STUDY REGARDING THE WATER QUALITY OF JIU RIVER IN DOLJ COUNTY

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Abstract:*The central objective of the European Water Framework Directive is to achieve a "good status" for all bodies of water, both surface and underground, with the exception of heavily modified and artificial bodies, for which the goal is to achieve a "good ecological potential". Based on the principles contained in this directive, at the level of the Jiu Craiova Water Basin Administration, a management plan is under development, a plan that has to solve the main problems related to water management, both quantitatively and qualitatively. Water management must provide solutions to ensure the current and future water needs of the population and the economy, starting from the renewable but limiting nature of freshwater resources. This paper presents a study carried out in the spring of this year, the main purpose of which was to characterize the Jiu River qualitatively on the administrative territory of Dolj county. Several water sampling campaigns from three control sections, established in partnership with the Jiu Craiova Water Basin Administration, were carried out for this purpose and the collected samples were analyzed in the analytical laboratory of the same institution and on the basis of the obtained results, conclusions were drawn regarding the Jiu River water quality in the analyzed sector, considering also the main existing sources of pollution.*

Key words: *Jiu River, pollution, quality categories, water quality*

INTRODUCTION

The water catchment area of the Jiu River has, in Romania, a reception area of 10,080 km^2 (about 4.2% of the country's surface).

A feature of Jiu H.B. (hydrographic basin) is the elongated form. The river basins of the 232 codified tributaries retain the same degree of elongation. The hydrographic network has a length of 3,876 km and a density of 0.34 km/km^2 (***, 2017).

The average altitude of the Jiu H.B. varies between 1,649 m in the northern area and 24,1 m in the confluence area. The average slope of the basin is of 5‰.

The hydrographic basins of the Danube tributaries in south-west Oltenia: Bahna, Topolnita, Blahniţa, Drincea, Balasan, Desnătuşi occupy an area of 6,596.6 km^2 (***, 2017)

The complex geological composition, the differentiated action of the climatic factors contributed to the formation of a wide variety of relief forms: mountains, hills, plains and swamps. These units are distributed in broad areas whose altitude declines from north to south. (figure 1).

In relation to the altitude, more than 21% of the area, namely the northern and the northern parts, are occupied by mountain areas. The hills belonging to the Getic Plateau and the Mehedinţi Plateau occupy about 47%, the plain area being of over 32%.

The mountainous region has different characters due to the complex geological and lithological structure and determines a proper distribution of all elements of the natural environment (climate, vegetation, soils, etc.)

Immediately to the south, the subcarpathian and piedmont area is developed under the mountain frame.

Subcarpathian depression includes:

- the depression of Celei - Novaci;

- sub-Carpathian hills;
- intercolinary depression Câlnic - Tg. Jiu - Câmpu Mare - Tg.Carbuneşti;
- the piedmont hills in the south.

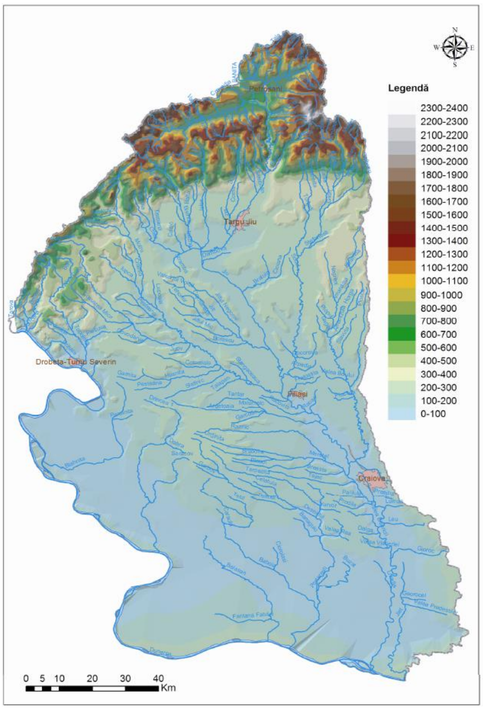

Fig. 1. The relief of Jiu basin

The piedmont area is represented by the Mehedinţi Plateau, located immediately in the south-east of Mehedinţi Mountains and represents a geographical individuality, although it is an organic continuation of the respective mountains.

