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THE NIŠAVA RIVER WATER QUALITY AS THE INDICATOR OF THE SUSTAINABLE DEVELOPMENT OF THE CITY OF NIŠ

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The Nišava River has a great importance for the sustainable development of the city of Niš. From the Mediana spring, which is on the bank of the Nišava, the city of Niš satisfies around 30% of its water demand. The aim of this paper is to, on the basis of the analysis of several tens of parameters of water quality; determine whether the Nišava River is a limiting factor to the sustainable development of the city of Niš.

For this purpose the data of Public Utility Company Naissus have been used, as it collects daily samples of the Nišava river water. The number of conducted analyses, depending on the water quality parameters, varies from 1 to 1,240. The obtained results, which have been presented in detail in the paper, indicate that a great majority of analyses, of almost all the water quality parameters, is within predicted range. At the end of the paper, certain measures have been proposed, which should contribute to the sustainable development of Niš in this field.

***Keywords:** sustainable development, indicator, Nišava River, City of Niš*

INTRODUCTION

The city of Niš, with a population of 250,000 is by size a third city in Serbia. This city, once a strong regional center, has been sharing the difficulties of the majority of cities in Serbia which have a similar structure of industry and population.

On the other hand, Niš possesses conditions to use the existing resources in the future and to achieve a sustainable development on the new basis and according to the European standards. In order to realize this, it is necessary to create a strategy of sustainable development of the city with and aim of accomplishing a sustainable and environmentally safe development through the long term reliance on own renewable resources. The Nišava River belongs to the most important natural resources of the city of Niš.

The spring of this river is located in Bulgaria, and the length of its course through Serbia is 195 km, and it is oriented SE-NW (Potic and Trajkovic, 2004). It is a tributary of the Southern Morava River and its confluence is at Trupale village. The surface area of the river basin is 3,974 km^2 in total, 3,641 km^2 belonging to Serbia. The river basin of the Nišava River is a sub-basin of the Southern Morava, and by this, of the Danube River. Significant tributaries of the Nišava are: Kutinska, Crvena, Koritnicka, Jerma, Visočica i Temštica rivers. In the Nišava River valley there are the following towns and cities: Dimitrovgrad, Pirot, Bela Palanka and Niš. The water of Nišava river, at the territory of the city of Niš, is used for drinking water supply, local irrigation on a small surface area, and for recreational fishing (Gocic et al. 2007). Water supply of the city of Niš is provided by three territorially separate water supply systems which are very interdependent, and those are:

- Water supply system "Mediana" – spring of ground water repleNišhed with the previously treated Nišava water, with a capacity up to 550 l/s.
- Water supply system "Studena" – karst natural source and the supply pipeline with accompanying structures, with a capacity 220-340 l/s.
- Water supply system "Ljuberađa-Niš" – a series of karst natural springs (Krupac, Mokra, Divljana and Ljuberađa) and the supply pipeline with accompanying structures, with a capacity 800 l/s.

The mentioned systems with their springs, supply pipelines, appropriate distribution network, pump stations and reservoirs represent one water supply system. It supplies water to around 240,000 people and the Niš industry with 37,732,608 m^3/year that is 103,377 m^3 day^{-1}.

The Mediana spring provides stability of the entire system in the periods of reduced yield of karst springs, and that is why the water quality of the Nišava River is of great importance for the development of the city of Niš. The aim of this paper is to, on the basis of the analysis of several tens of parameters of water quality; determine whether the Nišava river is a limiting factor to the sustainable development of the city of Niš.

THE NIŠAVA RIVER WATER QUALITY STATUS

The surface water status is evaluated according to the norms of the Decision of water classification (Official Journal of SR Serbia 5/68) and Code of the hazardous matters in water (Official Journal of SR Serbia 31/82).

The Public Utilities Company Naissus, which is responsible for water supply of the city of Niš, performs the daily water quality status checks at the location where water is taken in, in order to protect the water supply spring and the health of the citizens. The collected water samples are examined on the location or later in a laboratory, to ascertain the presence of several scores of organoleptic, physico-chemical and microbiologic indicators.

