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WATER QUALITY OF THE DJETINJA RIVER

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Абстракт: Воде реке Ђетиње користе се за водоснабдевање насеља и индустрије у самом сливу. Дужина реке износи 75,25 km. Квалитет воде се дуж тока мења. Резултати биолошких и хемијских анализа указују на деградацију речног екосистема кроз град Ужице и низводно од њега. Проблему загађења и заштите површинских вода мора се посветити посебна пажња с обзиром да је то један од највреднијих природних ресурса у овом подручју. У раду је приказано стање квалитета воде реке Ђетиње, регистровани највећи загађивачи и наведене су мере за њену заштиту.

Кључне речи: Ђетиња, квалитет воде, загађење водотока

Abstract: Đetinja river waters are used for water supply of settlements and industries in the basin. The length of the river is 75.25 km. Water quality along the flow changes. Results of biological and chemical analysis indicate the degradation of river ecosystems through the city of Užice and downstream. The problem of pollution and protection of surface water must be analyzed in detail because this is one of the most valuable natural resources in area. The paper describes the state of water quality of Đetinja, register the largest polluters and suggest measures for its protection.

Key words: Đetinja, water quality, water pollution

Introduction

The Djetinja River originated in the northern part of the Kremanska valley, connecting the Bratesina River, the Konjska River and the Uzice and Tomic streams. These confluences arise on the eastern and south-eastern slopes of Tara Mt. At the lowest part of the Pozega valley, it receives the Skrapez tributary, while more downstream, it forms significant water artery of Serbia, the Zapadna Morava with the Golijska Moravica. The Djetinja Basin is in the western part of Serbia, between 44+08/ and 43=42/N and 19=27/ and 20=06/E. The area of the Djetinja river basin is 1187.03 km^2, while the flow direction is parallel. The length

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of the river is 75.25 km. The main tributaries are from the left side, forming an asymmetrical basin-the left side comprised 71.4% of its total area. The length of the Djetinja basin is 49.6km, while the mean width is 23.9 m (Milijasevic, 2008). The accumulation "Vrutci" was built in 1987 and its role has been multifunctional one. It enables the satisfying of all needs for the water supply of the town of Uzice with theoretical provision of 100% delivery. Moreover, it contributes significantly to the protection of the town from flooding, because there is a space in the accumulation which is reserved to accept the flooding wave without overflowing the dam. Besides the significance in the water supply of the town of Uzice and other settlements downstream from this town, the accumulation has also been extremely significant in regard of the development of bathing, recreation and vacation and sports-manifestation tourism.

Natural characteristics of water ecosystems have recently been exposed to the significant changes caused above all, by urban and industrial waste waters.

Water Pollution

Industries of the Uice, Sevojno and Pozega settlements are the largest water polluters in the Djetinja river basin. Olga Savic (Savic, 1987) wrote about the territorial development of urban settlements in the Djetinja valley. The greatest organic pollution, as the main cause of the general water quality condition disturbance, gets to the river with the waste waters from the settlements with public sewerage systems.

The river gets pollutions of mainly organic nature at its upper course. It is above all related to the pollution of the Uzice stream by the "Omorika" Hotel at Kaludjerske bare. In the settlements of Kremna and Biosk, several septic tanks flow into the Djetinja, while the considerable quantities of various wastes also get to the river (Marković, 1995).

Uzice, with the Krcagovo and Sevojno suburban settlements, has correctly built sewerage system, including mainly all parts of the settlements. The construction of the sewerage system of Uzice started in 1968 according to separate system. Waste waters from the town's area are pouring out gravitationally into the Djetinja directly (there are around 6 drainpipes) or into the main collector. The main collector receives the greater part of gathered waste waters, ending by a drainpipe into the river towards Sevojno, upstream from the mouth of the Dragicevic stream. The main collector is the framework of the sewerage network and from the left side, waste waters of the lateral collectors flow into it from direction of the Kosticko

stream, Uremovacko and Gluvacko stream, as well as from the area of Krcagovo and Sevojno. The collectors from the direction of Turica, Medjaja and Zabucje flow into the main collector from the right side.

