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## SOME INDICATORS OF WATER QUALITY OF THE TAMIŠ RIVER

*This paper shows the results obtained in field analysis performed at the Tamiš River, starting from the settlement Jaša Tomić (the border between Serbia and Romania) to Pančevo (the confluence of Tamiš into the Danube). The Tamiš is a 359 km long river rising in the southern Carpathian Mountains. It flows through the Banat region and flows into the Danube near Pančevo. Over the years, the water quality of the river has severely deteriorated and badly affected the environment and the river ecosystem. In situ measurements enabled determination of physico-chemical parameters of water quality of the Tamiš River at every 400 m of the watercourse, such as: water temperature, pH value, electrical conductivity, contents of dissolved oxygen and oxygen saturation. The main reason of higher pollution of Tamiš is seen in connection to DTD hydro system. Sampling was performed at 7 points with regard to color, turbidity, total hardness, alkalinity, concentration of ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, iron, chlorides and sulphates in samples. The aim of the present work was to evaluate water quality in the Tamiš River taking into account significant pollution, which originates from settlements, industry and agriculture, and to suggest appropriate preventive measures to further decrease the pollution of the river's water.*

*Key words: water quality; Tamiš River; physico-chemical parameters; pollution; DTD canal; anthropogenic activities.*

The surface water chemistry of a river at any point reflects several major influences, including the lithology of the basin, atmospheric inputs, climatic conditions, and anthropogenic inputs [1,2]. Human activity affects river systems in numerous ways, for example, through afforestation or deforestation, urbanization, agricultural development, land drainage, pollutant discharge, and flow regulation [3-7]. Increasing water pollution causes not only the deterioration of water quality, but also threatens human health and the balance of aquatic ecosystems, economic development and social prosperity [8].

The Tamiš River is one of the most important rivers in the western part of Romania, with many tributaries which influence water quality and quantity. Pollution of the Tamiš River in the territory of Romania is due to discharges of sewage near the city Caransebeș, industrial waste near the cities Caransebeș and Lugoj and discharges of animal waste by

livestock farms near the communes Sag, Peciu Nou, Padureni, Parta and town Ciacova [9]. The Tamiš River flows through the Banat region and flows into the Danube near Pančevo, in northern Serbia. It plays an important role in the cultural landscape, for example for transportation, recreation and tourism. Previous measurements of water quality in Vojvodina have indicated general conclusion that majority of pollutants reach water through runoffs from agricultural land and from industrial and public sewage systems located along the watercourse and canals [10-12]. Based on data from the Republic Hydrometeorological Service of Serbia for the period 2001-2006, Veljković *et al.* [11] reported about the analysis of water quality in Tamiš, applying the Water Quality Index (WQI) method in the Jaša Tomić profile, the most upstream water measuring point of the Serbian flow of the river Tamiš, in the Botoš profile and in the Pančevo profile, before the confluence into the Danube. As for the Jaša Tomić profile, water quality in Tamiš was 84 WQI in 2001 (very good), while in 2006 it was 83 WQI (good). Downstream profile Botoš recorded quite low quality: in 2001 it was 72 WQI (good), while in 2006 it was 69 WQI (bad) with the lowest quality of 63 WQI (bad) in 2003. In the most downstream point of Pan-

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čevo, the quality ranges between 74 WQI (2001), 75 WQI (2002) and 73 WQI (2004), all in the category “good”, and 71 WQI (2003), 66 WQI (2005 and 2006) all in category “bad” [11]. Pajević *et al.* [13] reported that the rivers which flow into the Danube from its entering point in Serbia (the Tisza, the Sava, the Morava, and the Tamiš) significantly influence the chemical load (Fe, Mn, Cu and Cd) of water and sediment. Downstream from the mouth of the Tamiš River, higher concentrations of researched metals were registered in the Danube sediment [13]. Eutrophication is the main problem threatening the biodiversity and the economic potential of the riverine ecosystems, the Danube delta and the Black Sea. There is considerable uncertainty about the emissions of nutrients to the Danube River system from different sources and different countries [14,15]. Much more detailed studies are needed to develop a reasonably good understanding of the contribution from Serbia to the emissions of nutrients to the Danube River system. Some of pollution sources in the Tamiš watershed are hydro-technical water supply facilities of the hydro-system Danube-Tisza-Danube (DTD), numerous fish ponds, industrial facilities, agricultural husbandries, farms and urban settlements. They pollute water in the Tamiš, but they also pollute the surrounding soil. Pollution stemming from fertilizer plants can cause contamination of surrounding air and waterways.

