Quality analysis of surface waters of Rasina district by using the Water Quality Index method

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Abstract: Waters of surface flows of Rasina district are exposed to the influence of numerous pollutants, the most important among which are erosive processes and sediment input into river courses, artificial fertilizers and pesticides used in agricultural production, communal wastewaters of urban and rural settlements, as well as wastewaters of industrial plants in town centers of the district. Consequences of these negative influences are evident on all surface flows in the district where water quality is examined from the part of competent institutions. Most often, water quality does not comply with regulated rates, that is, it clearly deviates from the regulated water quality class II.

This paper analyzes the quality of the waters of surface flows of Rasina district according to the data of the Ministry of Environment on the profile Jasika (Zapadna Morava), Mojsinje (Južna Morava), Varvarin (Velika Morava) and Bivolje (Rasina), in the period from 2001 to 2012. For this calculation we used the data on water quality taken approximately once a month, according to appropriate parameters, by using the Water Quality Index method.

Obtained results show that the waters on all the analyzed profiles are within the limits of class III quality (WQI values from 66 to 71). Linear trend of the change in water quality shows that there is a trend of growth in Water Quality Index values on all the profiles, except in Varvarin on Velika Morava, which indicates the tendency of water quality deterioration on these courses.

Key words: surface waters quality, WQI

1. Introduction

Rasina district is situated in the south part of Central Serbia on the surface of 2668 km^2. The district is bounded by mountain grounds of Goč, Ljukten, Crni vrh and Željin on south-west and west. South-west part of the

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district is represented by Kopaonik, to which mountain range of Jastrebac is attached east of the river of Blatašnica. Northeast border of the district is represented by Mojsinjske Mountains, while the north border is represented by south slopes of Juhor and Gledićke mountains.

Rasina district includes the parts of the basins of Zapadna Morava, Južna Morava and immediate basin of Velika Morava.

The river of Zapadna Morava runs through the territory of Rasina district, from Trstenik to the confluence with Južna Morava, then the river of Južna Morava, from Đunis to Stalać, and the river of Velika Morava, from Stalać to Obrež. The largest part of the district pertains to the basin of Zapadna Morava – 2023.9 km^2 (75.9% of the total district surface), then to the basin of Južna Morava – 404.8 km^2 (15.2% of the district surface) and the basin of Velika Morava – 239.3 km^2 (8.9% of the district surface).

Waters of the rivers of Zapadna, Južna and Velika Morava are mostly burdened by organic compounds which originate from waste waters from the surrounding settlements which are let off into watercourses without any filtration. Waters from industrial plants also represent a big problem, but their share is significantly smaller compared to communal waters. Waste waters from industrial plants are mostly loaded with nitrogen and phosphorus (Popović et al., 1998). Agricultural soil water erosion, where large amounts of artificial fertilizers and pesticides in agriculture, as well as discharge of organic matters from cattle farms, also largely influence deterioration in the water quality of watercourses. All the above mentioned forms of pollution have become pronounced in the past few years because of draught periods and reduced amount of water in watercourses.

Hitherto water quality analyses in the basin of Zapadna Morava show that quality of the waters of its tributaries is on the crossing between class II and III (Đetinja, Skrapež, Moravica, Bjelica) or class III (Čemernica, Ibar, Rasina). The lowest water quality of the course of Zapadna Morava was recorded on the profiles of Kraljevo and Trstenik, where it is most often on the crossing between class III and IV (Obradović et al., 2009). In the upstream part, near the town of Čačak and Gugaljski Bridge, water quality is better and it pertains to class II and III, as well as in the most downstream profile in Jasika. Regulated water quality class on all the profiles in the basin of Zapadna Morava is II, IIa and IIb (Popović et al., 1998, 2000).

In the basin of Južna Morava waters on all the profiles belong to either class III or class IV. Waters of the lowest quality were registered on the river

of Toplica. These waters sometimes come out of the scope of class IV because of excessive pollution (Samardžić, 2013).

Due to such quality state of surface waters on the territory of the whole basin of Velika Morava, it is necessary to constantly analyze and control them. One of the ways to present the state and the trend of water quality change on a certain profile is applying Water Quality Index method, which is based on defining the most important parameters values of which largely influence water quality and reduce them to a certain index number.