Based on the available Expert finding of the results of the Uzice waste water research (Group of authors, 2006), the following values of represented parameters of water quality for four drains of the Djetinja Riever (waste water taken downstream from the main collector beneath the railroad bridge, near the bus station, downstream from the main collector Krcagovo-near Tannery and downstream from the main collector at Sevojno-near Copper Mill), have been ascertained:

- the results of physical-chemical analyses pointed to the $KMnO_4$ consumpti above the Maximum Acceptable Concentration (MAC) in the sample from the Djetinja River, taken downstream from the collector on the beach.
- the results of physical-chemical analyses pointed to ammonia, $KMnO_4$ consumption parameters above MAC in the sample from the Djetinja River, taken downstream from the collector near the bus station.
- the results of physical-chemical analyses pointed to ammonia, $KMnO_4$ consumption parameters above MAC in the sample from the Djetinja River, taken downstream from the collector near Tannery.
- the results of physical-chemical analyses pointed to ammonia, $KMnO_4$ consumption parameters above MAC in the sample from the Djetinja River, taken downstream from the collector near Copper Mill.

The samples were taken from the course of the Djetinja River, downstream from the sewerage drains directly, but almost after certain mixing and dilution of the included channel contents. The parameters which were above MAC in the examined samples (ammonia, grease and oil, $KMnO_4$ consumption) pointed that the water is very loaded by organic substance, which is understandable, taking into consideration that water originated mainly from the sewerage collectors. Ammonia is the product of the decay of organic substances which contain nitrogen, affected by micro-organisms. The presence of grease and oil is unwanted, because it causes the decrease of the oxygen contents used in the process of their degradation. The results of bacteriological analysis pointed to the load of this water by faecal pollution.

There is not organised evacuation of the waste waters in most of the rural settlements. Their evacuation is most often carried out by septic tanks built primitively, with the sinking of the liquid phase, or into the nearest gullies, channels, streams or rivers.

The waste waters are the consequence of the irrational managing the water resources and they represent the difference between the used water quantities in total and its irretrievable losses, originated in the process of production and for the needs of the population (Dukic, 1988).

Table 1. Industrial complex and other polluters of the Djetinja

Name of enterprise	Location	Production programme
Metaloprerada	Uzice	Produces radiators, heat modifiers, bulb boards, traffic signs, etc.
Prvi partizan	Uzice	Produces military, sports and hunting munition, medical equipment and various machines and tools;
FASAU	Uzice	Produces sanitary armature;
Metalservis	Uzice	Produces alluminium locksmith's trade, fences, paneling, roofing and façade sheets, gutters, metal gallantry;
Masinoimpeks	Uzice	Produces equipment for foundries, machines for pits, tools for casting non-ferrous metals;
ABC proizvod	Uzice	Factory of boilers, heaters and non-ferrous metals;
Woksal	Uzice	Production of hard and heavy metals, high-voltage contacts and fishing material;
Elektrotermija	Uzice	Produces electric heaters and thermo-elements;
Raketa	Uzice	Transportation enterprise;
Copper mill	Sevojno	Rolling mill produces sheet metal, strips, boards, pipes, wires and other various profiles from copper and alloys of copper;
Alluminium rolling mill	Sevojno	Similar assortment of production as previous rolling mill;
Froteks	Uzice	Textile industry for production of toweling fabrics and gallantry;
A.D. „Mlekara“	Sevojno	Purchase and processing of milk into various dairy products;
Dairy store „Zlatibor EKO“	Uzice	Production and processing of milk;
Meat market AD „Mesar“	Uzice	Slaughterhouse for production and meat packing;

Until now the purification of the communal waste waters has not been solved at none of the settlements. By the actual general plan, the location of the central purification plant was accepted at the left bank of the Djetinja towards Gorjani settlement, about 11.5 km downstream from Uzice (Group of authors, 2007). The quality of communal waste waters is mainly known and the basic groups of substances in them are of organic and inorganic origin, whereas they can be in the suspended or dissolved state.