The Getic Plateau is a large morphological unit extending south of the sub-Carpathian area up to the northern limit of the plain.

Oltenia Plain as a morphological subunit of the Romanian Plain takes place in the south and southwest of the analyzed area, being delimited by the Danube and Olt rivers. As genesis and evolution, the Oltenia Plain is exclusively a creation of the Danube, the predominant forms of the relief being represented by the Danube meadow and terraces, the Jiu Valley, to which the plain is added and, as a specific note, the relief of dunes.

MATERIAL AND METHODES

Pollution sources

In line with the Water Framework Directive, significant pressures are considered to be those that result in the failure to meet environmental objectives for the studied water body. Depending on how the body of water is operating, you can know if a pressure can cause an impact (BRETOTEAN ET AL., 2004).

Point sources of significant pollution

1. Urban pollution sources/human agglomerations

Urban wastewater contains, in particular, suspended matter, organic substances, nutrients, but also other pollutants such as heavy metals, detergents, petroleum hydrocarbons, organic micropollutants, etc. depending on the types of existing industry, as well as the pre-treatment level of the industrial waters collected in the urban system (figure 2).

Fig. 2. Point sources of pollution of Jiu River

In terms of releases of pollutants into surface water resources, table 1 shows the monitored quantities of organic substances (expressed as CCO - Cr and CBO_5) and nutrients (total nitrogen and total phosphorus) in the year 2016 per categories of agglomerations.

Table 1.

Discharges of organic substances and nutrients into the water resources from the human agglomerations in Jiu River basin (***, 2017)

Number of inhabitants (e.i.)	**Organic substances (CCO-Cr)**	**Organic substances (CBO_5)**	**N total**	**P total**
	t/year	t/year	t/year	t/year
>100.000	8061.424	3428.233	1836.405	868.688
10.000 – 100.000	1166.029	569.761	217.800	18.318
2.000 – 10.000	63.298	38.247	14.801	1.494
<2.000	-	-	-	-
Total	9290.751	4036.241	2069.006	888.500

2. Sources of industrial and agricultural pollution

Sources of industrial and agricultural pollution contribute to the pollution of water resources by evacuating pollutants specific to the type of activity carried out. Organic substances, nutrients (food industry, chemical industry, fertilizer industry, pulp and paper, livestock farms, etc.), heavy metals (extractive and processing industries, chemical industry, etc.), as well as dangerous organic micropollutants (organic chemical industry, petroleum industry, etc.) (***, 2017).

The most important and significant point sources of industrial and agricultural pollution identified in the studied area are:

- C.S. Energetic Complex Craiova - Işalniţa Electric Power Plant;
- C.S. Craiova Energetic Complex - Craiova II Electrocentrale Branch;
- C.S. Zahărul S.A. Podari;
- Petrom S.A. - Member of OMV Group. Petrom Craiova;
- DOLJCHIM Craiova;
- Leamna Pneumoftiziology Hospital;
- C.S. FELVIO Ltd. Bucovăţ (bird breeding);
- A.N.P.- Pelendava Craiova Penitentiary (agriculture, zootechny, meat processing and milk processing);
- C.S. GIM CO Ltd. (chicken intensive growth).

In terms of releases of pollutants into surface water resources, table 2 shows the monitored quantities of organic substances (expressed as CCO-Cr and CBO_5) and nutrients (total nitrogen and total phosphorus) in the year 2016 per categories of sources of pollution. Table 3 also shows the same situation, given the quantities of heavy metals measured and monitored.

Table 2.

Discharges of organic substances and nutrients into the water resources from the industrial and agricultural point sources in Jiu River basin (***, 2017)

Type of industry	**Organic substances (CCO-Cr)**	**Organic substances (CBO_5)**	**N total**	**P total**
	t/year	t/year	t/year	t/year
IPPC Industry	12933.143	1904.359	31.389	12.831
Non IPPC Industry	1313.617	321.987	16.295	26.009
Total Industy	14246.760	3226.346	47.684	38.84
Other punctual sources	170.997	8.606	8.509	0.056

Table 3.