The reliability of the Public Utilities Company Naissus was investigated in (Brankovic and Trajkovic, 2007) comparing them to the data of the Institute for Health protection of Niš. The following water quality indicators were compared: minimal, maximal and average values of parameters defining the class of the water course (dissolved oxygen, BPK, HPK, suspended matter, dry residue, pH and the total colliforms (TC)). The obtained results are presented in the Figure 1.

In all the analyzed parameters, the samples of the Public Utilities Company Naissus, have higher maximum values, and lower minimum values, which was expected due to the significantly higher number of samples. The average values of all parameters do not differ significantly irrespective of who processed the samples. This fact confirms that the obtained values are accurate and reliable.

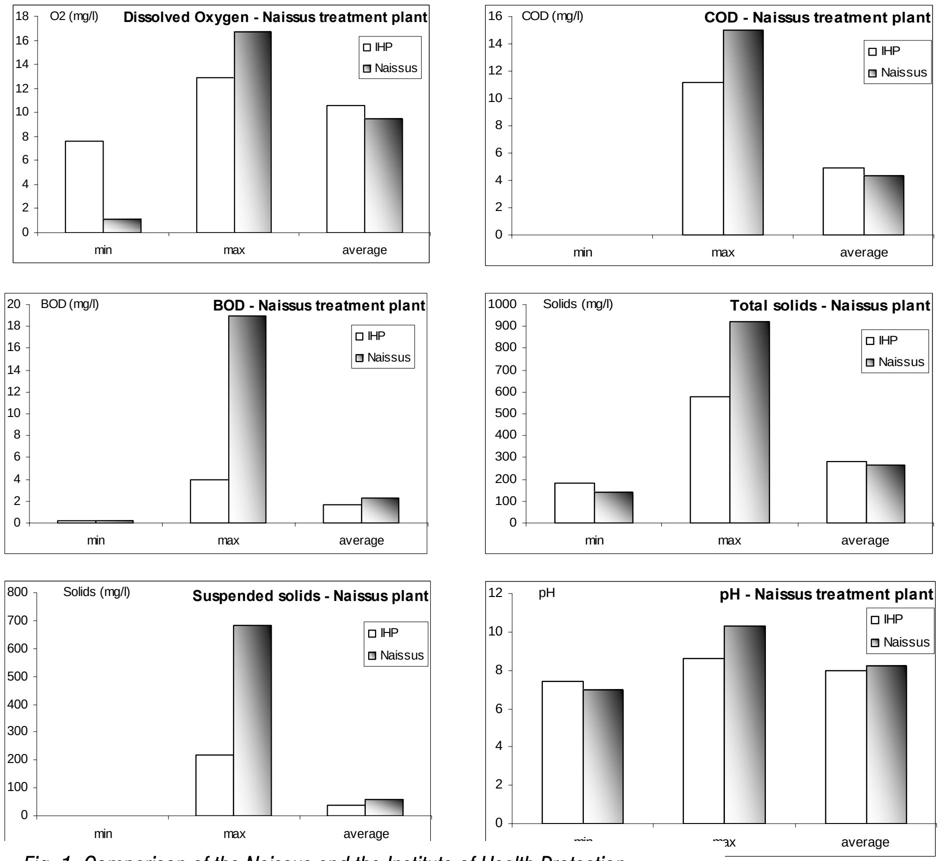

Fig. 1. Comparison of the Naissus and the Institute of Health Protection parameters (IHP)

For the purposes of this paper, the data of the Public Utilities Company Naissus from the period 1st January 2000 to 25th November 2004 were used. The number of analyzed samples in this research ranges between 1 and 1,240 depending on the water quality parameters. Statistic data analysis is given in the table 1 where it can be seen that a large majority of the results of analyses of almost all the water quality parameters is within predicted limits. There are numerous examples corroborating this assertion. Out of 670 analyses of the dissolved oxygen, only the results of one analysis do not comply with regulations. Only 2% of the analyses of Biochemical Oxygen Demand do not comply with the regulations.

Analyses of three parameters significantly do not satisfy the required quality:

- Suspended solids (58% analyses whose result does not comply with regulations)
- Nitrite (23% analyses whose result does not comply with regulations)
- Total Coliforms (78% analyses whose result does not comply with regulations)

Higher concentration of suspended solids can be explained by the fact that Public Utilities Company Naissus takes the water samples from the canal, and not from the river. The higher concentration of nitrites indicates occurrence of organic pollution. Microbiological pollution of the Nišava was not reduced by closing down the industrial facilities, because the main sources are sanitary waste waters. In the Nišava river, there is a high presence of pathogenic bacteria, protozoa, viruses and intestinal parasites. The received microbiological pollution obviously significantly exceeds the capacity of self-recovery of the river.

