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ASSESSMENT OF THE WATER QUALITY IN THE MORAČA RIVER BASIN (MONTENEGRO) USING WATER QUALITY INDEX

Abstract: In this paper, the water quality of the Morača River and its main tributaries (the Zeta and the Cijevna) were analyzed, using the Water Quality Index (WQI) methods. Data from 12 hydrological stations (HS) from 2010 to 2018 were used. The analysis included ten parameters of physic, chemical and microbiological water quality: oxygen saturation, BOD_5, ammonium ion, pH value, total nitrogen oxides, orthophosphates, suspended solids, temperature, electrical conductivity and coliform bacteria. Calculations for all 12 HS were made using the Serbian Water Quality Index (SWQI). The results of the research showed that the general situation is not discouraging, because the SWQI values ranged from 73-97, which according to the categorization of water quality corresponds to the classes good, very good and excellent. The only exceptions were the two measuring stations in the lower course of the Morača River (City Collector and Grbaci). During the entire observed period, the water quality was the worst on the profile of the City Collector (SWQI between 39 and 71) on Morača River. Also, downstream on Morača River, on HS Grbavci for 2015, the average annual value of SWQI was 70, which according to the gradation corresponds to the class of poor quality. The biggest sources of pollution were municipal wastewaters, followed by agricultural activities and illegal garbage disposal both along the stream and in the river itself. It follows that the lower part of the Morača River was the most polluted in the observed basin. This is a serious problem, especially since it is a part of the Morača River that flows through the most populated and most agriculturally active parts of Montenegro (Podgorica, Zeta Plain, Lješkopolje). Therefore, it is necessary to take adequate measures as soon as possible, which primarily relate to the introduction of wastewater treatment technology and to educate population about the importance of river water conservation.

Key words: SWQI, water pollution classes, Morača River Basin, Montenegro

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Introduction

In the age of accelerated social and economic development, as well as the growth of the world's population, the need for water and its consumption has increased. Meanwhile the amount of wastewater is also increasing. Precipitation and fecal waters are often discharged directly or without adequate treatment into watercourses and other water bodies. Polluted waters are less suitable for use or are almost completely unusable for any type of use (Dukić & Gavrilović, 2008). The number of natural lakes and reservoirs affected by eutrophication is also increasing, and neither the World Sea nor groundwater has been spared from wastewater pollution. The main users of surface and groundwater are settlements, industry and agriculture, and at the same time, in addition to thermal energy (thermal pollutants), these are the main sources of water pollution. In general, it could be concluded that the consumption of clean water is increasing, and that water resources are increasingly polluted. In addition to urban and industrial sources, surface and groundwater pollution also occurs due to various agricultural activities (Sasakova et al., 2018).

The catchment area of the Morača River is rich in numerous mountains, rivers, lakes, canyon valleys, flora and fauna. Let's mention some values: mountains Maganik, Prekornica, Garač, Prokletije (with peaks over 2,000 m), picturesque canyons (e.g. Platija Canyon, up to 1,100 m deep), several glacial lakes on mountains Kučki Komovi and Prokletije. There are also artificial lakes in Nikšić polje (Krupac, Vrtac, Slano and Liverovići), the largest lowlands of Montenegro (Zeta and Bjelopavlići), etc. Montenegro has 5 national parks (NP), and the border parts of the Morača River Basin belong to or are close to three national parks (Skadar Lake, Prokletije and Lovćen). These natural beauties need to be preserved from pollution, especially rivers. In order to obtain a more complete ecological picture, the main goal of this paper is to assess the water quality of the rivers Morača, Zeta and Cijevna, using the Water Quality Index (WQI) method.

There have been a growing number of water quality analyzes that rely on mathematical indices. Among them, Water Quality Index is most often used. Only physical and chemical parameters are used to calculate WQI by Mohiuddin-Farooqui (2020). Though, a number of authors (Morse et al., 2007; Yan et al., 2014; Rocha et al., 2015) emphasize the necessity of including various bio indicators in water quality assessment. Mititelu-Ionuş (2010) evaluated the water quality of the Motru River in Romania (a tributary of the Jiu River flowing into the Danube River) using WQI, i.e. all three groups of parameters (physical, chemical and biological). According to other researchers, the author indicates that in the Alps region, the ecological status of natural freshwaters was determined by analyzing phytoplankton as indicator - Brettum Index (BI) in Austria and Slovenia, Phytoplankton Saprobic Index (PSI) in Germany and Phytoplankton Trophic Index (PTI) in Italy.

