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10.46793/SBT26.357P

DOI: 10.46793/SBT26.357P

SEASONAL VARIATIONS OF THE ZAPADNA MORAVA RIVER WATER QUALITY

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Abstract: The water samples collected from four localities of the middle course of the Zapadna Morava River during 2020 were analyzed *via* the selected physico-chemical parameters with the aim to estimate the quality of surface water. According to the results of selected physico-chemical parameters (pH, conductivity, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand), analyzed surface water show a good chemical status, while the values of nutrient content (nitrate, nitrite, ammonium ion, total phosphorus) indicated the poor chemical status especially at the locality **4** probably due to the outflow of wastewater from the city of Čačak as well as from the influence of the polluted water of the Čemernica River.

Key words: water quality, dissolved oxygen, ammonium ion, total phosphorus

Introduction

Zapadna Morava River (308 km long) is the central component of the West Serbia hydrosystem. It rises in Požeška Kotlina valley from Moravica and Đetinja River which join the Južna Morava River near Stalać forming the Velika Morava River. The river bed is rocky-pebbly in its upper and middle course, while muddy substrate dominates in the downstream course. The river occasionally floods (the last catastrophic floods were recorded in 2014). There are more than 30 urban, several hundred rural settlements in the Zapadna Morava catchment river basin (area 15 849 km^2). The river is a big recipient of large quantities of wastewaters from Čačak, Kraljevo, Kruševac and other places and close to 200 industrial polluters (Marković et al., 2018). In the previous period the water quality of this watercourse was deteriorated by increased emission of nitrites, detergents, heavy metals (primarily mercury and cadmium), phenols and other pollutants (Obradović and Filipović, 2009; Novaković, 2013). The elevated levels of ammonium ion (NH_4^+) and bacterial contamination have been observed (Cakić et al., 2018), as well as the presence of mineral oils during 2019-2020 (unpublished data).

This work was aiming to evaluate the quality of the Zapadna Morava river water in different seasons based on the selected physicochemical parameters.

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Material and methods

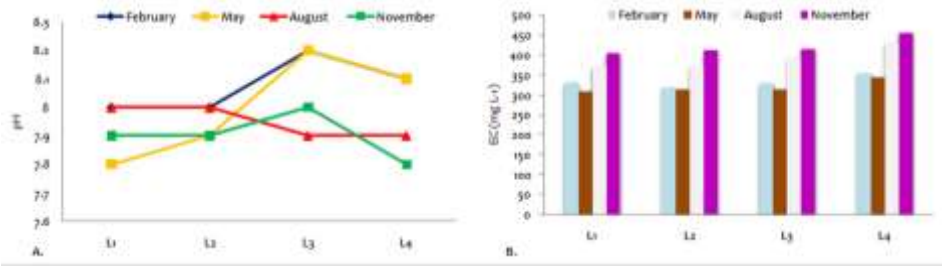
The samples of the Zapadna Morava River, labeled as **L1**-**L4**, were collected and analyzed during 2020 from four localities (**1**-**4**) of the Zapadna Morava's middle course (Figure 1). Selected physico-chemical parameters: pH, conductivity, dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrate (NO_3^-), nitrite (NO_2^-), ammonium ion (NH_4^+) and total phosphorus, were determined using standard methods (Kostić et al., 2016; APHA, AWWA, WPCF, 2012).

Figure 1. Localities **1**, **2**, **3** and **4** on the middle course of the Zapadna Morava River

Results and discussion

The results of physico-chemical parameters of investigated water samples are presented in Graphs 1 and 2.

The pH is one of the most important variables in water quality estimation due to the fact it affects many chemical and biological processes in water and all processes related to water supply and processing (Chapman and Kimstach, 1996).



Graph. 1. Seasonal variation of pH and conductivity (µS cm^{-1})

Graf 1. Sezonske promene vrednosti pH i provodljivosti (µS cm^{-1})

The measured pH values of all analyzed samples were around 8, which indicatethat the water is moderately alkaline throughout the year (Graph 1A).

Conductivity is the electrical property of water and depends on several factors such as concentration, mobility and charge of the ions present (Chapman and Kimstach, 1996). The water conductivity at most examined locations was below 400 μS cm^{-1} except for the water samples collected in November where the conductivity values were up to 450 μS cm^{-1} (Graph 1B). Measured conductivity values indicate favorable irrigation water quality, according to salinity hazard criterion (Bauder, 2011).