TOWARDS THE SUSTAINABLE MANAGEMENT OF THE NIŠAVA RIVER WATERS

On the basis of the presented result, it is obvious that the Nišava river quality at this moment is not a limiting factor of the sustainable development of the city of Niš. However, in order to provide an appropriate long-term water quality of the river Nišava, it is necessary to take certain measures which would enable a sustainable water management. The goal to be achieved is establishment of the optimum balance between water resources management and their sustainable usage. Sustainable management of the Nišava river waters should lead to:

Table 1. Maximal, minimal and average values of water quality parameters

No	Parameter	Class II Max Allowed Concent	No. of samples	Min	Max	Average	A	B
1	Air temperature (ºC)	/	167	-3.00	31.00	10.36	-	-
2	Water temperature (ºC)	/	1,212	-2.00	29.00	11.51	-	-
3	Color (Pt-Co scale)	/	1,224	0.00	0.00	0.00	0	0%
4	Odor (-)	/	1,112	0.00	0.00	0.00	0	0%
5	Turbidity (NTU)	/	1,161	0.30	1,000	13.00	-	-
6	Electroconductivity (μS/cm)	/	1,161	3.00	540.00	385.0	-	-
7	pH	6.8-8.5	1,162	7.02	8.90	8.28	5	0.4%
8	Total solids (mg/l)	1,000	430	140.0	920.00	267.1	0	0%
9	Consumption of K-permanganate (mg/l)	/	714	1.10	232.00	3.11	5	0.7%
10	Biochemical Oxygen Demand (mg/l)	4	659	0.16	9.36	2.02	16	2%
11	Chemical oxygen demand (mg/l)	/	4	0.00	15.00	4.36	-	-
12	K-permanganate demand (mg/l)	/	847	0.18	19.10	2.79	-	-
13	Settleable solids (mg/l)	/	3	0.00	2.10	0.77	-	-
14	Suspended solids (mg/l)	30	90	0.05	681.00	60.23	52	58%
15	Dissolved solids (mg/l)	/	164	6.83	428.00	228.5	-	-
16	Dissolved oxygen (mg/l)	>6	670	1.10	13.09	8.50	1	0.1%
17	M-alkalinity (ml 0.1 M HCl/l)	/	1,123	3.30	65.00	40.66	-	-
18	P-alkalinity (mg/l)	/	3	13.10	42.00	32.36	-	-
19	Alkaline hardness (ºdH)	/	61	2.60	15.30	7.53	-	-
20	Non-alkaline hardness (ºdH)	/	61	0.21	10.90	3.79	-	-
21	Total hardness (ºdH)	/	1,110	0.15	18.90	11.96	-	-
22	Aluminum (mg/l)	/	392	0.00	3.10	0.04	5	1%
23	Ammonia (mg/l)	0.1	1,240	0.00	5.70	0.01	1	0.1%
24	Arsenic (mg/l)	0.05	1	0.03	0.03	0.03	0	0%
25	Total Kjeldahl Nitrogen (mg/l)	/	35	0.00	6.80	0.31	-	-
26	Copper (mg/l)	0.1	16	0.00	0.01	0.00	0	0%
27	Cyanide (mg/l)	0.1	41	0.00	0.00	0.00	0	0%
28	Zinc (mg/l)	0.2	10	0.00	0.00	0.00	0	0%
29	Phenol (mg/l)	0.001	764	0.00	0.00	0.00	0	0%
30	Fluoride (mg/l)	1	31	0.00	0.10	0.01	0	0%
31	Iron (mg/l)	0.3	1,125	0.00	0.75	0.05	2	0.2%
32	Chloride (mg/l)	/	1,153	3.20	40.00	6.69	0	0%
33	Chromium III (mg/l)	0.1	1,121	0.00	0.00	0.00	0	0%
34	Chromium VI (mg/l)	0.1	1,121	0.00	0.00	0.00	0	0%
35	Cadmium (mg/l)	0.005	14	0.00	0.00	0.00	0	0%
36	Calcium (mg/l)	/	1,114	2.40	179.00	79.00	0	0%
37	Potassium (mg/l)	/	7	0.93	1.80	1.31	0	0%
38	Magnesium (mg/l)	/	1,112	1.80	86.60	8.81	2	0.2%
39	Manganese (mg/l)	/	1,130	0.00	0.17	0.00	0	0%
40	Sodium (mg/l)	/	8	3.80	7.00	5.30	0	0%