Jakovljević (2012) examined the quality of the Danube River water through Serbia for 2010, using the Serbian Water Quality Index (SWQI) and the Canadian Water Quality Index (CWQI). Based on the SWQI results for the Danube River through Serbia for 2010, Walker et al. (2015) concluded that with the help of alternative methods, additional data on river water quality could be obtained. Josimov-Dundjerski et al. (2016) used the WQI method to determine the water quality of the Danube in the Pannonian part of the flow through Serbia. Both Mladenović-Ranisavljević & Žerajić (2017) estimated the water quality of the Danube River based on data from 17 hydrological stations along the flow through Serbia, generating a Serbian and American model. Milijašević Joksimović et al. (2018) analyzed water quality in the Timok River Basin, using SQWI.

In other studies, different variants of the water quality index have been applied (Cude, 2001; Boyacioglu, 2007; Abuzaid, 2018). Both CWQI (Canadian Water Quality Index) or CCME WQI (Canadian Council of Ministers of the Environment Water Quality Index) and OWQI (Oregon Water Quality Index) (Khan et al., 2005; Lumb et al., 2006; Sutadian) were often used. et al., 2015). In any case, most WQI methods treat all three groups of indicators - physical, chemical and biological parameters of water quality (Rocha et al., 2015), which was applied in this paper as well. WQI has also been used successfully to test groundwater quality (Kawo & Karuppannan, 2018; Mohiuddin-Farooqui et al., 2020). Yisa & Jimoh (2010) point out that WQI method could be very useful in managing water resources and surface water catchments.

When it comes to Montenegro, Djurašković (2010) indicated that in the period from 2005 to 2009 water quality of Skadar Lake was very good i.e., it belonged to class "A", mostly. Vukašinović-Pešić et al. (2019) found an increase in surface water quality since 2012, but indicated that there were significant differences in the values of the considered chemical parameters between the rivers in the north (Black Sea Basin) and in the south (Adriatic Basin). Analysis of data from 2009 to 2018 indicated that the overall microbiological water quality in Montenegrin rivers was quite good (Kolarević et al., 2019).

Research Area

The study deals with the catchment area of the Morača River in Montenegro, which covers the area of six municipalities: Podgorica, Nikšić, Tuzi, Danilovgrad, Kolašin and Cetinje. Nearly 50% of the country's population lives in the Morača River catchment area. The Morača River and its right and, at the same time, the main tributary of the Zeta River (the longest and richest in water tributary of the Morača River) are autochthonous rivers in Montenegro (Fig. 1). The Cijevna River is a left tributary of the Morača River, which flows through Albania in its length of 23 km.

The Morača River originates at an elevation of 975 m above sea level (Ljevište), by merging a large number of occasional and permanent streams, which flow from the eastern slopes of mountains Zebalac, Šuplja stijena and the northern slopes of Moračka Kapa Mt. (Drecun et al., 1985). The area of the Morača River Basin is 3,257 km^2 (Hrvačević, 2004) and most of it (about 93%) is located in Montenegro. Only the upper part of the Cijevna River Basin is located in Albania. According to the data of the Institute of Hydrometeorology and Seismology of Montenegro (IHMSM)[2], the length of the Morača River is 113.4 km and it receives several larger and smaller tributaries. According to the Köppen classification, Podgorica, i.e., the entire area of the Zeta and Bjelopavlićka plains has a Csa type of climate, in the area of Nikšić and Cetinje Csb is present, while higher terrains above 1,000 m a.s.l. (upper part of the basin) have characteristics of a mountain climate - D climate (Burić et al., 2014).