Quality analysis of the river waters of Rasina district has been done on the basis of the data of the Ministry of Environment on the profiles of Jasika, Bivolje, Mojsinje and Varvarin in the period from 2001 to 2012, by defining the Water Quality Index (WQI), according to Veljković N. (2006).

2. Methodology of the research

This work uses classification system of describing surface waters quality by using the Water Quality Index (WQI) method, which represents a way of quality assessment of the group of chosen parameters. Water Quality Index (WQI) method uses nine chosen parameters (temperature, oxygen saturation, pH value, nitrogen oxides, phosphates, BPK5, suspended matters, turbidity and coliform bacteria) which in their quality (qi) represent the characteristics of surface waters by reducing them to a certain index number. This value is obtained from the appropriate diagram (curve) for each of the parameters[2] appropriate weight. We took the value for appropriate weight (w_i) for each of the parameters. If we multiply obtained water quality values and the appropriate weight, we get the values sum of which shows the value of Water Quality Index ($\sum q_i w_i$). (Veljković et al., 2007).

To describe obtained results and mark watercourse quality we used the method of quality indicators comparison according to our qualification and the Water Quality Index method. To surface waters quality which corresponds to class I according to our Regulation, WQI method allocates 84-85 points, class II corresponds to 72-78 points, class III to 48-63 points, while class IV corresponds to 37-38 points. Likewise, the values for descriptive quality indicator were adopted: WQI = 0 – 38 very bad, WQI = 39 – 71 bad, WQI =

[2]http://www.water-research.net/index.php/stream-water-quality-importance-of-temperature http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters 25.12.2014.

72 – 83 good, WQI = 84 – 89 very good, and WQI = 90 – 100 excellent (Veljković, 2006).

To analyze water quality by the WQI method on the chosen surface courses on the territory of Rasina district, we used the data of the Ministry of Environment on the chosen profiles of the rivers of Rasina district in the period 2001-2012, taken approximately once a month. On the basis of these data we calculated mean for each measuring point on a yearly level according to the appropriate parameters of the WQI method.

3. Results of the research

Results of the research are shown in tables and line charts. Tables 1-4 show calculated values of WQI for nine chosen parameters, based on their means in the analyzed twelve-year period.

Table 1 - Water Quality Index of Zapadna Morava in Jasika

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**$q_i w_i$**
Temperature (^{0}C)	12.4	36	0.10	3.6
Saturation of water with oxygen (%)	105.76	98	0.17	16.66
pH value	8.21	84	0.11	9.24
Nitrogen oxides (mg/ l)	2.24	95	0.10	9.5
Phosphates (mg/ l)	0.09	100	0.10	10
BPK_5 (mg/ l)	2.14	80	0.11	8.8
Dry residue (mg/ l)	257.07	65	0.07	4.55
Turbidity (NTU)	44.82	43	0.08	3.44
Escherichia coli/100 ml	240000	2	0.16	0.32
$\sum$			1.00	66.11

On the basis of the shown procedure of determining Water Quality Index (WQI), obtained value for the river of Zapadna Morava on the profile in Jasika amounts to 66.11, which classifies this river in class III of watercourses according to our categorization. If we used descriptive method to describe water quality of this watercourse, we would classify them as bad quality waters (WQI 39 -71).

Table 2 - Water Quality Index of Rasina in Bivolje

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	11.89	40	0.10	4.0
Saturation of water with oxygen (%)	100.24	99	0.17	16.83
pH value	7.97	88	0.11	9.68
Nitrogen oxides (mg/ l)	2.42	95	0.10	9.5
Phosphates (mg/ l)	0.1	100	0.10	10
BPK_5 (mg/ l)	1.80	95	0.11	10.45
Dry residue (mg/ l)	205.73	72	0.07	5.04
Turbidity (NTU)	16.48	66	0.08	5.28
Escherichia coli/100 ml	240000	2	0.16	0.32
∑			1.00	71.1

Obtained WQI values of 71.1 for the profile Bivolje on Rasina classify waters of this river in the category on the crossing between class III to class II, that is, from bad to good waters.

In Mojsinje on Južna Morava defined WQI value of 66.89 classifies its waters in class III waters, that is, bad quality waters.

