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A PAN-EUROPEAN CLASSIFICATION OF THE SKADAR LAKE ACCORDING TO ENVIRONMENTAL STANDARDS

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Abstract. *Nowadays, the values of natural fresh-water resources are increasing and a Pan-European methodology for water quality assessment was applied in the case of the Skadar Lake eco-system. The main goal of this paper was to classify Skadar Lake according to the environmental quality standards, prescribed in the EC directives and EUROWATERNET requirements. Basically, the criteria enable to classify the water as belonging to one of, usually, five classes with respect to a number of physicochemical and biological parameters. To determine the reference state, that could be expected if they were not significantly affected by human activities, was the second most important task. Some modeling was done to support interpretation of the measured data, taken seasonally from May to October in the 2002-2004 period. A clear picture of the current state of the Skadar Lake was created and the classification will facilitate the interpretation of the environmental data relating to the Skadar Lake ecosystem. As a general conclusion it could be stated that the lake ecosystem is still in good conditions, although a small care has been done to it in the past.*

Key words: *A Pan-European quality classification system of a lake; environmental quality standards; integrated monitoring; physical-chemical and biological analysis; water quality assessment, environmental modeling*

INTRODUCTION

Skadar Lake is the largest natural, shallow (mean depth 5m), freshwater lake of tectonic-karst origin in the Balkan region. The lake is a trans-boundary wetland (Ramsar site No. 784) located on the border between Albania and Montenegro and the National Park in Montenegro.

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The lake's natural resources such as biodiversity (plants, fishes, birds and waterfowl, amphibians, reptiles, invertebrate fauna), water (drinking water, agriculture), mineral resources, fertile soils, cultural and historical heritage, offer the possibility to develop sustainable activities like eco-tourism and rural tourism, ecological agriculture, fishing, hunting and peat exploitation.

The Skadar Lake National Park is a winter sanctuary for numerous birds that migrate from the frozen marshes of Northern Europe. When ice grips the northern hemisphere, up to 250,000 ducks, grebes and Coots find here a plenty of food [1]. Due to political tensions and wars in the Balkan region, in the past decade, this ecosystem has been in danger for the biggest scale of deterioration.

This paper presents a developed and integrated monitoring program of Skadar Lake where a persistent scientific cooperation was established to meet the needs of protection and sustainable use of this aquatic ecosystem. The research aimed to result an improved understanding of the management aspects of the lake ecosystem and its drainage area, and of the ecological and socio-economic importance of a state of Skadar Lake.

The final outcome of the project will be a clear classification of the current state of the lake and its trends, submitted to the policy-makers of both countries (Albania and Serbia & Montenegro).

WATER QUALITY ASSESSMENT

The physicochemical-biological characteristics of the waters of Skadar Lake are the results of inflow of the major tributaries, inflow from sublacustrine springs, exchange between sediments and overlying waters, the extensive flooding of the terrestrial environment, chemical exchange between waters and the extensive beds of aquatic macrophysics and anthropogenic pollution.

During the design phase of the project, the variables of concern have been clearly outlined. The variables, divided into sections, are listed below:

- Acidity
- Transparency
- Oxygen And Oxygen-Depleting Substances
- Nutrients/Eutrophication
- Metals
- Microbiology
- Plankton
- Bottom Fauna
- Freshwater fish species
- Aquatic Plants

Interpretation and discussion of each variable have been done separately [2-4]. This paper provides the results of those water quality variables for which analyses are typically conducted [5]. Assessments were based on the data from ten sampling points in the lake, taken monthly in the period May-October in three years. Mostly, the classification was done in five classes whose explanation was done on charts presented on Fig/1-8.

RESULTS

Acidity

Evaluations of acid conditions can be based on many variables but the most important are alkalinity and pH values. Both variables are measured *in situ*. The results are given in Figure 1.