[2] http://www.meteo.co.me/misc.php?text=24&sektor=2

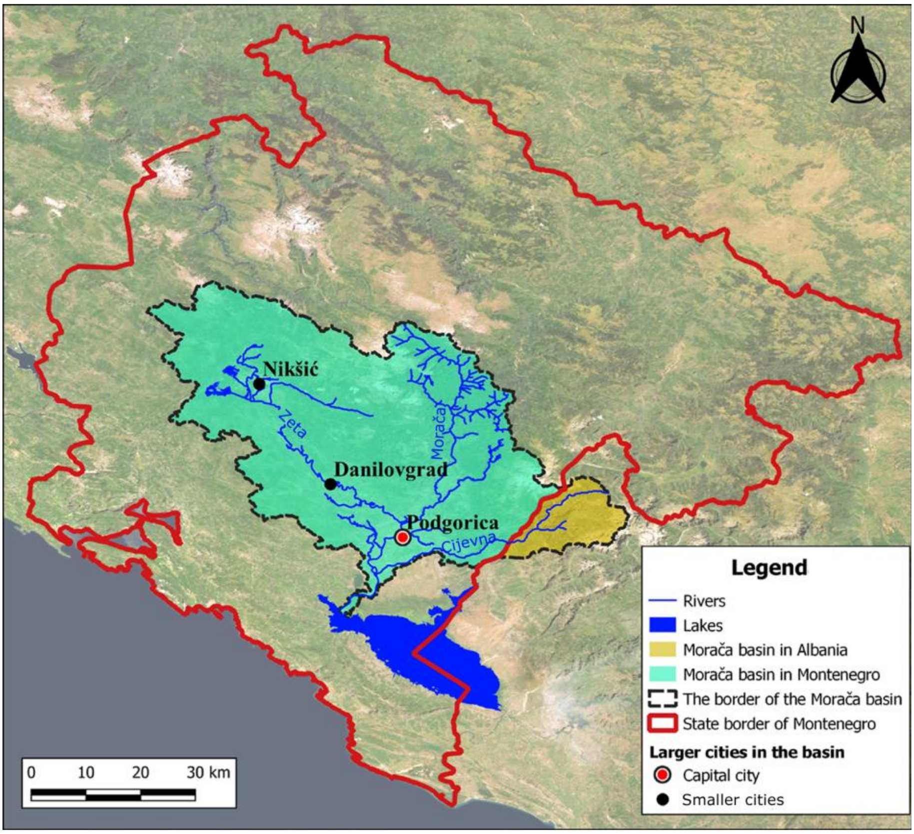

Fig. 1. Position of the Morača River Basin

The Morača River and its two most important tributaries, rivers Zeta and Cijevna, flow through the most populated part of Montenegro and are of great importance to the population. The problem of water pollution in the Morača River Basin appears in the second half of the 20th century, as a consequence of the accelerated development of industry and urbanization. In the Morača River Basin, according to the available data, communal waters are only partially treated in the city areas of Podgorica and Nikšić. Wastewater from Danilovgrad and other settlements in the Morača River catchment area is discharged directly into riverbeds, without any treatment. Agricultural activities are also a source of pollution, because rivers Morača, Zeta and Cijevna flow through the plains (Zeta and Bjelopavlićka plains). It should be noted that in the last two decades, industrial activity has decreased, because many large factories have stopped working, so it can be argued with a high degree of certainty that the share of industrial wastewater has decreased. The Agency for Nature and Environmental Protection of Montenegro (2020) points out that municipal wastewater is the largest source of surface and groundwater pollution, but that the influence of other factors is noticeable: agricultural activities, industry (mostly food), as well as small and medium enterprises, then "the growing impact of traffic infrastructure and fuel distribution, as well as construction works (road construction) on surface water quality."

Methodology and Data

For the purposes of this paper, data from the Annual Reports on River Water Quality of IHMSM[3], from 2010 to 2018 were used. Data from 12 hydrological stations (HS from three rivers) in the Morača River Basin were used: Morača River (6 stations), Zeta River (4 stations) and Cijevna River (2 stations). All HS are located in Montenegro (Fig. 2), and as already mentioned, the water quality of the Cijevna River was not measured in the upper part of the flow that belongs to Albania. A total of 10 parameters of physiochemical and microbiological water quality were considered from the 12 mentioned profiles: oxygen saturation (%), biochemical oxygen consumption for 5 days (BOD_5 in mg/l), ammonium ion (mg/l), pH value, total nitrogen oxides (mg/l), orthophosphates (mg/l), suspended solids (mg/l), temperature (^{o}C), electrical conductivity (μS/cm) and coliform bacteria (MPN in 100 ml).

