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Database with pollution sources and impact assessment in Bega and Timis River basins

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Abstract
This paper presents the ecological state of large areas of the Bega and Timis River basins, evaluated based on physical-chemical parameters of water samples in relation to the anthropogenic sources of pollution that occur along these rivers. For the monitoring program, twelve sampling points on the Bega and ten sampling points on the Timis were established in order to determine surface water quality. The potential sources of pollution were highlighted by a downstream vs. upstream analysis. Ecological conditions have been assessed taking into account the national legislation, which transposes the Water Framework Directive on promoting the sustainable use of water based on the long-term protection of water resources. The main sources of pollution were related to the discharges from localities and industry, but the current ecological status of the two water bodies analyzed is in a relatively good state.

Keywords: *freshwater, river, Bega, Timis, pollution*

INTRODUCTION

Freshwater is the most important, limited and vulnerable natural resource [1, 2]. Water supply is the key to civilization and offers opportunities for development in a certain geographical area. Assessing the water supply for domestic and industrial use requires a broad approach to define and determine the socio-cultural, demographic and economic benefits of water. A number of studies highlight the important role of water availability in maintaining and advancing living standards [3-5]. Although it seems to have a relative abundance of water, due to the image created by the existence of a balanced hydrographic network, which covers almost the entire territory of the country, Romania has quite low water resources compared to other states. Thus, the average natural water reserve in our country is estimated at about 1700m^3/inhabitant/year, compared to about 4200 m^3/inhabitant/year in France. From this point of view, Romania ranks 12th among European countries. In order to realize what this water resource of our country means, we must say that, in the opinion of specialists, the countries whose average natural reserves are below 1700m^3/inhabitant/year are deficient in terms of water [6].

Water resources are open to pollution due to population growth, technological development and increasing industrial activity [1]. Industrial activities are the largest and main source of water pollution due to the generation of effluents with distinct characteristics. Pollutants commonly found in water include pesticides, organic contaminants, metals, nitrogen compounds and sometimes-even radionuclides [6-9]. Moreover, water can contain many disease-causing organisms, such as bacteria, viruses, and parasites, which must be removed or inactivated for the human safety [3].

The water quality of the most important rivers in the Timis-Bega basin is influenced by the human activity and demographic characteristics, as well as the urbanization and industrialization [10]. The discharge of untreated wastewater from industry, households and pollution from agriculture (wastewater from rural areas and agro-food industry) are the main causes of freshwater and ground water pollution around the world and this region is no exception [11]. The pressure caused on the Timis and Bega River surface waters is induced by the total number of inhabitants (almost 700,000 people) [12] and by the urban inhabitants (428,168 people) [12] from cities such as Timisoara, Lugoj, Buzias, Faget, Recas, Ciacova, Caransebes and Otelu Rosu. The organic load is generated due to industrial activities, agricultural land use, animal farms and, finally, and also as a result of hydrographic network improvement [10].

The *Timis River* is the main lotic system of the south-western region of Romania, being the largest river in the Banat area, with a total basin area of 5795 km^2 and a length of 241 km on the Romanian national territory and a smaller part in Serbia. The source area of the river Timis is located in the eastern part of the Semenic mountains, near the Piatra Goznei peak (1145 m altitude), which crosses mountains, hills and plain areas. This river is actually formed by the confluence of four upper streams: Semenic, Gradistei, Brebu Nou and Paraul Lung [13-16]. The Timiș River gathers its tributaries from Banat, Tarc and Poiana Rusca mountains, and, finally, the Piedmont hills Lugoj and Poganis, with a total length of watercourses of about 462 km and a watershed surface of 5505 km^2 on the Romanian territory, representing approximately 2.31% of the total area of Romania [16].