Discharges of heavy metals into the water resources from the industrial and agricultural point sources in Jiu River basin (***, 2017)

Type of industry	**Cu**	**Zn**	**Cd**	**Ni**	**Pb**	**Hg**	**Cr**
	kg/year	kg/year	kg/year	kg/year	kg/year	kg/year	kg/year
IPPC Industry	-	-	-	-	-	-	-
Non IPPC Industry	0.9	1.9	-	-	0.1	-	0.1
Total Industry	0.9	1.9	-	-	0.1	-	0.1
Other punctual sources	0.1	0.1	-	-	-	-	1.0

Significant diffuse sources of pollution

The main categories of sources of diffuse pollution are represented by:

1. Human agglomerations/localities that do not have wastewater collection systems or adequate systems for collecting and removing sludge from sewage treatment plants as well as localities with non-compliant household waste dumps.

2. Agriculture - agrozootechnical farms that do not have adequate manure storage/utilization systems, communes identified as vulnerable or potentially vulnerable to pollution by nitrates from agricultural sources, pesticide units that do not comply with the legislation in force, other units/agricultural activities that can lead to significant diffuse emissions. The specific quantities of chemical fertilizers (expressed in active substance) used in 2016 were about 10% higher than the situation in 2012, when at the level of Jiu hydrographic basin there were used average quantities of approx. 6.910 kg N/ha of agricultural land, respectively 1.410 kg P/ha of agricultural land. In 2016, compared with 2012, the quantities of natural fertilizers used decreased by approx. 10% (***, 2017).

3. Industry - warehouses of raw materials, finished products, auxiliary products, non-compliant waste storage, units producing diffuse accidental pollution, abandoned industrial sites.

Establishing control sections and sampling

Water samples were taken on 20.05.2017, according to SR ISO 5667-6/2014 Water quality. Sampling Part 6: Guide for sampling of rivers and streams.

Establishing sampling locations has been done to allow for a comparative analysis. Sampling points can be located using fixed landmarks, GPS coordinates or stations or equipments with identification number. Sampling points were clearly marked to avoid any confusion (***, 2017).

In establishing the sampling points the legal methodology was considered, as well as the location of the most important points in which untreated waste waters are discharged into the Jiu River on the territory of Dolj County.

For the collection of samples to be analyzed in order to determine the quality of Jiu River in Dolj County, three control sections were established together with the Romanian Waters Administration (figure 2):

P1 - in Răcari locality - downstream of Filiaşi, at the entrance to Dolj County;

P2 - in the Podari village - downstream of Craiova;

P3 - in Gângiova - at approx. 15 km upstream of the Danube.

Fig. 2. Location of the sampling sections

The collected water samples were transported to the authorized laboratory of the Romanian Water Administration - Craiova where the analyzes were carried out according to the norms in force, the results of which are presented in the following paragraph.

RESULTS AND DISCUTIONS

Determining the quality class

The surface water classification is based on the results of water quality monitoring and provides for a surface water classification a system divided in five quality classes defined by Order 161/2006:

Class I (very good) corresponds to surface waters where there are no (or very low) alterations in the physical-chemical and biological quality values. Concentrations of synthetic pollutants do not affect the functioning of aquatic ecosystems and do not harm human health.

Surface waters corresponding to Class I can be designed for all types of use. Graphic representation uses blue color (ORDER 161, 2006).

Class II (good) corresponds to surface waters that have been affected to some extent by human activity, but nevertheless ensures all uses in an appropriate manner. The functioning of aquatic ecosystems is not affected. Simple methods of treatment are sufficient to prepare drinking water. Graphic representation uses green color (ORDER 161, 2006).

Class III (polluted) corresponds to surface waters whose high quality physicochemical and biological values deviate moderately from the natural water quality background due to human activities. There are moderate signs of disturbance of the functioning of the ecosystem. The necessary conditions for the *salmonidae* family can no longer be ensured. Simple treatment is not sufficient for the use of drinking water for normal treatment methods. Graphical representation uses yellow color (ORDER 161, 2006).

Class IV (polluted) corresponds to surface waters that show evidence of major alterations in physical-chemical and biological quality values from the natural water quality fund due to human activities. The conditions for the *cyprinidae* family can no longer be assured and do not meet the requirements for drinking water without applying advanced treatment methods. Graphic representation uses orange color (ORDER 161, 2006).