Fig. 2. Position of hydrological stations in the Morača River Basin

The WQI method was used to assess river water quality. In short, all 10 mentioned parameters are combined into one surface water quality indicator. But the share of each of them in the total water quality does not have the same relative importance. Therefore, each of the 10 parameters gets its own weight or rank of implication (wi) and number or registered value (qi) according to its share in endangering water quality. Finally, summing the product (qi x wi) gives an index of 100 as the ideal sum of the quality shares of all parameters (Babić et al., 2019).

The previously described calculation procedure (WQI = qi x wi), somewhat modified according to local and regional conditions, is mentioned by numerous authors (e.g.

[3] http://www.meteo.co.me/misc.php?text=57&sektor=3

Almeida & Schwarzbold, 2003; Lopes et al., 2008; Mititelu-Ionuş, 2010), and Liou et al. (2004) state that back in 1965, Horton first began using WQI to assess surface water quality.

For the purposes of this paper, the final WQI calculations were performed using a calculator available on the website of the Environmental Protection Agency of the Republic of Serbia (SEPA), because the formula used to determine water quality on the Morača River and its tributaries (Zeta and Cijevna) includes 10 mentioned physicochemical and biological parameters. This index is officially defined as the Serbian Water Quality Index (SWQI) and is used under that name in the world scientific literature (Babić et al., 2019). Therefore, for the purposes of this paper, SWQI is calculated according to the following formula:

$$SWQI = 1/100\left(\sum_{i=1}^{10} qiwi\right)$$

We can conclude that the WQI method was developed to avoid the analysis of individual parameters and reduce a large amount of data, because this index is defined as a simple number that shows the quality of surface waters (Lumb et al., 2011). Since the number and type of parameters, as well as their weighting coefficients, can be modified (adjusted) according to local or regional conditions (Hurley et al., 2012; Garcia et al., 2018), there are also differences in class intervals. That is why it is in Tab. 1. The classification of surface water quality, according to SWQI values, used by SEPA and the State Agency for Nature and Environmental Protection of Montenegro (ANEPM) is presented.

Tab. 1. Classification of surface water quality by the Serbian Water Quality Index (SWQI) method

Water quality	Class intervals	Color symbol
Excellent	90-100	
Very good	84-89	
Good	72-83	
Bad	39-71	
Very bad	0-38	

Source: www.sepa.gov.rs

The advantages of using the WQI method are numerous, but two are the most important: several variables are included in one number and it gives the possibility to compare water quality of one water body in time and to compare several water objects in space. The main disadvantages of this methodology are that it does not take into account data on some important parameters, such as inorganic pollution (e.g. heavy metals) and that WQI can be calculated even if not all of the mentioned parameters are present.

Results and Discussion

The results of the research are presented in Tab. 2, which show the calculated average annual values of the water quality index (SWQI) on the profiles of 12 hydrological stations on the rivers Morača, Zeta and Cijevna.

The analysis of the Zeta River was performed at the measuring stations Vidrovan, Duklov most, Danilovgrad and Vranjske njive. At the measuring station Vidrovan (Gornja Zeta, spring), the water quality in the entire observed period had values ranging from 90 to 94 SWQI (excellent). In the Information on the state of the environment in Montenegro for 2016, among other things, it says (Agency for Nature and Environmental Protection of Montenegro, 2017): "The waters of the Vidrovan measuring profile should belong to the highly required level, and as this part of Zeta River passes through settlements and is exposed to anthropogenic influence, this condition is disturbed, especially at low water levels". In the mentioned document, the quality of Zeta River water on the Vidrovan profile, as well as on other HS, was analyzed on the basis of content and other parameters (number of coli bacteria, fecal bacteria content, Ca/Mg ion ratio, etc.) and using another classification. Therefore, the water of the Zeta River on the Vidrovan profile, according to the SWQI value, is of excellent quality, and according to the ANEPM analysis for certain parameters, it is classified in lower classes (A2, K2, ...). These differences in water quality assessment are methodological in nature and point to shortcomings in WQI methodology, in general. Therefore, in future research, the WQI method should be used in combination with other methods to assess water quality.