The present study aims to evaluate water quality in the Tamiš River, taking into account the significant pollution generated in settlements, industry and agriculture. In order to identify potential pollution sources in the Tamiš watershed, a preliminary field survey was applied along the sides of both banks of the Tamiš River. This was followed by in situ measurements of temperature, pH, electrical conductivity, contents of dissolved oxygen and oxygen saturation at every 400 m of the watercourse. Also, 7 locations were selected for additional analyses of most important physico-chemical parameters of water quality of the Tamiš. This is the first comprehensive study relating the observed water quality with pollution sources generated within the Potamišje region. As far as we know, so far there have not been any in situ measurements in the Tamiš water which would include pH measurements, contents of dissolved oxygen and electrical conductivity for the whole watercourse of the Tamiš through Serbia.

## EXPERIMENTAL

### The study area

The Tamiš wells in northern parts of Romanian Carpathians, flows through Banat and finally reaches

the Danube near Pančevo (Figure 1). Its total length, from the spring to the confluence is 359 km, out of which 241 km belongs to Romania and 118 km to Serbia. The Tamiš River in Serbia passes through 15 settlements (Jaša Tomić, Boka, Sečanj, Neuzina, Botoš, Tomaševac, Orlovat, Idvor, Farkaždin, Sakule, Opovo, Sefkerin, Glogonj, Jabuka and Pančevo).



Figure 1. Location of sampling points.

Before field examinations of physico-chemical parameters of the Tamiš water, a field survey was performed along both banks of the river, in order to identify potential pollution sources in Potamišje region. Among potential pollution sources we found anthropogenic facilities such as chemical industry for production of soaps and detergents - Panonija in Pančevo, food processing industry (dairy plants) in Sakule, extraction of clay and bricks production in Orlovat and Sečanj, oil field in Boka, intensive fishery facilities (fish ponds) in Sečanj, Neuzina, Orlovat, Sakule, hydro-technical water supply facilities of the hydro-system Danube-Tisza-Danube (DTD): Botoš Lock, Tomaševac Lock, Opovo Lock and Pančevo Lock, slaughterhouses and swine farms in Sečanj and Farkaždin, inflow of melioration canals into the Tamiš River near the Jaša Tomić, Sakule, Sefkerin, Glogonj, Jabuka and Pančevo, discharges of sewage and number of septic tanks near the Jaša Tomić, Sečanj,

Boka, Idvor and Opovo, disposal of industrial and domestic waste in dumpsites near the Jabuka and Pančevo. The use of pesticides and mineral fertilizers in arable land result in partial absorption of those substances by plants, while the remaining part is dissolved in water under the influence of atmospheric rainfall and certain physico-chemical processes, passes through soil in runoffs, reaches ground water or melioration canals which flow into the river course as recipient, which pollutes water in the river course. Hydro-technical facilities of DTD hydro system are not conventional pollution sources, but they cause indirect reduction of the river water quality. Changes in water flow, which are caused by locks movements in DTD hydro systems, result in the pouring of polluted water onto the river bed and reduction of dissolved oxygen level in water. As a consequence, the eutrophication process is accelerated, while the autoperification process is slowed down, which could have extremely negative impact for biodiversity in the water bodies and in the surrounding wetlands and forests, and also for human health in the region [16-20]. As for dangerous substances, pesticides are obvious, those with organic chlorine compounds are carcinogenic and bioaccumulative according to their intrinsic properties. Through bioaccumulation process, they settle and build up in organisms, and through the food chain they reach end-users, *i.e.*, fish and people [21,22]. Waste disposal sites present extremely dangerous pollution sources. On the basis of the report issued by the Republic Environmental Inspectorate for the first half of 2009, it was concluded that only 1 landfill and 26 dumpsites are located in Pančevo, 4 dumpsites are located in Opovo and 20 dumpsites are located in Secanj. Types of waste which are being dumped include: communal waste, metal waste, used packaging material, agricultural waste, animal waste, green waste, construction waste, electronic waste, waste tyres, medical waste, etc. The municipal landfill in Pančevo is located next to the Tamiš River bank, and it does not meet basic sanitary requirements - protective foil and system for collection and treatment of leachate water. Taking into account the vicinity of the river and quantity and composition of waste which has been disposed on the site for more than a decade, it is very probable that leachate waters from the landfill have polluted ground waters and surface water of the Tamiš River as well.

