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ASSESSING SURFACE WATER QUALITY OF THE POREČKA RIVER

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Abstract: The Porečka River is located in Eastern Serbia and is a right tributary of the Danube. Using data from the Serbian Environmental Protection Agency (SEPA), the paper analyzes water quality using a combined physico-chemical index - Water Pollution Index (WPI). Data for the five year period 2018–2022 were analyzed on Mosna profile. The following parameters were taken into consideration: dissolved O_2, O_2 saturation, pH, suspended sediments, biological oxygen demand (BOD_5), chemical oxygen demand (COD_{Mn}), nitrites, ammonium, orthophosphates, metals (Fe, Mn, Ni, Cu, Pb, Cd, Hg), sulphates and coliform germs. The analyzed parameters provide insights into water quality and pollution levels.

Key words: The Porečka River, water quality, physical-chemical parameters, WPI;

INTRODUCTION

Water is a sustainable source of life and a key resource for human civilization. Researchers conduct extensive research on the quality of surface water, and the monitoring of its quality has an important impact on the planning of the sustainable use of water resources. This activity is considered a priority in all countries of the world.

The quality and quantity of water resources are influenced by population growth, land use changes, economic activities, climate change, and more. Human activities have significantly altered the physical, chemical, and biological characteristics of water ecosystems (Ding et al., 2015; Rajib et al., 2016). The quality of surface waters is determined by natural processes (geological, hydrological, climatic) and human activities (agriculture, mining, industry, urbanization, etc.).

Numerous research papers evaluate water quality using different water quality index models. Among other indices, authors most frequently refer to the WQI (Water Quality Index) as a simple indicator of watersheds pollution (Stricevic et al., 2021; Milijašević Joksimović et al., 2018; Leščešen et al., 2014; Iticescu et al., 2019; Qi et al., 2022) or apply the WPI (Water Pollution Index), which analyzes water quality using a combined physico-chemical index (Widodo et al.; 2019, Singh et al., 2023; Tran et al., 2023; Milanović Pešić et al., 2020; Milijašević et al. al, 2011; Popović et al., 2016; Brankov et al., 2012). The Water Pollution Index (Lyulko et al., 2001) represents an arithmetical way of integrating parameters for assessing the chemical and ecological status of inland waters.

This study assesses the Water Pollution Index (WPI) at the hydrological station Mosna on the Porečka River from 2018 to 2022. The analyzed parameters provide insights into water quality and pollution levels. The results can be used for further analysis of water quality and pollution in the Porečka River basin. Additionally, they can inform the development of guidelines and activities for water protection and utilization.

STUDY AREA

The Porečka River (Figure 1) flows into the Đerdap Lake near the town of Donji Milanovac. It is formed by the confluence of the Šaška and Crnajka rivers near Miloševa kula at an elevation of 155 meters above sea level. The Crnajka River originates from the slopes of Deli Jovan, while the Šaška River emerges below Velike Livade, northeast of Majdanpek. From their confluence to the mouth of

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the Porečka Bay, the river stretches for 19.1 km. The catchment area covers 516 km². Within the Đerdap National Park, there are 3.3 km of river course and 28.4 km² of catchment area (Milijašević, 2015). The river's estuary was submerged by the construction of the Đerdap Lake, and its valley has been transformed into an upstream bay near the settlement of Mosna. The river valley is wide, meandering, and elongated in a meridional direction between Liškovac and Veliki Greben. The largest right tributaries are Klokočevac, Zetnja, and Zmijanja, while the left tributaries include Radovica, Istrebinja, Topolnica, and Kosovica. It flows through the settlements of Klokočevac, Topolnica, and Mosna. The Porečka River belongs to rivers with a moderately continental variant of the rainy-snowy regime.

