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Assesment of Water Quality Parametres oF Drina River (West Serbia) in the Period 2004-2011

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Abstract. A Water Quality Index (WQI) is a numeric expression used to evaluate the quality of water bodies and make it easier understood by managers. This paper aims to assess water quality of Drina River in Serbia for the 2004 – 2011 period. For this purpose authors applied: Serbian Water Quality Index (SWQI). WQI value is dimensionless, single number ranging from 0 to 100 (best quality) derived from numerous physical, chemical, biological and microbiological parameters. For the Drina River SWQI was mainly rated as excellent. This study shows a clear decrease in water quality during summer period. Additionaly, this study shows that water quality along Drina River decreases slightly downstream, but it still provides values that according to SWQI descriptive quality indicator have been defined as excellent (90–100). This methodology includes parameters for assessment of organic loading, but does not involve parameters of heavy metals concentration.

Keywords: SWQI; Drina; River; Serbia; water quality.

Introduction

Rational and preservation utilization of water resources represent one of the main problems of the 21st century. The important aspects taken into consideration when examining the top-priority problems of water quality are the economic influence, the influence on human health, the influence on the ecosystem, the influence of the geographic area as well as the duration of the influence (Dalmacija, 2004).

In order to provide the sustainability of ecological balance, the presence and quality of water are very important (Karadavut et al., 2011) and there have been more researches based upon water quality observing (Ferenczi & Balog, 2010, Parvulescu & Hamchevici, 2010). Anthropogenic influences can cause negative consequencies in short period of time as far as water quality is concerned (Yunus & Nakagoshi, 2004), whereas waterbody pollution represents the result of human activities on one hand, and intensive urbanization development on the other hand (Dragićević et al., 2010). The organic solid load and the dynamics of its degradation are very good indicators of the anthropogenic impact on the waters (Gurzau et al., 2010).

Water Quality index attempts to provide a mechanism for presenting a cumulatively derived numerical expression defining certain level of water quality (Miller et al, 1986), and is useful for comparative purposes and when general questions are addressed (Hallock, 2002, Bordalo et al, 2006). In this study, the water quality status as well the spatial and temporal trends over eight year period were assessed to four different locations on Drina River.

Material and methods

Sampling Area

Drina River is right and the biggest tributary of Sava River. It is created by merger of Tara and Piva River at Šćepan Polje. Catchment area is 19 570km^2. In Serbia catchment area is 6007km^2 Drina River represents the state border between Republic Serbia and Bosnia and Herzegovina. Average altitude of catchment area is 934 m. Composition of Tara and Piva rivers is at 432 m and the confluence is at 75 m. The length of Drina River is 346 km (Gavrilović, Dukić, 2002).