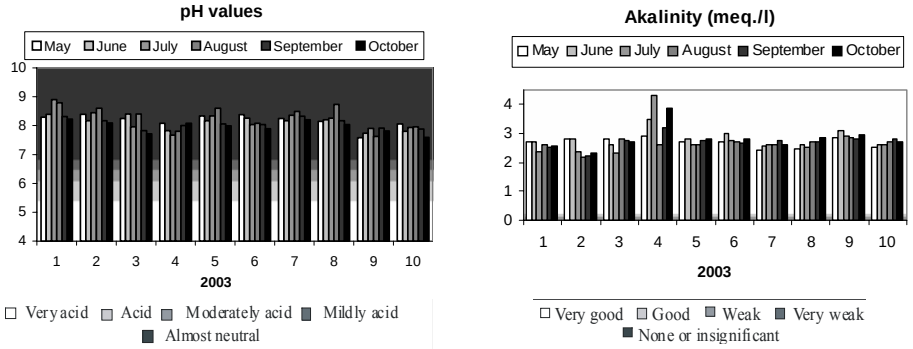

Fig. 1. Acidity parameters

Transparency

The three variables were chosen to assess the transparency of the Lake: water color, turbidity and Secchi depth.

The results are shown in the charts in Figure 2.

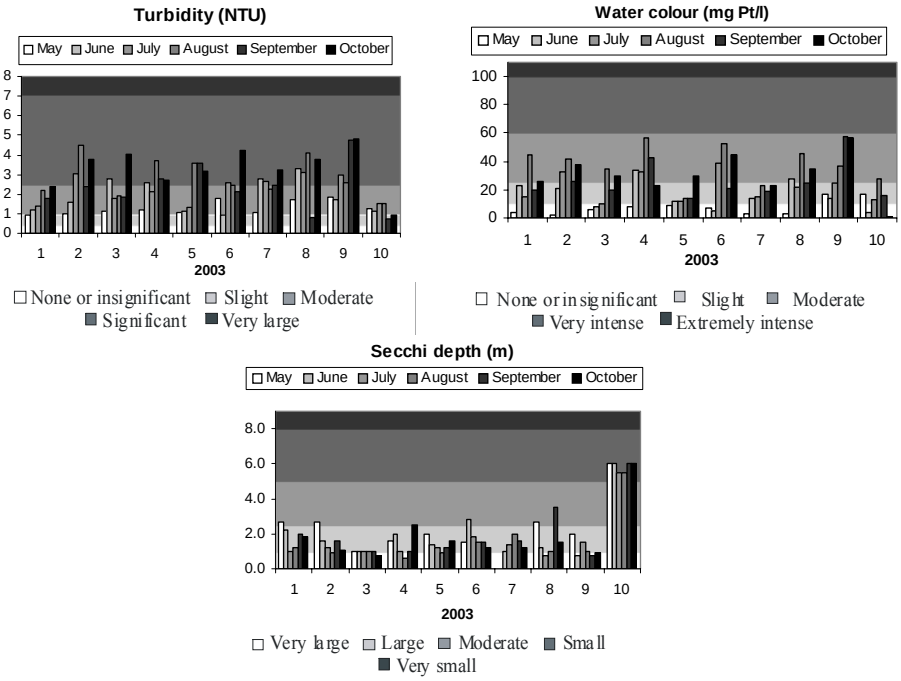

Fig. 2. Transparency parameters

Oxygen and oxygen-depleting substances

Dissolved oxygen and Chemical Oxygen Demand (COD) variables were measured. The results are presented in Figure 3.

