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DATABASE FOR MONITORING, PROTECTION AND MANAGEMENT OF RESERVOIRS IN SERBIA

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ABSTRACT. About 150 reservoirs have been constructed to date in Serbia to satisfy various needs of the population. Twenty-six of them occupy more than $10x10^6m^3$ and their total capacity is about $6x10^9m^3$. The most often problems concerning these reservoirs are lack of adequate monitoring, ecological protection and proper management. Investigations on which programs for monitoring, protection and remediation would be based mostly are not scientifically established and properly planed. One of reasons for this is lack and unavailability of suitable data. Because of that Faculty of Science, University of Kragujevac, has developed SeLaR Information System (Serbian Lake and Reservoirs Information system) which provides all the information of Serbian Lakes and Reservoirs. Information system is needed for transfer of knowledge and information, collaboration among participants in management and support of sustainable using of water resources. The paper presents the basic system components and some applications examples.

INTRODUCTION

Serbia belongs to the group of countries poor in water resources. Concerning water supplying, Serbia mostly rely on surface water resources. It is the explanation for the fact that more than 150 hydro reservoirs have been constructed here. Twenty-six of them occupy more than $10x10^6m^3$ and their total capacity is about $6x10^9m^3$ [1]. Most of them are being used for water supplying and for hydro energy while few of them are for irrigation, fishing and tourism etc.

The most often problems concerning these reservoirs are lack of adequate monitoring, ecological protection and proper management. One of reasons for this is lack and unavailability of suitable data. For management of any process the most important thing is to have enough information available. Although earliest researches correspond with construction of first reservoirs in Serbia [2], [3], up today only very a few reservoirs have been submitted to complex hydrobiological researches. Besides, existing data haven't been systematized properly and aren't available to all participants in sustainable exploitation.

The aim of this report is to present information system about lakes and reservoirs of Serbia (SeLaR - Serbian Lakes and Reservoirs Information system). There is database within this information system that includes general information and enables new and contemporary view on state of lakes and reservoirs in Serbia. This information included in database should give contribution to improvement of ecological protection and management as well as to sustainable exploitation of water resources. Having in mind that data about Serbian lakes aren't included in any existing site (www.worldlakes.org; www.livinglakes.org; www.ilec.or.jp/database/database.html) SeLaR info system makes data about Serbian lakes and reservoirs available to broad scientific and expert public.

SeLaR INFORMATION SYSTEM

Faculty of Science, University of Kragujevac develops SeLaR information system (Fig. 1) that includes all available and relevant data about lakes and reservoirs of Serbia. The information system is designed to provide users with scientific information and thus gives its contribution to adequate management of water resources and to sustainable development. In its initial phase SeLaR includes data about three larger reservoirs in Serbia - Gruza, Vlasina and Grosnica. It is available to all participants in proces of management of lakes and reservoars by Internet, and it can be found on the site of Faculty of Science in Kragujevac. These data are based on the results of researches that Faculty of Science conducted for years as well as on other available literal sources, [2], [4].

