Adem BEKTESHI*

ECOLOGICAL SITUATION OF A CYPRINID SHKODRA LAKE BASED ON THE CHEMICAL INDICATORS OF WATER

Përmbledhje: Në këtë artikull paraqiten të dhëna për parametrat fiziko-kimikë të Liqenit të Shkodrës. Bazuar në rezultatet e analizave, Liqeni i Shkodrës klasifikohet si liqen tipik cyprinid. Jonet kryesore në ujërat e Liqenit të Shkodrës janë bikarbonatet, kalciumi dhe magneziumi. U vunë re ndryshime stinore dhe të veçanta të ujit të Liqenit të Shkodrës. Ndryshimet më të rëndësishme u vëzhguan në përqëndrimin e ushqyesve në bregun lindor dhe perëndimor të liqenit (pjesa Shqiptare). Nuk u vu re ndotje nga metalet e rënda. Uji i Liqenit të Shkodrës ka kapacitet kompleksformues, që është i krahasueshëm me ujërat e tjerë natyralë.

Fjalë kyçe: *Liqeni i Shkodrës, ushqyesit, metalet e rënda, kapacitet kompleksformues*

Abstract: In this article are given data on the physic-chemical parameters of Shkodra Lake. Based on the results of analyses Shkodra Lake is classified as typical cyprinid lake. Main ions on the water of Shkodra Lake are bicarbonate, calcium and magnesium. There were seen seasonal changes and special changes on the water of Shkodra Lake. The most important changes were concentration of nutrients in east and west shore of the lake (Albanian part). There were not seen any pollution attributed to heavy metals. Shkodra lake water has the complexing capacity that is comparable with other natural waters.

Key words: *Shkodra Lake, nutrients, heavy metals, complexing capacity*

INTRODUCTION

Shkodra Lake is located on the North – West of Albania (40° 10' N, 19° 15' E) on the Albanian Montenegro border. It is the largest of Balkan lakes, with surface area, which fluctuated seasonally from 370 to 600 km². Approximately one –third of the lake (142 km²) lies in Albania. Lake has one outlet Buna River and some inlets,

* Adem Bekteshi, Department of Biology-Chemistry, Faculty of Natural Sciences, University „Luigj Gurakuqi", Shkodra

the biggest of which is Moraca River (Annonymus, 1984; Karaman & Beeton, 1981). West shore of the lake is rocky and East shore is agricultural field.

Chemistry of the water of lake has an important role in the biological life. Shkodra Lake has a developed flora and fauna (Dhora, 2005; Dhora & Sokoli, 2000). Lake is very important for a lot of species that are endemic and threatened (Dhora, 2004; Dhora, 2003). In this context determination of the chemistry of the water is important as from the chemistry of water depends mostly the biological activity on the lake. A lot of studies are done for the chemistry of the water of Shkodra Lake (Karaman & Beeton, 1981; Bekteshi, 1997–2000, 2004, 2008; Bekteshi & Mijoviç, 2003) which determined the chemistry of lake as bicarbonate one. Main ions in Shkodra Lake water are bicarbonate with 45% of all ionic balance, calcium Ca^{2+} with 40%, magnesium Mg^{2+} with 8% etc.

This paper present a new study based on the previous study for Albanian part of Shkodra Lake and compares the results of the previous study with the recommendation of EC for fresh waters. The paper presents the changes of chemical parameters of water in season and in space. Pollution of water and sediments by heavy metals is shown with the capacity of water in complexing heavy metals.

MATERIALS AND METHODS

Lake and catchment area description

The main morphometric and hydrological variables of Shkodra lake area are presented on Table 1. From these variables Shkodra Lake can be considered as a shallow lake and field lake, even though Shkodra Lake gathers water for a relatively high altitude. Domination on the catchment area of carbonate rocks gives the characteristics of the water. On the basis of bathymetric values catchment area of Shkodra Lake on Albanian part can be divided into two basins, West and East basin.

West basin is short and rocky. Lake on this side is deeper. West side of lake is mostly used for fishing and as a recreation place for people coming from Shkodra

Table 1. Morphometric and hydrological variables of Shkodra Lake.

Lake area		370–600 km²
	Albania part	142 km²
Lake altitude		5,6 m a. s. l
Max length		45,2 km
Max width		26 km
Mean deep		7,8 m
Max deep		44 m
Catchment area		5179 km²
	Albanian part	1025 km²
Mean catchment altitude		770 m a. s. l
Shoreline length		207 km
	Albanian part	57 km.

city and villages near the lake. Actually, on this side of lake with beautiful places is growing the number of recreations centres, as the number of people going for fishing, bathing and water sports is growing every year.