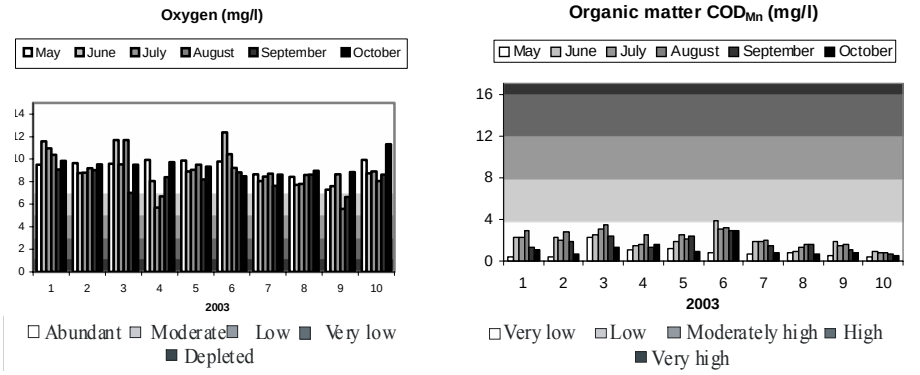

Fig. 3. Oxygen parameters

Nutrients/Eutrophycation

Assessments are based on analyses of total phosphorous and total nitrogen and the weight quotient total phosphorus/total nitrogen. The results are given in Figure 4.

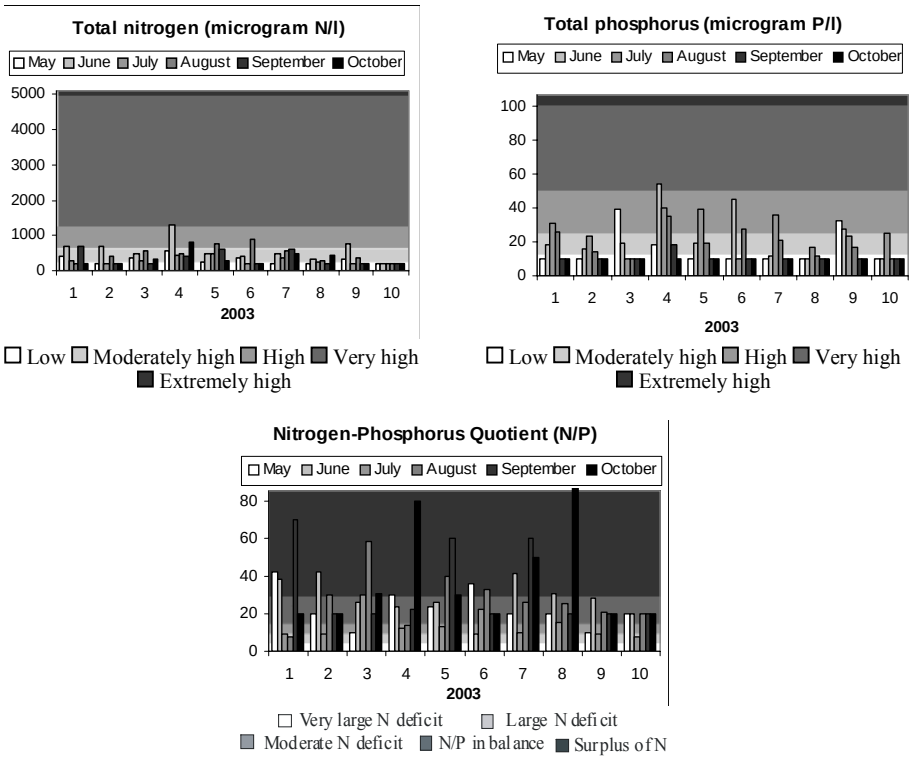

Fig. 4. Nutrients/Eutrophycation

Metals

Assessment criteria for the Lake include those relating to levels of various metals in waters and sediments.

Some results are presented in Figure 5.