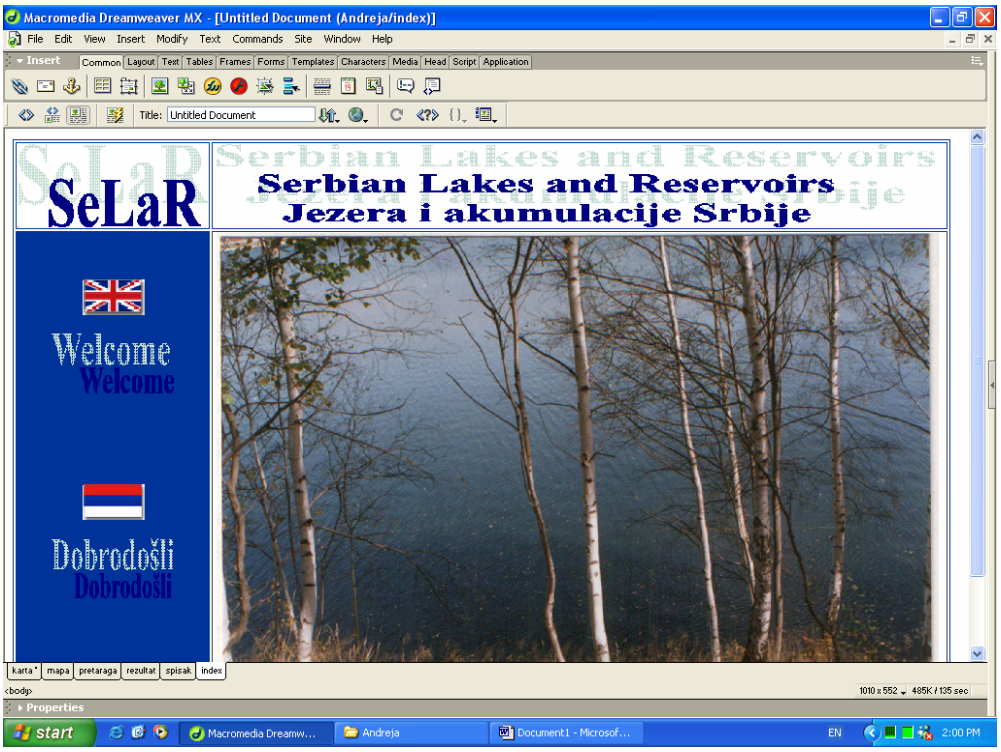

Figure 1. SeLaR Home page

SeLaR info system is available on internet to all participants in the process of water resources management and it doesn't require special tools for exploring.

DATABASE

The database is designed to accommodate three different levels of detail: (a) general information about each lake/reservoir (Fig.4), (b) specific description of previously mentioned data and (c) bibliography and where possible whole papers.

The basis of database includes following main data:

- Location and Position,
- Physical dimensions
- Physical features
- Chemical features,
- Lake water quality,
- Biological Features (zooplankton, phytoplankton, bacterial community, algae, macrophyta, ichthiofauna, etc),
- Trophic status,
- Socio-economic conditions,
- Lake utilization,
- Deterioration of lake environments and hazards,
- Wastewater treatment,
- Improvement measures in the lake,
- Dam characteristics and
- If reservoir is used for water supplying it includes technological processes as well.

Integral parts of data base are photos, maps, schemes, etc.

Assessment of data is possible in three different ways:

(a) Searching by index (first letter of the reservoir name arranged in alphabetical order) enables access to information about size, location and usage of lakes and reservoirs (Fig. 2);

(b) Searching by marking sites on the map that enables more detailed access into location of reservoirs (Fig. 3);

(c) Searching by key words (zooplankton, phytoplankton, bacterioplankton, benthos, algae, macro vegetation, water quality, hypolimnetic aeration, ecological protection, etc) and by names of reservoirs.