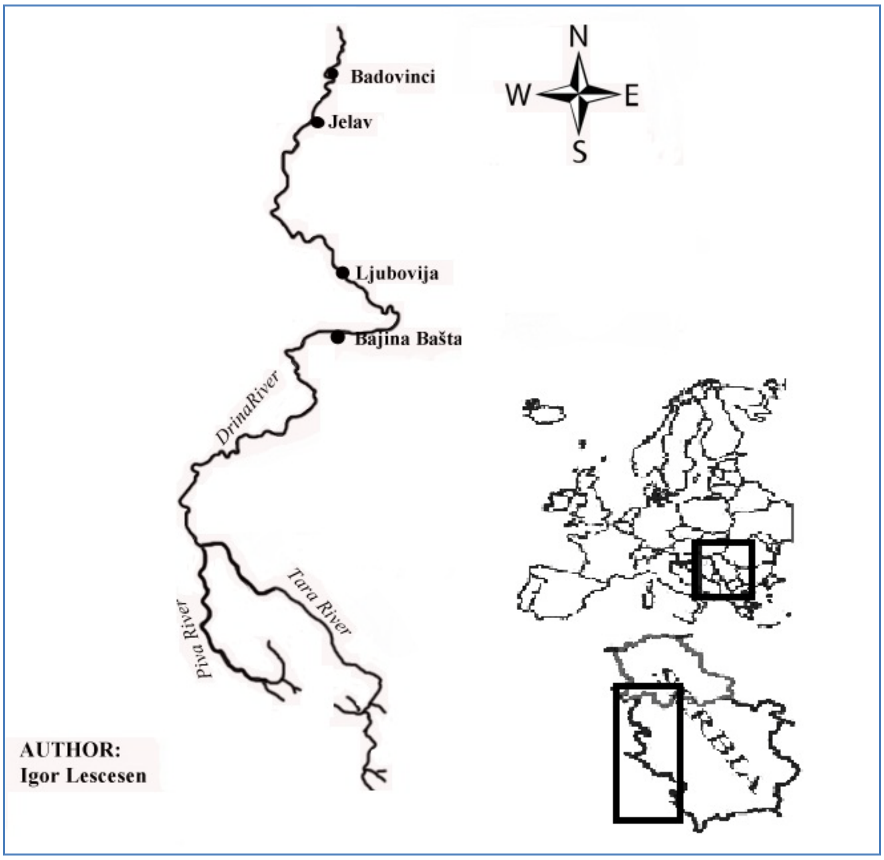


Figure 1: Geographical location of stations used for assessment of SWQI for Drina River (made by: Igor Leščešen)

Data and Methods

Database of Republic Hydrometeorological Service for period 2004-2011 (RHMS, 2009) was used to present the existing state of water quality of Drina river. Waterflows in Serbia are divided in I, IIa, IIb, III and IV classes according to set limit values of quality markers (Official Bulletin of SFRY nb. 6/78).

Parameters of physical, chemical, biological and microbiological water quality were measured at the four stations on Drina river: Bajina Bašta, Ljubovija, Jelav and Badovnici during period 2004-2011. Their values are presented in Hydrological annual book for 2004, 2005, 2006, 2007, 2008, 2009, 2010 and 2011 of Republic Hydrometeorological Service of Serbia. SWQI was calculated for each station and each measuring.

Serbian Water Quality Index (SWQI) was used for description of water quality. This system of surface waterbodies quality description represents the way of quality estimation for certain paramteres group, whereas earlier researches and studies show that this method ensures general overwiev of surface water quality at certain place (Veljković, 2000a; Veljković 2001; Veljković 2003; Đurašković & Vujović, 2004; Veljković, 2007; Đurašković & Tomić, 2009, Pantelić et al., 2012). This method is based upon the fact that ten chosen paramtres (oxygen saturation, BOD, ammonium, Ph value, total oxidised nitrogen, orthophospates, suspended solids, temperature, conductivity and coliform bacteria) with their quality (*qi*) represent features of surface water reducing them at one index number. Influence of each of ten chosen parametres on general water quality is not the same, so that each of them was assigned the wieght (*wi*) and score of points according to their contribution to water quality endangering. The result (*qi*x*wi*) gives the index100, as an ideal summation of weights of all parametres (Oregon Water Quality Index Summary Report, 1996-2005*)*. Index points from 0 to 100 will be assigned to particular waterbody according to the points assigned to particular parametres. Formula used for SWQI calculation is:

$$SWQI = 0{,}18\%O2 + 0{,}15BPK5 + 0{,}12NO4 + 0{,}09pH + 0{,}08N + 0{,}08PO4 + 0{,}07SM + 0{,}05t + 0{,}06\mu S + 0{,}12MPN$$

Descriptive quality indicator have been defined for each SWQI vales ranging from very poor (0–38), poor (39–71), good (72–83), very good (84–89), and excellent (90–100). Main limitation for SWQI is relative small number of parameters. Used parameters provide information about organic loading, but not about heavy metal pollution. Also, SWQI can be calculated even in a case of missing some values. It means that, practically, SWQI can be calculated on the basis of just one parameter.

Results

Since there is no single, universal parameter that adequately describes surface water quality, investigators typically use several indicators related to sanitary quality, ability to sustain aquatic life, ecosystem productivity and aesthetics (Pharino, 2007).