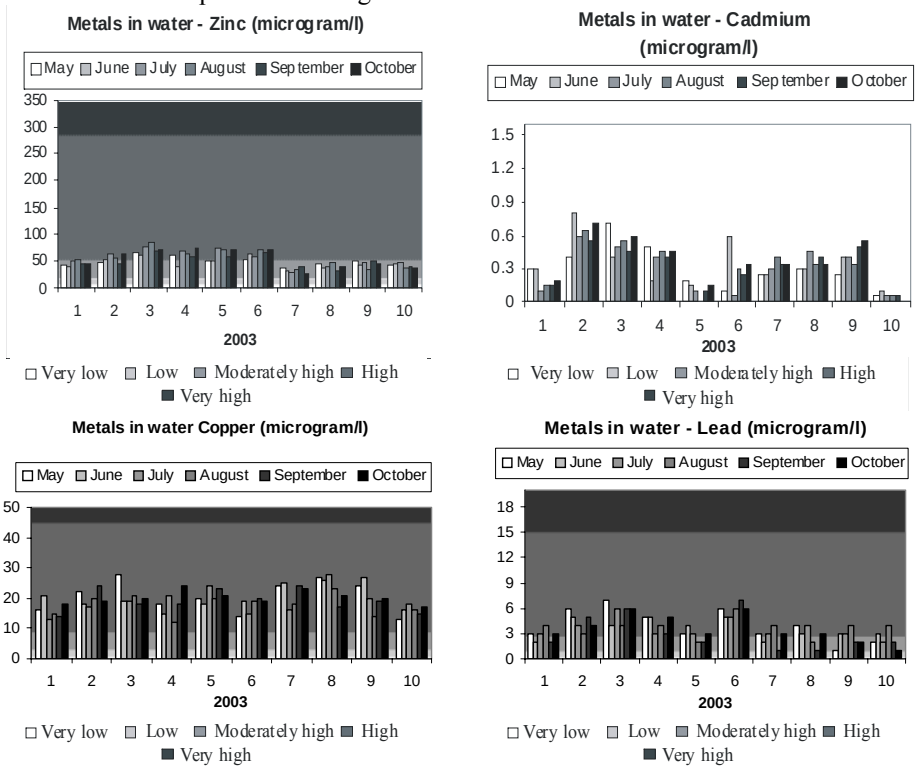

Fig. 5. Metals in water

Microbiology

Total Bacterial Count has shown great variability per month and per station. From this reason the averaged values are presented in Figure 6.

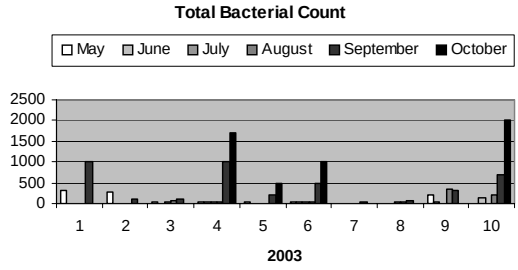

Fig. 6. Microbiological parameters-Total Bacterial Count

The classification of the Lake was done according to Total Coliform Bacterial Counts (The Former Federal Law of Yugoslavia) and the results are shown in Fig. 7. Three classes of water are distinguished:
□ I class; ▒ II class; ■ III class.

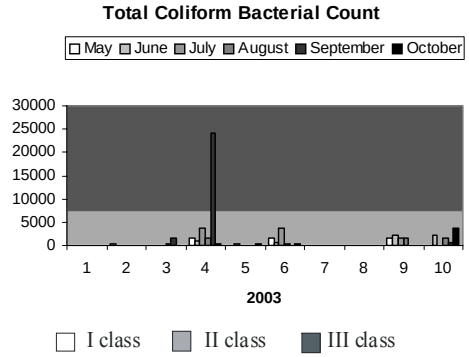

Fig. 7. Microbiological parameters-Total Coliform Bacterial Count

Plankton

Several measurements of plankton algae in lakes are presented here. Some of the measurements are related to eutrophication that may have occurred, while others are more appropriate for studying algae, which may cause various kinds of problems.

The classification of the Lake is based on chlorophyll levels. The amount of chlorophyll is directly related to the total volume of algae. The proportion of chlorophyll is assumed to be 0.5 percent of the plankton volume [2].

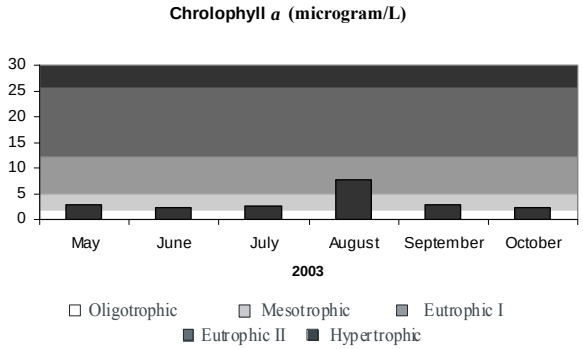

Fig. 8. Plankton's parameters

The number of cyanobacterial genera with the ability to produce toxic substances was used as an indicator of the risk of long-term algal-related problems in the lake.