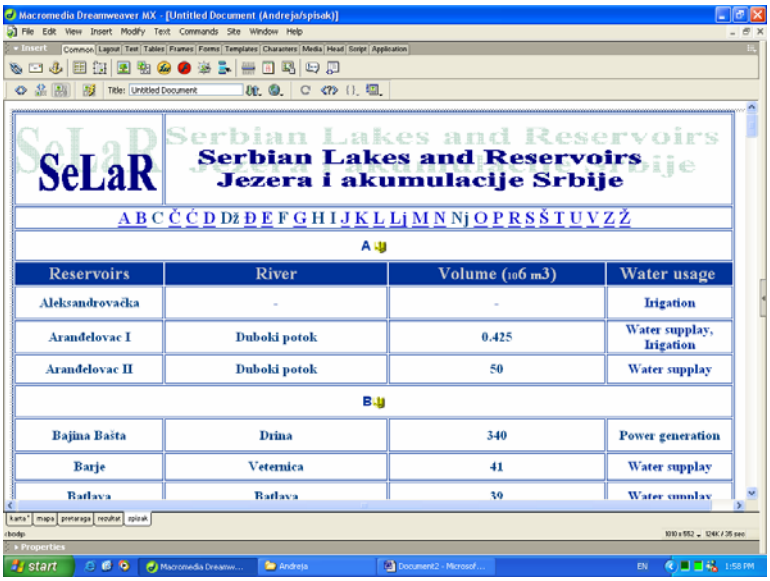

Figure 2. Searching by index

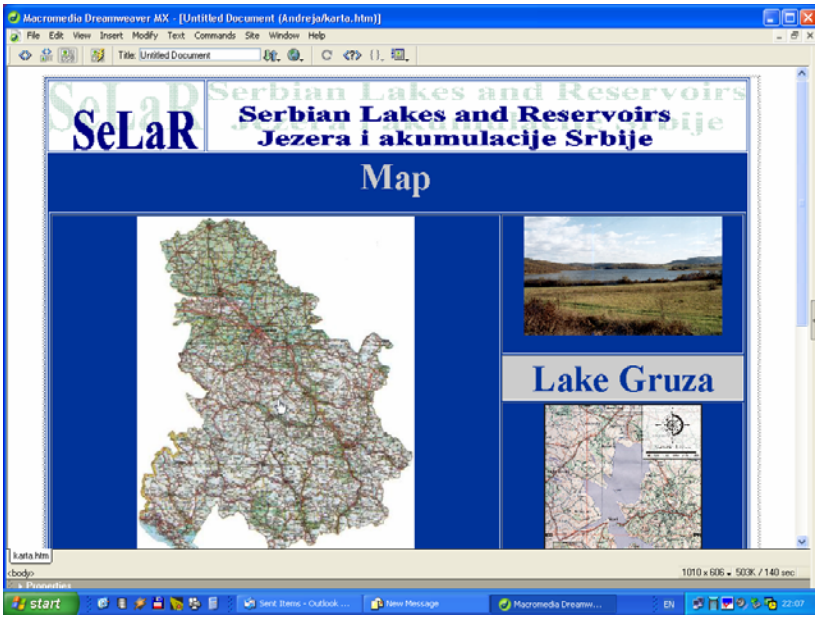

Figure 3. Searching by marking sites on the map

LAKE/RESERVOIRS STATUS RECORDS FROM SERBIA

Presently, data base includes data about Gruža, Grošnica and Vlasina reservoirs and we expect data base to be widened with information about other lakes and reservoirs of Serbia soon.

GRUŽA RESERVOIR

Reservoir Gruža which has been the subject for wide researches from its construction till today, has been taken as an example for shoving data about a lake or a reservoir.

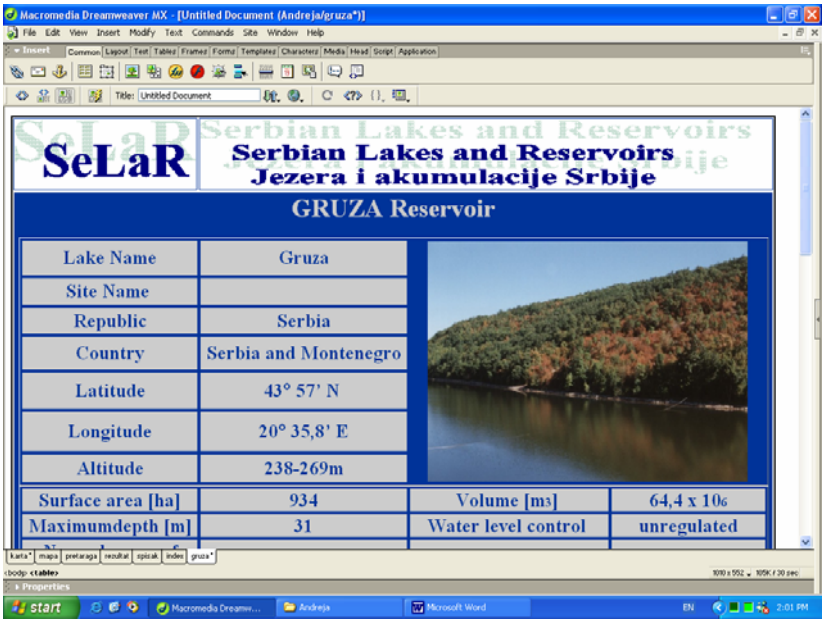

Figure 4. General information on Gruza Reservoir

Short survey of some main features of Gruža Reservoir, included in data base, follows in further text:

NAME:	Gruza
RIVER:	Gruza
LOCATION:	23km south-west of Kragujevac town, Serbia, Yugoslavia
POSITION:	43^0 57' N, 20^0 35.8' E;
ALTITUDE:	238-269m above sea level.
PURPOSE:	to supply drinking water for the city (250.000 inhabitants).

