

Basic Physico-Chemical Parameters of the Zapadna Morava River Water Quality in the Ovcар-Kablar Gorge Area

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Abstract: The Zapadna Morava River is an important component of the Republic of Serbia hydrosystem. During 2004, physico-chemical analyses were made of the Zapadna Morava water in the Ovcар-Kablar Gorge, a protected natural property where two hydroelectric power stations and two reservoirs are located. The physico-chemical analyses results show that the Zapadna Morava River water in 2004 was of lower quality than being prescribed for the I-II class. Throughout the greater part of the year, the water was polluted with ammonia. Nitrite and phenol concentrations were also occasionally higher than the I-II class standard prescribed. The presence of toxic substances in the water was due to a discharge of non-purified municipal and industrial waste waters. Toxic ammonia and nitrite effects on the living world of the river, on fish in particular, were determined.

Key words: the Zapadna Morava River, Ovcар-Kablar Gorge, pollution, eutrophication

Introduction

The Ovcар-Kablar Gorge area with its two hydroelectric power stations and two reservoirs, the Ovcар-Kablar and Medjuvrsje reservoirs, is protected as a natural property of the Republic of Serbia. According to the Regulation on Water Classification (Official Gazette of the RS 5/68), the prescribed water quality of the Zapadna Morava River in this area is of the II class. A discharge of unprocessed and inadequately purified industrial and municipal waste waters into

the watercourse has caused contamination of the water and a disturbance in the existing balances in the aquatic ecosystem.

Constant shallowing and influx of nutrients intensifying the eutrophication process, apart from permanent pollution, are characteristic of the ecosystems of the reservoirs.

Material and Method

Over 2004, physico-chemical analyses of the Zapadna Morava water in the Ovcar-Kablar Gorge were made. Samples for the analysis were collected from the "Ovcar Banja" (Ovcar Spa) Hydroelectric Power (HEP) Station canal as well as from the Morava river bed downstream from the dam of the "Medjuvrsje" hydroelectric power station. The analyses were made in the laboratories of the Health Institute Cacak and the Faculty of Agronomy in Cacak. The results obtained were analyzed and the effect of pollution (the presence of toxic substances) on the living communities exposed was examined.

Results and Discussion

The content of different substances and their impact on hydrobionts was largely affected by water temperature. The river water temperature in the Ovcar-Kablar Gorge ranged from 3°C in January and February to 20°C in July, August and September. The temperature difference between the surface layer of the water and the water layer at the bottom of the reservoir was highest in the warmest part of the year (July-September period) and did not exceed 4.5°C. It was observed that in relatively colder water spawning of thermophilic fish species is prolonged (Alabaster, Lloyd, 1982).

Throughout 2004, the river water had a mildly alkaline reaction. pH value ranged from 7.5 to 8.2 and from 7.7. to 8.2 downstream from the "Medjuvrsje" hydroelectric power station dam and in the "Ovcar Banja" hydroelectric power station canal, respectively. The values registered were within the I-II class standard. A more alkaline water reaction (pH>8.4), emphasized by the presence of ammonia, hinders the survival of ichthyofauna and other members of the water communities. It may be concluded that the Zapadna Morava water reaction in the Ovcar-Kablar Gorge area in 2004 was favourable for hydrobiont existence.

Total water hardness of the Zapadna Morava varied from 9.02 to 15.86°dH and transient hardness from 7.9 to 14.74°dH. The content of Ca^{2+} and Mg^{2+} ions in the river water downstream from the "Medjuvrsje" hydroelectric power station dam during 2004 is presented in Fig. 1. The electrical conductivity of the water ranged from 274.0 to 425.0 $\mu\text{S cm}^{-1}$. The results obtained point to its mild mineralization.

The ion content of certain heavy metals was examined in the channel of the 'Ovcar Banja' hydroelectric power station and downstream from the dam of the 'Medjuvrsje' station. For better transparency, only the contents of these potentially harmful substances in the river water downstream from the 'Medjuvrsje' station were presented (Fig. 2 and Fig. 3). Similar results were

obtained by analysis of the water in the channel of the 'Ovcar Banja' HE station. The diagram shows that ion concentrations of copper, lead, zinc, manganese, divalent and six-valent chrome are considerably (over fifty times on average) lower than the standards prescribed for the I-II-class waters.