Oxygen is essential to all forms of aquatic life, including those organisms responsible for the self-purification processes in natural waters (Chapman and Kimstach, 1996). The lowest values of dissolved oxygen were noticed in samples taken in August (≈ 7 mg L^{-1}), while the highest values were obtained for samples collected in February, especially at locality **4** (11.2 mg L^{-1}) (Graph 2E and A, respectively). According to the criteria of water quality for fish culture, the river contains a desirable range of dissolved oxygen to provide the basic conditions for fish survival (Bhatnagar and Devi, 2013).

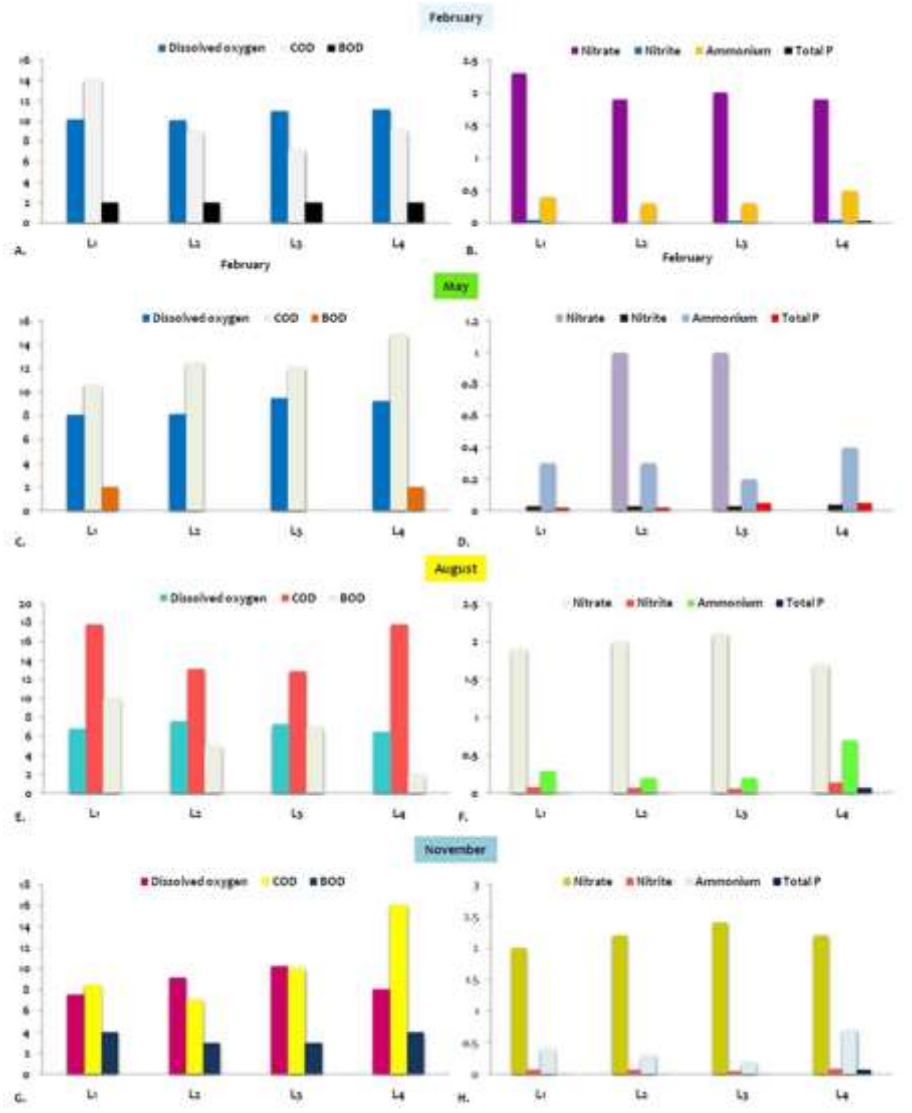
The chemical oxygen demand (COD) is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in the water bodies and in the effluents from sewage and industrial plants. On the other hand, the biochemical oxygen demand (BOD) is an approximate measure of the amount of biochemically degradable organic matter present in a water sample (Chapman and Kimstach, 1996). The results have shown that the values for COD and BOD were the highest in summer indicating that the pollution of the river is higher at that time of year (Graph 2A, C, E and G).

In addition, it was noticed that the concentration of NO_3^- was the lowest in May (≈ 1 mg L^{-1}), while in other measured periods value of nitrate was around 2 mg L^{-1} (Graph 2A, C, E and G). Natural sources of nitrate to surface waters include igneous rocks, land drainage and plant and animal debris (Chapman and Kimstach, 1996).

Further, the samples collected in May and February contained the lowest amount of NO_2^- (0.02-0.04 mg L^{-1}), while the values of this parameter were 2-3 fold higher in August and November (Graph 2B, D, F and H). High nitrite concentrations are generally indicative for industrial effluents and are often associated with unsatisfactory microbiological quality of water (Chapman and Kimstach, 1996).