Industrial waste waters, in contrast to communal, contain wider spectre of polluting substances, while both seasonal and daily variations of the quality are also possible. The town of Uzice with the industrial complex of Krcagovo and Sevojno cause serious aggravation in regard of the contents of heavy metals by letting the waste industrial waters out. The increase of copper and zinc is the most significant, while the concentration of lead and chromium is little.

About 80% of used water from households and around 85% from industry return to the collectors (Dukic, 1980).

Economic enterprises which contribute most to the pollution of the river are the following:
Copper mill, Sevojno-the mill produces sheet metal, strips, boards, pipes, wires and other various profiles made of alloys of copper. Technological waste waters can be classified into three groups: washable, bichromate soluble and emulsions. Waste waters are mostly loaded by copper and zinc ions. The quantity of waste water is around 100m^3/hour on the average. The corresponding devices were built for the purification of waste waters. The results of the research of waste waters of Copper Mill at Sevojno, after the treatment on devices, indicated the base character of waste waters, with the increasing consumption of potassium permanganate and most probable number of coliform germs which is the indicator of faecal pollution.

Aluminium rolling mill Sevojno – the production assortment of this rolling mill is similar to the previous one, with a difference that aluminium is used in this production. Technological waste waters are similar, whereas ions of aluminium and zinc are present. The waste waters are drained at mutual installations for purification with the previous ones "Raketa", Uzice- transportation enterprise within which there are car wash services for heavy and light vehicles, as well as service for the motor pool maintenance. The waste waters from washing and removed grease are pouring out into the sewerage system of the town. The average quantity of waste waters is around 10m^3/hour (Group of authors, 2007).

Besides the mentioned economic buildings (Table 1), there are private farms, abattoirs and dairy stores at many settlements. The waste waters of mainly organic origin are poured out from these buildings into the river without any purification.

Figure 1. Regional landfill waste near Pozega
(Taken by Milijašević D.)

Considering that the polluters' legal obligation is to examine the impact of waste waters on the quality of the Djetinja River, the controls are carried out once a year by the Public Communal Enterprise "Vodovod", Uzice. The results of the chemical analysis of the samples of water throughout 2006 from Turija to Potocinje showed insignificant deviation in regard of the increase in the contents of organic substances, ammonia and grease, which is expectable, taking into consideration the sort and quantity of sanitary waters poured out. The bacteriological analyses of the samples from Turica to Potocinja showed that the river water was of the II category in the Turica, the bacteriological pollution was very strong in the part through the town and up to Srevojno, while at Potocinja near the bridge, the bacteriological situation was considerably more favourable and belonged to the third category (Group of authors, 2007).

There are not any industrial buildings downstream from Sevojno to Pozega. In this town, the industrial and urban waste waters are poured out into the Skrapez River. At Rasna village, near Pozega, by the very riverbed of the Djetinja River, there

is a regional landfill waste (Figure 1) which is a large water polluter. Besides the communal and industrial pollution, other forms of the pollution of the Djetinja and its tributaries should also be mentioned.

The water quality is also destroyed by harmful influence of the quarry which is located on relatively small distance from the exit of the gorge, by the right side of the M-21 highway Uzice-Nova Varos. Throughout the operation of the quarry, it unavoidably comes to the making of the waste waters, polluted by motor oil and grease. The Djetinja River is the closest recipient being on about hundred meters away from the quarry. Since there is not a sewerage network near the quarry, the problem of the waste water pollution is solved by devices for purification. By the use of the technology of exploitation of stone (placing mines), it comes to the crashing down of the significant quantities of stone mass into the Djetinja. It is necessary to have such degradation removed or at least reduced to the minimum, especially when considered that there is a dam in Turica, on the Djetinja River, downstream from the quarry. Until the construction of "Vrutci" accumulation, the dam served for the water supply of Uzice, while nowadays it has served as the water supplying reserve.