Figure 1. Porečka River near Mosna (Photo: M. Vuletić, 2024)

MATERIALS AND METHODS

Systematic analysis of the river water quality has been performed at the hydrological station profile Mosna. The research is based on the data from the Environmental Protection Agency, for the period from 2018 to 2022 (Ministry of Environmental Protection of the Republic of Serbia 2018-2022) (Annual report, 2018, 2019, 2020, 2021, 2022) for 18 physico-chemical parameters: dissolved O_2, O_2 saturation, pH, suspended sediments, biological oxygen demand (BOD_5), chemical oxygen demand (COD_{Mn}), nitrites, ammonium, orthophosphates, metals (Fe, Mn, Ni, Cu, Pb, Cd, Hg), sulphates and coliform germs.

The average annual values of the analyzed parameters were determined as the arithmetic mean of the conducted measurements. For metals, this occurs 3 to 6 times per year, while for coliform germs, it is approximately 4 times per year. As for the other parameters, measurements are carried out 10 to 12 times annually. However, coliform germs were not measured in the Porečka River during 2021. Therefore, the Water Pollution Index (WPI) for that year was calculated based on 17 parameters.

The WPI represents the sum of the ratio between the observed parameters and regulated standard values:

$$WPI = \sum_{i=1}^{n} \frac{Ci}{SFQS} \cdot \frac{1}{n}$$

where *Ci* is the average annual concentration of the analyzed parameters obtained on river water quality data. *SFQS* represents the standard values for the I water quality class in Serbia, while *n* indicates the number of analyzed parameters in the research. Standard threshold values of parameters are defined for each country by regulations. In Serbia, *SFQS* are values of parameters for class I of surface water according to national legislation (Official Gazette of the Republic of Serbia, No. 74/2011). The quality class according to WPI (Lyulko et al., 2000) are given in Table 1. Water quality is presented using 6 classes.

Table 1. Surface water classification based on WPI index

Class	Characteristics	WPI
I	Very pure	≤0.3
II	Pure	0.3-1
III	Moderately polluted	1-2
IV	Polluted	2-4
V	Impure	4-6
VI	Heavily impure	>6

The advantage of the WPI index is that it allows combination of different parameters. There is no limitation in the number or types of the used parameters.

RESULTS

The annual Water Pollution Index (WPI) values in the analyzed years indicate moderately polluted, polluted, and heavily impure water. Therefore, the water quality of the Porečka River falls within the range of categories III to VI. The lowest WPI values were observed in 2021 (WPI= 1.10), 2022 (WPI= 1.32), and 2019 (WPI= 1.39) when the river was categorized as III (Moderately polluted). In 2018, the WPI value was 2.87, corresponding to category IV (Polluted). The poorest water quality was recorded in 2020 with WPI values of 9.74, placing it in category VI (Heavily impure).

Apart from the average annual WPI values which indicate the pollution level of this river, the analysis of the influence of some parameters on the pollution level is also important. As it can be noticed from data in Table 2.

During 2020, the poorest water quality was observed due to a significantly increased concentration of coliform germs. The average value of coliform germs based on 4 measurements was 317,700 n/l. This concentration is 158.8 times higher than the permissible limit for the I water quality class in Serbia. If we exclude this parameter and calculate the Water Pollution Index (WPI) for 2020 based on the other 17 parameters, we obtain a WPI value ranging from 0.3 to 1, which corresponds to water quality category II (pure). This also serves as an indicator of how a single parameter can influence and alter water quality. The elevated number of coliform germs points to significant pollution originating from communal wastewater discharged by households in the surrounding settlements.

