# WATER QUALITY AT THREE SPECIAL NATURE RESERVES IN VOJVODINA, SERBIA: PRELIMINARY RESEARCH

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**ABSTRACT. – Water Quality at Three Special Nature Reserves in Vojvodina, Serbia: Preliminary Research.** Degradation of water quality caused by an anthropogenic influence is a problem which is present even at some special nature reserves (SNRs) in the Province of Vojvodina, Serbia. The aim of this paper is to present results of preliminary research on water quality on three SNRs. Whereas in the SNR Ludaško jezero (Ludaš Lake) and in the SNR Obedska bara (Obedska Pond) serious euthropic processes are present due to agricultural runoff and untreated wastewater, the SNR Stari Begej – Carska bara (Old Bega River - Imperial Pond) is under the potential influences of fish farms and agriculture. The monitoring conducted in spring/summer period and in autumn in all SNR included water sampling on several locations within each SNR. The analyses included basic water quality parameters, water mineralization and microbiological analyses. Both, water quality and microbiological results have proven highly eutrophic status of the SNR Ludaško jezero and significant difference in salinity in the north and in the south of the lake. The results on the other two investigated SNRs are a bit better indicating moderate eutrophic conditions, except for autumn sampling at SNR Stari Begej-Carska bara when serious deterioration of water quality was determined.

**Keywords:** water quality, special nature reserve, Ludaško jezero, Obedska bara, Stari Begej - Carska bara.

## 1. INTRODUCTION

Degradation of water quality caused by an anthropogenic influence is a problem for the most of the water bodies. Therefore, established networks of hydro-meteorological services are monitoring changes in water quality in order to provide exact data, upon which dominant processes might be indicated. Water quality in *special nature reserves* (SNR) is a basis for sustaining its biodiversity. However, in Serbia the monitoring is covering only rare water bodies within SNRs, while the water quality of others is being monitored only occasionally.

According to the Low on Nature Protection of the Republic of Serbia (Official Gazette of RS, 91/2010) „SNR is an area with unchanged or almost unchanged nature, which is extremely significant because of its uniqueness, rarity or representativeness, and which includes habitat of endangered wild kinds of plants, animals and fungi, without settlements or with rare settlements where man lives in harmony with nature.

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Special nature reserve can be botanical, forest, ornithological, ichtyological, geological, paleontological, hydrogeological, hydrological, etc."

Although, within SNRs it is restricted to perform any kind of activity which might degrade or pollute its environment, these are not isolated from sources of pollution originating from outside SNRs. Therefore, the aim of this research was to examine water quality at three SNRs, in the Province of Vojvodina, Serbia, where degradation of the environment due to anthropogenic influences is present. Whereas in the SNR Ludaško jezero (Ludaš Lake) and in the SNR Obedska bara (Obedska Pond) serious euthropic processes are present due to agricultural runoff and untreated wastewater, the SNR Stari Begej - Carska bara (Old Bega River - Imperial Pond) is under the potential influence of fish farms and agriculture. Besides, the SNRs are not covered by the hydro-meteorological monitoring network and therefore this research will provide valuable data on water quality.

## 2. MATERIAL AND METHODS

### 2.1. Study sites

Water samples were taken from water bodies within three SNRs within the Province of Vojvodina which are protected since they represent natural features of unique value and beauty (Fig. 1).