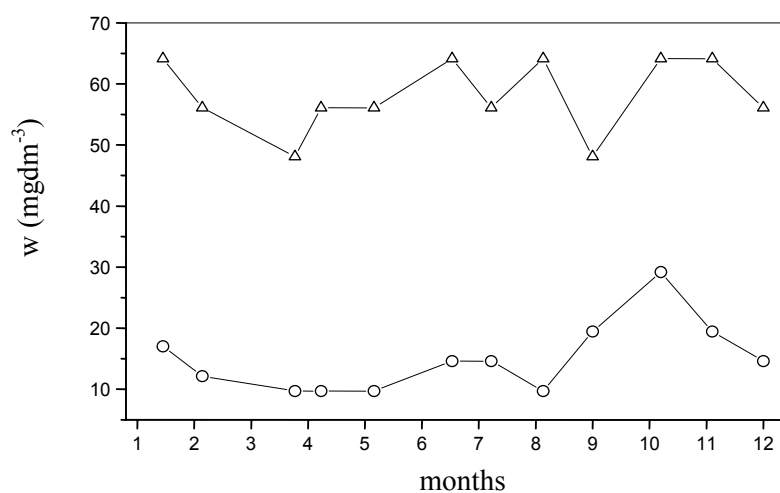


Fig. 1. Mass concentrations of: $\Delta\text{-Ca}^{2+}$ and O-Mg^{2+} in the Zapadna Morava water downstream from the "Medjuvrsje" dam during 2004

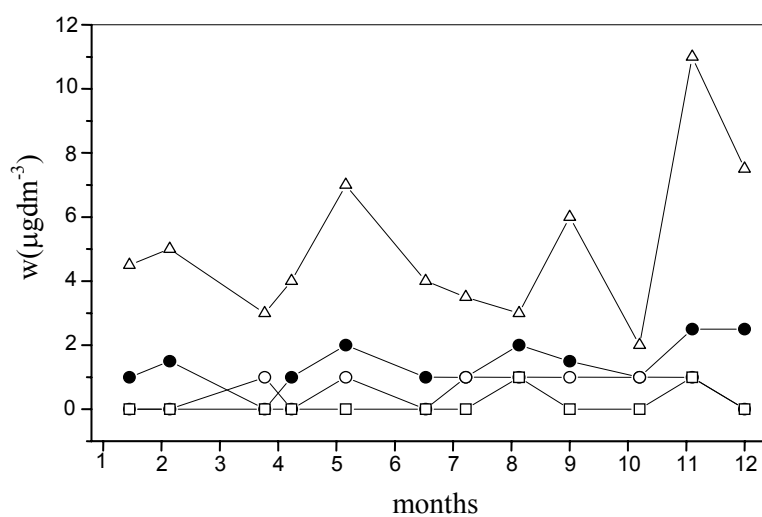


Fig. 2. Mass concentrations of: $\Delta\text{-Ca}^{2+}$; $\bullet\text{-CrO}_4^{2-}$; O-Pb^{2+} ; $\square\text{-Cr}^{3+}$ in the Zapadna Morava water downstream from the "Medjuvrsje" dam during 2004

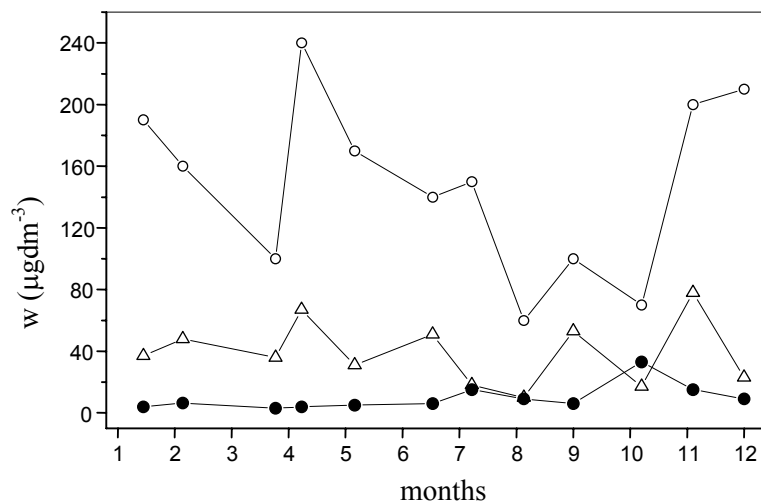


Fig. 3. Mass concentrations of: O-iron; Δ-manganese and •-zinc in the Zapadna Morava water downstream from the "Medjuvrsje" dam during 2004