The *Bega Channel* and the *Bega River* are located in Banat, a region that lays down from the eastern part of the Pannonian plain to the south-western slopes of the Carpathians to the Tisza River, crossing the borders of Serbia, Romania and Hungary [17]. Bega River rises from Poiana Rusca mountains, under Pades peak (1359 m), from an altitude of 1150 m [18]. The combined length of the Bega Channel and river is 240 km, 115 km representing the channel. On average, Bega River has about 2.5 m deep, 30 m wide and a flow of 10-25 m^3/s. The Bega Channel represents 2.1 km of the border between Serbia and Romania and represent an artificial canal that flows as an extension of the Bega River from Timisoara, Romania, to its confluence in the Tisza River downstream of Zrenjanin, Serbia [17]. In previous years, starting with 1760 [19], the Bega Channel was an important transnational navigable route between the Danube River in north eastern Serbia and the city of Timisoara, but for political and economic reasons, the navigation of the canal was suspended in 1958 on the Yugoslav-Romanian border [17]. The Bega River provides approximately 70% of the raw water used for the production of drinking water in Timisoara Municipality [20].

The aim of the paper was to identify anthropogenic factors and to assess their impact on the Timis and Bega River chemical status.

EXPERIMENTAL PART

Study area

The selection of sampling points from both rivers aimed to cover their superior course up to the Serbian border, taking into account the impact generated by the potential sources of pollution on the surface water quality. For this purpose, the sampling points were established upstream and downstream for each potential source of pollution.

Table 1 indicate the pollution sources generated by the anthropogenic activities (livestock farms, effluents from urban treatment plants and industrial units) along the Bega and Timis Rivers. The sampling points were named with symbols from B1 to B 12 for Bega River and with symbols from T1 to T10 for Timis River, monitoring program starting from the sources to the border with Serbia.

Table 1. Sampling points location on Bega (B) and Timis (T) rivers

Sample symbol	*Sampling points*	*Observations*	*Geographical coordinates*
B1	Upstream Luncanii de Jos	The section Bega source –Luncani. Without notable pollution sources	45°43'16.34"N 22°18'20.39"E
B2	Upstream Tomesti	The section Luncani – Tomesti. Without notable pollution sources	45°46'54.09"N 22°18'44.36"E
B3	Downstream Tomesti	No anthropogenic pollution. The glass factory has ceased operations for at least 15 years	45°47'9.94"N 22°18'31.32"E

B4	Upstream Margina	No anthropogenic pollution.	45°51'29.12"N 22°16'16.35"E
B5	Downstream Margina	An industrial unit in the field of organic chemical industry has been operating in the Margina area for a long time. The unit was closed, but due to improper wastewater management there is still a risk of groundwater and indirect contamination of the Bega River.	45°51'41.45"N 22°15'59.28"E
B6	Downstream Faget (Rachita)	Potential sources of pollution: Faget locality and several wood processing units in the area.	45°50'21.40"N 22° 6'13.55"E
B7	Balint	The sampling site is located upstream of the Timis / Bega Channel. Without notable pollution sources.	45°48'42.14"N 21°51'27.74"E
B8	Chizatau	The sampling site is located upstream of the Timis / Bega Channel. Without notable pollution sources.	45°45'37.25"N 21°43'46.71"E
B9	Remetea Mare	Without notable sources of pollution. The Remetea sampling point is located upstream of Timisoara.	45°46'40.40"N 21°22'32.69"E
B10	Timisoara- downstream Aquatim and upstream Smithfield Prod	At the level of Timisoara, there are two major sources of pollution: the treatment plant (municipal) and a slaughterhouse for pork processing. This sampling point highlights the impact of the treatment plant discharges.	45°44'11.40"N 21°10'39.76"E
B11	Sanmihaiu Roman - downstream Smithfield Prod	The sampling point highlights the general impact determined by the pollution sources from Timisoara Municipality area.	45°42'22.95"N 21° 5'20.72"E
B12	Otelec - border	Without notable sources of pollution in the Sanmihaiu Roman – Otelec section (border with Serbia).	45°37'7.49"N 20°50'46.56"E
T1	Upstream Rusca	The section Timis source –Rusca. Without notable pollution sources.	45° 8'22.46"N 22°20'46.89"E
T2	Buchin – upstream Caransebes	Without notable sources of pollution up to the Caransebes sampling point.	45°22'43.82"N 22°13'13.42"E
T3	Caransebes – Sebes river	The Sebes River is an affluent of the Timis River. The sampling point is located upstream of the confluence.	45°24'28.33"N 22°12'47.78"E
T4	Downstream sewage treatment plant Caransebes	The section can highlight the impact generated by the Caransebes treatment plant. The sampling point is located upstream of the confluence with the Bistra River.	45°24'54.93"N 22°12'1.34"E
T5	Bistra River– upstream the confluence with Timis river	It is possible to highlight the contribution brought by the Bistra River that crosses the Otelu Rosu industrial area and obviously it can influence the quality of the Timis River	45°28'48.07"N 22°11'10.41"E
T6	Cavaran – downstream the confluence with Bistra river	Evaluation of the impact generated by the Bistra River	45°32'55.50"N 22° 9'21.39"E
T7	Upstream Lugoj	There are no significant sources of pollution in the Cavaran section - upstream of Lugoj	45°40'36.79"N 21°55'47.72"E
T8	Hitias	Sampling point allows the evaluation of the impact generated by the municipality of Lugoj (industrial units and the municipal treatment plant) but also by the evacuation of the treatment plant of the Ghizela landfill	45°43'35.14"N 21°34'34.73"E
T9	Albina	In the Hitias - Albina section, Timis River receives the Surgani affluent, with the risk of	45°41'40.01"N 21°23'48.51"E