Average eight year values for ten parameters used for SWQI calculations are presented in Table 1, Temperature increased continuously downstream, from 11,9 °C to 12,5 °C. The water acidity measures grom 8, till 8,1. Highest average conductivity was recorded on Jelav station 299,2 μS cm-1. Average Oxygen saturation for research period is 102,4%. Biochemical oxygen demand is used as a measure of organic wasteload strength, and on Drina River it varies 0,8 on Ljubovija station till 1,6 on Bajina Bašta station. Another important indicator of water quality is the amount of solids in the water column – both dissolved (filterable) solids and not dissolved (suspended) solids (Pharino, 2007). Suspended solids show progressive increase from Bajina Bašta station (4,7 mg/l) till Badovinci station (14,6 mg/l). Orthophospates show stable stable values on all stations during 2004 - 2011 period, (0,1mg/l). Values of coliform bacteria rise continuously from Bajina Bašta station (1824,8), Ljubovija station (2746,5) till Jelav station, were the highest values have been measured (4771,9). on Badovinci station the value the value of coliform bacteria is second lowest (after Bajina Bašta) and measures 2600 n/l.

Table 1: Averaged values for ten water parameters included for calculation of SWQI for Drina River coverd by this study during 2004 – 2011 period

Station	Temperature (°C)	pH	Conductivity (μS cm^{-1})	Oxygen saturation (%)	BOD_5 (mg/l)	Suspended solids (mg/l)	Total oxidised nitrogen	Orthophospates (mg/l)	Amonium (mg/l)	coliform bacteria (n/l)

							(mg/l)			
Bajina Bašta	11,9	8	285,4	103,1	1,6	4,7	0,5	0,01	0,02	1824,8
Ljubovija	11,7	8,1	287,9	102,5	0,8	7,3	0,5	0,01	0,01	2746,5
Jelav	12,3	8,1	299,2	101,8	0,9	8,3	0,5	0,01	0,05	4771,9
Badovinci	12,5	8,1	297,4	102,3	1	14,6	0,4	0,01	0,02	2600

SWQI was calculated 80 times for eight years for Bajina Bašta station (table 1) and ranged from 92 to 94 (bouth excelent). In the case where the SWQI was lowest (92 and 93) in 2006, 2007, 2008, 2010 and 2011, result should be considered as questionable, because of lack of values for some months (-, in table).

Table 2: Monthly values of SWQI for Bajina Bašta station

Mounth	2004	2005	2006	2007	2008	2009	2010	2011
I	95	95	-	-	-	96	95	-
II	95	97	91	93	93	-	89	92
III	96	93	-	-	93	95	95	-
IV	89	94	94	-	93	-	94	95
V	95	96	94	94	94	95	94	93
VI	93	95	92	95	93	96	94	94
VII	93	94	-	93	92	89	94	91
VIII	93	92	92	90	90	89	85	89
IX	88	92	91	94	94	90	91	92
X	95	93	90	94	91	96	-	91
XI	97	93	93	93	-	94	93	-
XI	97	93	-	-	89	97	94	93
Average	**94**	**94**	**92**	**93**	**92**	**94**	**93**	**92**

SWQI was calculated 89 times for Ljubovija station (Table 3) and ranged on average from 92 to 94 (excelent).

Table 3: Monthly values of SWQI for Ljubovija station

Months	2004	2005	2006	2007	2008	2009	2010	2011
I	93	94	-	94	-	97	95	95
II	95	89	91	94	94	94	95	-
III	95	95	95	-	94	97	95	-
IV	95	93	94	95	93	97	97	97
V	95	90	97	92	94	95	92	97
VI	95	96	97	94	86	94	93	94
VII	90	90	93	90	92	91	92	92
VIII	89	90	94	-	92	89	92	92
IX	90	92	93	94	93	91	94	93
X	95	96	94	93	95	96	92	91

XI	97	97	95	-	88	92	85	93
XII	97	98	95	97	91	94	97	93
Average	**94**	**93**	**94**	**94**	**92**	**94**	**93**	**94**

For Jelav station SWQI was calculated 96 times on monthly basis for eight years. Its values ranged from 91 to 94 (excelent). The monthly results are represented in table 4.