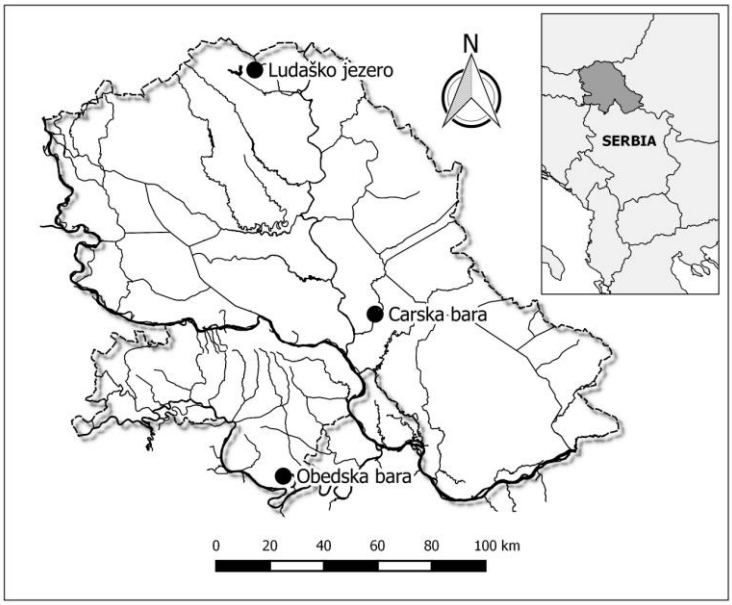


**Fig. 1.** ***SNRs within Vojvodina province where monitoring was conducted***

SNR Ludaško jezero is located in the north of Vojvodina close to the border with Hungary. The lake is the only shallow lake of the steppe region in

Serbia. Its water originates from draining of sandy area and a series of salty depressions and from the river Kireš (Amidžić et al., 2007). The whole protected area is on 846 ha (http://biodiverzitet-chm.rs/).

SNR Stari Begej – Carska Bara is positioned in central Banat, in the alluvial plane of the rivers Tisa and Begej. It represents a mosaic of natural ecosystems (river, pond, swamp, salt marsh, steppe, meadow, and forest) and anthropogenic ones (commercial fish pond and arable land) resulting in exceptional richness of species and ecosystems (Amidžić et al., 2007) and outspreads on 4 726 ha (http://biodiverzitet-chm.rs/).

SNR Obedska bara is situated in the alluvial plane of the river Sava in the very south of the Vojvodina province. It is the largest alluvial area in Serbia composed of a variety of ecosystems (forest, pond, swamp and meadows) (Amidžić et al., 2007) covering 9 820 ha (http://biodiverzitet-chm.rs/).

### 2.2. Sampling and analyses

The monitoring conducted in spring/summer period (Jun-July) and in autumn (October-November) in 2015 at all SNRs included water sampling. The samples were taken from two locations at SNR Ludaško jezero, from the north and the south part in order to examine water quality parameters and microbiology since difference of salinity has been reported (Rudić et al., 2014). The sampling conducted at SNR Stari Begej-Carska bara was performed at four locations: at areas under protection – Traktor bara (Traktor pond) and Stari Begej (Old Bega River) - auxiliary dock; neraby canals – Šovajka kanal – a canal buffering influences of comercial fish ponds towards protected areas and from ameliorative canal G1 kanal which directly discharges into Carska bara. Whereas, the sampling at SNR Obedska bara was conducted at two loctions: Obedska bara and ameliorative canal Revenice kanal which is finishing into the protected pond. All samples were taken from 0-50cm depth.

The monitoring included basic water quality parameters measured on site (air and water temperature, dissolved oxygen (DO), pH and conductivity). Furthermore, samples were taken to the Faculty of Agriculture, University of Novi Sad where other parameters were analysed in laborathores. Laborathory analyses included biochemical oxygen demand (BOD), total organic carbon (TOC) and nutrient parameters: ammonium ($NH_4$-N), nitrites ($NO_2$-N), nitrates ($NO_3$-N), orthophosphates ($PO_4$) and total phosphorus (total P). A special attention has been paid to water mineralization involving analyses of anions ($CO_3^{2-}$, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$) and cations ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$).

Microbiological analysis included the determination of total number of saprophytic bacteria, the number of fungi, number of coliform bacteria, number of *Echerichia coli* and the number of sulphite reducing clostridia (genus *Clostridia*). The number of microorganisms was determined, using the dilution method (Trolldenier 1996). Appropriate nutrient media were used: nutrient agar for the number of saprophytic bacteria, Chapeck–Dox agar for fungi, HiCrome Salmonella agar for the number of coliform bacteria and *Echerichia coli*, and medium with

pepton (pepton 15 g $l^{-1}$, extract yeast 9 g $l^{-1}$, $NaSO_3$ 0.5 g $l^{-1}$, agar 15 g $l^{-1}$; after medium sterilization, 20 ml of 7% solution of FeSO4 was added) for the sulphite reducing clostridia.