PHYSICAL DIMENSIONS (Fig. 4)

Surface area [ha]	934
Volume [m^3]	64.4×10^6
Maximum depth [m]	31
Mean depth [m]	6.3
Water level	Unregulated
Normal range of annual water level fluctuation [m]	3-5
Retention time [yr]	2
Watershed area [km^2]	318.2
Sanitary protection area [ha]	1450

LAND USE IN THE CATCHMENT AREA

- 56.1% plough land and orchards;
- 26.2% forest;
- 17.1% fields;
- 0.6% sterile lend

ACTIVITIES

- Agricultural production;
- Rural tourism;
- Sport, recreation;
- Traffic

POPULATION IN THE SURROUNDING AREA

- number of households in sanitary zone of protection 93
- Villages in surrounding area: Žune, Dragušica, Toponica, Kusevac, Grabovac
- Population density $45/km^2$
- Total number of inhabitants in Knić 18.724

PHYSICAL AND CHEMICAL FEATURES

Physical and chemical features include data of water temperature, transparency, conductivity, pH, $KMnO_4$ consump., nitrates, nitrites and ammonia, chlorides, total phosphates, Mn and Fe, oxygen concentration, saturation, BOD, etc.

The main features of the lake are its high concentration of the total Mn (up to 4.6mg/l), high temperature (up to 29^0C), and hypolimnetic oxygen deficit (1.23mg O_2/l) during summer stratification, [5]. In Gruza reservoir a high concentration of phosphates was found (up to 0.645mg/l), while the concentration of nitrates was 0.03mg/l with enormously high ammonia concentration, up to 2.4mg/l, [6].

BIOLOGICAL FEATURES

Zooplankton

Analysis of collected samples revealed the presence of 99 taxa [six (6.1%) in the group Rhizopoda; nine (9.1%) in the group Ciliata; 63 (63.6%) in the group Rotifera; 15 (15.2%) in the group Cladocera; and six (6.1%) in the group Copepoda], the majority of which are cosmopolitan. Most of the registered taxa occurred occasionally and with a small number of specimens, while only 15 taxa were constantly present throughout the entire period of investigation, often in massive numbers. Increased abundance was recorded in relation to previous investigations. Only 10 taxa in the group Rotatoria recorded by [6] and dominance of the genera *Bosmina* and *Ceriodaphnia* in the group Cladocera, while only species of the genus *Cyclops* were registered in the group Copepoda. Evidently, a considerable increase has occurred with the passage of time in diversity of the group Rotatoria (but of other groups as well), representatives of which dominate the list of registered taxa.

Phytoplankton

In Gruža reservoir 74 species of algae have been recorded. Chlorophyta and Bacilariophyta are dominant in regard to diversity and abundance, although massive development of Cyanobacteria occurs in certain periods, which can cause "blooming" of the water, [7].

Microbial community

The Gruža Reservoirs with its microbiological features belongs to class I-III bonity [8, 9]. Bacterial density comprised $0.20x10^6$bact/ml -$1.97x10^6$bact/ml. In bacterial community heterotrophic bacteria are dominant. Structure and dynamics of the heterotrophs are changing and depend on the phytoplankton and the presence on autochthonous organic matter. Among heterotrophs, proteolytic bacteria were dominant at the beginning of vegetation period. In the same period phytoplankton was present in the small number of individuals and species were from division Bacilariophyta. In summer, amylolotic and phosphomineralizing bacteria were predominant, while Cyanophyta and Chlorophyta prevailed in phytoplankton. The repeated domination of proteolytic bacteria was in late outmn with the simultaneous maximum of Bacillariophyta. Nitrogenfixing bacteria were most numerous in spring. The most encountered species was *Azotobacter agilis*. Among celulolitics *Cellvibrio fulvus* was dominant bacteria [7, 10].

Fungal community

The autochthonous fungal community was composed of the following species: *Achlya racemosa, Catenaria* sp.*, Margaritispora aquatica, Saprolegnia ferax, S. hypogina, S. monoica, Pythium ultimum*. The allochthonous community included 36 species. The following ones were reported for Srebian freshwaters for the first time: *Absidia spinosa, Chloridium chlamydosporis, Colletotrichum gloesporoides, Cryptococcus albidus, Dactylium dendroides, Fusarium aquaeductuum, Mucor mucedo, M. racemosus, Penicillium funiculosum, Rhiyopus nigricans* and *Thielavia sepedonium,* [5].