Tab. 2. Average annual water quality in the Morača River Basin according to SWQI

River	Hydrological station	Mean annual values of WQI								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
Zeta	Vidrovan	94	90	91	94	93	91	93	93	94
Zeta	Duklov most	81	73	82	86	86	80	88	74	88
Zeta	Danilovgrad	87	89	82	83	90	86	87	76	93
Zeta	Vranjske njive	86	84	79	85	87	88	91	90	91
Morača	Pernica	94	95	88	94	94	93	93	91	94
Morača	Zlatica	94	88	90	92	93	89	90	90	94
Morača	Gradska plaža	89	88	91	91	91	87	91	92	92
Morača	Gradski kolektor	56	39	65	67	68	61	71	57	66
Morača	Grbavci	82	75	78	81	87	70	83	78	79
Morača	Vukovci	87	84	82	85	82	86	86	84	84
Cijevna	Trgaj	92	89	94	92	91	91	93	93	95
Cijevna	Cijevna na ušću	96	89	91	80	94	93	94	92	97

Downstream, at the Duklov most station, SWQI values ranged between 73-81 (2010, 2011, 2012, 2015 and 2017) and 86-88 (2013, 2014, 2016 and 2018), which according to the categorization belongs to the class of water quality good, that is, very good. In relation to the other three measuring points, the obtained results indicated that the water of the Zeta River was of the worst quality on the profile of Duklov most. This was to be expected, as it was the part of the flow that flew through the most populated and most agriculturally active part of the Zeta River Basin (urban area and surrounding settlements of Nikšić, the largest city in the Zeta Valley).

During the observed period, HS Danilovgrad recorded the largest variation in water quality: good water quality was registered during 3 years (2012, 2013 and 2017), very good class belongs to 4 years (2010, 2011, 2015 and 2016), while the average values of 90 and 93 SWQI obtained for 2014 and 2018 (excellent water quality class). A similar situation was recorded at HS Vranjske njive (near the mouth of the rivers Zeta and Morača), with the proviso that certain periodic movements of water quality in a positive direction can be observed here. Namely, in the period from 2010 to 2015 water quality was in the range very good (84-88 SWQI), with the exception of 2012 when water quality had a value of SWQI 79 (good), followed by the period from 2016 to 2018 in which the water quality is improved, i.e. rated as excellent (90-91 SWQI).

The Morača River was analyzed on the basis of data from 6 HS: Pernica, Zlatica, Gradska plaža, Gradski kolektor, Grbavci and Vukovci. At HS Pernica, which is located in the upper course, the water quality belonged to the excellent class almost throughout the observed period (91-95 SWQI), with the exception of 2012 when the water of the Morača River was rated as very good on the mentioned profile (SWQI = 88). The situation is similar with HS Zlatica, which is located at the entrance of the Morača River in the city area of Podgorica, where water quality was excellent (90-94 SWQI) in most of the observed period, except in 2011 and 2015 when the value of SWQI was 88 units, which corresponds to a very good class. However, downstream, the number of years belonging to the excellent class is decreasing because the river flows through the urban area, so it was to be expected that the increased human impact on water resources would worsen the quality of river water. In the observed 9-year period (2010-2018), HS Gradska plaža registered for 6 years with excellent water quality, while in 2010, 2011 and 2015 they belong to the class very good (87-89 SWQI). Of all the observed stations on the Morača River and its tributaries, HS Gradski kolektor had the lowest values of water quality in the observed period, which ranged between 39-71 SWQI which according to the classification belonged to the interval of poor quality. Downstream, leaving the city area, the Morača River becomes somewhat cleaner, so at the station Grbavci the water quality was almost in the category of good (75-82 SWQI), and the exceptions are 2014 (SWQI = 87) and 2015 (SWQI = 70) years, when the water quality of the river Morača on the mentioned profile was assessed as very good, i.e. bad. At the last (lowest) HS Vukovci, the water quality of the Morača River belonged to the classes very good (7 years) and good (2012 and 2014).

