Study on Evaluation of Water Quality Indicators of the Jiu River in Rovinari

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The study aimed to assess the quality of the Jiu river in Rovinari to highlight the influence that sewage discharges of industrial units in the area and municipal wastewater have on the quality of the receiving water. In the period 2011-2013, was made monitoring of indicators biochemical oxygen demand (BOD_5), dissolved oxygen (DO), $N\text{-}NH_4^+$, $N\text{-}NO_3^-$, $N\text{-}NO_2^-$ by analyzing water samples taken upstream and downstream of the city Rovinari. The monitoring results indicated nitrite concentrations exceeding, a load with low organic matter and a good oxygen content to water in the analyzed section.

Key words: monitoring, quality indicators, surface water

Knowing the quality of surface water is the specific activity that is conducted systematically and regularly at regional and national level in order to obtain fundamental elements for assessing water quality evolution and decision making in water quality management. The quality assessment of surface waters is complex and depends on the pollution sources and processes of polluation, on the nature of pollutants present in water, demanding legislative norms and regulations [1,2]. Water quality has lost its character abstract notion, becoming, along with quantity, one dimension of water, which can be measured by determining an ensemble of elements called quality indicators. In terms of statistical and mathematical quality indicators are on the nature of continuous variables, ie of quantitative features that can take any numerical value within certain limits [3,4]. In a general sense, so that the silt is undissolved material and chemical substances dissolved or suspended in water as well as micro-organisms, that microscopic algae, plankton etc. are elements that characterize water quality, although their origin is different. Besides the mentioned substances originating from the natural watershed waters present a range of chemicals from human activities, the industrial waste water discharged into the environment, as well as municipal wastewater treated more or less [5 - 7]. The presence of inorganic nitrogen compounds such as ammonium, nitrite, nitrate is a signal of water pollution by organic substances which imposes the need to highlight their biodegradable chemical methods. Their presence in water excessive cause eutrophication water with algae development, leading to a glut of macrophytes which has negative influences on the exchange of oxygen from the water-air interface [8-10]. The organic substances in natural or artificial origin present in water consumes oxygen necessary to self-cleaning aerobic processes, specifically aerobic bacteria that oxidize organic matter and ultimately lead to self-cleaning water. Therefore oxygen deficiency which vary in proportion to the amount of organic matter in the water has the effect of stopping the self-purification processes aerobic sometimes very serious consequences [11-13].

Experimental part

Quality rating of Jiu river in the Rovinari city was achieved by monitoring the indicators of the oxygen regime (BOD_5, DO) and the regime of nutrients ($N\text{-}NH_4^+$, $N\text{-}NO_3^-$, $N\text{-}NO_2^-$). Samples were taken from the Jiu river, upstream and downstream of the city Rovinari, distance between the two points is about 20 Km. Over this distance Jiu is receiving all the city's sewage and industrial areas Rovinari (Rovinari Power Plant and lignite careers). Were analyzed in the study a total of 72 samples which were collected monthly during the years 2011-2013. Sampling were used of plastic material containers, each of which is washed with water sampling at the river Jiu, so the risk of contamination with impurities from the material container production its a minimum. Containers were filled with water and sealed during immersion to no air bubbles and prevent oxidative processes samples taken [14]. To determine the nutrient standard spectrophotometric methods were applied and absorbances was measured using UV-VIS spectrophotometer - T70. Determination of nitrate ions was achieved by spectrometric method with sulfosalicylic acid. In its reaction with nitrate ions in an alkaline medium forms a yellow complex whose absorbance was measured at a wavelength of 415 nm [15]. For the determination of nitrite in water samples was applied the method based on color reaction with nitrite ion 4-amino benzene sulfonamide in the presence of orthophosphoric acid. The absorbance of the complex formed was measured at a wavelength of 540 nm [16]. Determination of ammonium ions based on the measurement of absorbance at 650 nm of the blue colored compound formed by coupling reaction of salicylate ions, ammonium ion and hypochlorite in the presence of sodium nitroprusside [17]. The indicators of the oxygen regime were determined according to standard electrochemical methods using a multiparameter type Consort [18,19].

