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SEASONAL VARIATION OF CHLOROPHYLL PHYTOPLANKTON IN RELATION TO TROPHIC STATUS OF SHKODRA LAKE

Përmbledhje: Liqeni i Shkodrës është liqeni më i madh i Gadishullit Ballkanik. Ndodhet në pjesën veri-perëndimore të Shqipërisë dhe përfaqëson një nga ekosistemet më të rëndësishëm. Monitorimi i Liqenit të Shkodrës gjatë një viti, nga muaji prill deri në tetor, u realizua për herë të parë në vitin 2009. Sasia e klorofili a e fitoplanktonit, shpërndarja e pigmenteve fotosintetikë, turbullira dhe sasia e fosfateve në ujë u përdoren si bio-indikatorë për të vlerësuar gjendjen trofike. Stacionet e përzgjedhura të Liqenit të Shkodrës mund të karakterizohen nga gjendje të ndryshme trofike, bazuar në kriteret Hakanson dhe Carlson. U vëzhguan variacione stinore të gjendjes trofike të stacioneve të perzgjedhura, nga oligotrofike në mezotrofike. Diferencat e vëzhguara mund të shpjegohen me ndotjen pranë zonave urbane, veanërisht gjatë verës.

Fjalë kyçe: *Klorofili a, sasia e fosfateve, pigmented fotosintetikë, fitoplanktoni, indeksi i gjendjes trofike*

Abstract: Shkodra Lake is the largest lake on the Balkan Peninsula. It is situated in the north-western part of Albania and represents one of the most important ecosystems. Monitoring of Shkodra Lake during a year from April to October was realized for the first time on 2009. Phytoplankton chlorophyll a content, photosynthetic pigment distribution, turbidity and phosphate content in water were applied as bio-indicators to evaluate the trophic status. Selected stations of Shkodra Lake can be characterized by different trophic status based on Hakanson and Carlson criteria. Seasonal variation of trophic state of the selected stations from oligotrophic to mesotrophic was observed. The observed differences can be explain by the pollution near the urban areas particularly during the summer.

Key words: *Chlorophyll a, phosphate content, photosynthetic pigments, phytoplankton, trophic state index*

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INTRODUCTION

Chlorophyll *a,* total phosphorus, total nitrogen and water clarity can be used as indicators to measure „biological productivity" of a water body or capacity to support life (Carlson, 1977; Hakanson *et al.*, 2007). Monitoring of the water bodies based in these four indices allow to classify their trophic status. Necessity for the development of a complex system of organic and inorganic indicators for a more complete study and monitoring of the dynamics of trophic state of the lagoons is emphasized by the Fourth European Conference of Environmental Ministers, Aarhus (July 1998, Denmark), technical Reports of European Agency of Environment and European Council and numerous projects. The indicator system is useful to create a clear view on the situation of the lake.

Trophic status is classified by four levels, from the lower to the higher level of the biological productivity: *Oligotrophic* (clear and blue water, very low levels of nutrients and algae), *Mesotrophic* (slightly green water, still clear, moderate levels of nutrients and algae), *Eutrophic* (green and murky water, higher amounts of nutrients and algae) and *Hypertrophic* (supersaturated in phosphorus and nitrogen, excessive phytoplankton growth, poor water clarity). Eutrofication is as a result of reduction of fresh water, inorganic and organic pollution, anthropogenic factors and erosion. The algae cells in water bodies are most easily determined by measuring the chlorophyll content of phytoplankton in the water. Chlorophylls are green pigments that capture the energy of sunlight and transfer it to the other molecules to realize photosynthesis. Chlorophyll *a* is the main member of the chlorophyll family (chlorophylls *a, b, c*) and its concentration is considered an expression of phytoplankton biomass. Chlorophyll *a* is a good indicator of the total quantity of algae in a lake. Large amounts of algae can decrease the clarity of the water, alter the colour of the water (making it greener), form surface scum, reduce dissolved oxygen, alter the pH of the water, produce unpleasant tastes and smells. As a primary nutrient responsible for algae growth, phosphorus content allows to characterize water bodies according to their trophic status too. It is established a direct relationship between phosphorus concentrations, chlorophyll *a*, and clarity; as phosphorus drives algal growth.