No	Parameter	Class II Max Allowed Concent	No. of samples	Min	Max	Average	A	B
41	Nickel (mg/l)	0.05	1	0.00	0.00	0.00	0	0%
42	Nitrate (mg/l)	10	886	1.20	19.00	6.30	41	5%
43	Nitrite (mg/l)	0.05	1,205	0.00	5.00	0.04	276	23%
44	O-phosphate (mg/l)	/	654	0.00	48.00	0.15	22	3%
45	Lead (mg/l)	0.05	15	0.00	0.01	0.00	0	0%
46	Mercury (mg/l)	0.001	1	0.00	0.00	0.00	0	0%
47	Free chlorine (mg/l)	/	143	0.00	20.00	0.39	-	-
48	Combined chlorine (mg/l)	/	2	0.00	0.00	0.00	0	0%
49	Silicate (mg/l)	/	36	0.00	8.10	4.26	0	0%
50	Free carbon dioxide (mg/l)	/	978	0.00	11.00	1.65	-	-
51	Sulfate (mg/l)	/	812	3.00	90.00	42.50	0	0%
52	Sulfide (mg/l)	/	42	0.00	39.00	0.95	-	-
53	Total phosphates (mg/l)	/	600	0.00	0.71	0.12	0	-
54	Detergent anion (mg/l)	/	751	0.00	0.10	0.00	-	-
55	Oils and fats (mg/l)	0.05	23	0.00	0.50	0.03	0	0%
56	1,2-Dichloroethane (μg/l)	/	268	0.00	0.00	0.00	-	-
57	1,1,1-Trichloroethane (μg/l)	/	268	0.00	0.00	0.00	-	-
58	Bromoform (μg/l)	/	269	0	0	0	-	-
59	Dibromchlormethane (μg/l)	/	269	0	0	0	-	-
60	Dichlorbrommethane (μg/l)	/	269	0	0	0	-	-
61	Chloroform (μg/l)	/	269	0	0.2	0.00	-	-
62	Tetrachloroethylene (μg/l)	/	269	0	0.2	0.00	-	-
63	Trichloroethylene (μg/l)	500	269	0	0.2	0.00	0	0%
64	Carbontetrachlorid (μg/l)	300	266	0	0	0	0	0%
65	Total trihalometani (μg/l)	/	269	0	0.2	0.00	-	-
66	Total Coliforms (No./100(0) ml)	$6*10^4$	1,186	1,500	$24*10^4$	172,212	924	78%
67	Total Viable Count, 22 ºC (No./1ml)	/	1,186	0	$3*10^6$	7932	-	-
68	Total Viable Count, 37 ºC		1,187	0	$92*10^3$	1,494	-	-
69	Fecal Coliforms (No./100(0) ml)	/	1,187	220	$38*10^4$	154,270	-	-
70	Streptococcus Feacalis (No./100(0))	/	1,187	100	$24*10^4$	44,002	-	-
71	Sulfitor.SporogenAnaerob.(No/100(0)	/	1,187	100	$37*10^3$	1,339	-	-
72	Bacteriofag (No./100(0) ml)	/	35	10	$63*10^3$	2,096	-	-
73	Citrobacter. sp.	/	138	0.00	0.00	0.00	-	-
74	Enterobacter. sp	/	282	0.00	0.00	0.00	-	-
75	Eschericia colli	/	1,130	0.00	0.00	0.00	-	-
76	Eschericia sp	/	157	0.00	0.00	0.00	-	-
77	Hafnia	/	8	0.00	0.00	0.00	-	-
78	Klebsillea	/	17	0.00	0.00	0.00	-	-
79	Morganella	/	2	0.00	0.00	0.00	-	-
80	Proteus mirabilis	/	3	0.00	0.00	0.00	-	-
81	Proteus sp. (No./100(0) ml)	/	1,187	200	$38*10^3$	2,169	-	-
82	Proteus vulgaris	/	2	0.00	0.00	0.00	-	-
83	Providencia sp	/	2	0.00	0.00	0.00	-	-
84	PseudomoNiš aeruginosa	/	1,184	200	$24*10^4$	2,585	-	-
85	Serratia sp.	/	14	0.00	0.00	0.00	-	-