The analysis of the Cijevna River was made on the basis of data from the measuring stations Trgaj and Cijevna at the mouth. At the Trgaj station, which is located at about 15 river kilometers (r.k.), the water quality was in the excellent class almost throughout the period (91-95 SWQI), and only 2011 belonged to the good class interval (SWQI = 89). Downstream from the mentioned HS, the river Cijevna flows through the inhabited and agricultural area in Montenegro (Zeta plain). Nevertheless, the data of HS Cijevna show that this river had excellent water quality (91 to 97 SWQI) at the mouth of the Morača River. The exceptions are 2011 and 2013, when the average annual SWQI at the mouth of the Cijevna River was rated as very good and good, respectively.

Analyzing the average annual values of SWQI for the entire observed period (2010-2018), calculated as the arithmetic mean of annual SWQI, the calculation results show that the water quality of the Morača River and its tributaries (Zeta and Cijevna) is excellent (6 HS), very good) and good (2 HS). Only on the profile of the HS Gradski kolektor the river Morača was in the class of poor quality during the whole period (Fig. 3).

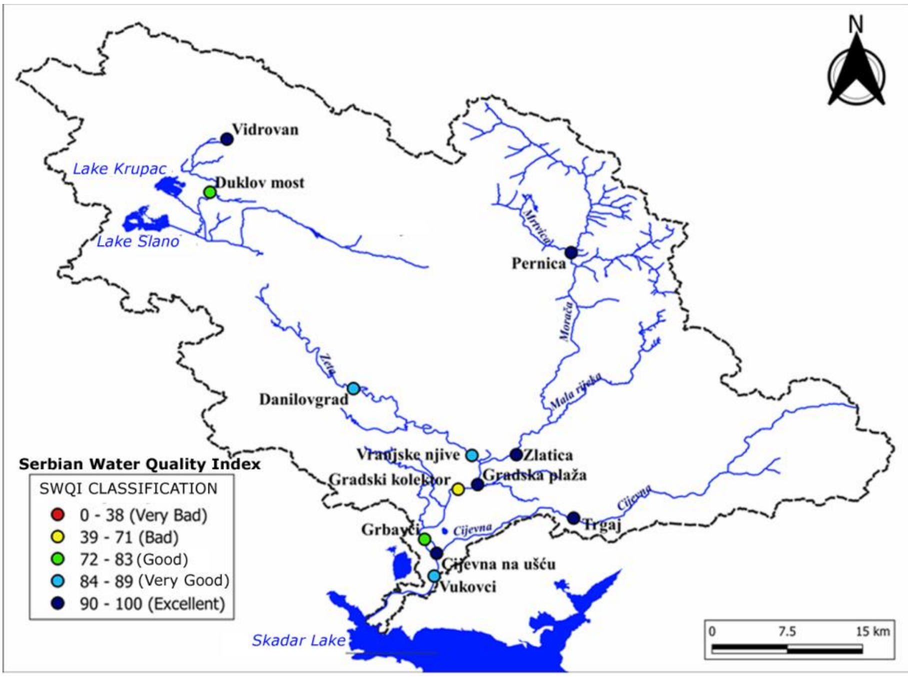

Fig. 3. Measuring stations in the Morača River Basin with average SWQI values for 2010-2018

The SQWI results indicate that the river water quality in the observed profiles has improved in recent years of the analyzed period, in general. This is probably due to the reduction of the share of industrial wastewater (many factories have been closed) and the taking of certain pollution prevention measures (e.g. the penal policy of illegal waste disposal). It is further noted that on some profiles there are somewhat more pronounced year-on-year variations - e.g. on HS Danilovgrad and Vranjske njive on the river Zeta. The observed variations are most likely related to the increased/decreased amount of wastewater from settlements, agricultural sources (e.g. livestock and poultry mini farms) and illegal disposal of garbage and other waste both along the flow and into the forest river. As he already mentioned, of all the observed HS, the worst quality is the water of the river Morača on the profile of the City Collector, and that is the result of increased wastewater (mostly untreated) from the city area of Podgorica (the most populated part of Montenegro).