East basin is agricultural field. It is longer and the lake has gradual deep. This part of lake is the most important and the most sensible one from biological point of view (Dhora & Sokoli, 2000; Dhora, 2005). Most of incoming waters (spring, underground and runoff waters) are on this part. Those waters are sending to the lake not only the materials that are coming from the bathymetry of catchment area, but also the products that are used of the farms on this side of the lake.

Sampling and methods

In order to consider the changes in the water parameters in both lake shores samples are gathered from surface waters in different points based on the methods describe in Keith, 1998 (Fig. 1).

Water samples were preserved in polythene bottles previously washed with hydrochloric acid 5% and rinsed out with abundant distilled water in the laboratory and abundant lake water immediately before collection. The bottles with samples of water were transferred in the laboratory and are stored in the refrigerator in 2–4°C and analyses were performed 24 hours after collection. On the field were measured pH and DO (WTW pH meter, WTW Oxi meter), and oxygen fixation was made immediately after the samples were arrived at laboratory for subsequent analyses (Winkler titration) (APHA, 1988; Filipini & Calabresi, 1995).

The methods reported in APHA, 1988; Filipini &

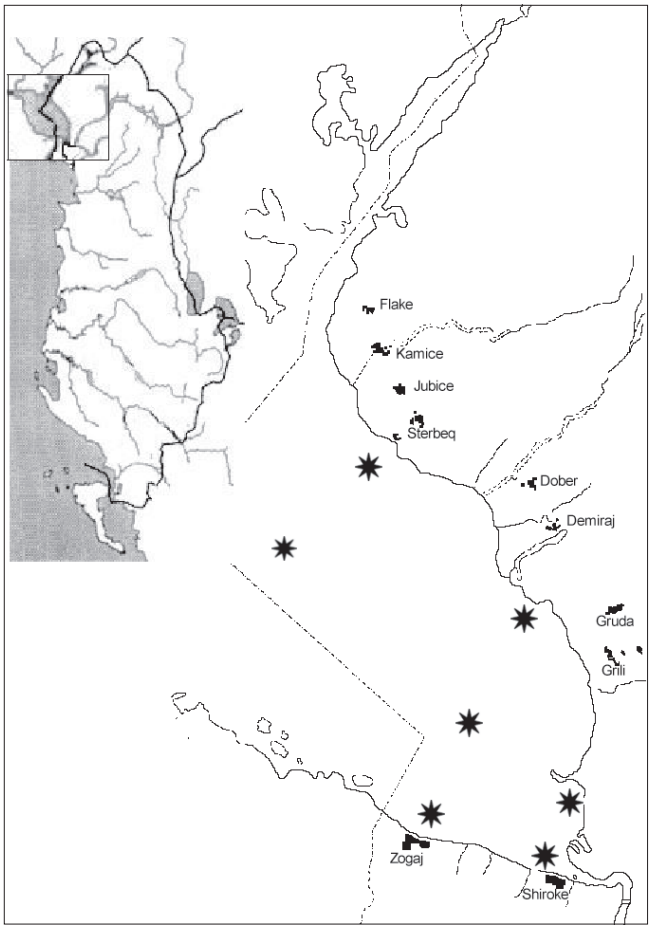


Figure 1. Sampling points on Shkodra Lake

Calabrezi 1995; Hunt &Wilson, 1990, Rodier, 1984) were used for chemical analyses. Alkalinity was determined by potentiometric titration, hardness by EDTA titration, conductivity (25°C) was measured by Conductivity meter. Nitrite, nitrate, phosphate, ammonium, and sulfate were determined by spectrophotometry (Perkin Elmer Lambda 1A). K^{+1} and Na^{+1} ion were measured with flame Atomic absorber NovaA400.

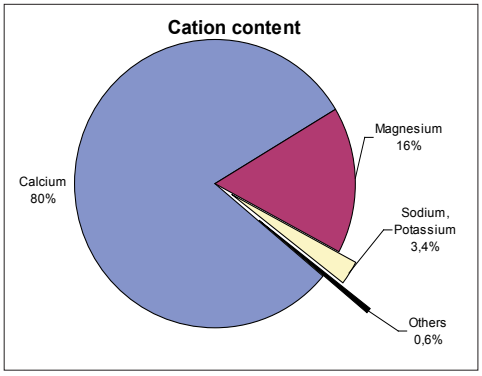
The analytical methods were checked and verified by comparison of the results from laboratories on Shkodra University with the other laboratories in Tirana University. All the results were elaborated, based on the literature (Miller & Miller, 1988).