Table 4: Monthly values of SWQI for Jelav station

Month	2004	2005	2006	2007	2008	2009	2010	2011
I	94	95	92	92	91	93	93	93
II	96	95	94	93	93	97	92	95
III	95	90	92	93	92	90	95	94
IV	94	93	85	93	93	95	95	94
V	96	95	97	92	94	95	95	93
VI	97	94	86	87	87	92	94	91
VII	92	91	91	85	90	86	88	91
VIII	91	88	88	90	84	90	89	89
IX	86	93	90	93	94	91	91	89
X	95	94	92	90	93	91	92	90
XI	93	95	98	91	91	95	93	95
XII	94	94	94	94	90	94	94	85
Average	**94**	**93**	**92**	**91**	**91**	**92**	**93**	**92**

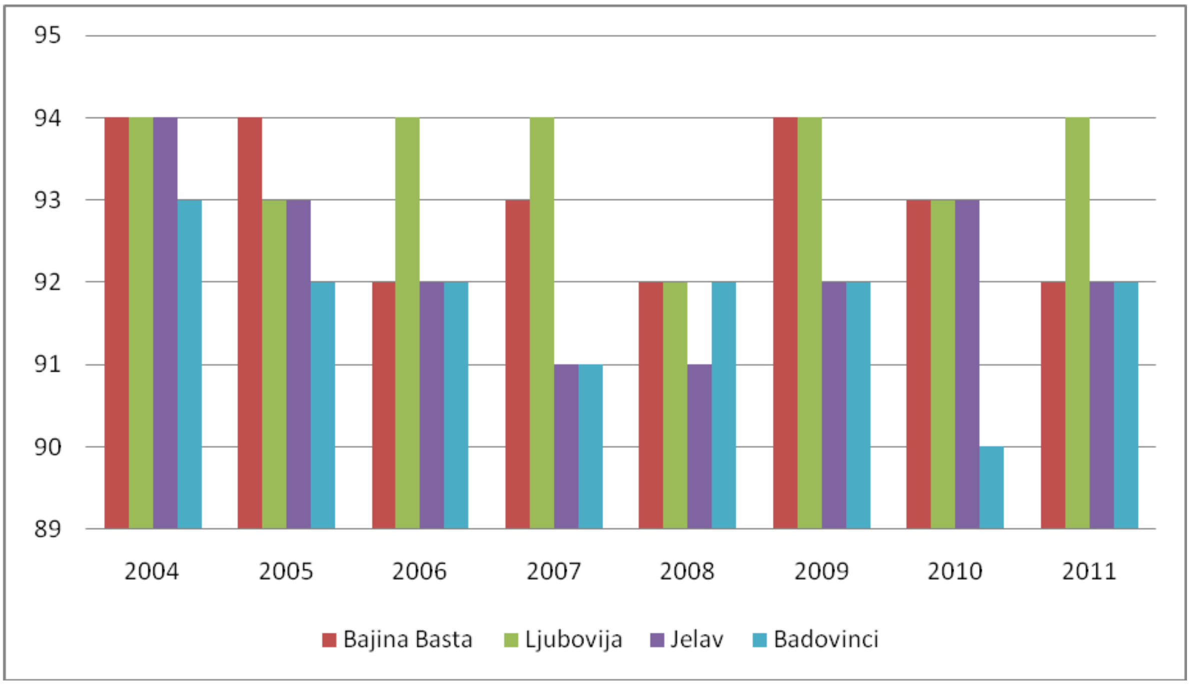
Badovinci is the forth station from which date was used for calculating SWQI. It was calculated 95 times and its values ranged from 90 to 93 (excelent). The lovest average year value of SWQI for entire Drina river was measured on this station in 2010, 90.