Therefore, chlorophyll allows to classify water bodies according to their trophic status as oligotrophic (< 2.5 mg/m^3), mesotrophic (2.5–8 mg/m^3), eutrophic (8–25 mg/m^3) and hypereutrophic (> 25 mg/m^3). as oligotrophic (Phosphorus content < 10 mg/m^3), mesotrophic (10–30 mg/m^3), eutrophic (30–100 mg/m^3) and hypereutrophic (> 100 mg/m^3) (Carlson & Simpson; 1996; Hakanson *et al*., 2007).

The aim of the presented work was to monitor and to evaluate the trophic status of the water bodies of Shkodra Lake (Albanian part).

MATERIAL AND METHODS

Shkodra Lake is the largest lake on the Balkan Peninsula in terms of water surface. It is situated in the north-western part of Albania. This lake represents one of the most important ecosystems in Albania. The monitoring is carried out every month from April to October during the year 2009. Four selected stations in the lake

were chosen to represent areas characterized by different possible urban pollution. Coordinates of the stations were – GPS: Station 1 – N 42° 03' 31.6", E 019° 28' 40.0"; Station 2 – N 42° 03' 53.8", E 19° 27' 49.8"; Station 3 – N 42° 04' 07.8", E 019° 25' 48.2"; Station 4 – N 42° 04' 32.7"; E 019° 23' 87.8"

Content of chlorophyll *a*, b, and *c* was determined according to the acetone trichromatic methods using the equations based on the absorption maxima for each component respectively (with coefficients of Jeffrey & Humphrey). Pheophytin *a* is determined by the acidification based on the Lorenzen method. All absorbance values are corrected taking in consideration the turbidity of acetone extracts (Jeffrey & Humphrey, 1975; Lorenzen, 1967; Ston & Kosakowska, 2000).

Phosphor content in water is determined spectrophotometrically using the appropriate kit. Turbidity is determined by measuring water transmittance.

RESULTS AND DISCUSSION

The temperature of the lake is increased from 17°C on April up to 28–30°C on July which represented the highest values during the monitoring period. Then, the temperature is decreased up to 20°C on October. It can be observed that the variation of temperature is the same for all stations (Fig. 1).

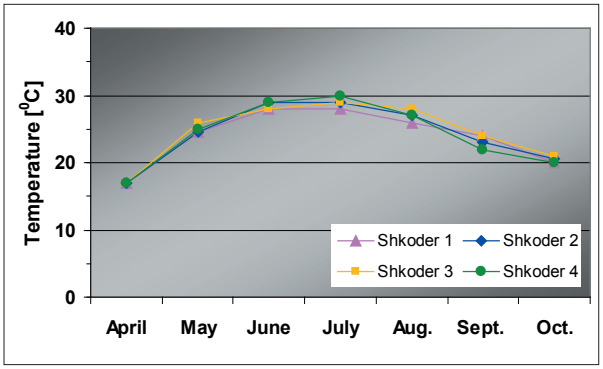

Fig. 1. Water temperature of Shkodra Lake during the monitoring period.

Shkodra Lake can be characterized by high water temperatures. The water pH varied from 6.5 to 8 indicating that the lake could support a well-balanced fish population (Carlson & Simpson, 1996).