Atmospheric deposits, surface wash, all sorts of waste materials, wash out of cultivated and uncultivated agricultural land are mentioned as the sources of the river pollution. Agricultural production gives certainly the significant contribution to the pollution and it is the dispersed sources of the pollution about at which the reduction of the emission of polluting substances cannot be carried out by building-technological devices, but agro-technical measures mainly.

Water Quality

In accordance with legal regulation, the control of water in nature has been within the competence of the Meteorological Bureau. The way of the control, researching frequency and the scope of the research are regulated by law.

The quality of water of the Djetinja River is observed at Gorobilje station, at the accumulation "Vrutci" and at the first rank Biosk-Djetinja spring. The physical-chemical, saprobiological and bacteriological parameters are observed.

According to the Regulation on the categorisation of water and the Regulation on the classification of waters in the Republic of Serbia, waters are classified into I, II a, II b, III and IV class by the given limiting values of the indexes of quality. The classes of the quality of waters are defined by 12 parameters: dissolved oxygen,

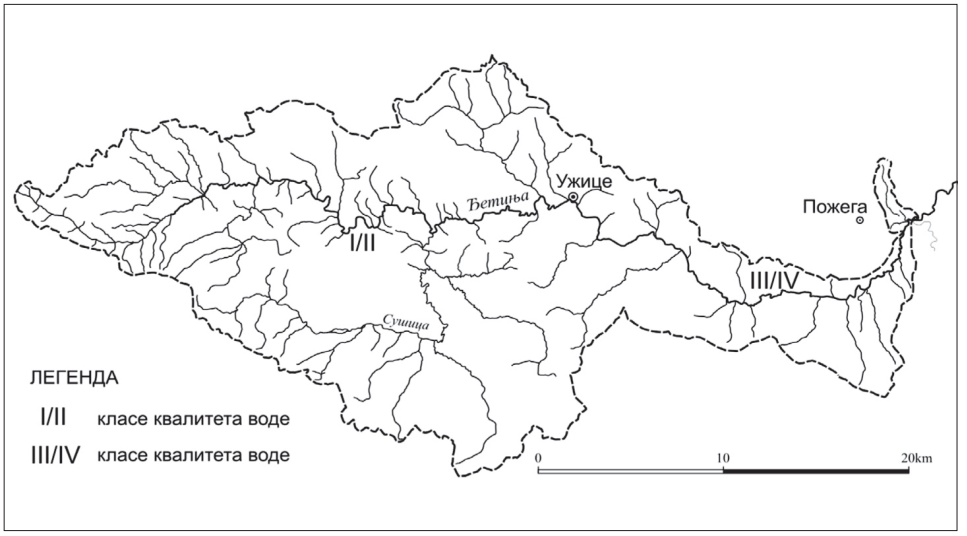

Figure 2. Classes of the water quality in the Djetinja River

percentage of saturation by oxygen, BPK-5, HPK, saprobic degree, the most probable number of coli-germs, suspended substances, dissolved substances, pH, visible waste substances, colour and smell (Urosev, 2006).

The classes of all 12 parameters for the Djetinja River in the period from 1992 to 2005 are shown in the Table 2.

Analysing the parameters, it is concluded that the quality of saprobiological and physical-chemical parameters is mainly satisfying (I and II class), while the exception is BPK-5. The bacteriological parameters are out of the given classes. The biochemical consumption of oxygen (BPK-5) represents the used quantity of oxygen dissolved in water for the process of oxidation and dissolution of organic substances. The increased BPK-5 points to the organic nature pollution.

The formation of the structure of water developed in the accumulations under the influence of the external factors and processes in the very accumulation system. The quality of water from the accumulations that are used for water supplying is represented descriptively due to the non existence of the legal regulations on the water quality of the accumulations.