		pollution from the zootechnical farms in the area and from Buzias treatment plant	
T10	Graniceri - border	Downstream of Albina and up to the border, the surface water quality could be affected by the livestock farms (especially pigs) and anthropogenic activities in general.	45°26'46.65"N 20°53'9.47"E

In the figures 1 and 2 are represented the sampling points, located on the map (satellite view).

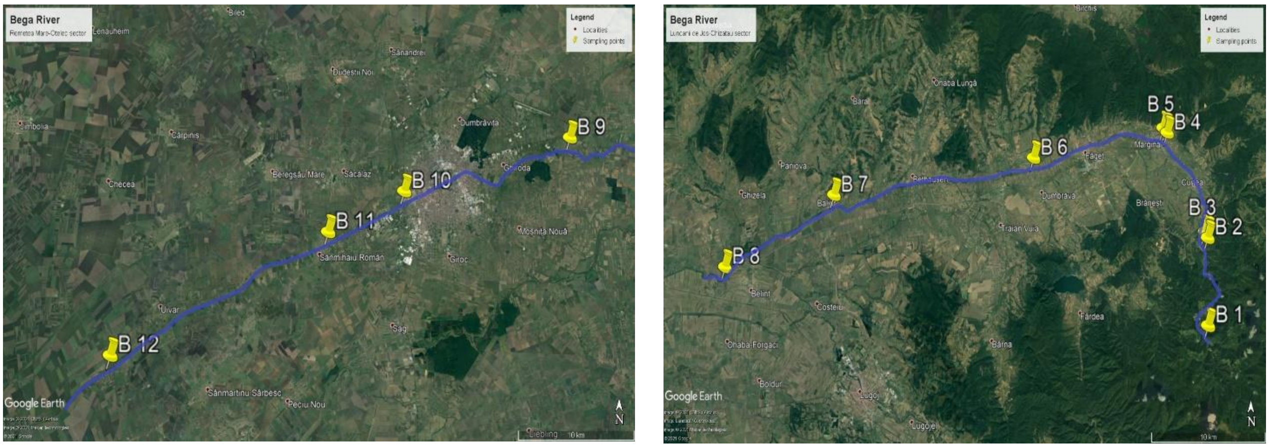

Fig. 1. Sampling points location on the river Bega, from right (B1) to left (B12)