RESULTS AND DISCUSSION

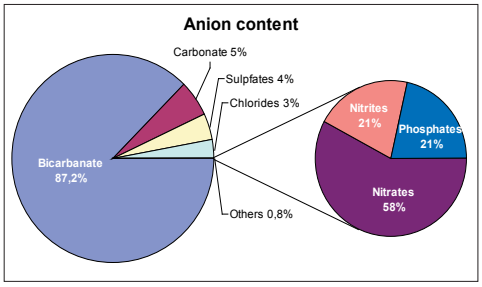
Physico-chemical parameters of water

The results of analyses of samples from Shkodra Lake are reported on Table 1.

Water of Shkodra Lake is slightly alkaline; the pH of the water varies from 7.4 to 8.6. Alkaline water of Shkodra Lake contains mostly bicarbonates and is well buffered. The values of conductivity (224.4 μScm^{-1}) and dry residue (193 mg l^{-1}) told that water of Shkodra Lake was slightly mineralized the content of ions in water were low.



a



b

Figure 2. Cations (a) and Anions (b), water contents of Shkodra Lake.

The content of DO in water varied from 7.4 to 13.7 mg O_2 l^{-1} with a mean value 10.5 mg O_2 l^{-1}. Oxygen saturation varied from 85% to 110%. These values told that the lake had a developed biological live. The alkalinity of water varied from 2.16 to 3.2 meq l^{-1} with mean value 2.46 meq l^{-1} and was mainly bicarbonate alkalinity (only in some occasions it was observed alkalinity due to carbonate). The content of organic matter soluble in water expressed as permanganate consumption was 12–30.5 mg $O_2 l^{-1}$, with a mean value 20 mg $O_2 l^{-1}$. The results show that organic matter on water was all the time higher in shore zone compare to open waters.

The concentrations of the nutrients in the lake were used to determine the trophic state of the lake. The mean concentration of nitrate was 1.4 μeq NO_3-N l^{-1}, nitrite 0.5, ammonium 1.8 μeq l^{-1} and the mean concentration for phosphate was 0.54 μeq PO_4^{3-}-P l^{-1}. The mean concentration of the sulphates was 0.12 meq SO_4^{2-} l^{-1}. The concentration of cations

shown the prevalence of Ca^{++} followed by $Mg^{++,}$ Na^{+} and K^{+}. The main anion on the lake was bicarbonate followed by chlorides, sulphates and then others. On the water of Shkodra Lake main ion was bicarbonate (43% of the total ions in equivalents), calcium (42%), magnesium (8%), sulphates (2%) and other ions 5% in total (Fig. 2).

Table 2. The values of the parameters determined

Parameter		Mean (SD)	Min value	Max value
Temperature	°C	16.7 (7)	6.2	30.4
PH		7.9(0.3)	7.3	8.5
Conductivity	µS/cm	254(25)	190	305
Alkalinity	meql–1	2.46(0.8)	2.16	3.2
Total hardness	mg CaCO 3/l	147(6,6)	134	162
DO	mg O 2/l	10.5(2.5)	7.4	13.7
Dry residue	mg/l	193(14)	165	220
KMnO 4 consumption	mg/l	20(6.7)	12	30.5
Calcium	meql–1	2.45(0.15)	2.23	2.63
Magnesium	meql–1	0.51(0.15)	0.43	0.63
Chloride	meql–1	0.09(0.014)	0.06	0.12
Sulphate	meql–1	0.119(0.014)	0.09	0.14
Ammonium	µeql–1	1.85(0.6)	0.5	2.5
Nitrite	µeql–1	0.5(0.3)	0.22	1.3
Nitrate	µeql–1	1.4(0.3)	0.8	1.9
Phosphate	µeql–1	0.54(0.4)	0.09	1.32

Variation of the chemical parameters in time and in both sides of the lake

Physic-chemical parameters of Shkodra Lake varied in time. The variation is determined by the variation of the temperature and the biological activity on the lake. The values of some parameters determined in different seasons show the concentration of different seasons.