In the lake, three genera of this kind of algae were found: *Mycrocystis*, *Planktotrix* (*Oscilatoria*) and *Anabaena.*

Bottom fauna

The diversity and distribution of benthic macro-invertebrate species or species assemblages in the lake provide useful information about the affects of such phenomena as eutrophication, organic pollutants and acidification. The assessment criteria used here are based on three difference indices of bottom fauna conditions:

- **ASPT (Average Score per Taxon)** [5];
- **Acidity Index** [6];
- **O/C Index** [7];

The observed *families* of macro-invertebrates and their family weights are listed below:

Ephemeridae (10), *Viviparidae* (6), *Valvatidae* (3), *Physidae* (3), *Chironomida* (2), *Oligochaeta* (1) .

The values of these indices, averaged per five samples, are: **ASPT index (2.8); Acidity index (1.8) and O/C index (0.1)**.

Plants

The diversity and distribution of submerged and leafy floating plants in lakes are used as indicators of the aquatic ecosystem's general condition. The assessment method presented here is based primarily on the number of species of both submerged and leafy floating plants. Each species is assigned according to the Trophic Ranking Score (TRS) [8].

Fishes in the lake

The results from a simulation of the eutrophication processes in Malo Blato (a northern part of the Skadar Lake) using WASP program are presented below. The chosen variables were: dissolved oxygen, chemical and biological oxygen demand and phytoplankton. The simulation was done in the period from January 1, 2003 to December 31, 2004 and the results are shown in Figure 9.

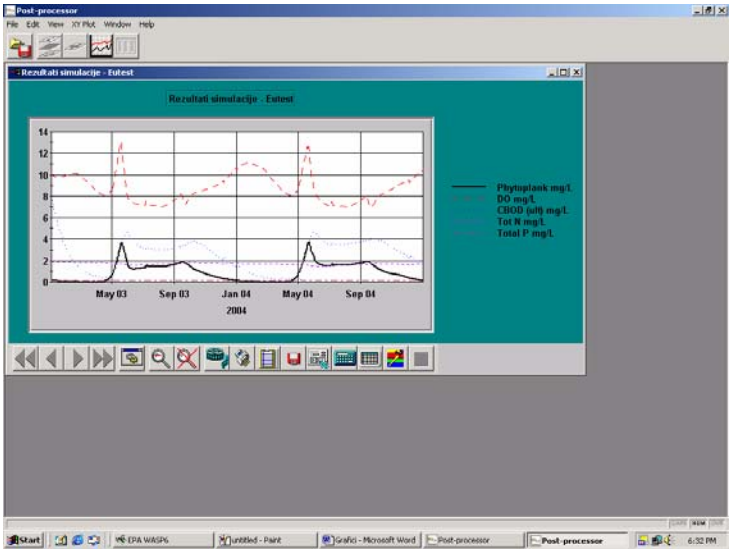

Fig. 9. Plankton's parameters

DISCUSSION AND CONCLUSIONS

At first glance, the data of the measured variables suggest that they are in agreement with one another, i.e., they are not mutually exclusive. The main results of the classification are:

- From the charts above one can see that the buffer capacity of the Lake is very good and the Lake is not likely to be sensitive to acidification in the near future. Values of pH represent that the Lake is basal, and the pH values slightly increase in the May-August at some points. It indicates that primary production is related to these places;
- The classification of the Lake according the water colour is as follows: The water of the Lake is between slight and moderately colored. The turbidity was mainly moderate and significant in some sampling stations. Transparency of the Lake related to Secchi depth is: the water has moderate or small Secchi depth;
- Mostly, the Lake is abundant in oxygen except for some places where significant depletion of oxygen occurred in July-August. As a consequence, the COD should be very low as it was proved by the data shown in the second chart;
- Concerning to the phosphorus, the Lake is mainly oligotrophic and mesotrophic with a non-expectable high concentration in two stations in June. Nitrogen is mainly moderately deficit nutrient. It needs more investigation;
- From the charts above the water of the Lake is polluted by heavy metals and there are increased risks of biological effects. Surprisingly, the concentration of heavy metals in sediments (the measured values are not shown here) is very low and almost with no biological risks. Further investigations are recommended;
- Concerning the presence of the *Coliform bacteria* the water of the lake is mainly of the second class;
- Concerning the chlorophyll concentration the lake is between oligotrophic and mesotrophic states with some signs of eutrophication in August. There is a moderate risk of cyanobacteria;
- The averaged value of ASPT index proves the presence of tolerant species in the lake. The values of O/C index prove a high concentration of oxygen and low concentration of organic pollutants. The value of acidity index proves the absence of pH sensitive species;
- The number of plants and fishes species proves that Skadar/Shkoder Lake is a hot spot of biodiversity in Europe.

A comparison of the current measured values of the monitored variables with the old data [1] (approx. 30years ago) shows no significant differences. From this fact, one can conclude that the current state of the lake could be consider as the reference state for future monitoring and management of the lake.

As a general conclusion it could be stated that the lake ecosystem is still in good condition, although a little care has been provided to it in the past. From this reason precautionary measures can be introduced for preserving the current state of the Lake and providing a sustainable use of this ecosystem.

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REFERENCES

1. Karaman G (1981): in the book/The Biota and Limnology of Lake Skadar,Titograd
2. Quevauviller P (2000): in the book/Hydrological and Limnological Aspects of Lake Monitoring, John Wiley & Sons Ltd, England
3. Internet (2003): Swedish Environmental Protection Agency http://www.internat.environ.se/index.php3
4. Internet (2003): Understanding Lake Ecology http: //wow.nrri.umn.edu/wow/under/primer/page16.html
5. Internet (2003): Guidelines for Interpreting Water Quality Data. Copyright 1988 Province of British Columbia http://www.for.gov.bc.ca/ric/pubs/aquatic/interp/index.htm
6. Armitage D, Moss D, Wright F, Furse T (1983): The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running waters. Water Research 17, 333-347
7. Henrikson L, Medin M (1986):Biologisk bedömning av försurningspåverkan på Lelångens tillflöden och grundområden. Aquaekologerna: Report to Älvsborgs County Administrative Board
8. Wiederholm T, (1980): Use of benthos in lake monitoring. Journal of the Water Pollution Control Federation 52, 537-547
9. Palmer A, Bell S, Butterfield I (1992): A botanical classification of standing waters in Britain-applications for conservation and monitoring. Aqutic conservation- Marine and freshwater ecosystems. 2. no.2, 125-143
10. Maric D, Krivokapic M, (1997): Stanje faune riba u slivu Skadarskog jezera. CANU Zbornik radova Prirodne vrijednosti i zastita Skadarskog jezera 44, 215-223

PAN-EVROPSKA KLASIFIKACIJA SKADARSKOG JEZERA U SKLADU SA STANDARDIMA ZA ŽIVOTNU SREDINU

S. R. Mijović, Ž. Vuković, A. Madžgalj

Vrednost slatko-vodnih prirodnih resursa raste i jedna Pan-Evropska metodologija za ocenu zagađenja i kvaliteta vode je prezentirana na primeru Skadarskog jezera. Glavni zadatak u ovom radu je klasifikacija Skadarskog jezera po standardima za životnu sredinu, opisanim u Direktivama EU. Određivanje referentnog stanja tj., očekivanog stanja u slučaju beznačajnog antropološkog uticaja, je drugi važan zadatak. Jasna slika sadašnjeg statusa Skadarskog jezera je dobijena i klasifikacija će poslužiti u interpretaciji podataka za ekosistem-Skadarsko jezero. Opšti je zaključak da je kvalitet vode Skadarskog jezera još uvek zadovoljavajući iako mu je posvećeno malo pažnje u zadnjoj deceniji.