#### Analytical methods and equipment

The following parameters were measured: air temperature, water temperature, pH, electrical conductivity (EC), contents of dissolved oxygen (DO) and

oxygen saturation. In addition to these data, color, turbidity, total hardness, alkalinity, concentration of ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, iron, chloride and sulphate were measured at 7 points. The measurements were conducted in the period between 26 August and 2 September, 2009. The following equipment and instruments were used for field analysis: air temperature and pH were measured with a LaMotte pH 5 Series Meter (pH value range 0.0-14.0, accuracy  $\pm 0.01$ , pH and air temperature range 0.0-100.0 °C, accuracy  $\pm 0.5$  °C) calibrated with buffer solutions pH 4.01, 7.00 and 10.00; water temperature, EC, DO and oxygen saturation with a Hach HQ40d Digital Multi-Parameter Meter with automatic temperature calibration (water temperature range 0.0-80.0 °C, accuracy  $\pm 0.5$  °C; EC range 0.1  $\mu$ S-200 mS, accuracy  $\pm 0.5\%$ ; DO range 0-20 mg/L, accuracy  $\pm 0.01$  and oxygen saturation range 0 to 200%, accuracy  $\pm 1\%$ ) [23]. In order to determine color, turbidity, total hardness, alkalinity, concentration of ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, iron, chloride and sulphate, a portable laboratory LaMotte Smart Water Analysis, Model SCL-05, with LaMotte Smart2 calorimeter was used [24]. Blanks were run through all experiments to detect any contamination.

#### Position of sampling points

*In situ* measurements were done at each 400 m down the Tamiš. Measurements performed from the boat at even distance from the banks. Every measurement point was located by the means of Garmin Etrex Legend GPS device. Table 1 contains data about 7 sampling points along the Tamiš watercourse. Water was sampled from the boat in surface layer (0.5 m), at even distance from the banks (10-30 m). These sampling points are shown in Figure 1.

## RESULTS AND DISCUSSION

#### Electric conductivity, dissolved oxygen and pH

The results of pH measurement, measurements of EC and contents of DO are presented in Figure 2. On the basis of *in situ* measurements of pH, EC and contents of DO, we divided Tamiš River into three sections (Figure 1), as follows:

Upper Tamiš (up to the inflow of DTD canal) - downstream from 118 to 86 km (Jaša Tomić, Boka, Sečanj, Neuzina, Botoš, Tomaševac);

Middle Tamiš (up to the Opovo Lock) - downstream from 86 to 39 km (Orlovat, Idvor, Farkaždin, Sakule);

Lower Tamiš (up to its confluence into the Danube) - downstream from 39 to 0 km (Opovo, Sefkerin, Glogonj, Jabuka and Pančevo).

Table 1. Sampling points along the Tamiš watercourse

Sample	Location	Pollution sources	GPS coordinates
1	Jaša Tomić	Agriculture, waste disposal sites, discharges of sewage	45°25'56.25"N 20°51'59.10"E
2	Sečanj	Agriculture, waste disposal sites, extraction of clay and bricks production, fish ponds, discharges of sewage	45°21'28.80"N 20°46'23.60"E
3	Tomaševac	Agriculture, waste disposal sites, canal DTD, fish ponds	45°16'18.90"N 20°36'44.45"E
4	Opovo Lock	Agriculture, food processing industry, discharges of sewage, waste disposal sites	45° 3'25.13"N 20°24'59.93"E
5	Opovo (after the lock)	Agriculture, discharges of sewage, waste disposal sites	45° 3'18.17"N 20°24'59.20"E
6	Pančevo (quay)	Industry, discharges of sewage, agriculture, waste disposal sites, chemical industry	44°51'54.91"N 20°38'19.90"E
7	Pančevo (confluence into the Danube)	Industry, waste disposal sites, chemical industry	44°50'54.01"N 20°38'9.61"E

Water temperature ranged between 24.3 and 28.1 °C during the measurements. The observed pH of Tamiš River ranged from 7.3 to 9.4, and the highest pH values were observed in the area of Upper Tamiš (up to the inflow of DTD canal), which range from 8.4 to 9.4. This may be due to the fact that algae and macrophytes reduce the amount of carbon dioxide as a result of photosynthesis, thus reducing the production of carbonic acid and increasing the pH. The largest variety of aquatic animals prefers a pH range of 6.5–8.0, and the biodiversity decreases as the pH goes out of this range [25,26]. Figure 2 also shows almost constant pH values from the inflow of DTD canal to the confluence of Tamiš into the Danube, where it ranged between 7.3 and 7.7.