## 3. RESULATS AND DISCUSSION

### 3.1. Chemical status of SNRs

Chemical status of surface water bodies in Serbia has been characterized by the Regulation 50/2012/RS and Regulation 74/2011/RS, both complying with the Water Framework Directive of the EU (Directive 2000/60/EC). Results of the monitoring conducted at the three SNRs are interpreted in the following text according to the mentioned regulations.

One of the most important WQ parameters important for sustaining aquatic life is the DO. The highest values of this parameter, as well as % of DO saturation measured at Ludaško jezero at both sites for spring/summer are showing supersaturation which is an indicator of algal blooms; for Ludaš north and south respectively: >17 and 15.24 $mgO_2/L$; >200 and 170%. Besides, high pH values above 9 were also indicating the same process. At all other sampling locations and for both seasons DO and DO saturation were in range of moderate to good except at Traktor bara and Stari Begej in autumn when a DO deficit has been measured (30% and 33% respectively). BOD measurement conducted only for spring/summer period showed bad status (>20 $mgO_2/L$) at most sampling sites when values were in range 18.0 - 29.5 $mgO_2/L$. Only moderate status was observed at Ludaš south (10.4 $mgO_2/L$). Apart from the mentioned pH values monitored at sites at Ludaš pH values were in range 7.4 - 7.86 referring to high - moderate status. The highest values for conductivity were observed at Ludaš south in autumn 1347 μS/cm and in spring/summer 1068 μS/cm indicating high salinity. Moreover, high values were measured also in autumn in amelioration canals Revenice kanal (1009 μS/cm) and G1 kanal (1267 μS/cm). At all other sites conductivity was relatively low ranging from 340 μS/cm at canal Šovajka in spring/summer to 879μS/cm at Ludaš north in autumn.

For most of the sampling sites nitrites concentrations were below 0.03 mgN/L indicating high status for this parameter, except for autumn measurements at Traktor bara and Stari Begej were 0.07 mgN/L of nitrites was recorded indicating moderate status. Concerning nitrates, high status (<1 mgN/L) has been measured at most sites except for Ludaš north (autumn), Ludaš south (spring/summer), Obedska bara (autumn) and G1 kanal (autumn) were moderate status was observed with concentrations <3 mgN/L. At most sampling sites ammonium concentrations were relatively low ranging from <0.02 to 0.11 $mgNH_4/L$ and showing high to good status. The highest concentrations were measured in autumn at Ludaš north (1.25 $mgNH_4/L$) and G1 kanal (1.19 $mgNH_4/L$) leading to bad status, whereas at Traktor bara (0.76 $mgNH_4/L$) the status was moderate (0.3 - 0.8 $mgNH_4/L$) and bad status (0.8 - 1 $mgNH_4/L$) was recorded at Stari Begej (0.83 $mgNH_4/L$).

Good status of orthophosphates (<0.1 mg$PO_4$/L) was recorded only at Ludaš north and south, whereas at all other sampling point concentrations were relatively high 0.29 - 0.99 mg$PO_4$/L indicating poor - bad status. In contrast to low concentrations of orthophosphates at Ludaško jezero sampling sites concentrations of total P are moderate to poor which indicates that inorganic P has been converted to organic during algal bloom. Moderate status (0.2 - 0.4 mgP/L) for total P has been recorded at nine sampling sites and poor status (0.4 - 1 mg$PO_4$/L) was measured at seven sampling sites (Fig. 2b).