Dynamics of Chl *a* content of the selected stations represented almost the same variation from April to October. The Chl content is increased from April to July demonstrating the highest values on this month. After that, the Chl content is decreased on August and then demonstrated a slight increase on October (Fig. 2, Table 1). This variation of Chl content can be explained by the higher pollution especially during summer as the tourist season. Chl content of one of the station (St. 2) of the lake represented lower values than the others. This station was selected in an ar-

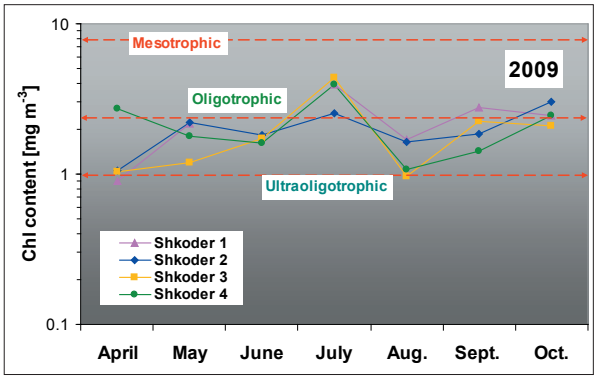

Fig. 2. Dynamics of chlorophyll a content in Shkodra Lake.

ea considered with less urban effect than the other selected stations. Comparison the Chl content variation and temperature variation of water during the monitoring period of the lake showed that the highest values of Chl content is observed when the temperature arrived the highest values too.

Based on the trophic status classification (Carlson, 1977; Carlson & Simpson, 1996; Hakanson *et al.*, 2007), selected stations can be characterized by a low mesotrophic status on July (Station 1, 3 and 4) and on October (station 2) whereas on the other months all stations can be characterized by an oligotrophic status (Fig. 1, Table 1)

Table 1. Trophic status via phytoplankton Chl content of Shkodra Lake

2009	Trophic index: Chl a (mg /m3)			
	Shkoder 1	Shkoder 2	Shkoder 3	Shkoder 4
April	0.904	1.061	1.040	2.719
May	2.178	2.219	1.199	1.786
June	1.790	1.805	1.733	1.621
July	3.911	2.555	4.340	3.924
Aug.	1.705	1.645	0.973	1.082
Sept.	2.759	1.843	2.238	1.428
Oct.	2.438	3.007	2.102	2.464

Taking in consideration the mean values of Chl content of the selected stations over the period of monitoring, all stations can be characterized by the same trophic status – oligotrophic one (Table 2).

The calculated Chl trophic state index (Carlson, 1977; Carlson & Simpson, 1996) represented values from 40 to 50 on July that characterize a mesotrophic class by water moderately clear with an increasing probability of anoxia in hypolimnion during summer and an increase presence of iron and manganese. The values of this index on the other months during the monitoring period from 30 to 40 demonstrate that lake still exhibit oligotrophy by clear water, but could become anoxic in the hy-

Table 2. Trophic status via phytoplankton Chl content of Shkodra Lake, mean values during monitoring period

	Trophic index: Chl a (mg m–3)	2009	Mean	Trophic status
Shkodra Lake	Station 1	2.32	2.10	Oligotrophic
	Station 2	2.02		
	Station 3	1.95		
	Station 4	2.15		

polimnion during the summer (Table 3). Mean values of Chl trophic state index of the selected stations during the period of monitoring (respectively 37.70, 37.04, 35.87 and 37.28 for stations 1–4) can be characterized the same trophic status – oligotrophy with possible anoxy.

Table 3. Trophic status via Chl trophic status index of Shkodra Lake

2009	Chlorophyll TSI (TSIC)			
	Shkoder 1	Shkoder 2	Shkoder 3	Shkoder 4
April	29.6	31.2	31.0	40.4
May	38.2	38.4	32.4	36.3
June	36.3	36.4	36.0	35.3
July	44.0	39.8	45.0	44.0
Aug.	35.8	35.5	30.3	31.4
Sept.	40.6	36.6	38.5	34.1
Oct.	39.3	41.4	37.9	39.4

The distribution of chlorophyll *a* and accessory pigments, Chl*b*, Chl*c* and carotenoids, as well as the relative chlorophylls content (ratio of Chl*a*/Chl*b*, Chl*a*/Chl*c* and Chl*a*/Carot) exhibited small differences through monitored stations (Table 4). These values demonstrate almost the same relative content of Cyanophyceae to other algae group indicating nearly no differences on trophic state in selected station as was evaluated by chlorophyll trophic indexes too (Table 2) (Schlüter *et al*., 2000).