Macrophytes

Floristic investigations of the Gruza Reservoir revealed the presence of 65 plant species belonging to 30 families. With respect to the number of families and species, Magnoliopsida are dominant with 63% of the families (61.54% of the species), while Liliopsida are present with 33.3% of the families and 35.8% of the species. Phytogeographic analysis of the hydrophilic flora of the Gruža Reservoir confirmed several floristic elements grouped into five areal types. The greatest number of species has ranges of the Holarctic (66.15%) and

cosmopolitan (20%) area types, but species with the Mediterranean-continental (7.69%), Central European (4.62%) and adventive types (1.54%) are also represented.
Analysis of life forms showed that 38.46% of plants of the Gruža Reservoir are hemicryptophytes, 10.77% are geophytes, 3.07% are therophytes; only 1.54% plant species are phanerophytes, chamaephytes and scandentophytes; and dominant (43.08%) are hygro-heliophytes and amphibious, flotant, and submersed hydrophytes. Within these categories emersed plants constitute 53.57%, submersed plants 32.14%, and flotant plants 14.29% of the species [11].

Macrozoobenthos

A small number of markedly eutropic species of Oligochaeta [12] recorded in the deepest layers, the density of their populations being very low, while they are completely absent during certain periods of the year. The composition and density of representatives of the macrozoobenthos indicate a hypeutrophic nature of the reservoir with elements of degradation.

Ichthyofauna

Ichthyofauna of the Gruža reservoir included 18 species (13 autochthonous and 5 allochthonous), from five families (Cyprinidae, Siluridae, Esocidae, Percidae and Centrarchidae). The family Cyprinidae predominates in the number of species (13) and the number of individual specimens (74.68% caught). Over-production of "trash" fish observed whereas number of predators decreased. Propagation of allochthonous fish, especially *Carassius gibelio* (Bloch, 1782), threatens allochthonous ichthyofauna. The changes in the ichthyofauna composition beside analysis of other hydrochemical and hydrobiological parameters indicated the aggravation of general ecological conditions of this ecosystem [13].

STATE OF SEWERAGE SYSTEM AND REFINE OF WASTE WATERS

- Households in sanitary protection zone have regulation of waste waters;
- Drainage network is built only for part of Knić settlement, and at the same time it is atmospheric and fecal;
- Rural settlements have not drainage system, so there directly effusion of waste waters in water current is present (diffuse sources)
- Industrial waters refine partially before release (point source: slaughterhouse, factory for production of mushrooms).

CHARACTERISTICS OF THE DAM

Height	51.50m
Chord in crown	207.89m
Ratio between chords in crown and height of dam	4.04
Length of cupola in crown	230.30m,
Length	288.05m

INTERVENTIONS IN THE RESERVOIRS

Addition of $CuSO_4$ as a prevention of massive development of algae during summer, when temporary flowering (algal bloom) of Cyanobacteria occurs, simultaneously with development of Chlorophyta. $CuSO_4$ beside algaecidal action also show bactericidal action, that reflects in decreased number of heterotrophs (saprophytes), which leads to

disturbances in transformation of organic materials (increased consumption of $KMnO_4$ – mean values 17.2-27.7mg/l).

Application of hypolimnetic aeration – for decrease of Mn concentration in water and increase O_2. However, existing aerator in summer condition can introduce to 400kg O_2/d, which is insufficient, because evaluated requirement is 1000kg O_2/d. Still, during summer is expressive anoxia (Fig.5).