In the environment, besides nitrate and nitrite, nitrogen also occurs as an ammonium ion (NH_4^+). It has been known that ammonia is toxic to fish and that its toxicity increases with increasing pH and temperature of the water (Bhatnagar and Devi, 2013). The study of the examined water samples indicated that the highest concentration of NH_4^+ ions was recorded at the locality **4** during all tested time period and ranged from 0.4-0.7 mg L^{-1} (Graph 2B, D, F and H). According to the basic criteria that the water must fulfill for fish culture, obtained results showed that the river at this locality contains the amount of NH_4^+ which could be detrimental for fish survival (Bhatnagar and Devi, 2013). Based on the average

values of NH_4^+ ion, the water quality on locality **4** corresponded to poor ecological status (class IV of surface water) (Official Gazzete, 2001).



Graph. 2. Seasonal variation of dissolved oxygen (mg L^{-1}), chemical oxygen demand (COD)(mg L^{-1}), biochemical oxygen demand (BOD)(mg L^{-1}), nitrate (mg L^{-1}), nitrite (mg L^{-1}), ammonium ion(mg L^{-1}), total phosphorus (mg L^{-1})

Graf 2. Sezonske promene rastvorenog kiseonika (mg L^{-1}), hemijske potrošnje kiseonika (mg L^{-1}), biološke potrošnje kiseonika (mg L^{-1}), nitrata (mg L^{-1}), nitrita (mg L^{-1}), amonijum jona (mg L^{-1}) i ukupnog fosfora (mg L^{-1})

In natural waters, phosphorus occurs mostly as dissolved orthophosphates and organically bound phosphates (Chapman and Kimstach, 1996). It is a restrictive nutrient for algal growth and controls the primary productivity of a water body. Artificial increase in concentration due to human activities is the main cause of eutrophication. Similarly to NH_4^+ ion, the highest concentration of total phosphorus was recorded on locality **4** with the range from 0.04 mg L^{-1} in February to 0.08 mg L^{-1} in August and November, while the tested water samples collected on other localities show values between 0.02-0.03 mg L^{-1} (Graph 2B, D, F and H).

Chemical status of analyzed surface water was assessed by comparing the obtained results (Graphs 1 and 2) with the national quality status directive (Official Gazzete, 2001). General physico-chemical parameters (pH and conductivity) were within the limits of good chemical status: pH values were in the range 6.8–8.5 and conductivity was mostly below 400 μS cm^{-1}, except in November, when a slight increase in conductivity was registered, due to lower water level of the Zapadna Morava River. Parameters describing the oxygen regime – dissolved oxygen, COD and BOD, mostly indicated good chemical status, with the exception of elevated values of BOD (> 4 mg L^{-1}) in August, stipulating moderate to poor chemical status of Zapadna Morava River. This is attributable to intensified degradation of organic matter during the summer period.

However, nutrient content (nitrate, nitrite, ammonium ion and total phosphorus) on each location indicated the poor chemical status of analyzed surface waters. Nitrate concentrations were not especially high – all registered values were in the range 1–5 mg L^{-1}, or even < 1 mg L^{-1}, which was consistent with good chemical status. Excessive nitrite concentrations (> 0.05 mg L^{-1}), indicating poor surface water quality, were typical for August and November, as the result of low water levels and the speed reduction of the river flow. Particularly high concentrations of ammonium ion (> 0.4 mg L^{-1}) and of total phosphorus (> 0.05 mg L^{-1}) were registered at the locality **4**, for the most part of the year, indicating poor chemical status. This locality is downstream from the outflow of wastewater from the city of Čačak, as well as from the mouth of the Čemernica River – the indirect wastewater receiver of the city of Gornji Milanovac (Marković et al., 2018).

Conclusion

The obtained results of the water quality of the middle course of the Zapadna Morava River analyzed during 2020. have shown that the values of studied general physico-chemical parameters were within the limits of good chemical status, with the exception of elevated values of BOD in August which had moderate to poor chemical status. On the other hand, nutrient content (nitrate, nitrite, ammonium ion, total phosphorous) in the each location exhibited the poor chemical status of examined water samples particularly at the locality **4** for the most part of the year, probably due to the fact that this locality is downstream from the outpouring of wastewater from the city of Čačak.

Acknowledgment

This work created as a result of research within the contract of the realization and financing of scientific research work in 2020 between the Faculty of Agriculture in Belgrade and Faculty of Agronomy in Čačak and the Ministry of Education, Science and Technological Development of the Republic of Serbia (Nos. 451-03-68/2020-14/200116, and 451-03-9/2021-14).

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