The water quality has been examined in the accumulation “Vrutci” since 1991 by the Republic Meteorological Bureau on the following profiles: near the dam on

Table 2. Water quality of the Djetinja River near Gorobilje 1992 – 2005. year

	1992.	1993.	1995.	1996.	1997.	2001.	2003.	2004.	2005.
Dissolved oxygen	I	I	I	I	I	III	I	I	II
Percentage of saturation by oxygen	II	II	II	III	II	II	IV	III	II
BPK-5	III	III	IV	III	III	II	III		II
HPK	I	I	I	I	I	I	I	I	I
Saprobic degree	II	II	II	III	II	II	II	II	II
Most probable number of coli germs	II	II	III	IV	III	IV	IV		IV
Suspended substances	IV	I	VK	VK	II	II	I	II	II
Dissolved substances	I	II	II	II	I	II	I	I	I
pH	I	I	I	I	I	I	I	I	II
Visible waste substances	I	I	I	I	I	I	I	I	I
Colour	I	I	I	I	I	I	I	I	I
Smell	I	I	I	I	I	I	I	I	I
Real class	II/III	II/III	III/IV	III/IV	II/III	II/III	III/IV		III
Demanded class	IV	IV	IIA	IIA	IIA	IIA	IIA	IV	IV

three depths at points A-1 (0.5 m), A-2 (25 m), A-3 (50 m); in the middle of the lake on three depths at points B-1 (0.5 m), B-2 (8 m), B-3 (15 m); and at the beginning of the lake on three depths at points V-1 (0.5 m), V-2 (2.5 m) and V-3 (5 m). In 2006 the sampling was done on September 27th and the measured value of the suspended substances in the sample B-3 corresponded to the III class. The fall of the contents of dissolved oxygen was noticed, i.e. low values of dissolved O2 and the percentage of the saturation of water by oxygen, the deficit of oxygen at A-3 and B-3 points (III and IV class). In the A-1, B-1 and V-1 samples, the pH value showed the alkali reaction, so by that index it belonged to the III class. According to the saprobic degree it belonged to beta mesosaprobic waters. In 2007, the sampling of water of the accumulation was done on September 18th. The percentage of the saturation of water by oxygen at A-3 and B-3 points corresponded to the III class

(deficit of oxygen). The pH value showed the alkali reaction at the surface layer, at A-1, B-1, V-1 samples, and by that index it belonged to the III class.

In the period from 2003 to 2007 it came to the significant decrease of the dissolved oxygen concentration and to the increase of HPK value in the accumulation "Vrutci". Among dangerous and harmful substances the increased concentrations of iron, manganese, nickel and mercury were registered at the bottom of the accumulation.

There is a lack of the permanent examination of the water quality downstream from the dam in order that the effect of the accumulation on the quality of water could be established.

Conclusion

The industries of the Uzice, Sevojno and Pozega settlements are the largest polluters of the Djetinja River. Based on the results of biological and chemical analyses, it was concluded that the quality of water was being changed along the flow. Upstream from Uzice, the quality of water was passing from the first to the II class, from Uzice to Pozega the flow was exposed to the intensive pollution and partial self purification, while the quality of water was in the III, i.e. the IV class. The degradation of the river ecosystem was noticed through the town of Uzice and downstream from it.

Uzice municipality has still not made the local ecological action plan by which the largest problems of the environment would be defined and adequate solutions offered. The problems in the field of the protection of waters lie in disregard of the existing regulation as well as in the regulations that were brought several of tens years ago and they had significant lacks whereof the following ones have been the most important:

- the lack of standards for the emissions of pollution;
- the limited values of some parameters for establishing the classes of surface waters are not adequate (e.g. MAC values are not established for nutrients, while the standards are far gentler than those in EU for some dangerous substances);
- the unsaid and inadequate instruments for carrying out the "polluter pays" policy;
- the areas intended for recreation and bathing are not defined as "protected areas";

More qualitative water would enable the realisation of the modern irrigational systems in the Morava valley, the use of underground waters as the source of water supplying of the population and the use of water for sports, recreation, fishing, etc.

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