Results and discussions

Analysis of the quality indicators of water samples taken from the river Jiu in the area of Rovinari was performed by calculating the results of the tests performed statistical indicators to assess the oxygen regime and nutrients in

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Monitored section		Statistical data BOD_5					
		Media	Standard error	Standard deviation	Dispersion	Minimum	Maximum
2011	upstream	2.900	0.177	0.434	0.188	2.4	3.40
	downstream	3.170	0.278	0.682	0.465	2.4	4.42
2012	upstream	3.350	0.206	0.412	0.170	2.8	3.80
	downstream	3.550	0.233	0.465	0.217	3.1	4.20
2013	upstream	3.300	0.147	0.294	0.087	3.0	3.70
	downstream	3.750	0.132	0.265	0.070	3.5	4.10

Table 1
STATISTICAL INDICATORS FOR BIOCHEMICAL OXYGEN DEMAND

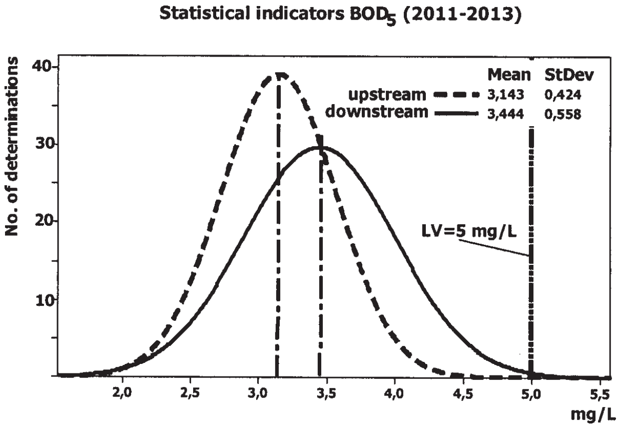

Fig.1. Statistical indicators for biochemical oxygen demand (2011-2013)

the period studied. The resulting data were reported to the provisions of Order 161 of 16 February 2006 for the approval of the Normative concerning the classification of surface water quality in order to determine the ecological status of water bodies [20]. In table 1 are presented the statistical indicators for biodegradable organic substances as measured by BOD_5. From the results presented shows that the average annual of the biochemical oxygen demand in 2011-2013 was within the upstream, between 2,90 -3,35 mg/L, and downstream, between 3.17 to 3.75 mg/L, below the limit value corresponding class II quality (LV = 5mg/L). The maximum value recorded was 4.42 mg/L, below the maximum concentration allowed and the minimum was 2.4 mg/L. Standard deviations calculated for the period monitored were 0.424 upstream and 0.558 downstream (fig.1). Standard errors are calculated for each year subunit and are between 0.132 to 0.278 (downstream) and from 0.147 to 0.206 (upstream).

The average values recorded of the indicator BOD_5 downstream (3.444 mg/L) are higher than upstream (3.143 mg/L). Graphic representation of the results of the statistical interpretation of the average values of BOD_5 (fig. 1) indicates framing them under limit value for class II quality.

In table 2 are presented the statistical indicators for dissolved oxygen content. Annual average values of dissolved oxygen are between 9.75 to 10.71 mg/L (upstream) and from 8. 767 to 9.043 mg/L (downstream). Average dissolved oxygen in three years, upstream was 10.04 mg/L (1.43LV), higher than the average downstream which was 8.898 mg/L (1.27LV) (fig. 2). The average values dissolved oxygen is above the limit value to class II quality under Order 161/2006 (LV = 7mg/L), indicating a load with low organic matter and a good oxygen content to the water on the studied section. Maximum values recorded each year varies in upstream, between 12.42 - 12.80 mg/L, and downstream between 10.06 - 10.8 mg/L.

Standard deviation for 2011-2013 is to 2.002 upstream, respectively downstream 1.335 (fig. 2). Standard errors calculated for years in which determinations are made subunit ranging from 0.77 to 1.17 (upstream) and from 0.502 to 0947 (downstream). In figure 2 are presented the results of the statistical interpretation of the average values recorded for dissolved oxygen in the monitored period.

The statistical data, shows that 93.56 % upstream and 92.24 % downstream of all measurements taken, were above the limit for class II quality. Upstream values obtained are more dispersed than those recorded downstream monitored period (fig. 2).

Determined results made for ammonium (table 3) show that the annual average ranging between 0.0850 to 0.1203

Monitored section		Statistical data DO					
		Media	Standard error	Standard deviation	Dispersion	Minimum	Maximum
2011	upstream	9.787	0.770	1.886	3.559	7.90	12.42
	downstream	8.767	0.502	1.231	1.515	7.10	10.50
2012	upstream	9.750	1.170	2.340	5.480	7.20	12.80
	downstream	8.950	0.947	1.895	3.590	6.70	10.80
2013	upstream	10.710	1.130	2.260	5.120	7.62	12.48
	downstream	9.043	0.621	1.241	1.540	7.25	10.06

Table 2
STATISTICAL INDICATORS FOR DISSOLVED OXYGEN

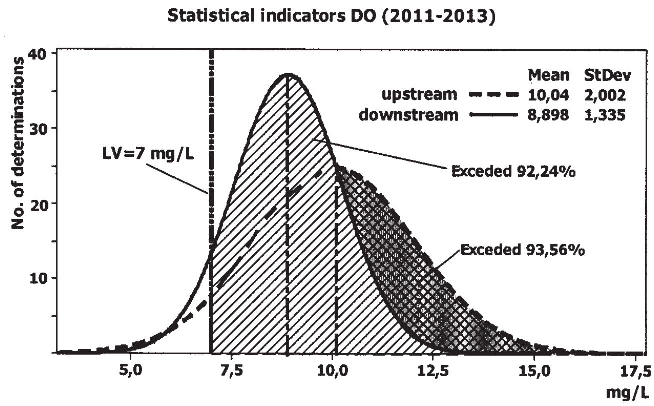

Fig.2. Statistical indicators for dissolved oxygen (2011-2013)