Table 5: Monthly values of SWQI for Badovinci station

Month	2004	2005	2006	2007	2008	2009	2010	2011
I	90	97	-	89	94	91	89	94
II	95	95	93	93	94	95	92	95
III	93	91	93	92	93	95	90	93
IV	93	94	86	86	93	95	91	95
V	95	94	91	93	91	91	97	94
VI	93	92	92	87	85	93	88	90
VII	91	89	91	86	91	91	89	90
VIII	93	86	90	91	88	89	87	90
IX	91	90	92	93	92	91	92	86
X	95	94	93	90	94	93	93	93
XI	95	92	95	97	92	94	84	93
XII	95	92	94	95	91	90	91	93
Average	**93**	**92**	**92**	**91**	**92**	**92**	**90**	**92**

The data which are used for this study are the most complete for the Jelav and Badovinci stations, as for the other two stations, that are more upriver, Bajina Bašta and Ljubovija, there are some missing data on monthly period, specifically, in on Bajina Bašta station in 2006 there is no data for January, March, July and December. For 2007, January, March, April and December, 2008, January and November, 2009, February, April, 2010, October and 2011, January, March and November. For the Ljubovija station in 2006 there is no data for January, 2007, March, August and November, 2008, January, and 2011, February and March.

Figure 2: Average values of SWQI for Drina river per year



Values of SWQI for research period 2004 to 2011 are presented on Figure 1. We can see that the highest values are measured on Ljubovija station. On average for the entire research period value of SWQI for Ljubovija station is 93,5. Average value for Bajina Bašta is 93, Jelav station 92,3 and Badovinci station 91,8. These values indicate that the quality of water in Drina river, according to SWQI can be classified as excellent.

Discussion

The water quality status and the spatial and temporal trends along Drina River were assessed through the application of ten parameter WQI, to a eight year public database of environmental data. In the case of Drina River in should be stated that the index is not adopted to a specific use, such as bathing water or fish spawning, but rather prodced a general index to determine the overall water quality.

According to the SWQI, water quality of Drina River in Serbia during period 2004 - 2011, was assessed excellent. Values of SWQI for research period vary from 90 to 94. Both values are classified according to SWQI descriptive quality indicator have been defined as excellent (90-100). However, these results should be accepted as questionable, because SWQI gives information about organic loading, but not about heavy metals pollution. Along 346 km stretch of the river, the water quality droped modestly but steadily downstream.

Temperature can also have influence on water quality. If water tempereature in river is higher, there is intensive biological activity and dissolved oxygen concentration lessens (Sa´nchez, 2007). Sesonal variance in water quality was observed and some patterns were noticed on all four stations. Lowest values were opserved at all stations during July, August, September and October. On the Bajina Bašta statino, average water quality index for August during 2004 – 2011 period is 89 (very good). Highest values were observed during spring and winter months. Therefore, water quality is worse in warmer period of the year. Numerous researches stated the same trend, Suquia

River, Argentina (Pesce & Wunderlin, 2000), Odzi River, Zimbabwe (Jonnalagadda & Mhere, 2001), Bangpakong River, Thailand (Bordalo et al., 2001), San Vicente Bay, Chile (Rudolf et al., 2002), Pampa Murillo, Mexico (Herna´ndez-Romero et al., 2004), Veliki Bački kanal, Serbia (Pantelić et al, 2012). This study shows a clear decrease in water quality during summer period.

According to statistical data processing we can state that water quality of Drina river at four measuring points allows its exploitation. Season and natural factors such as air temperature, do not have significant influence on Drina river pollution.

In conclusion, this study shows the importance of applying a WQI that reflects the collectiv influence of various criteria and allows easy interpretation of data from monitoring networks. Additionaly, this study shows that water quality along Drina River decreases slightly downstream, but it still provides values that according to SWQI descriptive quality indicator have been defined as excellent (90–100). Based on the results of the study that analysed the impact of ten parameters measured on four stations during 2004-2001 period on water quality of the Drina River it has been established that natural factors, primarily water temperature affect changes in water quality throughout the years. Although the anthropogenic impact on the quality of river is far more intensive, this study has established that natural factors may affect the increase or reduction of Water Quality Index throughout the investigated period up to a certain extent.

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