Table 3 - Water Quality Index of Južna Morava in Mojsinje

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	13.68	34	0.10	3.4
Saturation of water with oxygen (%)	101.68	99	0.17	16.83
pH value	7.94	88	0.11	9.68
Nitrogen oxides (mg/ l)	2.09	95	0.10	9.5
Phosphates (mg/ l)	0.13	100	0.10	10
$БПК_5$ (mg/ l)	2.68	80	0.11	8.8
Dry residue (mg/ l)	233.71	68	0.07	4.76
Turbidity (NTU)	40.59	45	0.08	3.6
Escherichia coli/100 ml	200000	2	0.16	0.32
∑			1	66.89

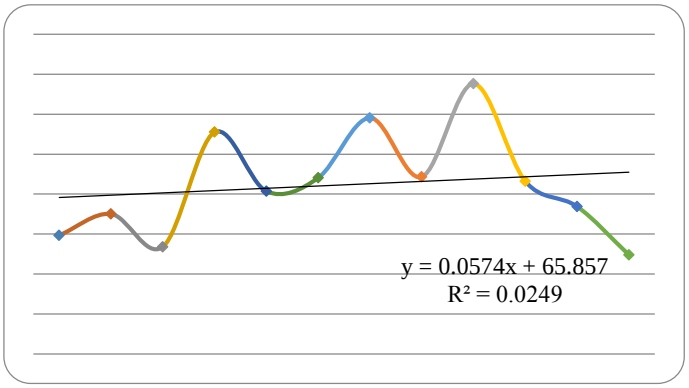
On Velika Morava in Varvarin, as well as in Zapadna and Južna Morava, river waters belong to class III water quality, that is, to waters which can be used for irrigation, possibly for industrial production (except food production), but only after the process of detailed filtration.

Table 4 – Water Quality Index of Velika Morava in Varvarin

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**$q_i w_i$**
Temperature (^{0}C)	12.85	36	0.10	3.6
Saturation of water with oxygen (%)	103.93	99	0.17	16.83
pH value	8.25	84	0.11	9.24
Nitrogen oxides (mg/ l)	2.3	95	0.10	9.5
Phosphates (mg/ l)	0.11	100	0.10	10
БПК$_5$ (mg/ l)	2.47	80	0.11	8.8
Dry residue (mg/ l)	251	66	0.07	4.62
Turbidity a (NTU)	139.29	5	0.08	0.4
Escherichia coli/100 ml	200000	2	0.16	0.32
∑			1	63.31

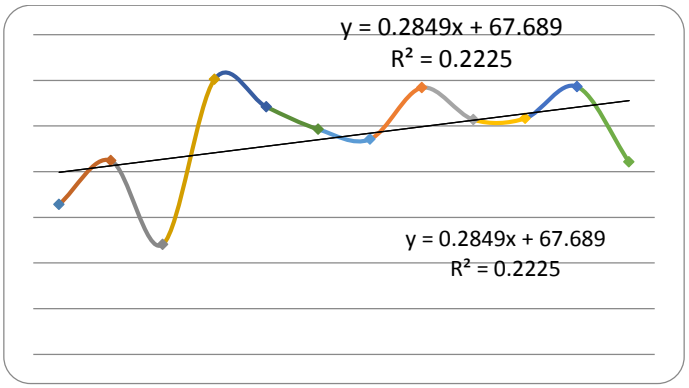
Shown values of the parameters used to analyze water quality in the period 2001-2012 were related to their means for the given period. Water quality is not a fixed category and it is influenced by a number of factors .Some of these factors are lasting and change slowly in time, while others appear suddenly, without any order and disturb the existing state of water quality. These factors can represent unexpected seasonal hydrologic changes, or sudden, often accidental, discharge of large amounts of waste waters in watercourses, which briefly disturbs their existing quality (Stričević, 2015).

For all the analyzed profiles in Rasina district yearly values of Water Quality Index (WQI) and their linear correlation were determined and shown in charts 1-4. On the basis of these charts it is possible to observe the tendency of change in water quality in the analyzed period.