Monitored section		Statistical data N-NH_4^+					
		Media	Standard error	Standard deviation	Dispersion	Minimum	Maximum
2011	upstream	0.12030	0.02600	0.06370	0.00410	0.079	0.240
	downstream	0.11770	0.01600	0.03930	0.00150	0.078	0.162
2012	upstream	0.08500	0.00610	0.01219	0.00015	0.068	0.097
	downstream	0.11150	0.01420	0.02850	0.00080	0.070	0.131
2013	upstream	0.12000	0.00884	0.01768	0.00031	0.100	0.143
	downstream	0.13225	0.00897	0.01793	0.00032	0.108	0.150

Table 3
STATISTICAL INDICATORS FOR N- NH_4^+

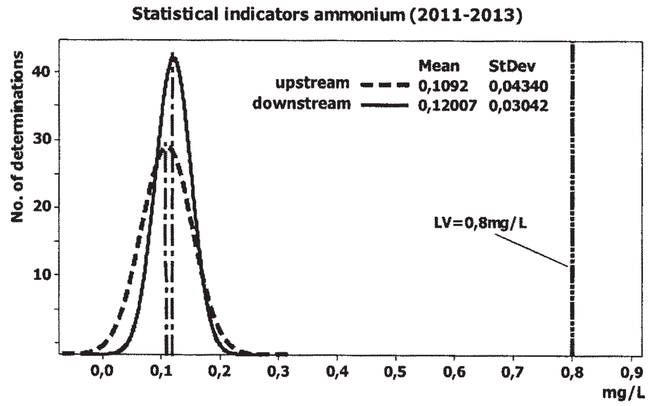

Fig.3. Statistical indicators for N-NH_4^+ (2011-2013)

mg/L (upstream) and from 0.111 to 0.132 mg/L (downstream). The average values for the three years of the study were 0.1092 mg/L, upstream, respectively 0,120 mg/L downstream (fig. 3), which are located well below the limit value corresponding class II quality (LV= 0.8 mg/L).

Maximum values recorded were between 0.097 - 0.24 mg/L (upstream) and from 0.131 - 0.162 mg/L (downstream). Standard deviation of the data recorded in the period 2011-2013 is to 0.0434 upstream of the city Rovinari and 0.0304 downstream (fig. 3).

The standard errors are calculated annually subunit (0.006 - 0.02 upstream, respectively 0.008 - 0.014 downstream). The average value for the indicator of ammonium downstream are higher to those recorded for the entire period monitored upstream (fig. 3).

The determinations carried out to assess nitrite ion (table 4) show framing annual average values i n the range 0.031-0.047 mg/L (upstream) and 0.040 - 0.056 mg/L (downstream), by exceeding the limit value to class II quality under order 161/2006 (LV = 0.03 mg/L).

The average value for 2011-2013 is upstream of 0.039 mg/L and downstream of 0.048 mg/L (fig. 4), indicating a concentration exceeding the maximum permitted by 1,3LV(upstream) respectively 1,6LV (downstream). The maximum values registered are in the range 0.039 to 0,055 mg/L upstream and from 0.046 to 0.072 mg/L downstream. Exceeding the limit value compared to 1,3 - 1.83 LV (upstream) and 1.53 – 2.4 LV (downstream). The standard deviation calculated for the three years of monitoring was 0.012 upstream and downstream 0.014 (fig. 4). The standard errors were between from 0.001 - 0.008 upstream and 0.002 - 0.011 downstream. From the statistical data presented in fig. 4 it can be seen that the overruns of the limit value in 2011-2013 were 77.28 % upstream and 88.82 % downstream of all measurements taken.

From the analysis of statistical indicators for the indicator N-NO_3^- presented in table 5 it is noted that the average values are between 0.857 - 0.963 mg/L, upstream and 0.711 - 1.10 mg/L downstream of Rovinari.

The average for the three years was 0.922 (upstream), respectively 0.944 mg/L (downstream) (fig. 5), as the limit value to class II of quality (LV = 3mg/L). The maximum values range from 0.91 to 1.11 mg/L (upstream), respectively from 1.00 - 1.31 mg/L (downstream). Statistical analysis of the data indicates a standard deviation value for 2011-2013 of 0.089 upstream and downstream 0.2478 (fig. 5).