Most of the parameters determined did not shown the significant spatial changes. So for most of the parameters the values in the west and east shore of the lake were the same or nearly the same. The concentration of the phosphates, nitrates, ammonium, and nitrites was higher on the east shore than in west shore (Fig. 3). The high concentrations of the nutrients create favourable condition for vegetation in the east shore. The high concentration of the nutrients on the east shore mainly comes

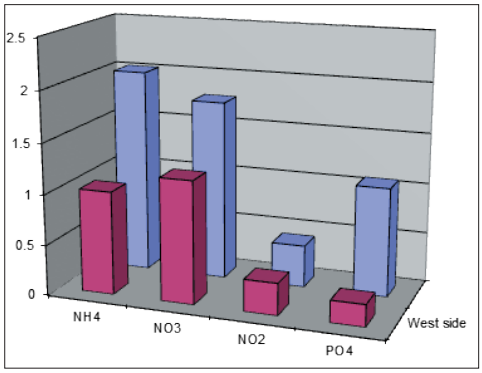


Figure 3. Mean concentration for East and West side (Units: µeq l^{-1})

from anthropogenic sources (agricultural field). Concentration of all parameters were higher on east side, especially for phosphate, ammonium and nitrate.

Heavy metals in the water of Shkodra Lake

Results taken by determination of heavy metals in water and sediments of Shkodra Lake are shown in the table 3 (on the table below are shown mean values).

Table 3. Concentration of metals in water and sediments of Shkodra Lake (in water mg l^{-1} and in sediments mg kg^{-1}).

Environment	Cu	Zn	Cd	Pb	Cr	Mn	Co	Fe
Water	21,5	45,4	0,54	5,11	21,3	14,5	–	28,5
Sediment (soluble)	2,8	2,28	1,18	2,12	1,48	17,3	6,68	1,97
Sediment (Total)	30,0	53,3	2,17	34,9	36,7	145,5	16,8	26175

Concentration of heavy metals in water of Shkodra Lake is different. Zinc and iron show the higher concentration on the water (respectively 45.4 and 28.5 mgl^{-1}), while the lowest concentration were seen for cobalt (under the detectable concentration) and cadmium with 0.54 mgl^{-1}.

The higher concentration in sediments was for iron (26.2 g kg^{-1}) after that manganese, zinc and copper. Figure 4 and 5 show the concentration of metals in water and sediments (as a total concentration).

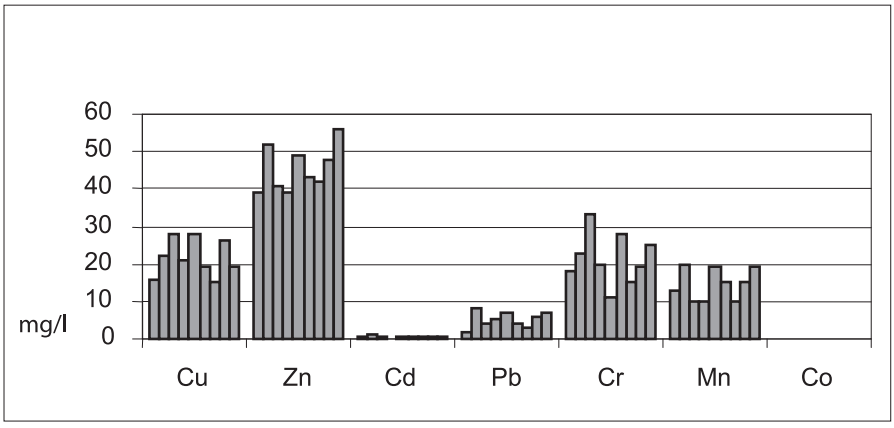


Figure 4. Concentration of the metals in water

Surface water of Shkodra Lake showed complex capacity for heavy metals. Complexing capacity is determined using Cu (II) ion as complexing metal. The mean complexing capacity of water of Shkodra Lake is found to be 0.26 μmol Cu (II) l^{-1}. The complexing capacity was not dependent from the concentration of CU (II) ion on solution and the maximum value for complexing capacity was found to be 0.42

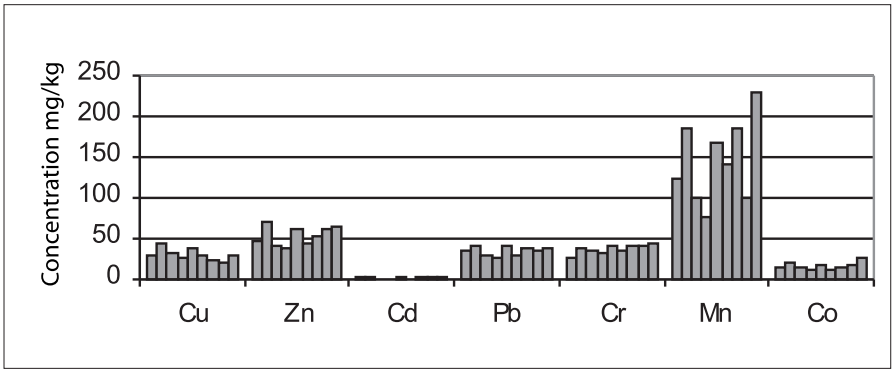


Figure 5. Total concentration of metals in sediments

μmol Cu (II) l^{-1}, this value is comparable with other studies done in other lakes (Chau, *et al*., 1994, Davwy *et al*., 2003).