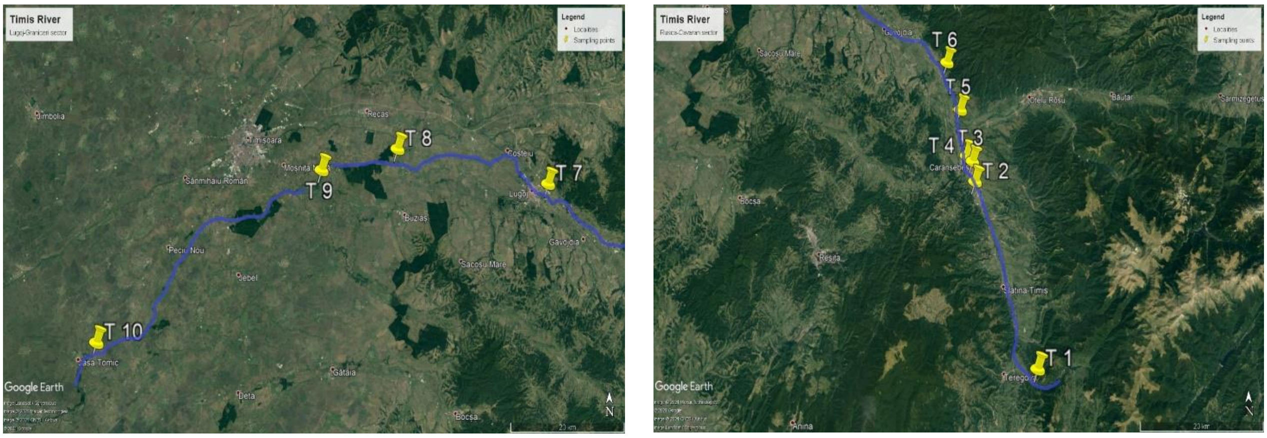

Fig. 2. Sampling points location the river Timis, from right (T1) to left (T10)

Physical-chemical parameters

The analysed parameters in the surface water were pH for the acidification regime; CCO-Mn for the oxygen regime; nutrients such as ammonium ($N\text{-}NH_4$), nitrates ($N\text{-}NO_3$), total nitrogen (N), total phosphorus (P); dry residue at 105° C, chlorides, sulphates, calcium, magnesium, sodium for the salinity evaluation and finally, zinc and iron. The parameters were selected from the list provided by the Romanian Order 161/2006 [21].

Within the normative are established five physical-chemical qualities for surface water: very good (I), good (II), moderate (III), weak (IV) and bad (V), table 2. In order to use as source of raw water for water intended for human consumption, surface water must have very good or good qualities.

From each sampling point, three samples were collected in January, March and May 2019. All the samples were taken from the bridges, directly in the median area of the river stream. The samples were preserved in refrigerated boxes until the analysis were performed in specialized laboratory, which has accredited the activity and fulfils the requirements of the SR EN ISO/IEC 17025: 2018 standard, regarding the performance of sampling and testing activities.

Table 2. Clasification of surface water quality according to Romanian Order 161/2006

Parameter	Unit	Surface water quality class				
		I	II	III	IV	V
Acidification regime						
pH	pH unit	6.5 – 8.5				
Oxygen regime						
COD-Mn	mg O_2/L	5	10	20	50	>50
Nutrients						
Ammonium	mg N/L	0.4	0.8	1.2	3.2	>3.2
Nitrates	mg N/L	1	3	5.6	11.2	>11.2
Total nitrogen	mg N/L	1.5	7	12	16	>16
Total phosphorus	mg P/L	0.15	0.4	0.75	1.2	>1.2
Salinity						
Dry residue at 105°C	mg/L	500	750	1000	1300	>1300
Chloride	mg/L	25	50	250	300	>300
Sulphates	mg/L	60	120	250	300	>300
Calcium	mg/L	50	100	200	300	>300
Magnesium	mg/L	12	50	100	200	>200
Sodium	mg/L	25	50	100	200	>200
Toxic pollutants of natural origin						
Zinc	µg/L	100	200	500	1000	>1000
Iron	mg/L	0.3	0.5	1.0	2	>2

RESULTS AND DISCUSSION

Assessment of the Bega River basin chemical status

In table 3 are presented the mean values of the chemical indicators determinate within three sampling campaigns for each site. The parameter values in yellow color indicate II-class quality of the surface water, turquoise color correspond to III-class quality, while dark green indicate IV-class quality [21]. The values in white color were situated within I-class quality.

