Assessment of Motru and Motru Sec Rivers Quality by Monitoring of Physico-chemical Parameters and Water Quality Index

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This paper presents a research study related to assessment of the quality status of Motru and Motru Sec rivers from measured values for physico-chemical parameters such as temperature, pH, suspended solids, nitrate, total phosphorus, dissolved oxygen and biochemical oxygen into three monitoring sections in 2012-2014. By analyzing the results obtained it can be concluded that the Motru river and its tributary, Motru Sec are included in I quality class for all parameters analyzed, except for dissolved oxygen. With respect to dissolved oxygen, the Motru river is included in class II quality for all monitored sections. The quality index value indicated that Motru river has a high status corresponding to an unpolluted river.

Keywords: water quality monitoring, surfacewaters, quality index

Romania, just like other any european country is facing an excessive use of surface waters. This leads to a rapid exhaustion of water bodies and increasing pollution [1]. As a consequence, water quality represents a very important issue that should concern all of us.

Water quality can be defined as a set of conventional physical, chemical, biological and bacteriological characteristics. Water quality criteria are represented by all water quality indicators that are used for decision-making policies regarding water potability and its uses [2, 3].

According to the Order 161/2006 regarding the classification of surface water to determine the ecological status of water bodies, five quality classes were defined for rivers. They are: high ecological status (Class I) coded blue, good ecological status (Class II), coded green; moderate ecological status (Class III), coded yellow; poor ecological status (Class IV), encoded by orange and bad status (Class V), encoded by red. The limit value for each class is the maximum accepatble value for respective quality class [4].

Water Quality Index is a numerical expression used in river quality assessment by classification into five classes of values range from 1-100% [5,6]. For each class corresponds a certain quality status, respectively one different field of use. The index was first used in order to reflect physico-chemically changes in river quality as a result of monitoring and quality management activities. Mathematical methods were used to indicate the global quality state of the surface waters with the use of a quality index [7]. Subsequently, by development of methodology of calculation it was possible to use this index to characterize the entire aquatic system [8,9].

The protection of high and good status waters is important for states in their approach to improving water quality. This issue is emphasised by the Water Framework Directive. In order to achieve "high ecological status" the environmental quality standards must be monitored for the priority pollutants in all water bodies [10].

Motru River is the biggest tributary stream of the river Jiu basin, it covers an area of 1874 km^2 with an average altitude of 401 m and an average slope of the basin of 78 m/km. It springs from SW of Valcan Mountain, at an altitude of 1230 m. Motru River firstly crosses one area consisting of crystalline schists and granite, afterwards it enters a limestone region of Mehedinti Plateau, then it separates Piedmont Coşuştea by Jiu Hills. It passes through Motru and Strehaia towns, and it drains the largest coalfield of Oltenia. The main pollution sources of the river Motru are point sources represented by household and industrial activity, respectively diffuse sources of pollution. As a result, the monitoring of the river Motru quality is a fundamental tool in the management of freshwater resources in Jiu county.

Motrul Sec River is an impermanent stream located in the mountains, a tributary of the river Motru. Springs of Motru and Motru Sec are in Cerna ridge, and between these two rivers there is the small massive limestone Piatra Cloşani.

The main aim of this paper is to present the assessment of the state of Motru River over a period of three years of monitoring.

Experimental part

In order to assess the state of the river Motru and Motru Sec quality and to determine the water quality index, the quality parameters such as temperature, pH, suspended solids, nitrate, total phosphorus, dissolved oxygen and biochemical oxygen were measured. The period of analysis is three years (2012-2014) and measurements were performed in the following sections of monitoring Motru River: upstream of Great Valley reservoir (S1), downstream of Great Valley reservoir (S2). The upstream of Motru Sec village section (S3) was chosen for Motru Sec river. Monitoring sections are included in the Surveillance System of Jiu Water Basin Administration. These sections were selected according to the delineation of water bodies in the river basin level.