Measurement results for contents of DO presented in Figure 2 indicate that concentration of DO

had its maximal value of 14.17 mg/L, while the minimal measured value of DO was 2.8 mg/L. As shown in Figure 2, a sharp decrease of DO concentration begins immediately after the inflow of DTD canal (86 km on the abscissa), falling from 9.5 to 5.1 mg/L. This decrease is due to abundant introduction of organic pollutants which consume the dissolved oxygen. In the area of Upper Tamiš, value of DO ranged between 7.7 and 14.2 mg/L and the value of oxygen saturation ranged between 95 and 177.6%. This supersaturated (over 100%) values can indicate problems, such as excessive plant growth and high photosynthetic activity. Oxygen saturation above 110% can be harmful to aquatic life. Fish in water containing excessive concentration of DO may suffer from „gas bubble disease“ [27]. In the area of Middle and Lower Tamiš, concentration of DO ranged between 4.7 and

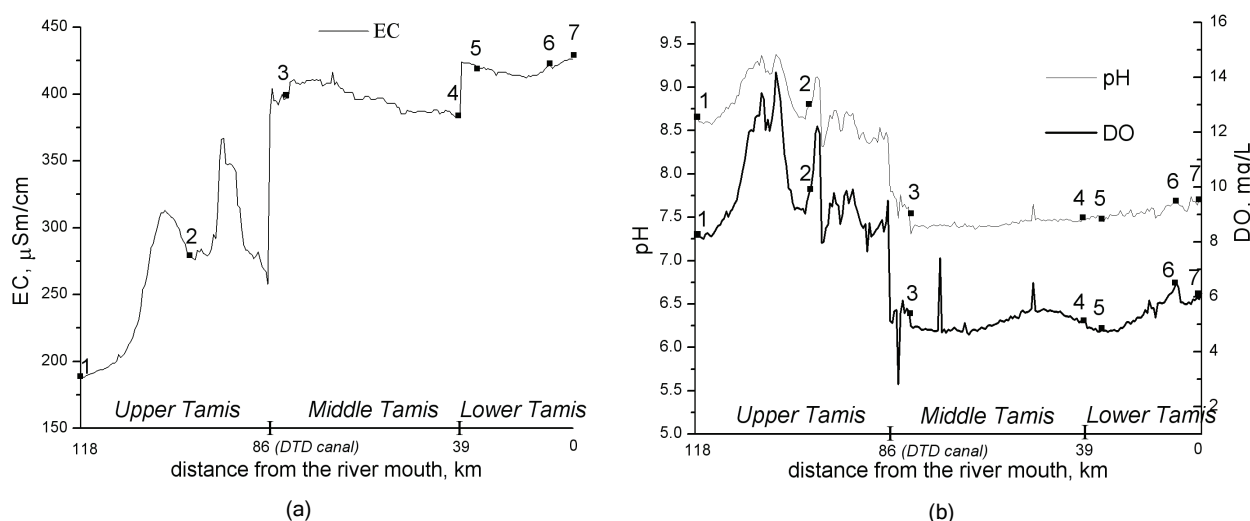


Figure 2. Changes in physico-chemical parameters of river water in middle stream along the examined section; a) electrical conductivity; b) pH and concentration of dissolved oxygen.

6.5 mg/L with the exception of two peaks, in which concentration amounted to 2.8 and 7.4 mg/L. As DO levels in water drop below 5.0 mg/L, aquatic life is put under stress [25].

The increase in EC occurs due to higher anionic (carbonate, bicarbonate, chloride and nitrite ions) and cationic (calcium and magnesium ions) contents in water. The leaching of chemical fertilizers spread on agricultural lands by rainwater also causes high values of EC [28]. Figure 2 shows that lowest value for EC was measured at the course beginning (188.2  $\mu\text{S}/\text{cm}$ ), while greatest value was measured at the confluence of Tamiš into the Danube, in Pančevo (426  $\mu\text{S}/\text{cm}$ ). In the area of Upper Tamiš EC ranged between 188.2 to 367  $\mu\text{S}/\text{cm}$ , then it had a sharp increase to 404  $\mu\text{S}/\text{cm}$  immediately after the inflow of DTD canal into the Tamiš, an indication of the increasing salt and ion concentrations. The main reason of higher pollution of Tamiš is seen in connection to DTD hydro system, because DO content decreases, whilst EC increases. Waters if the 1st class has pH ranging between 6.8 and 8.5, which means that pH of the Tamiš water after the inflow of DTD canal is within range of the 1<sup>st</sup> class of waters; however, when DO is used as the parameter for water status evaluation, Tamiš may be classified as 2<sup>nd</sup> and 3<sup>rd</sup> class of water [29].