Table 3. The mean results of the parameters for surface water samples collected from Bega River

Parameter	*Unit*	*Measured values (averages) / quality class*											
		B1	***B2***	***B3***	***B4***	***B5***	***B6***	***B7***	***B8***	***B9***	***B10***	***B11***	***B12***
Acidification regime													
pH	pH unit	7.2	7.0	7.1	6.9	7.2	7.2	6.8	7.0	7.3	7.0	7.1	6.8
Oxygen regime													
COD-Mn	mg O_2/L	2.15	1.86	3.20	2.55	2.96	2.56	1.71	2.07	2.41	2.23	1.75	<1.6
Nutrients													
Ammonium	mg N/L	<0.022	<0.022	<0.022	0.05	0.04	0.26	<0.022	<0.022	<0.022	0.21	0.55	0.13
Nitrates	mg N/L	0.74	0.68	0.78	0.62	0.63	0.60	0.36	0.28	0.26	1.09	0.64	0.83
Total nitrogen	mg N/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.31	1.73	1.28
Total phosphorus	mg P/L	<0.01	0.03	0.03	0.03	0.03	0.02	<0.01	<0.01	<0.01	0.27	0.16	0.05
Salinity													
Dry residue at 105°C	mg/L	177	189	183	163	174	186	175	184	191	296	276	290
Chloride	mg/L	28.2	25.1	25.3	25.7	23.8	27.1	28.2	28.6	27.4	39.6	40.6	28.4
Sulphates	mg/L	74.1	84.9	84.3	88.4	93.5	86.3	81.6	81.8	83.3	133	128	134
Calcium	mg/L	37.2	42.3	39.7	34.0	32.3	35.4	31.6	38.9	33.7	33.3	33.9	36.5
Magnesium	mg/L	1.34	1.20	0.76	1.04	3.21	1.88	3.50	0.88	5.05	2.05	1.27	1.29
Sodium	mg/L	0.61	0.51	0.58	0.67	0.80	1.77	3.48	4.60	9.33	51.7	42.9	36.6
Toxic pollutants of natural origin													
Zinc	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Iron	mg/L	1.05	0.95	0.57	0.26	0.30	0.32	0.23	0.15	0.27	0.18	0.32	0.26

"<" represents the detection limit of the test method

Acidification regime
No changes were recorded in the acidification regime caused by anthropogenic pressures. The pH values fall within the limits of category I, respectively 6.5 - 8.5.

Oxygen regime
The content of organic substances expressed by COD-Mn varies between 1.60 (detection limit) and 3.20 mg O_2/L, less than 5 mg O_2/L, the limit for I-class quality category.
The worsening of the oxygen regime is not signaled even in the sampling points located downstream of the potential pollution sources, such as Margina industrial site from, Faget treatment plant and especially, Timisoara treatment plant and a pork processing slaughterhouse. The oxygen regime was on very good level in the investigated period on the Timisoara - Serbia border section.

Nutrients
The main potential pollution sources in the Bega basin are urban wastewater treatment plants and a food industry station (slaughterhouse) that can discharge nitrogen (ammonium, nitrates, total nitrogen) and phosphorus compounds. In the area of the abandoned industrial site from Margina and of Faget treatment plant (points B4 to B6), the presence of ammonium was reported in small concentrations. Next, up to Timisoara, ammonium was below the detection limit. In the sampling point B11 located downstream of the one major discharges (Timisoara treatment plant), ammonium appears in higher concentrations, the river section being in II-class category in terms of ammonium and total nitrogen. The ammonium parameter persisted in the border section, but at lower level. The presence of ammonium could be from an anthropogenic cause, related with presence of discharges from Timisoara treatment plant and slaughterhouse treatment plant.
Nitrates occur in low concentrations throughout the river. Due to this fact, the surface water was classified in I-class quality, exception being B10 sampling point, where the value of nitrates slightly exceeds 1 mg/L. In conclusion, the presence of nitrates in the Bega River has natural causes on the upper and middle course and anthropogenic causes on the lower course.
Following somewhat the evolution of inorganic compounds with nitrogen, total nitrogen was below the detection limit throughout the course from source to Timisoara. At the last three sampling points, downstream of Timisoara, the total nitrogen has values, which includes Bega River in II-class in B11 monitoring point.
Total phosphorus ranged between detection limit and 0.03 mg/L until Timisoara area. The samples collected from B10, B11 and B12 points, show the increase of the total phosphorus content caused by the discharges from the Timisoara treatment plant and pork-processing slaughterhouse.