Concerning total N high status was recorded at nine sampling sites (<1 mgN/L), at one it was good (1 - 2 mgN/L), at five locations it was moderate (2 - 8 mgN/L) and only for Ludaš north in spring/summer it was poor - 8.8 mgN/L (Fig. 2a). TOC was measured only in spring/summer period and moderate status was recorded at five sampling sites were concentrations were in range 14 - 23 mgC/L, while at other three status was bad (> 23 mgC/L): Traktor bara - 34 mgC/L, Ludaš south - 64 mgC/L and Ludaš north - 86 mgC/L (Fig. 2c).

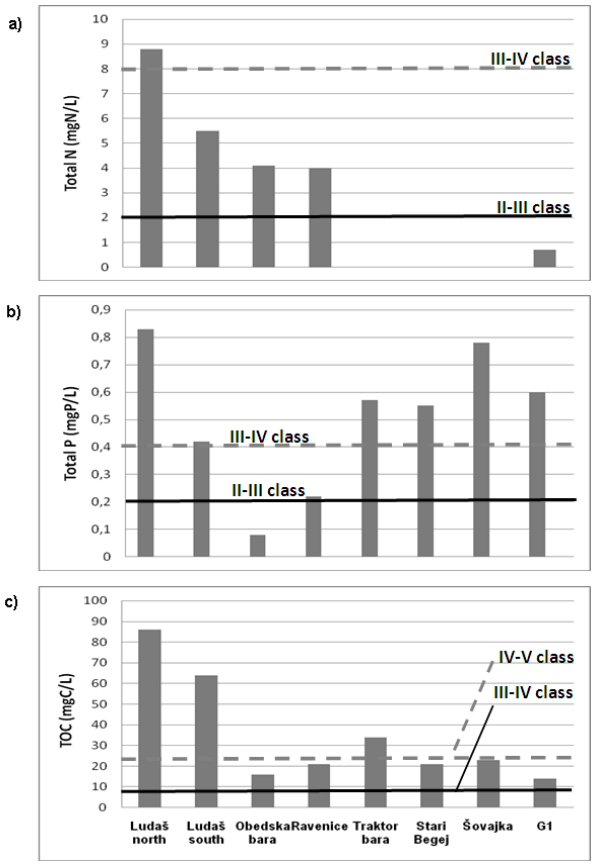


**Fig. 2.** ***Concentrations of total N (a), total P (b) and TOC (c) measured at SNRs in spring/summer period***

### 3.2. Mineralization of SNRs

The geological evolution of the Pannonian plain is that of a desiccated basin in which surface and underground waters have played a major part in the shaping and dynamics (Petrović, 1980). Therefore, salinity of shallow lakes and ponds in the region of Vojvodina has been developed due to processes of draining saline underground waters into these shallow surface water bodies. One of the aims of the paper was to examine chemical composition of anions and cations which contribute to salinity of water at SNRs and the results are presented in the Table 1.

**Table 1.** ***Minarelization at monitored SNPs for spring/summer period***

| No. | Sampling site | **Aniones** (mg/L) | | | | **Cationes** (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $CO_3^{2-}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ |
| **1.** | Ludaš north | 45.0 | 342.9 | 140.4 | 441.4 | 240.5 | 236.6 | 9.92 | 62.53 |
| **2.** | Ludaš south | 48.0 | 480.2 | 216.6 | 438.0 | 290.6 | 303.8 | 11.42 | 73.10 |
| **3.** | Obedska bara | 0.0 | 380.2 | 83.0 | 378.0 | 108.5 | 34.4 | 44.22 | 31.06 |
| **4.** | Revenice kanal | 0.0 | 577.9 | 76.6 | 385.2 | 159.3 | 89.1 | 40.04 | 46.33 |
| **5.** | Traktor bara | 0.0 | 661.5 | 487.1 | 385.2 | 189.7 | 188.1 | 52.90 | 15.83 |
| **6.** | Stari Begej | 0.0 | 169.6 | 33.0 | 375.1 | 79.8 | 20.7 | 34.20 | 9.10 |
| **7.** | Šovajka kanal | 0.0 | 317.3 | 47.1 | 373.7 | 115.0 | 49.3 | 34.03 | 16.11 |
| **8.** | G1 kanal | 0.0 | 203.8 | 37.2 | 377.0 | 86.7 | 101.7 | 30.38 | 11.52 |