The iron concentrations were 1.3 to 6 times lower than the I-II water class standard. Relatively higher iron ion content, compared to ions of other heavy metals, was probably due not only to the character of the pedological substrate but also to corrosion of waste iron objects found in the beds of the Zapadna Morava and its tributary streams. Cadmium, arsenic, nickel and mercury contents were not systematically established (a small number of samples). Registered concentrations of these elements were considerably lower than the prescribed I-II water class standard. However, it should be underlined that the Zapadna Morava ecosystem was polluted with mercury several times a dozen years ago (Markovic 1996). Most of the heavy-metal ions are cumulative toxins being deposited in certain tissues of live organisms (liver, muscles and other fish organs). Cadmium contents exceeding the permitted standards were registered in dead nase bodies sampled in the river water in the Ovcara-Kablar Gorge area during 2002 (Lazic et al. 2003).

The concentration of dissolved oxygen in the Zapadna Morava water in the Ovcara-Kablar Gorge region ranged mostly from 6.0 to 10.5 mg dm⁻³. Lower dissolved oxygen concentrations were recorded during summer months. The registered dissolved oxygen amounts were adequate for normal hydrobiont life activities. It should be emphasized that relatively high concentrations (higher than 7 mg dm⁻³O₂) of dissolved oxygen are required for an optimal cyprinid species growth (Mitrovic-Tutundzic, Brkovic-Popovic 1995).

Values of biological and chemical oxygen consumption being BOC₅ < 3.7 mg dm⁻³ and COC < 6.0 mg dm⁻³, respectively, as well as those of KMnO₄

consumption indicated the presence of small amounts of organic matters and a reduced microbiological watercourse load.

During 2004, the suspended matter contents were generally within the I- and II_A-class standards – mostly below 22 mg dm⁻³. Inert suspended matter concentrations higher than 25 mg dm⁻³ reduce fish production whereas concentrations higher than 400 mg dm⁻³ make it completely cease (Alabaster, Lloyd 1982).

Detergent concentration varied from 0.012 to 0.040 mg dm⁻³, being considerably lower than the permitted I and II water class values (0.4 mg dm⁻³).

Phosphate content in the "Ovcar Banja" hydroelectric power station canal and that registered downstream from the "Medjuvsje" HEP station dam ranged from 0.133 to 0.020 mg dm⁻³ and from 0.074 to 0.005 mg dm⁻³, respectively. Higher phosphate content in the "Ovcar Banja" canal water indicated that the relatively high pollution was caused by fecal and partly by other waste water discharges in the upstream watercourse. Lower phosphate concentrations in the watercourse downstream from the "Medjuvsje" reservoir resulted from their being used by plankton algae and higher plants (macrophytes) in the lake and incorporated into the plant tissue structures. Registered phosphate concentrations confirm the intensive eutrophication of the lake ecosystem.

Phenol concentrations were determined only in the river water downstream from the dam of the "Medjuvsje" hydroelectric power station. In the first 5 months of 2004, the phenol concentration was about 0.001 mg dm⁻³. In the second half of the year (at lower water levels) it was a little higher, about 0.002 mg dm⁻³. The phenol in the Zapadna Morava river water generally originates from a discharge of non-purified waste waters from sawmills. The presence of the toxicant was less due to degradation of dead phytoplanktonic organisms (autochthonous pollution).

The phenol present did not cause nerve-paralytic, necrotic, inflammatory or other typical pathological changes in the fish. However, it should be stressed that the phenol effect on hydrobionts increases in the presence of other damaging substances (ammonia, copper, zinc etc.) – the incidence of synergism. Phenols are cumulative toxins that accumulate in certain tissues over time. Fish cannot acclimatize to the presence of phenol in natural conditions (Mitrovic-Tutundzic, Brkovic-Popovic 1995).

Nitrate concentrations in the Zapadna Morava water in the Ovcar-Kablar Gorge region were within the I-II-class standards and ranged from 1.00 to 2.40 mg dm⁻³.