Salinity
Unlike nutrients that can be generated from anthropogenic activities, the presence of salinity has mostly natural causes. Following the variation of salinity through the parameter "dry residue at 105ºC" it was founded that the measured values are between 163 - 296 mg/L, they fall into the category of quality I throughout the river.
The chlorides concentration were situated between 23.0 - 40.6 mg/L over the entire course of the river. The Bega water body falls into II quality category in terms of chloride content.
There are no relevant variations in the sulfate content, but the concentrations were situated above limit for I-class quality. From this point of view, the Bega River falls into II-class quality, for most of the course (until the evacuation of the Timisoara treatment plant). In B10 to B12 monitoring points, the water body falls into III-class quality, the sulfate concentration exceeds the threshold (maximum concentration recorded being 134 mg/L).
Another component of salinity that has natural causes and an uneven variation on a relatively narrow range (31.6 - 42.3 mg/L) is the calcium concentration. The quality of surface water in most sampling points was I-class. Same situation was reported for magnesium, the values ranking from 5.80 to 16.3 mg/L. In B1 to B9 sampling points, meaning the source-upstream section Timisoara, the sodium level was relatively constant and very low (0.500 – 3.00 mg/L). A significant increase

was registered after the evacuation of the Timisoara treatment plant, from 9.33 mg/L to 51.7 mg/L. The cause could be the discharges from the municipal treatment plant. A level of 36.0 mg/L was recorded towards the border.

Toxic pollutants of natural origin
Zinc concentrations were situated below the detection limit of the applied analytical method (100 µg/L). The results indicated that no contamination with zinc in Bega River, neither from anthropogenic sources or from natural sources.
Instead, in the case of iron, the results indicated the present from source of the river, possible as result of natural background.
The highest concentrations were founded on the upper course, then decrease constantly by dilution due to the contribution of flows brought by the tributaries. On the upper course, the water quality falls into category III and even IV quality, but this is not caused by anthropogenic activities.

As a conclusion, if one parameter indicate IV-class quality entire body will be classified in IV-class quality for surface water. Therefore, in B1 sampling point, Bega River was included in IV-class quality, the section from B4 to B9 fall into II-class quality, while the sections between B2-B3 and B10-B12 were situated in III-class quality.

Assessment of the Timis River basin chemical status
In table 4 are presented the mean results of the analysed parameters for ten sampling points situated on the Timis River. Same parameters were investigated as in Bega River case.

Table 4. The mean results of the parameters for surface water samples collected from Timis River

Parameter	*Unit*	*Measured values (averages) / quality class*									
		T1	***T2***	***T3***	***T4***	***T5***	***T6***	***T7***	***T8***	***T9***	***T10***
Acidification regime											
pH	pH unit	6.9	7.0	6.9	6.9	6.9	6.6	6.5	6.5	6.6	6.6
Oxygen regime											
COD-Mn	mg O_2/L	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	2.49	2.38	<1.6	<1.6
Nutrients											
Ammonium	mgN/L	<0.022	0.04	<0.022	<0.022	<0.022	0.09	<0.022	<0.022	0.05	<0.022
Nitrates	mgN/L	0.72	0.87	0.68	0.94	0.59	0.72	0.36	1.63	1.52	1.63
Total nitrogen	mgN/L	<1	<1	<1	<1	<1	<1	<1	1.70	1.60	1.65
Total phosphorus	mgP/L	0.19	0.03	0.04	0.04	0.03	0.03	0.05	0.07	0.05	0.05
Salinity											
Dry residue at 105°C	mg/L	143	168	136	176	185	181	144	178	164	158
Chloride	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	19.0	8.00
Sulphates	mg/L	82.1	88.2	66.1	86.5	94.3	89.4	80.9	96.1	85.8	81.3
Calcium	mg/L	21.0	14.6	22.1	18.7	19.8	13.8	20.2	25.0	15.3	20.2
Magnesium	mg/L	9.70	16.3	6.20	12.9	7.29	6.59	5.82	5.97	9.52	7.49
Sodium	mg/L	0.66	0.75	0.98	1.28	1.04	1.09	1.41	2.29	2.00	3.10
Toxic pollutants of natural origin											
Zinc	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Iron	mg/L	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	0.25	<0.12

"<" represents the detection limit of the test method

Acidification regime
All pH values fall within the limits of I-class quality for surface water, respectively 6.5 - 8.5.