### Water quality of the Tamiš River

Measurement results for physico-chemical parameters, nutrients and metals in water samples of the Tamiš River in seven different locations are presented in Table 2.

The highest EC level was found in sample 7 (confluence into the Danube). The increasing in EC (Figure 2) is in correlation with the increase in alkalinity, total hardness and chloride contents, with the increase in nitrite nitrogen and nitrate nitrogen contents (Table 2 and Table 3). According to Olsen's classification [30] on the basis of conductivity, waters with conductivity values between 250 and 1000  $\mu\text{S}/\text{cm}$  are rich in electrolytes and are characterised as eutrophic. Our results for all studied samples generally belong to this range, except for sample 1 (Jaša Tomić). The lowest DO level (4.78 mg/L) was found in samples 3-5. This suggests that the discharge of food processing industry and domestic wastewater induced serious organic pollution in these samples from Tomaševac and Opovo, since the decrease of DO was mainly caused by the decomposition of organic compounds [31]. The low concentrations of DO in the water-courses from Tomaševac may be attributed to the discharges of DTD canal. Values for contents of sulphates and turbidity in water samples were quite even. The iron concentrations were slightly higher in sample 3 and sample 5 than the 1<sup>st</sup> and 2<sup>nd</sup> water class standard (0.3 mg/L) [32]. Possible origins of Fe could be the geology of the area, corrosion of waste iron objects in the river and the vicinity of Botoš Lock and Opovo Lock. The total hardness in water samples ranged between 70 and 128 mg/L as  $\text{CaCO}_3$ , while alkalinity ranged between 84 and 115 mg/L as  $\text{CaCO}_3$ . Data in Table 4 reveal that total hardness and alkalinity had very strong correlations with contents of nitrate nitrogen and chloride. U.S. EPA Directive recom-

Table 2. Physico-chemical parameters, nutrients and metals in water samples of the Tamiš River

Parameter	Sample						
	1	2	3	4	5	6	7
Air temperature, °C	28	30	30	23	27	28.6	27.6
Water temperature, °C	24.4	27.3	25.8	26	24.6	25.6	25.9
pH value	8.7	8.8	7.6	7.5	7.5	7.7	7.7
EC, $\mu\text{S}/\text{cm}$	188.2	278	398	379	421	426	427
DO, mg/L	8.2	9.78	5.35	5.26	4.78	5.97	6.18
Oxygen saturation, %	99.5	124.3	65.9	64	57.3	73.9	76.3
Color, PCU	50	13	56	16	63	20	56
Turbidity, NTU	10	6	11	1	8	6	10
Total hardness, mg/L as $\text{CaCO}_3$	76	104	126	124	128	124	128
Alkalinity, mg/L as $\text{CaCO}_3$	85	84	112	100	104	115	112
Ammonia nitrogen, mg/L	0.12	0.19	0.08	0.12	0.14	0.07	0.09
Nitrite nitrogen, mg/L	0.005	0.036	0.054	0.061	0.1	0.031	0.077
Nitrate nitrogen, mg/L	0.06	0.11	1	0.94	1.01	0.81	1.08
Iron, mg/L	0.19	0.23	0.43	0.17	0.32	0.13	0.14
Chlorides, mg/L	12	12	36	36	40	42	40
Sulphates, mg/L	30	53	26	38	49	48	43

mends minimal alkalinity level of 20 mg/L as CaCO<sub>3</sub>. High alkalinity and total water hardness may partially abate toxic effects of heavy metals to water life. Metals are more toxic at lower pH values, and according to EPA Directive pH values of 5-6 or lower are considered to be toxic to fish [25,26]. The pH values of samples ranged between 7.5 and 8.8.