Class V (very polluted) corresponds to surface waters that show evidence of major alterations in physico-chemical and biological values from the natural water quality fund due to human activities. Biological components, especially fish, are damaged and water can not be used for drinking purposes. Graphic representation uses red color (ORDER 161, 2006).

From the ecological point of view, the five qualities are the following:

- Class I quality - very good ecological status;
- Class II quality - good ecological status;
- Class III quality - moderate ecological status;
- Class IV quality - poor ecological status;
- Class V – very poor ecological status.

Table 4 presents the results of the analyzes performed on the water samples collected from the three control sections.

Table 4.

Analysis results from 20.05.2017

Crt. No.	Indicator	MU	Analysis method	Sampling section		
				P1 Răcari	P2 Podari	P3 Gângiva
1	Temperature water/air	^{0}C	STAS 6324/1961	16/16.5	17/17	18/18
2	pH (22.0^{0}C)	UpH	SR ISO 10523/2012	7.96	8.03	7.62
3	Total suspensions	mg /l	SR EN 872/2005	8	9	8
4	Conductivity	µS/cm	SR EN 27888/1997	321	451	489
5	Fixed residue at 105^{0}C	mg/l	STAS 9187:1984	201	221	293
6	Dissolved oxygen	mg/l	SR EN 25813/2000	8.9	8.8	8.5
7	Saturation	%	SR EN 25813/2000	82.45	82.41	75.96
8	CBO_5	mg /l	SR EN1899-2/2002	5.7	5.9	6.0
9	CCO - Cr	mg /l	DIN 38409/2008	19.45	20.33	22.41
10	Alkalinity	mmol/l	SR EN ISO 9963-1/2002	2.289	2.981	3.210
11	Bicarbonates	mg /l	SR EN ISO 9963-1/2002	189.32	189.45	195.81
12	Chlorine	mg /l	SR ISO 9297/2001	26.678	27.345	26.989
13	Sulphure	mg/l	EPA 375.4/2005	75.344	76.786	78.724
14	Ammonium - N- NH_4	mgN /l	SR ISO 7150-1/2001	0.2134	0.5678	0.5964
15	Nitrates - N-NO_3	mgN /l	SR ISO 7890-3/2000	0.7501	1.1234	1.1650
16	Nitrites - N-NO_2	mgN /l	SR EN 26777/C91/2006	0.0121	0.0231	0.0325
17	Total nitrate -N	mg /l	SR EN 12260/2004	2.0112	2.1456	2.3180
18	O-phosphate – P-PO_4	mgP /l	SR EN ISO 6878/2005	0.1567	0.1534	0.1895

19	Total phosphorus – PT	mg /l	SR EN ISO 6878/2005	0.0451	0.020	0.1974
20	Calcium	mg/l	STAS 3662/1990	63.334	63.245	62.962
21	Durity	mg/l CaCO3	SR ISO 6059/2008	267.23	265.234	266.36
22	Detergents ANA	mg/l	SR EN 903/2003	0.109	0.109	0.132
23	Phenol	mg/l	SR ISO 6439/2001	<0,004	<0,004	<0,004

In order to assess the Jiu River water quality in Dolj County, we have performed a comparative analysis of the characteristic quality parameters for the three sampling points (P1, P2, P3) presented in table 4.

- the dissolved oxygen shows that at point P1 the degree of saturation is of 82.45%, which qualifies Jiul in quality class I. This parameter is affected, by an decrease in value, so at point P3 the value reaches only 75.96%. This evolution is due to the organic pollutant load between the collection points;

- CBO5 is a parameter in correlation with dissolved oxygen, its evolution is in the opposite direction. That is, at point P1 we have a low oxygen biochemical consumption (5.7 mg/l), wich increases in P2 to 5.9 mg/l and in P3 to 6.0. The determined values place Jiu River in the third class of quality, a moderate ecological state;

- the pH value falls within the range of variations characteristic to natural water courses, with a slightly basic character;

- the temperature of Jiu River undergoes a small change, it increases from 16ºC in point P1 to about 18ºC at point P3. This is due to the influence of air temperature as can be seen from the attached analysis bulletins;

- the nitrate concentration suffers a negative change (the concentration rising from 0.75 mg/l in P1 to 1.16 mg/l in P3), suggesting that sewage discharges occur between the analysis sections (or wastewaters from zootechnical farms);

- the phosphate concentration increases between the first two sampling points, after that it remains practically constant;

- turbidity evolution is influenced in turn by domestic wastewater spillage and due to the high hydraulic stability of the suspended particles, favored by the predominantly laminar flow regime.