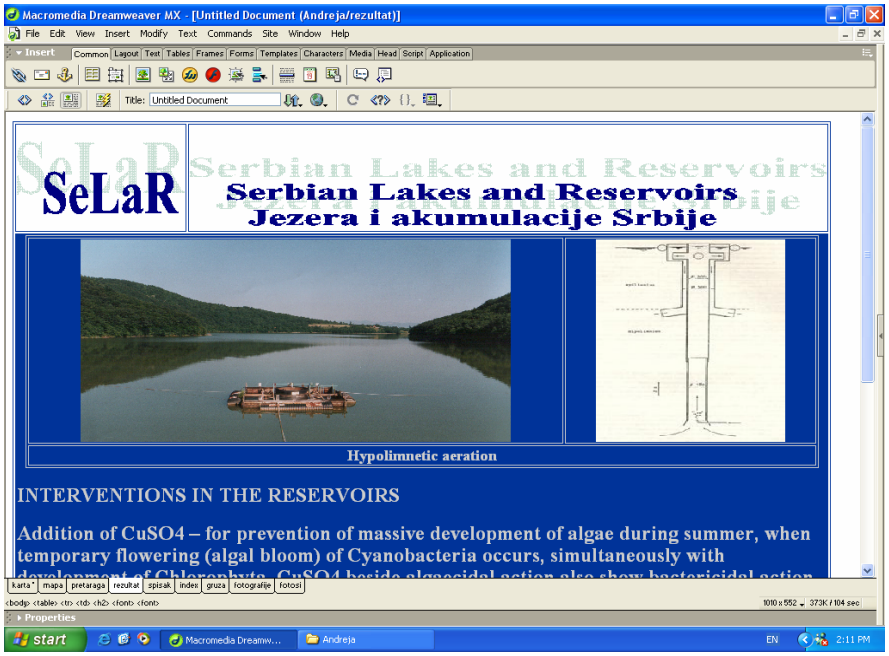

Figure 5. Hypolimnetic aeration in Gruza Reservoir

DATA SOURCES

For data base we used results of researches that Faculty of Science in Kragujevac has been conducting for years as well as literal data concerning lakes and reservoirs of Serbia. We have also contacted all those organizations that take care of water quality or who manage reservoirs in Serbia and thus we provided valid information. Data have been converted into proposed format and put into data base.

SYSTEM SOFTWARE

Relational database SQL server is used for implementation of the informational system SeLaR, and Dreamweaver MX is used for creating the internet presentation.

References

[1] Bogdanović, Z. & Pavić, D. (2003): Hydroreservoirs in Serbia. In: *Hydroreservoirs*, (ed. A. Ivanc & B. Miljanovic), Fac. of Sci, Univ. of Novi Sad, Serbia and Montenegro.

[2] Blaženčić, J. (1997): Vlasina Reservoir: hydrobiological study. Fac. of Biol. Sci, Univ.of Belgrade, Serbia.

[3] Ostojić, A. (2000): Effect of eutrophication on changes in the composition of zooplankton in the Grošnica Reservoir (Serbia, Yugoslavia). *Hydrobiologia,* **436**.

[4] Ivanc, A. & Miljanović, B. (2003): *Hydroreservoirs*. Faculty of Sci, Univ. of N. Sad. Serbia and Montenegro.

[5] Čomić, Lj., Ranković, B.& Barbič, F. (1996): Community of fungi in Gruža reservoir, Yugoslavia. *Arch. Hydrobiol. Spec. Issues Advanc. Limnol*. **48**, 105-111.

[6] Martinović-Vitanović, V. & Kalafatić, V. (1990): Classification of some reservoirs in SR Serbia (SFR Yugoslavia) based on analysis of plankton species as indicators of trophic conditions. *Arch. Hydrobiol. Beih*. **33**, 831-837.

[7] Čomić, Lj. & Ranković, B. (1991): Changes of bacteria population and phytoplankton and their relationship in accumulative lake Gruža. In: *Evolution of freshwater lakes, part II*, (ed. Burchardt, L), Adam Mickiewicz Univ. Press Poznan, series biologia NR 46: 129-139.

[8] Ćurčić, S. & Čomić, Lj. (2002): Microbiological index of Water Quality (mWQI) tested on the Gruža Reservoir. *Arch. Biol. Sci*. **54**, 3-4.

[9] Ćurčić, S. & Čomić, Lj. (2002): A microbiological index in estimation of surface water quality. *Hydrobiologia*, **489**, 212-224.

[10] Čomić, Lj., Ranković, B. & Barbič, F. (1993): Structure and dynamics of the bacteria in the sediment of the Gruža storage lake. *Mikrobiologija* **30**, 2, 107-114.

[11] Topuzović, M. & Pavlović D. (2003): The vascular flora of the Gruza Reservoir in the Šumadija region of Serbia. *Kragujevac J. Sci*. **25**, 107-120.

[12] Simić, V., Simić, S. (1999): The bottom fauna as an indicator of the eutrophication level in some reservoirs in Serbia. *The 28th Annual Conference of Yugoslav Water Pollution Control Society "Water Pollution Control 1999", Conf. Proc*., Jugoslovensko društvo za zaštitu voda, Belgrade, Serbia and Montenegro: 181-186.

[13] Simović, S. & Marković, G. (1996): The ichthyofauna of the Gruža reservoir. *Arch. Biol. Sci.*, Belgrade, **48,** 3-4.

Internet sources:

www.worldlakes.org
www.livinglakes.org
www.ilec.or.jp/database/database.html