Year-on-year variations in SWQI can be partly explained by changes in hydrological conditions. On the profile Gradski kolektor, the worst water quality was recorded in 2011 (SWQI = 39). Such a situation can be explained by the unfavorable hydrological situation, i.e. the lowest flow of the Morača River, not only in the observed period, but since 1948. Namely, the average annual flow of Morača River for 2011 to HS Podgorica (city) was only 74.8 m^3/s. This is supported by the fact that in 2011 the lowest average annual water level of Skadar Lake since 1948 was registered - only 100 cm. The hydrological situation was also very unfavorable in 2015, when the water of the Morača River in the Grbavci profile was in a class of poor quality (SWQI = 70).

Increased concentrations of BOD_5 and ammonium ions were observed on almost all profiles for the years with the lowest SQWI. This is also logical, because the value of BOD_5 is an indicator of the biological activity of wastewater, i.e. the degree of pollution with organic substances. Ammonium ion concentrations are an indicator of pollution from agricultural sources and industrial facilities (Hernea & Teche-Constantinescu, 2013). For the mentioned 2011, the highest average annual concentrations of BOD_5 and ammonium ions (> 7 mg/l and 6.01 mg/l, respectively) were registered at HS Gradski kolektor, when the water of the Morača River was of the worst quality. Thus, the results obtained in this paper showed that the state of water quality of the rivers Morača, Zeta and Cijevna is not worrying, in general. In recent years, there has been an improvement in the quality of river water. Similar statements about the state of quality of rivers in Montenegro are made by Kolarević et al. (2019) and Vukašinović-Pešić et al. (2019).

Conclusion

The aim of this study was to determine the quality of river water in the Morača River Basin, using WQI methods. The advantage of the WQI method is that it can be adapted to local and regional conditions and that all the considered parameters are combined into one number, which shows a realistic picture of the ecological condition of rivers. It should be noted that the WQI methodology also has certain limitations, because it does not take into account some important parameters, such as data on inorganic pollution (e.g. heavy metals) and what WQI can be calculated even if not all parameters considered. Therefore, in future research, it would be desirable to apply this index in combination with other methods for assessing water quality. Nevertheless, many countries in the world and in our region have adopted the WQI method in official use, and recently it is used by the State Agency for Nature and Environmental Protection of Montenegro. The Environmental Protection Agency of the Republic of Serbia (SEPA) has adapted this method for its needs and developed the SWQI (Serbian Water Quality Index). For the purposes of this paper, SWQI was calculated, using a SEPA calculator. SWQI was calculated based on 10 parameters of physical-chemical and microbiological quality of the river water of Morača, Zeta and Cijevna. Data from 12 hydrological stations for the period from 2010 to 2018 were used.

The results obtained in this paper show that the general condition is not discouraging, except for the Morača River in the profile of the City Collector (39-71 SWQI) and partly in the downstream part of the flow. Certainly, this is a serious problem, especially since it is a part of the Morača River that flows through the most populated and most agriculturally active parts of Montenegro (Podgorica and Zeta plain). Poor river water quality in the lower part of the Morača River is the result of increased wastewater (mostly untreated) from the city and surrounding area of Podgorica (the most populated part of Montenegro) and agricultural activities (Zeta Plain, Lješkopolje), but also illegal disposal of garbage and other waste. The unfavorable hydrological situation in some years, such as in 2011 (the lowest flows on the Morača River in the instrumental period), further worsens the quality of river water. In any case, it is necessary to detect the source of pollution and apply adequate technology, in order to solve the problem of (non) treatment of wastewater and thus reduce the pollution of the river Morača in its lower course. The obtained results can serve as a good basis for reviewing the general state of river water quality in the Morača River Basin.