Table 2. Ratio of mean annual concentration and standards of the I water quality class for analyzed parameters and WPI

Parameter	2018	2019	2020	2021	2022
Dissolved O_2 (mg/l)	1.29	1.21	1.20	1.31	1.33
O_2 saturation (%)	1.06	1.03	1.00	1.05	1.12
pH	0.95	0.94	0.96	0.95	0.96
Suspended sediments (mg/l)	0.88	0.46	1.80	1.39	0.52
Biological oxygen demand (BOD_5) (mg/l)	2.10	1.29	1.03	1.43	1.24
Chemical oxygen demand (COD_{Mn}) (mg/l)	0.35	0.48	0.35	0.48	0.40
Nitrites (mg/l)	0.27	0.40	0.57	0.33	0.33
Ammonium (mg/l)	0.94	0.84	1.13	0.67	1.00
Fe (mg/l)	0.05	0.05	0.24	0.15	0.03
Mn (mg/l)	0.22	0.34	0.52	0.22	0.20

Ni (μg/l)	0.09	0.06	0.09	0.05	0.10
Hg (μg/l)	0.07	0.06	0.07	0.07	0.07
Sulphates (mg/l)	0.16	0.22	0.25	0.15	0.19
Orthophosphates (mg/l)	7.2	7.0	7.2	10.4	12.6
Cu (μg/l)	0.002	0.002	0.002	0.002	0.003
Pb (μg/l)	0.01	0.01	0.02	0.01	0.01
Cd (μg/l)	0.01	0.01	0.01	0.01	0.005
Coliform germs (n/l)	36.01	10.7	158.8		3.65
WPI	**2.87**	**1.39**	**9.74**	**1.10**	**1.32**

As it can be noticed from data in Table 2, certain parameters (pH, nitrites, sulfates, chemical oxygen demand (COD_{Mn}), metals analyzed, etc) are mostly within allowed limits of the regulated standard values for the I water quality class in Serbia and they do not have any influence on the pollution of Porečka River. On the other hand, the values of elements which are organic pollution indicators have increased considerably (BOD_5, coliform germs and orthophosphates). The average annual value of orthophosphate was 7.2 - 12.6 times higher than allowed for the I water quality class in Serbia.

Excess orthophosphate-P has a detrimental impact on river water quality worldwide (Tappin et al., 2016). Orthophosphates (PO_4^{3-}) are commonly found in water bodies, including rivers. They can come from agriculture (use of artificial fertilizers), municipal wastewater, industry. Soil erosion from agricultural lands transports phosphates into rivers. High phosphate levels contribute to eutrophi cation, excessive growth of algae and aquatic plants. Eutrophication reduces dissolved oxygen levels, affecting aquatic life.

CONCLUSION

The Water Pollution Index is based on assessing the deviation of specific parameters from the allowable values set by regulations for the first class. This approach allows us to identify parameters that have a more significant impact on pollution. For the Porečka River, the index is calculated based on 18 physico-chemical parameters. The index values indicate that water quality ranges from moderately polluted to heavily impure. The poorest water quality was observed in 2020, while the best was recorded in 2021. However, it's worth noting that coliform germs were not measured in 2021, which may have influenced the index value due to their exclusion from the calculation.

During the analyzed period, the most significant deviations from the standard values for Class I water quality in Serbia are coliform bacteria, orthophosphates, and BOD_5. This indicates that the waters of the Porečka River and its tributaries are mostly contaminated with organic compounds originating from untreated wastewater discharged from settlements.

The primary pollution sources in settlements include fecal contamination resulting from human activities, unregulated storage of household waste, and the discharge of inadequately treated wastewater. In the surroundings of the rural settlements there is a large number of uncontrolled trash dumps. These factors significantly impact water quality and pose risks to both the environment and public health. Improving the quality of surface water in the Porečka River basin involves constructing appropriate devices and systems for municipal water treatment, removing illegal landfills, and educating the population about the necessity of water protection.

The EU Strategy for the Danube Region (EUSDR) was collaboratively developed by the European Commission, Danube region countries, and relevant stakeholders, with the aim of addressing common challenges. One of the objectives of the EUSDR is to promote sustainable development and environmental protection in the Danube region. This includes activities related to conserving water resources, biodiversity, and reducing pollution. Implementing the strategy through various projects and activities can contribute to water protection within the Porečka River Basin.

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