The classes of water samples for the seven parameters for evaluation water quality are shown in Table 3. According to Regulation on dangerous substances in the water [32], waters of the 1<sup>st</sup> and 2<sup>nd</sup> class may contain maximally 0.1 mg/L of ammonia nitrogen (NH<sub>3</sub>-N), 10.0 mg/L of nitrate nitrogen (NO<sub>3</sub>-N), 0.05 mg/L of nitrite nitrogen (NO<sub>2</sub>-N) and 0.3 mg/L of iron, while waters of the 3<sup>rd</sup> and 4<sup>th</sup> class may contain maximally 0.5 mg/L of ammonia nitrogen (NH<sub>3</sub>-N), 15.0 mg/L of nitrate nitrogen (NO<sub>3</sub>-N), 0.5 mg/L of nitrite nitrogen (NO<sub>2</sub>-N) and 1.0 mg/L of iron. Samples 1, 2, 4 and 5 (Jaša Tomić, Sečanj and Opovo) showed ammonia nitrogen concentrations (Table 2) within range of the 3<sup>rd</sup> and 4<sup>th</sup> class of waters according to Regulation on dangerous substances in the water [32]. The source of water contamination in samples 1, 2, 4 and 5 are discharged of domestic sewage and use of fertilizers containing ammonium salts. All samples had nitrate nitrogen concentrations within range of the 1<sup>st</sup> and 2<sup>nd</sup> class of waters according to Regulation on dangerous substances in the water [32]. According to Regulation on water classification [29], waters of the 1<sup>st</sup> class have pH which ranges between 6.8 and 8.5 and that requirement is met by samples 3, 4, 5, 6 and 7, while samples 1 and 2 have values for pH higher than 8.5 and they belong in the 3<sup>rd</sup> class. 1<sup>st</sup> class waters have concentration of dissolved oxygen of at least 8 mg/L (samples 1 and 2), 2<sup>nd</sup> class waters of at least 6 mg/L (sample 7), 2<sup>nd</sup>-b class waters of at least 5 mg/L (samples 3, 4 and 6), and 3<sup>rd</sup> class waters have concentration of dissolved oxygen of at least 4 mg/L (sample 5). According to Regulation on classification of inter-republic water flows and interstate waters and coastal sea waters of

Yugoslavia, waters of the 1<sup>st</sup> class have oxygen saturation which ranges between 90 and 105, waters of the 2<sup>nd</sup> class have oxygen saturation which ranges between 75 and 90, and oxygen supersaturation which ranges between 105 and 115, waters of the 3<sup>rd</sup> class have oxygen saturation which ranges between 50 and 75, and oxygen supersaturation which ranges between 115 and 125, waters of the 4<sup>th</sup> class have oxygen saturation which ranges between 30 and 50, and oxygen supersaturation which ranges between 125 and 130. Correlation coefficients between various parameters are shown in Table 4.

Nenin *et al.* [34] reported that contents of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and iron in water samples of the Tamiš River ranged between 0.5 and 6.2 mg NH<sub>3</sub>-N/L; 0.06 and 1.3 mg NO<sub>2</sub>-N/L; 1.0 and 10.0 mg NO<sub>3</sub>-N/L; 0.3 mg Fe/L and 1.0 mg Fe/L, respectively. The results obtained in this research have shown that contents of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and iron are reduced in comparison to values of these parameters obtained through examination of water quality of Tamiš in 1996 [34]. This result is probably the consequence of reduced consumption of mineral fertilizers in agricultural production in comparison to previous years and reduction of nitrogen deposition from the air. Also, Živadinović *et al.* [15] reported constant improvement of the eco-chemical status of the Danube River in the region of Serbia from 1992 until 2006 [15].

Between 1992 and 2006 median concentration of ammonia nitrogen in European rivers fell from 0.8 to 0.3 mg NH<sub>3</sub>-N/L, while median BOD concentration fell from 5 to 2 mg O<sub>2</sub>/L, and median concentration of nitrates in Northern Europe fell from 0.5 to 0.3 mg NO<sub>3</sub>-N/L, in Western Europe from 4.3 to 3.8 mg NO<sub>3</sub>-N/L, in Eastern from 2.1 to 2.0 mg NO<sub>3</sub>-N/L [35]. The reason for reduction of organic pollution in European rivers are mainly improvements in wastewater treatment (nowadays it is more common to apply secondary, *i.e.*, biological treatment process). Also, nitrogen