Nitrite concentrations during 2004 are presented in Figure 4. The dependence concerned show that there was a rapid nitrite concentration increase in the "Ovcar Banja" HEP station canal during July and downstream from the "Medjuvsje" dam in June and July. Based upon the diagram presented it could be concluded that the rapid nitrite concentration increase was caused by draining of waste waters from the industrial facilities located upstream. The high nitrite pollution was likely to be the cause of fish death in this part of the watercourse during 2004.

Nitrites are intermediates of mineralization and denitrification. Their content increases under poor aeration conditions. Since aeration is poorest on the bottom of the reservoir, the highest nitrite concentrations are present in this zone.

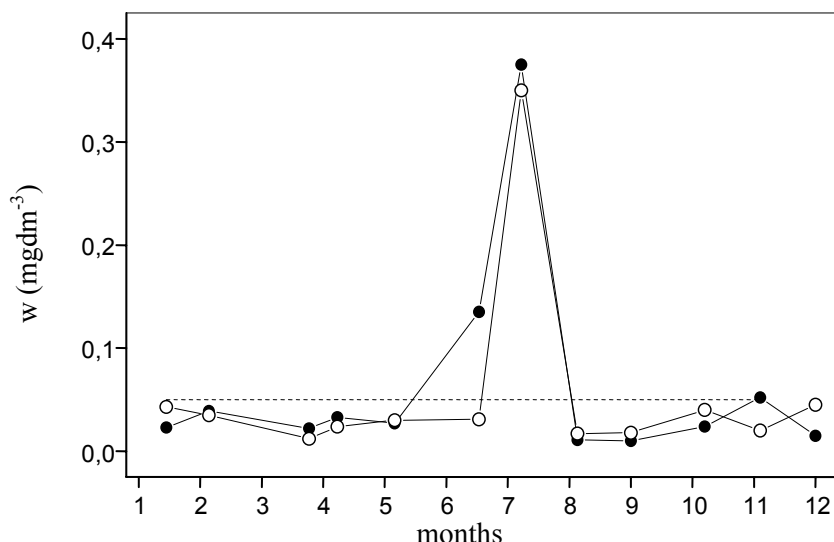


Fig. 4. Mass nitrite concentration in the Zapadna Morava river water; ●- downstream from the "Medjuvrsje" HEP station dam and ○- in the "Ovcar Banja" HEP station canal. The line presented (-----) stands for nitrite standards for I- and II- water class.

The water pollution of the Zapadna Morava river in the Ovcar-Kablar Gorge region originated mainly from the presence of ammonia (Fig. 5). The ammonia concentration during 2004 was in most samples considerably higher than the concentration prescribed by the I-II water class standard (0.1 mg dm^{-3}). The increase in the ammonia content in the water was generally caused by discharge of non-purified municipal and industrial waste waters. In the streambank area of the Zapadna Morava in the Ovcar-Kablar Gorge region there is a large number of weekend cottages whose residents discharge feces directly into the river causing increased ammonia content in the water. Degradation of dead plant and animal organisms in the lake (autochthonous pollution) contributes to the ammonia content increase.

There exists a balance between NH_3 and NH_4^+ in the aqueous solution. With the increases in temperature and pH value of the solution the balance shifts towards an increase in NH_3 concentration. In warmer water, ammonia has a pronounced toxic effect on the living world, particularly on the fish that are the most pollution-sensitive members of aquatic biocenoses. Ammonia concentrations from 0.2 to 2.0 mg dm^{-3} cause certain pathological changes and even death of some fish species. In the exosystem examined, symptoms of ammonia fish intoxication were registered, being the following – gill epithelium necrosis, caudal fin injuries and turning of fish with stomach up (Markovic et al. 2003). The toxic ammonia effect

is most pronounced in fry and sexually immature individuals (Alabaster, Lloyd 1982). The ammonia effect on cyprinoid species is most pronounced in the chub (*Leuciscus cephalus*), gudgeon (*Gobio gobio*) and perch (*Perca fluviatilis*) (Lukjanenko 1983).