Since the salinity of these shallow water bodies is very variable depending on the seasons and years the major ion composition and chemical types has been determined for all sampling sites according to the percentage of equivalent sum of total cations or anions exceeding 25% in a simmilar manner as Petrović (1980). According to the obtained results water bodies at sampling sites SNRs can be characterised as Na - K- $HCO_3$ - $SO_4$. Exceptions are Traktor bara with Na - K- $HCO_3$ - Cl and Stari Begej and Obedska bara with Na - $HCO_3$ - $SO_4$.

### 3.3. Microbiological aspect

Saprophytic bacteria play an important role in the process of water purification. In this study, the number of saprophytic bacteria was very high at the sampling sites within protected are at SNR Stari Begej – Carska bara in autumn ($5.17 \times 10^4$ CFU/ml), while the minimum was in July at the sampling site Obedska bara, $6.43 \times 10^2$ CFU/ml. These bacteria have capability to use a variety of pollutants as a source of nutrients.

*Escherichia coli* cause many human diseases such as diarrhea, urogenital tract infection, sepsis and other. It also serves as an indicator of water quality (Higgins et al., 2009). The presence of enterobacteria *E. coli* in the water at all sampling sites for spring/summer and autumn period indicates the flow of raw sewage into the water, while a relatively high abundance of these bacteria indicates a large contamination of the investigated localities. The largest number of *E. coli*

was recorded at the sampling sites within protected area of SNR Stari Begej - Carska bara in autumn and it was 4,30 x $10^3$ CFU/ml.

Bacteria of the *Clostridium* genus are anaerobic, commonly present in natural environment, e.g. they live in dust, soil, water, bottom sediments and in human and animal alimentary canals (Moriishi *et al*., 1996). Species of the genus *Clostridium* can synthesize strong exotoxins which can be lethal to humans and animals (Beckers *et al*., 2010). The total number of sulphite reducing clostridia in the water of invesigated localities was very high. The highest number was found at the sampling sites within protected area of SNR Stari Begej - Carska bara in autumn - 7,80 x $10^3$ CFU/ml.

## 4. CONCLUSIONS

Upon research and analyses conducted at three SNRs during 2015, for spring/summer and autumn period, major remarks can be summed up as following:

- Both, water quality and microbiological results have proven highly eutrophic status of the SNR Ludaško jezero. Generally, water quality of Ludaško jezero shows difference in salinity for Ludaš north and Ludaš south, which is higher in south part. Moreover, high values of total N, total P and TOC at both sampling sites are a consequence of algal bloom. Obtained results about difference in lake conductivity, nutrient contents and high pH agree with the results reported by Rudić et al. (2014).
- Water quality of sampling sites at SNR Stari Begej - Carska bara is ranging from high to moderate for most of the parameters. Generally, better water quality was monitored at sites within protected areas compared to ameliorative canal G1 kanal and Šovajka kanal. Besides, it is worth mentioning that in autumn at Traktor bara and Stari begej water was deteriorated due to extremely low water regime. Microbiological analyses also support this fact because presence of high number of saprophytic bacteria, *E. coli* and *Clostridium* have been determined.
- Monitoring conducted at SNR Obedska bara revealed that water quality at both sampling sites was better in autumn than in spring/summer period. Comparing the two sampling sites water was of better quality at Obedska bara than in ameliorative canal Revenice. Despite the good/moderate status of total N and P at Obedska bara, poor status for TOC and bad status of orthophosphates are indicating eutrophic processes.

According to the obtained results ionic composition of water at sampling sites within SNRs can be characterised as Na - K- $HCO_3$ - $SO_4$. Exceptions are Traktor bara with Na - K- $HCO_3$ - Cl and Stari Begej and Obedska bara with Na - $HCO_3$ - $SO_4$.

Presented results are just preliminary and further monitoring is needed in order to confirm dominant processes and to support an idea of necessity of establishing continuous monitoring stations at these SNRs.

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