Table 3. Water quality of the Tamiš river

Parameter	Sample						
	1	2	3	4	5	6	7
Ammonia nitrogen, mg/L [32]	III, IV	III, IV	I, II	III, IV	III, IV	I, II	I, II
Nitrite nitrogen, mg/L [32]	I, II	I, II	I, II	III, IV	III, IV	I, II	III, IV
Nitrate nitrogen, mg/L [32]	I, II	I, II	I, II	I, II	I, II	I, II	I, II
Iron, mg/L [32]	I, II	I, II	III, IV	I, II	III, IV	I, II	I, II
pH value [29]	III	III	I	I	I	I	I
Dissolved oxygen, mg/L [32]	I	I	II-b	II-b	III	II-b	II
Oxygen saturation, % [33]	I	III	III	III	III	III	II

Table 4. Correlation coefficients between the parameters ( $T_{air}$  - air temperature;  $T_{wat}$  - water temperature; EC - electrical conductivity; DO - contents of dissolved oxygen; Ox. sat - oxygen saturation; Turb - turbidity; TH - total hardness, A - alkalinity;  $NH_3$ -N - ammonia nitrogen;  $NO_2$ -N - nitrite nitrogen;  $NO_3$ -N - nitrate nitrogen)

Parameter	$T_{air}$	$T_{wat}$	pH	EC	DO	Ox.sat	Color	Turb	TH	A	$NH_3$ -N	$NO_2$ -N	$NO_3$ -N	Fe	Cl	$SO_4$
$T_{air}$	1															
$T_{wat}$	0.20	1														
pH	0.44	0.21	1													
EC	-0.19	0.08	-0.90 <sup>a</sup>	1												
DO	0.50	0.41	0.96 <sup>a</sup>	-0.76 <sup>a</sup>	1											
Ox. sat	0.48	0.47	0.96 <sup>a</sup>	-0.76 <sup>a</sup>	0.99 <sup>a</sup>	1										
Color	0.18	-0.65	-0.27	0.15	-0.43	-0.42	1									
Turb	0.69	-0.36	0.15	-0.11	0.07	0.05	0.79 <sup>a</sup>	1								
TH	-0.20	0.22	-0.87 <sup>a</sup>	0.98 <sup>a</sup>	-0.73	-0.71	0.08	-0.19	1							
A	-0.02	-0.11	-0.85 <sup>a</sup>	0.90 <sup>a</sup>	-0.74	-0.77 <sup>a</sup>	0.28	0.15	0.82 <sup>a</sup>	1						
$NH_3$ -N	0.02	0.35	0.60	-0.49	0.56	0.62	-0.29	-0.28	-0.37	-0.81 <sup>a</sup>	1					
$NO_2$ -N	-0.32	-0.04	-0.71	0.75	-0.70	-0.64	0.42	-0.04	0.79 <sup>a</sup>	0.48	0.01	1				
$NO_3$ -N	-0.34	-0.10	-0.97 <sup>a</sup>	0.94 <sup>a</sup>	-0.91 <sup>a</sup>	-0.89 <sup>a</sup>	0.34	-0.02	0.91 <sup>a</sup>	0.89 <sup>a</sup>	-0.59	0.77 <sup>a</sup>	1			
Fe	0.38	-0.08	-0.18	0.11	-0.28	-0.24	0.48	0.42	0.18	0.09	0.06	0.29	0.18	1		
Cl	-0.31	-0.17	-0.96 <sup>a</sup>	0.96 <sup>a</sup>	-0.87 <sup>a</sup>	-0.89 <sup>a</sup>	0.24	-0.08	0.90 <sup>a</sup>	0.94 <sup>a</sup>	-0.66	0.67	0.96 <sup>a</sup>	0.04	1	
$SO_4$	0.03	0.37	0.08	0.24	0.25	0.24	-0.40	-0.38	0.25	-0.06	0.48	0.29	-0.05	-0.38	0.07	1

<sup>a</sup>Marked correlations are significant at  $p < 0.05$

oxide emissions have been reduced in Europe by one-third over the past 15 years and reduced agricultural pollution is the reason why nitrate concentrations have been reduced in European rivers.

Between 1999 and 2008 the median BOD concentration in Serbian rivers remained unchanged (2.5 mg  $O_2$ /L), for the Danube river basin BOD fell from 3 to 2.6 mg  $O_2$ /L; median concentration of ammonia nitrogen in rivers fell from 0.1 to 0.03 mg  $NH_3$ -N/L, for the Danube river basin from 0.23 to 0.1 mg  $NH_3$ -N/L, median concentration of nitrates in rivers fell from 1.9 to 1.2 mg  $NO_3$ -N/L, and for the Danube river basin from 1.6 to 0.95 mg  $NO_3$ -N/L [36].