- the concentration of total dissolved salts is similar in evolution (increases in P3 compared to P1), appreciating that this is achieved mainly by the intake of wastewaters with higher content of salts.

As a general conclusion, considering the water quality of Jiu River on the analyzed section, in terms of the values of the parameters selected in the three test sections compared with those listed in Order 161/2006, and taking into account the recommendations from it, we can say that the wastewater generated by household activities and which are discharged directly into it, have a negative influence. However, the quality of Jiul River does not suffer a significant worsening, falling into the third category in all three sections.

Applying a control method

Another way of assessing the quality of Jiu River water for the three analysis sections is based on the calculation of the Water Quality Index (WQI).

The Water Quality Index (WQI) was conceptually defined in the early 1970's by the National Sanitation Foundation (NSF) to compare water quality from different water sources and to monitor water quality variations over time. For this purpose, 142 experts carried out 25 different tests and selected 9 indicators, with the main objective of aggregating individual indicators (expressed in physical units) into a single water quality index (on a conventional scale 0-100) (SOLOMON, 1977). The steps to achieve the set goal were as follows:

- translating each of the 9 indicators into a quality index;

- performing a weighted average of the obtained values.

This method involves the interpolation of the result of the water quality parameters analysis with a series of predefined curves (shown in the literature) to obtain the value of Q, after which the Qi value will be assigned a given weight Wi, and the quality index is calculated by the formula WQI = ΣiQiWi (LAZĂR AND DUMITRESCU, 2006).

For each sample a table is produced with all the results for the water quality parameters, and then using the scale of quality (table 5) we determine the quality of the water according to the score.

Table 5.

Quality scale for WQI

Points	Quality	Category
91 - 100	**excellent**	**A**
71 - 90	**good**	**B**
51 - 70	**medium**	**C**
26 - 50	**poor**	**D**
0 - 25	**very poor**	**E**

Table 6 presents the data which are at the base on the calculation of the water quality index for the three control sections considered on the Jiu River, and table 7 presents the values determined for Q in order to characterize its quality in the Dolj County. As can be seen, for the calculation of the water quality index additional analyzes were performed for the determination of fecal coliforms, turbidity and dissolved solids.

Table 6.

Indicators required for WQI calculation

Crt. No.	Indicator	UM	Sampling section		
			Răcari	**Podari**	**Gângiva**
1	Dissolved oxygen	%	82,45	82,41	75,96
2	Fecal coliforms	Colonii/100ml	180	268	280
3	CBO_5	mg/l	5,7	5,9	6,0
4	pH		7,96	8,03	7,62
5	Nitrates	mg/l	0,75	1,12	1,16
6	Temperature	ºC	16	17	18
7	Total phosphates	mg/l	0,045	0,020	0,19
8	Turbidity	NTU	28	58	61
9	TDS	mg/l	0,3	0,7	0,8

Table 7.

Calculated values for determination of WQI

Crt. No.	Indicator	P1 Răcari			P2 Podari			P3 Gângiva		
		Value Q_i	**Proportion W_i**	**Total**	**Value Q_i**	**Proportion W_i**	**Total**	**Value Q_i**	**Proportion W_i**	**Total**
1	Dissolved oxygen	90	0.17	15.30	90	0.17	15.30	80	0.17	13.60
2	Fecal coliforms	50	0.11	5.50	42	0.11	4.62	41	0.11	4.51
3	CBO_5	52	0.11	7.72	51	0.11	5.61	52	0.11	7.72
4	pH	89	0,11	9.79	82	0.11	9.02	92	0.11	10.12
5	Nitrates	90	0.10	9.00	89	0.10	8.90	90	0.10	9.00
6	Temperature	27	0.10	2.70	26	0.10	2.60	22	0.10	2.20
7	Total phosphates	99	0.10	9.90	99	0.10	9.90	98	0.10	9.80
8	Turbidity	52	0.08	4.16	34	0.08	2.72	33	0.08	2.64
9	TDS	80	0.07	5.60	80	0.07	5.60	80	0.07	5.60
10	**TOTAL**	-	-	**67.67**	-	-	**64.27**	-	-	**63.19**

Using the three values calculated for the Water Quality Index, the chart in figure 3 was constructed, which allows us to observe how the Jiu River water quality evolves on the section investigated in Dolj County.