Standard errors are subunitary, ranging from 0.025 - 0.047 upstream and 0.041- 0.209 downstream (table 5).

Monitored section		Statistical data N-NO_2^-					
		Media	Standard error	Standard deviation	Dispersion	Minimum	Maximum
2011	upstream	0.04771	0.00316	0.00836	0.00007	0.033	0.055
	downstream	0.05686	0.00401	0.01062	0.00011	0.046	0.072
2012	upstream	0.03300	0.00803	0.01606	0.00026	0.012	0.047
	downstream	0.04050	0.01160	0.02320	0.00050	0.010	0.063
2013	upstream	0.03180	0.00188	0.00421	0.00002	0.029	0.039
	downstream	0.04200	0.00210	0.00469	0.00002	0.034	0.046

Table 4
STATISTICAL INDICATORS FOR N-NO_2

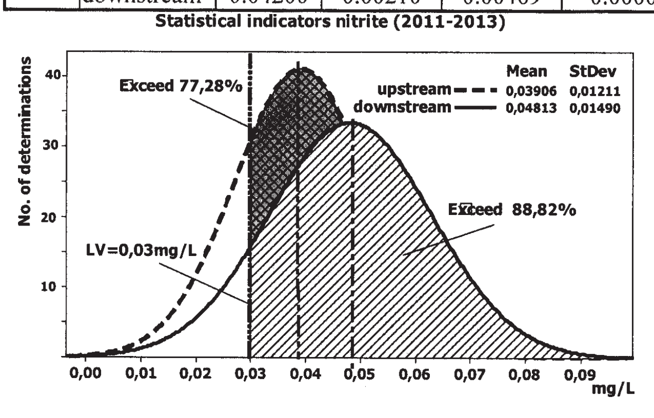

Fig.4. Statistical indicators for N-NO_2^- (2011-2013)

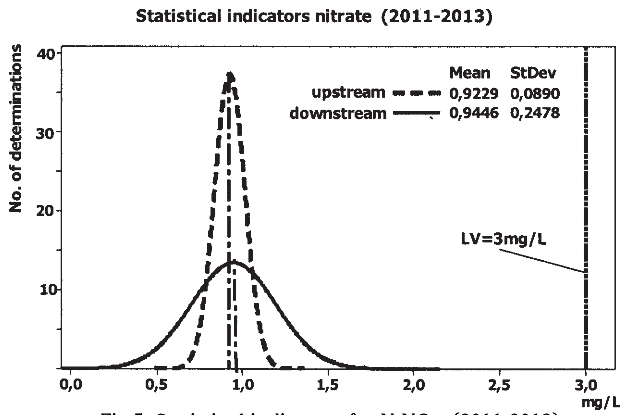

Fig.5. Statistical indicators for N-NO_3^- (2011-2013)

Monitored section		Statistical data $N-NO_3^-$					
		Media	Standard error	Standard deviation	Dispersion	Minimum	Maximum
2011	upstream	0.9633	0.0371	0.0909	0.0083	0.880	1.11
	downstream	1.1000	0.0501	0.1226	0.0150	0.930	1.31
2012	upstream	0.9275	0.0477	0.0954	0.0091	0.810	1.04
	downstream	0.7110	0.2090	0.4170	0.1740	0.094	1.00
2013	upstream	0.8575	0.0250	0.0499	0.0025	0.790	0.91
	downstream	0.9450	0.0419	0.0839	0.0070	0.830	1.03

Table 5
STATISTICAL INDICATORS FOR THE INDICATOR $N-NO_3$

Downstream values obtained are more dispersed than those recorded upstream monitored period.

Conclusions

In the complex work to protect water quality main element is the knowledge of its quality every time. Based on the data obtained and analyzed can be made forecasting evolution trend of water quality. Continuous surveillance of water quality measurements and observations on certain sections, under the influence of human activities is one of the basic actions in protecting water quality. The present study was conducted to determine the influence activities in the area of water quality Jiu of Rovinari in 2011-2013. In this regard were monitored the next water quality indicators: BOD_5, DO, $N-NH_4^+$, $N-NO_3^-$, $N-NO_2^-$.

By correlating the results obtained for the ions nitrate, nitrite, ammonium present in the water with organic matter values determined in section monitored, it can be appreciated a good self-cleaning capacity of the river Jiu and a reduced influence of anthropogenic activities in zone of Rovinari on water quality. Chemical analyzes of the experimental data shows that the recorded values for indicators of nutrient regime are slightly elevated downstream of those upstream. It falls into the class II of quality provided by Order 161/2006, with exeption for nitrites which were recorded exceeding, the limit value. Evaluation of the oxygen regime of the river Jiu indicate a load factor with low organic matter and a good oxygen to water on the analyzed section. The calculated statistical indicators show smaller standard deviations and standard errors which confirms a maintain constant pollution levels throughout the period monitored.

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