Concentration of ammonia nitrogen in examined samples of the Tamiš River water ranged between 0.07 and 0.19 mg  $NH_3$ -N/L. Accordingly, water samples of the Tamiš River contained lower concentrations of ammonia nitrogen than median concentration of ammonia nitrogen in European rivers and higher concentration of ammonia nitrogen than median concentration of ammonia nitrogen in Serbian rivers. The concentrations of nitrate nitrogen in water samples of the Tamiš River ranged between 0.06 and 1.08 mg  $NO_3$ -N/L, which is lower value than the median concentration of nitrate nitrogen in Serbian rivers and rivers of the Western and Eastern Europe.

## CONCLUSIONS

In comparison with the Serbian part of the Danube River where monitoring is conducted regularly at

seventeen sampling stations and the data compared for 15-year period [15], for Serbian part of the Tamiš River there is no available data analysis of physico-chemical parameters. In this work, in order to provide detailed monitoring of the Tamiš River through Serbia, certain physico-chemical parameters were measured in situ, during sailing down the Tamiš.

It may be concluded from the results obtained in the examination of the Tamiš River water quality that certain improvements in water quality have been achieved, but this is not enough to classify Tamiš along its course into the 2<sup>nd</sup> water class which is suitable for bathing, recreation and water sports. It may be concluded from the results that quality of the Tamiš River water is uneven and that certain parameters correspond to the 1<sup>st</sup> and 2<sup>nd</sup> class, but in the majority of locations, the quality corresponds to the 3<sup>rd</sup> and 4<sup>th</sup> class.

The studies reveal that the Tamiš River is receiving a considerable amount of physical and chemical pollutants at discharge of the DTD canal. This is why it is necessary to undertake appropriate preventive measures in order to prevent further pollution of the Tamiš River. It is necessary to develop utility infrastructure in all settlements in the Tamiš watershed, including construction of sanitary landfills and wastewater treatment systems to treat wastewaters from households and commercial entities. Also, it is necessary to establish continual monitoring which will serve as control at selected points on the Tamiš River and

in certain selected canals, such as the DTD canal. Taking into account that significant changes in measurement parameters in the Tamiš watershed occurred due to the inflow of the DTD canal into the river, it is proposed to apply more detailed examination in the future, which will examine the impact of other effluents to the Tamiš river water quality.

This study is important for understanding the water quality of the river Tamiš and it will be useful for the future activities regarding integral water resource pollution control and the implementation of the Water Framework Directive 2000/60/EC. Project “Eco Status of the Tamiš River” may be of use for local authorities, commercial entities and citizens of Potamišje in the development of action plans as basis for rational and optimal utilization of natural resources of the river shed. Not only can this revitalize, but it can also improve eco status of the Tamiš River.

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## NEKI POKAZATELJI KVALITETA VODE REKE TAMIŠ

*U radu su prikazani rezultati terenske analize vode reke Tamiš, od naselja Jaša Tomić - granice Srbije sa Rumunijom do Pančeva - ušća Tamiša u Dunav. Tamiš izvire u severnim delovima rumunskih Karpata prolazi kroz Banat i uliva se u Dunav kod Pančeva. Ukupna dužina, od izvora do ušća iznosi 359 km. Godinama kvalitet vode reke je ozbiljno pogoršan i loše utiče na životnu sredinu i ekosistem reke. Merenjima "in situ" određivani su fizičko-hemijski parametri kvaliteta vode reke Tamiš na svakih 400 m toka, kao što su: temperatura vode, pH, električna provodljivost, sadržaj rastvorenog kiseonika i saturacija kiseonikom. Najveći uzrok zagađenja vode reke Tamiš predstavlja uključanje u hidrosistem DTD. Na 7 lokacija (uzoraka) duž toka mereni su boja, mutnoća, ukupna tvrdoća, alkalitet, amonijakni azot, nitritni azot, nitratni azot, koncentracija gvožđa, hlorida i sulfata u uzorcima. Cilj ovog rada je da se proceni kvalitet vode reke Tamiš s obzirom na značajan unos zagađenja poreklom iz naselja, industrije i poljoprivrede, i da se predlože odgovarajuće preventivne mere za smanjivanje daljeg zagađenja vode reke Tamiš.*

*Ključne reči: kvalitet vode; reka Tamiš; fizičko-hemijski parametri; zagađenje; Kanal DTD; antropogene aktivnosti.*