5-4.0

Average values of saprobic indices of three first stations rated from 2.02 to 2.38 (Kamica), which corresponded to β-mezosaprobic to β-mezo/α-mezosaprobic level or to Second Class (II^{nd}– III^{d}) of the water quality, while value 1.4 in Shegan (st.4) corresponds to oligosaprobic level or to First Class of water quality.

5. Index of the relative purity

The relative purity was performed according of KNÖP (1954) taking in consideration indicator species that influence only in a class of saprobity (Table 5). The values of relative purity rated from 0.75 to 0.85 which mean that lake waters are moderately polluted by organic matters.

Table 5. Values of the Indexes of relative purity

Stations	Index of relative purity (I)
1	0.76
2	0.75
3	0.78
4	0.85

High diversity of diatoms and low abundance dominated namely by oligo-mesotrophic group taxa, in general showing a good situation of Shkodra Lake water and conditions for life, and it may be perfect for fish breeding. But, the presence of some large forms of the eutrophic diatoms and water bloom filamentous species with potential toxin-producing of cyanobacteria during the summer, especially in littoral part of lake showed a high level of the organic matters, due to discharged directly to lake of a part of the urban and wastewaters from Shkodra city and some villages round it. The treatment of urban and wastewaters, strong measures to restore and protect the whole watershed, supporting reforestation activities and permanent monitoring would be applied.

Concusions

1. The values of diversity indices and Trophic valences indicate that of the Lake Shkodra waters belong to Second Classes of the water quality or mesotrophic level.
2. Average values of the saprobity indices (1.45-2.36) and relative purity (0.75 – 0.85) calculated for dissolved and indicator species indicate that waters of Lake Shkodra belong to β-mezosaprobic level, which mean that waters are moderately polluted by organic matters
3. Differences of the values for some parameters at different stations indicate heterogeneity of Lake Ecosystem.
4. High values for some parameters and presence of some species with high trophic and saprobic valences indicate human influence on this ecosystem.
5. A detailed insight and an effective permanent monitoring will be necessary.

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