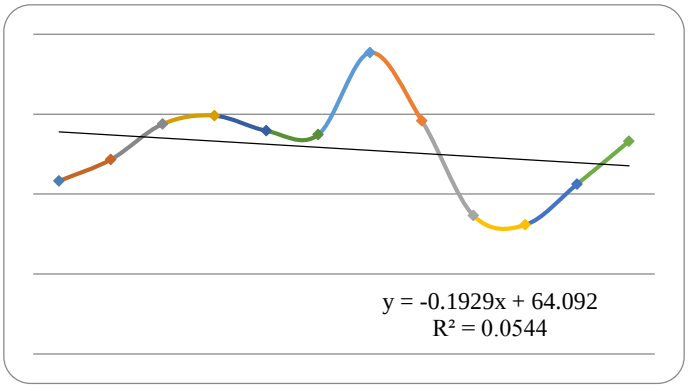
Graph 1 - Linear trend of the change in water quality of the river of Zapadna Morava in Jasika station,
in the period 2001-2012 expressed using WQI method

When analyzing charts on water-meter station Jasika on Zapadna Morava we can perceive linear trend showing average WQI value of 65.85 in the reference period, while average growth in each year amounted to 0.057 index points.



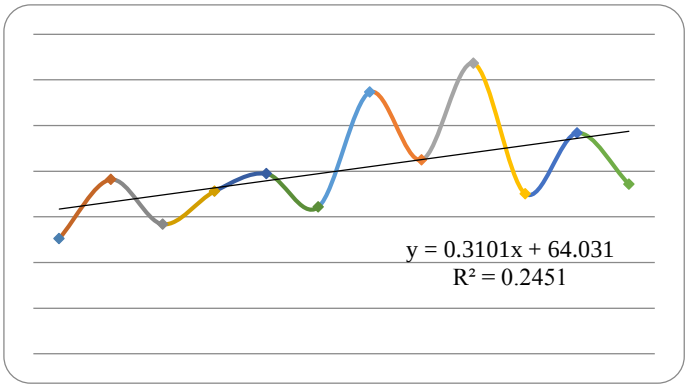
Graph 2 - Linear trend of the change in water quality of the river of Rasina on Bivolje station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Bivolje station amounted to 67.68, while average growth in each year amounted to 0.28 index points.



Graph 3 - Linear trend of the change in water quality of the river of Velika Morava on Varvarin station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Varvarin station amounted to 64.09, while average drop in each year amounted to 0.19 index points.



Graph 4 - Linear trend of the change in water quality of the river of Južna Morava on Mojsinje station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Mojsinje station amounted to 64.03, while average growth in each year amounted to 0.31 index points.

4. Discussion

Obtained values of mean Water Quality Index (WQI) during several years on the analyzed profiles of the rivers of Rasina district show that those waters mostly belong to class III water quality.

In the analyzed twelve-year period on Zapadna Morava in Jasika the lowest WQI value of 64.78 was registered in 2012, while the highest value was registered in 2009 – 68.76. 2009 was the year of very low water levels on this profile. On the basis of the above mentioned values, we can say that the waters of Zapadna Morava in the most downstream part of the course were of bad quality in this period.

The lowest WQI value of 64.81 was registered in 2003 on the river of Rasina in Bivolje, while the highest value was registered in 2004 – it amounted to 72.05. These results show that the waters of Rasina River at its confluence to Zapadna Morava are on the border between bad and good waters.

The lowest WQI value of 58.07 was registered in 2010 on the river of Velika Morava in Varvarin, while the highest value was registered in 2007 – it amounted to 68.85, which indicates bad quality of waters of this river in its most upstream part.

On Južna Morava in Mojsinje the lowest WQI value of 63.04 was registered in 2001, while the highest value was registered in 2009 – it amounted to70.72, which also indicates bad quality of waters of this river in its most downstream part.

On the basis of the shown linear correlation we can conclude that there is a trend of growth of Water Quality Index value in all of the profiles except the one in Varvarin, which indicates the tendency of deterioration of water quality in these watercourses.

Water quality analysis by using Water Quality Index (WQI) method enables a comprehensive approach of surface waters quality state through analyzing the most important parameters. It also enables analyzing the trend in the change of water quality, which can be a basis for more detailed analysis of the cause of pollution of surface waters and defining guidelines and activities in the process of water protection. Apart from using numerical mode, results of water quality analysis can be shown in a descriptive way, that is, using descriptive indicator. Descriptive indicator is, above all, useful for informing the population on water quality, namely on the possibilities of using those

waters for certain purposes. This index does not have numerical values, but its description was derived on their basis.

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