Oxygen regime

The content of organic substances expressed by CCO-Mn parameter was below the analytical detection limit in most monitoring points of the watercourse. In the area located downstream of the Lugoj city treatment plant and the evacuation of the Ghizela non-hazardous waste landfill, the values recorded were situated around 2.50 mg O_2/L, the river section being in I-class quality.

Regarding the oxygen regime, the water was framed in I-class quality. There was no evidence of organic load increasing in the sampling points located downstream even if in the monitoring program were included potential pollution sources locations such as Caransebes treatment plant, Lugoj treatment plant and Ghizela non-hazardous waste landfill.

Nutrients

The analyzed nutrients were nitrogen compounds (ammonium, nitrates, total nitrogen) and total phosphorus. Ammonium was below the detection limit in most points, Timis River surface water falls into the I-class quality along the entire watercourse.

The nitrates occur on the upper course of the Timis River from natural sources and in the sampling points T8, T9 and T10 the values slightly exceeds 1.50 mg/L, limit for II-class quality.

The total nitrogen was situated below the detection limit from the source of the river until Ghizela point, where the discharges of non-hazardous waste landfill were evacuated. At the last three sampling points, the total nitrogen content has values situated in II-class quality.

Total phosphorus concentrations were situated in the range 0.03 to 0.19 mg/L, the highest value was recorder in T1 sampling point, were surface water quality indicate II-class category.

Salinity

Following the variation of salinity through the parameter “dry residue at 105º C”, recorded values were situated from 136 mg/L to 185 mg/L, surface water being in I-class category.

The chloride concentrations were below the detection limit on most part of the river, no significant variation were reported.

The sulphates parameter framed Timis surface water in II-class quality; the values were included in the range 66.1 mg/L to 96.1 mg/L.

Regarding calcium and sodium, the surface water quality fall into I-class category. While calcium concentrations were situated around 20 mg/L, sodium level was much lower, less than 3 mg/L.

Magnesium content was situated lower than 10 mg/L, except for two monitoring points (T2 and T4), where this value was exceeded and the surface water was classified in the second-class quality.

Toxic pollutants of natural origin

Zinc values were situated below the analytical detection limit (100 µg/L) on the entire river. Same situation in the case of iron, with one exception, in T9, but the mean value was lower than threshold limit of II-class quality. There was no contamination with Zn and Fe from anthropogenic or natural sources.

In the investigated period, Timis surface water was situated in II-class quality for the entire body, as result of nitrates, total nitrogen, total phosphorus, sulphates and magnesium concentrations.

CONCLUSIONS

The results of the study indicated that Timis surface water could be used as a raw water source for water intended for human consumption, in the investigated period surface water quality falling into the II-class category. On the entire section, only some parameters exceeded the limit value for I-class quality, such as nitrates, total nitrogen, total phosphorus, sulphates and magnesium

Instead, Bega surface water quality could be used as a potential raw water for drinking water production only in the sections B4 to B9, where II-class quality was reported.

In the sections B1 to B3, respectively B9 to B12, surface water quality fall into III-class or even IV-class (B1) quality.
Responsible for this classification were iron concentrations (section B1 to B3), sulphates and sodium values in B9 to B12 section. If in B1 to B3 section, the cause could be a natural one, in section B9 to B12, the discharges from Timisoara treatment plant and slaughterhouse treatment plant affected the surface water quality.
Even if large investments in the wastewater management infrastructure were done, improvement are needed, so environmentally friendly methods for wastewater treatment must be applied.

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