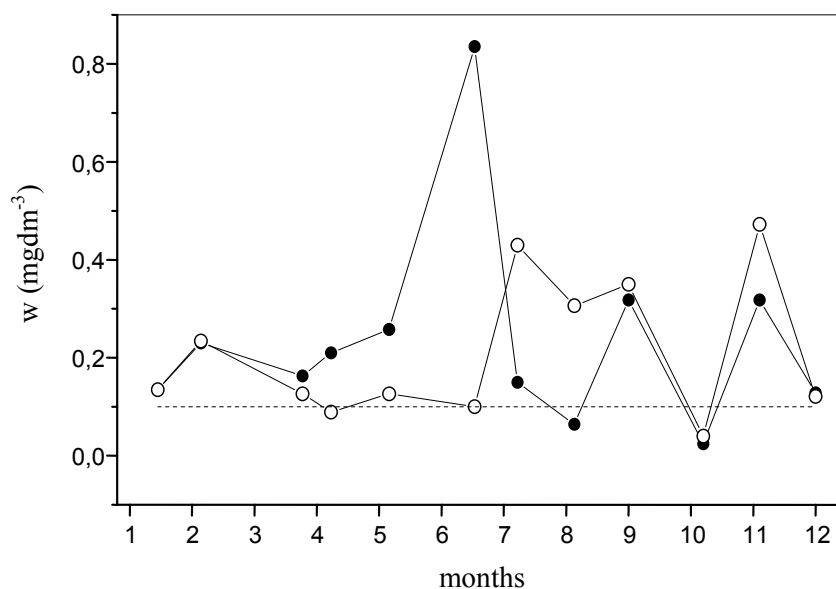


Fig. 5. Mass ammonia concentration in the Zapadna Morava River water; ●- downstream from the "Medjuvrsje" dam and ○- in the "Ovcar Banja" canal. The line presented (-----) stands for ammonia standards for I- and II- water class

Conclusion

The physico-chemical analyses results show that the Zapadna Morava River water in 2004 was of lower quality than being prescribed for the class I-II. Throughout the greater part of the year, the water was polluted with ammonia. Nitrite and phenol concentrations were also occasionally higher than the I-II class standard prescribed. The presence of toxic substances in the water was due to a discharge of non-purified municipal and industrial waste waters. Toxic ammonia and nitrite effects on the living world of the river, on fish in particular, were determined.

References

- Alabaster, J., Lloyd, R. (1982): Water Quality Criteria for Freshwater Fish. Butterworths, FAO, England.
- Lazić, T., Marković, G., Nikolić, D., Đurić, S. (2003): Prisustvo teških metala u nekim vrstama riba akumulacije Međuvršje. *Zaštita voda* 2003, Zlatibor, 59-62.
- Lukjanenko, V.I. (1983): Obščaja i piščevaja promišlenost. Moskva, s. 320.
- Marković, G. (1996): Živa – letalna opasnost za ribe naših voda. *Voda i sanitarna tehnika*, 26 (5), 57-62.
- Marković, G., Lazić, T., Aćamović – Đoković, G., Đurić, S. (2003): The effect of ammonia pollution on the Medjuvrsje reservoir ichthyofauna during the year 2002. II Regional Symposium "*Chemistry and the Environment*", Kruševac, 209-210.
- Marković, G., Spasojević, M., Rafailović, L., Ribić-Zelenović, L. (2004): Physico-chemical characteristics of the Zapadna Morava river water on the area of the Ovcara-Kablar gorge (West Serbia). *XVIII Congress of the Chemists and Technologists of Macedonia*. Ohrid, pp. ECH-13.
- Mitrović-Tutundžić, V., Brković-Popović, I. (1995): Normativi kvaliteta voda za ribarstvo. II Jugoslovensko savetovanje "Ribarstvo Jugoslavije" '95, Kotor, 121-126.

**OSNOVNI FIZIČKO-HEMIJSKI POKAZATELJI KVALITETA
VODE REKE ZAPADNE MORAVE NA PODRUČJU OVČARSKO-
KABLARSKE KLISURE**

- originalni naučni rad -

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Rezime

Rezultati fizičko-hemijskih analiza pokazuju da je voda reke Zapadne Morave tokom 2004. godine bila lošijeg kvaliteta nego što je predviđeno za I-II klasu. Tokom većeg dela 2004. godine, voda je bila zagađena amonijakom. Povremeno su i koncentracije nitrata i fenola bile veće od predviđenog normativa za I i II klasu. Prisustvo toksičnih supstanci u vodi je predstavljalo posledicu izlivanja neprečišćenih komunalnih i industrijskih otpadnih voda. Ustanovljen je toksičan efekat amonijaka i nitrita na živi svet vodotoka, posebno na ribe.