Table 4. Relative content of pigments of Shkodra Lake, mean values during monitoring period

Lake 2009	Chla/Chlb	Chla/Chlc	Chlb/Chlc	Chla/Carot
Station 1	7.96	4.34	0.60	1.06
Station 2	8.99	4.53	0.54	1.04
Station 3	6.67	2.71	0.47	0.80
Station 4	9.37	4.84	0.59	1.05

The values of pigment ratio chlorophyll a to pheophytin a as a bio-indicator to characterize the physiological status of the phytoplankton exhibited an active state

as these ratio represented the values higher than 3 in all stations of the lake (mean values of 11.08, 8.36, 21.37 and 22.86 respectively for stations 1–4).

Phosphorus content in the lake water exhibited an oligotrophic level (Table 5). The values of this trophic index of all stations represented almost the same variation from April to October.

Table 5. Total phosphorous content on the water of Shkodra Lake, mean values during monitoring period.

	Trophic index: Total phosphorus (mg/m3)	2009	Mean	Trophic status
Shkodra Lake	Station 1	3.21	3.26	Oligotrophic
	Station 2	3.29		
	Station 3	3.36		
	Station 4	3.17		

Turbidity, as a measure of water clarity or how cloudy the water is, demonstrated almost the same variation through selected station during monitoring period, represented highest values on July. It is observed clearer water of station 2 than others. The values of this index with a variation from 4 to 7 (mean values of 5.01, 4.91, 4.87 and 5.20 respectively for stations 1–4) indicated that Shkodra Lake can be characterized by clear water. Relationship between chlorophyll content of phytoplankton and turbidity of lake water can be express by a possible linear correlation (R=0.70)

CONCLUSIONS

1. Trophic state of Shkodra Lake, Albania part, was evaluated for the first time monitoring this water body during the year 2009 (April – October).

2. Based on the chlorophyll *a* content, the trophic state can be characterized by a low status evaluated as oligotrophic one, with a tendency to mesotrophic on summer.

3. Based on the determination of the phosphorous content Shkodra Lake can be characterized by an oligotrophy.

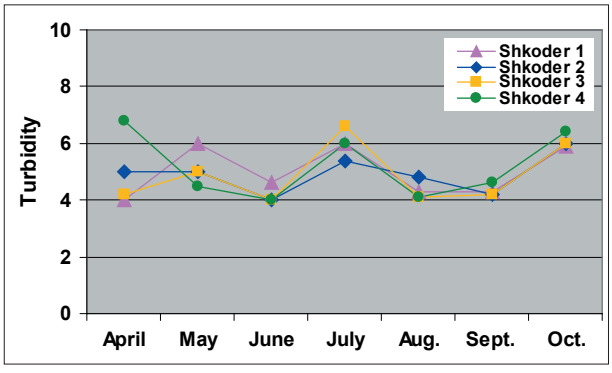

Fig. 3. Variation of water turbidity of Shkodra Lake, 2009.

4. Relative chlorophylls content exhibited nearly no differences through monitored stations, which demonstrate almost the same distribution of phytoplankton pigments indicating nearly no differences on trophic state in selected station as was evaluated by chlorophyll trophic indexes too.

5. Turbidity values also exhibited small differences through monitored stations showing higher values on July. A possible correlation between the chlorophyll *a* content and the water turbidity can be existed (R=0.70).

6. Chlorophyll content and turbidity demonstrated almost the same variation through selected station during monitoring period, exhibiting the highest values on July, when the temperature of water represented the highest values too. This variation of analyzed bio-indicators can be explained by the high pollution especially during summer as the tourist season. Lower trophic status of one of the station (St. 2 on July) of the lake can be related to the lower urban pollution of this area.

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