A Number of analyses whose result does not comply with regulations
B % of analyses whose result does not comply with regulations

- Improvement of the quality of life of the entire population of the region,
- Protection of health of the population in the entire region,
- Improvement of the environmental conditions in the entire river basin.

The strategy of the sustainable management of the river waters of Nišava should be harmonized with the Water resources plan of the Republic of Serbia. This strategy should be harmonized with the activities in this field within the process of fulfilling the obligations of our country as a member of ICPDR-u (International Commission for Protection of Danube River) and with the activities of the recently adopted National strategy of sustainable development.

Within the sustainable management of waters, it is necessary to promote institutional strengthening, development and enforcement of the law, establish and develop public awareness, with the active participation of the public in the decision process being a component of this new approach (Libra 2007). The implementation plans should be based on the principles of the sustainable development, proximity and the regional approach, precaution, polluter pays, application of the best available technique and responsibility of all the participants in the process (Davis 2007).

In the framework of the measures leading to the sustainable Nišava water management, a proposition of the solution of the environmental status of the Nišava should be provided, of the cadastre of polluters, give a proposition of monitoring according to the Framework Directive on Waters, propose an early warning system, solution of the treatment of communal and industrial waste waters of the city of Niš. All the solutions should be implemented according to the solutions at the National level, and the existing regional solutions, taking into account the experience from the EU.

In the implementation phase, it is necessary to:

- plan, approve and prepare the design documents,
- implement solutions, monitor realization of projects and monitor environment factors,
- educate population and
- train the participants of the process.

CONCLUSIONS

The Nišava River belongs to the most important natural resources of the city of Niš. The Nišava river water, on the territory of the city of Niš, is used for water supply, and its quality may be a limiting factor for the sustainable development of the city of Niš. On the basis of the analyzed water samples the following conclusions can be drawn:

- The water quality status at the water intake location is satisfactory, excluding the total coliforms (TC). This parameter is a constant problem of the Nišava river quality. Concentration of suspended matter and nitrites can occasionally be over the permissible limits.
- The biggest Nišava river water polluters are waste waters from the sewages of the upstream places and of the city of Niš. Industrial waste waters, for the time being, do not represent a big threat for the river course. However, an increase of the industrial production may cause deterioration of water quality.
- In order to provide an appropriate long-term water quality of the river Nišava, it is necessary to take certain measures which would enable a sustainable water management in the entire Nišava river basin. The sustainable development of the city of Niš in this area is not possible without the wider regional approach.

References

Branković, S. and Trajković, S. (2007), The Nišava River water quality downstream of the Sicevo gorge, Monography „Sicevo and Jelasnica gorges environmental status monitoring, Trajkovic and Brankovic (eds.), Institute for Nature Conservation of Serbia and Faculty of Civil Engineering and Architecture, 83 – 92.

Davis, D. M. (2007), Integrated Water Resource Management and Water Sharing, Journal of Water Resources Planning and Management, 133 (5), 427-445.

Gocić, M., Branković, S., Stanković, P., Trajković, S. and Stanković, M. (2007), Monitoring the quality of running waters in the protected areas of the Jelasnica nad Sicevo gorges: project overview, Monography „Sicevo and Jelasnica gorges environmental status monitoring, Trajkovic and Brankovic (eds.), Institute for Nature Conservation of Serbia and Faculty of Civil Engineering and Architecture, 97-100.

Libra, A. J. (2007), Environmental Process Engineering: Building Capacity for Sustainability, Journal of Professional Issues in Engineering Education and Practice, 133(4), 308-319.

Potic, O. and Trajkovic, S. (2004), Irrigation of the Bela Palanka field from the “Zavoj” reservoir, International Conference BALWOIS 2004, Ohrid, Macedonia, fp-113.