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ПРОЦЕНА КВАЛИТЕТА ВОДЕ У СЛИВУ РЕКЕ МОРАЧЕ (ЦРНА ГОРА) КОРИШЋЕЊЕМ ИНДЕКСА КВАЛИТЕТА ВОДЕ

Резиме: Циљ рада био је утврдити квалитет речне воде у сливу Мораче. Коришћена је метода израчунавања Индекса Квалитета Воде (WQI - Water Quality Index) на основу 10 параметара физичко-хемијског и микробиолошког квалитета речне воде Мораче, Зете и Цијевне са 12 хидролошких станица у периоду 2010-2018. Предност WQI је у томе што је свих 10 разматраних параметара обједињено у један број, који показује реалну слику еколошког стања река. Многе земље у региону су прихватиле овај метод (WQI) у званичној употреби, а од недавно користи га и државна Агенције за заштиту природе и животне средине Црне Горе. Агенције за заштиту животне средине Републике Србије је за своје потребе прилагодила WQI метод и развила SWQI (Serbian Water Quality Index). За потребе овог рада коришћен је SWQI, односно израчунат помоћу калкулатора Агенције за заштиту животне средине Републике Србије. На основу добијених вредности SWQI дата је процена квалитета воде на 12 профила поменутих река у Црној Гори.

Добијене вредности SWQI су показале да најбољи квалитет воде у сливу Мораче има река Цијевна. У посматраном 9-годишњем периоду, готово сваке године на оба профила (ХС Тргај и ХС Цијевна) вода реке Цијевне оцењена је као одлична. Ипак, од 12 хидролошких станица у сливу Мораче, једино је вода реке Зете на профилу Видрован (извоуришни део Горње Зете) током целог посматраног периода (2010-2018.) сврстана у класу одличан, јер су средње годишње вредности SWQI биле између 90-94. На остале три низводније ХС на реци Зети (Дуклов мост, Даниловград и Врањске њиве), вода је слабијег квалитета – преовлађује класа добар и веома добар. Када је Морача у питању, анализа десет параметара физичко-хемијског и микробиолошког квалитета речне воде са 6 профила, указује на слабији квалитет њене воде у односу на воде Зете и Цијевне. На профилу ХС Градски колектор, током целог посматраног периода вода реке Мораче била је лошег квалитета (SWQI између 39 и 71), а то је последица испуштања непречишћених или делимично пречишћених комуналних вода, а мањим делом и пољопривредне активности у непосредном узводнијем делу слива реке Мораче. Узводно од ХС Градски колектор (профили Градска плажа, Златица и Перница), вода реке Мораче је бољег квалитета, те преовлађује класа одличан, посебно у горњем току (ХС Перница). И низводно од ХС Градски колектор побољшава се квалитет воде реке Мораче, али спорије у односу на узводни део. Наиме, доњи део тока реке Мораче протиче кроз Зетску равницу, па осим отпадних вода са градског подручја и околних насеља, утицаја има и интензивнија пољопривредна активност становништва, која негативно утиче на квалитет њене воде. Томе у прилог чињеница да на две низводније ХС (Грбавци и Вуковци) ни у једној посматраној

години вода реке Мораче није припадала класи одличан – на ХС Грбавци доминира класа добар, а на низводнијој ХС Вуковци (на око 8. р.к.) квалитет воде реке Мораче је врло добар.

Резултати који су предочени у овом раду показују да генерално стање није забрињавајуће, осим реке Мораче на профилу Градски колектор и делимично низводнијем делу тока. Свакако, то је озбиљан проблем, тим пре што се ради о делу тока Мораче који протиче кроз најнасељеније и пољопривредно најактивније крајеве Црне Горе (Подгорица, Зетска равница, Љешкопоље). У вези с тим, неопходна је детекција извора загађења и примена адекватне технологије, како би се решио проблем (не)пречишћавања отпадних вода и тиме смањило загађење реке Мораче у њеном доњем току. У сваком случају, добијени резултати могу послужити као добра основа за сагледавање генералног стања квалитета речне воде у сливу Мораче. У циљу добијања целовитије слике еколошког стања сливова свих река у Црној Гори, потребно је наставити са мониторингом и на другим воденим објектима.

Предности коришћења WQI метода су бројне, али две су најважније: више варијабли је укључено у један број и даје могућност поређења квалитета воде како једног воденог тела у времену тако и поређења више водених објеката у простору. Основни недостаци ове методологије су у томе што не узима у обзир неке значајне параметре, као нпр. податке о неорганском загађењу (нпр. тешки метали) и што се WQI може израчунати и уколико нема свих поменутих параметара. Зато је пожељно WQI резултате упоредити са неком другом "осетљивијом" методом процене квалитета воде.