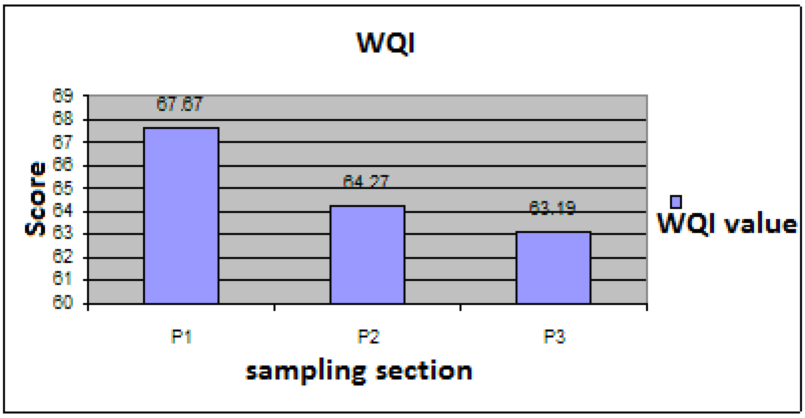

Fig. 3. Values of the Water Quality Index in the three analyzed sections

Although the value of the Water Quality Index falls slightly from P1 to P3, from the point of view of classification, the water of the Jiu River remains of medium quality (class C of quality) according with the methodology.

CONCLUSIONS

In the context of sustainable development, the protection of surface water quality occupies a major place, considering that water, which has long been considered an inexhaustible and renewable resource has become and is becoming increasingly evident as one of the limiting factors in the socio- economic development. As a major environmental factor and major vector of local and cross-border pollution propagation, as a vital resource of life support, water quality monitoring has seen a number of steps in terms of organization and implementation.

The main anthropogenic sources of pollution from the analyzed section were analyzed and their impact on the quality of surface waters was analyzed. As shown in the present study, the main sources of pollution are industrial and agricultural activities, followed by wastewater discharged into the Jiu River without proper treatment.

From the researches carried out on the Jiu River water quality in Dolj County on the Răcari - Gângiva section, a series of general conclusions with a theoretical and practical significance are revealed:

1. Considering the phosphate concentrations and the biochemical oxygen demand, it falls within the class III of quality - moderate ecological status.

2. Depending on the concentration of nitrates and coliforms, it is in the class II of quality - good ecological conditions.

3. Depending on the temperature, pH and dissolved oxygen it falls into Class I - very good environmental status.

4. Based on the importance of quality parameters, we believe that Jiu River should be classified in quality class III.

Analyzing through the Water Quality Index, all three points show that the water has a medium quality, and therefore the overall quality of Jiu River on the analyzed section is medium.

In other words, both methods used to determine the quality of the Jiu River in the county of Dolj led to the same result, namely a medium-quality water.

This shows that it is absolutely necessary to implement urgent measures to bring the Jiu River to a higher quality level, in line with the European objectives in the field, namely to ensure a good ecological potential. To this end, the authors recommend:

- connection to sewage collection and treatment systems to prevent river pollution by domestic wastewater drainage, directly into the river and pollution of the groundwater through the infiltration of waste water into the soil;
- ensuring efficient systems for evacuation of rainwater and waste water;
- increase the efficiency of operation of sewage systems and wastewater treatment plants.
- apply less polluting and/or more water-efficient technological processes, save water through recycling, and in some cases - extract useful substances from waste water and sediments and avoid waste and/or losses of water;
- progressively reduce discharges of priority substances and priority hazardous substances (including the total exclusion of priority hazardous waste discharges).

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