CONCLUSIONS

The characteristics of the catchment area play a great role on the quality of water of Shkodra Lake. So the characteristics of each side of the Shkodra Lake are influencing on the water quality. Based on the physic-chemical parameters of the water of Shkodra Lake compared with the EC recommendations for cyprinid lakes, one can say that lake is typically cyprinid lake.

The physic-chemical parameters determined show a variation on time and in space on the lake. Changes in temperature of water causes the changes of some parameters the other main changes are changes caused from the vegetation on the lake. One of the most important spatial variations shown in the lake was the difference of the nutrients in east and west part of the lake. Based on the level of nitrate, ammonium and especially phosphate one can see that eutrophication processes are more developed on the East side of the lake.

Based on the results of analyses waters and sediments of Shkodra Lake do not results pollution from heavy metals. The concentration of heavy metals in water and sediments all the time was lower then the EC recommendations for lakes. Water of Shkodra Lake show a tendency for complexing heavy metals and complexing capacity of water of Shkodra Lake was comparable with other lakes.

REFERENCES

[1] *Annonymus, 1984:* Hidrologjia e Shqiperise. Akademia e Shkencave. Tirane.
[2] *APHA, AWWA, WPCF. 1989*: Standard methods for the examination of water and wastewater. APHA, Washington DC 17th Edition
[3] *Bekteshi, A. & Mijoviç, S. 2003*: Të dhëna paraprake mbi përqendrimin e metaleve në Liqenin e Shkodrës. *Buletini Shkencor i Universitetit të Shkodrës, Seria e shkencave Natyrore*. Nr. 53: 29–34.

[4] *Bekteshi, A. 1997–2000:* Karakterizimi kimik i ujërave të liqenit të Shkodrës. *Buletini shkencor i Universitetit të Shkodrës, Seria e shkencave natyrore*, Nr. 50: 23–36.
[5] *Bekteshi, A. 2004*: Bilanci jonik i ujërave të liqenit të Shkodrës. *Buletini Shkencor i Universitetit të Shkodrës, Seria e Shkencave Natyrore,* Nr. 54: 31–36
[6] *Bekteshi, A. 2008:* Përcaktimi i kapacitetit kompleksformues të ujërave të liqenit të Shkodrës. *Buletini i Universitetit të Shkodrës, Seria e Shkencave të Natyrës*, Nr. 58: 37–41.
[7] *Chau, Y. K., Gachter, R. & Lum-Shue-Chan, K. 1994*: Determination of the aparent complexcing capacity of lake waters. *Journal of Fish. Res*. Canada 31: 1515–1519.
[8] *Davwy, E. W., Morgan, M. J. & Ericson, S. J. 2003*: Aparent complexing capacity of natyral waters. *Limnology Oceanography*, Nr. 18: 993–998.
[9] *Dhora 2005*: Liqeni i Shkodrës. Shtëpia Botuese Camaj-Pipaj.
[10] *Dhora, Dh & Sokoli F. 2000*: Liqeni i Shkodres, Biodiversiteti Camaj Pipaj.
[11] *Dhora, Dh. 2003*: Molusqet e Liqenit të Shkodrës. *Buletini Shkencor i USH, Seria e Shkencave Natyrore*, Nr. 53: 83–98.
[12] *Dhora, Dh. 2004*: Vlerësimi i popullatave dhe menaxhimi i resursevetë peshqve më të rendësishëm të Liqenit të Shkodrës. *Buletini Shkencor i USH, Seria e Shkencave të Natyrës*, Nr. 54: 118–124.
[13] *Filippini, R. & Calabresi, F. 1995*: Guida alle esercitazioni di chimica. Patron Editore Milano 5 ta ed.
[14] *Karaman, G. S. & Beeton, A. M. 1981*: The biota and limnology of Lake Skadar. GRO „Prosveta" Beograd.
[15] *Keith, L. H. 1988*: Principles of environmental sampling. ACS professional Reference Book.
[16] *Miller, J. C. & Miller, J. N. 1988*: Statistics for analytical chemistry. John Wiley and Sons
[17] *Rodier, J 1984.* L'analyse de l'eau. Dunot Paris.