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Table 1
MOTRU RIVER PHYSICO-CHEMICAL PARAMETERS FOR GREAT VALLEY – UPSTREAM OF ACCUMULATION SECTION (S1)

Monitored parameters	Upstream of Accumulation Great Valley Section (S1)								
	2012			2013			2014		
	March	Aug.	Nov.	March	June	Sept.	Febr.	June	Sept.
Temperature (^{0}C)	5	17	6	3	10	13	2	18	11
Suspended solids (mg/L)	24	25	25	18	24	16	21	24	23
pH	7.21	7.02	7.44	7.22	7.31	7.28	6.89	7.30	6.9
Nitrates (mg/L)	0.33	0.29	0.25	0.32	0.33	0.42	0.33	0.48	0.54
Total phosphorus (mg/L)	0.009	0.006	0.006	0.009	0.008	0.01	0.006	0.004	0.03
Dissolved oxygen (mg/L)	12	8.9	11.88	13.02	10.68	9.92	12.87	8.7	9.4
Oxygen saturation (%)	93.67	87.09	95.19	96.51	94.09	93.4	92.92	93.09	84.68
BOD_5 (mg/L)	2.5	2.3	2.2	2	2.2	1.9	1.8	2.6	2.4

Sampling was performed according to standards in force using plastic containers, washed with water at the sampling points with Motru river, to prevent the risk of samples contamination with impurities from the container manufacturing material. Containers used for sampling were filled with water and sealed not to allow air bubbles to enter and cause oxidation processes [11].

The methods used for determining the parameters monitored were in accordance with the standards for water quality. Nitrate content was determined by sulfosalicylic acid spectrometric method by measuring absorbance of the resulting yellow complex resulted from reaction to a wavelength of 415 nm with a UV-VIS spectrometer, model Cintra 101 [12]. Dissolved oxygen and biochemical oxygen demand were determined by electrochemical methods standardized using a multiparameter Consort type [13, 14]. A potentioetric method using a portable pH meter Hanna model was used to determine the *p*H, and a portable turbidity meter Micro TPI model was used to measure water turbidity. Total phosphate content was determined by ammonium molybdate spectrometric method, and suspended matter was determined gravimetrically.

Results and discussions

The measured values for the parameters that were monitored for Motru river water in the period 2012-2014, in the section upstream of accumulation Great Valley (S1) are shown in table 1. The saturation concentrations of oxygen at temperatures measured were considered in order to determine oxygen saturation (%) required to calculate water quality index.

Motru river water temperature is characterized by a high variability which is directly proportional to the air thermal condition. The influence of climatic factors on variation of temperature Motru river was observed from the graphical representation of physico-chemical parameters variation (fig. 1) for section S1. The highest temperature was recorded in June 2014, and the lowest in February 2014. *p*H values are according to the reference conditions from Normative 161/2006 (*p*H 6.5) and suspended solids concentration is in 16-25 mg/L range. Low values of suspended solids suggest no contamination of Motru river possibly due to domestic sewage, agricultural run-off, and industrial wastewater.

From the nutrients content assessed by measuring nitrate and total phosphorus for section S1 (fig. 2) it can be concluded that Motru River in section S1 is in Class I according to Norm 161/2006.

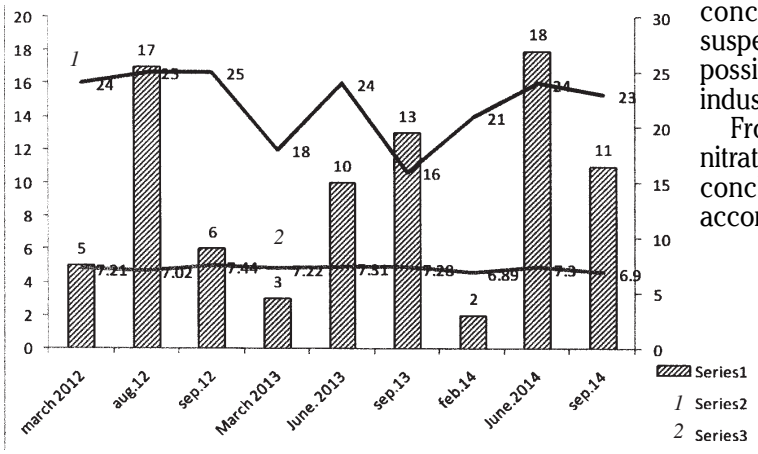

Fig.1. The physico-chemical parameters variation for section S1

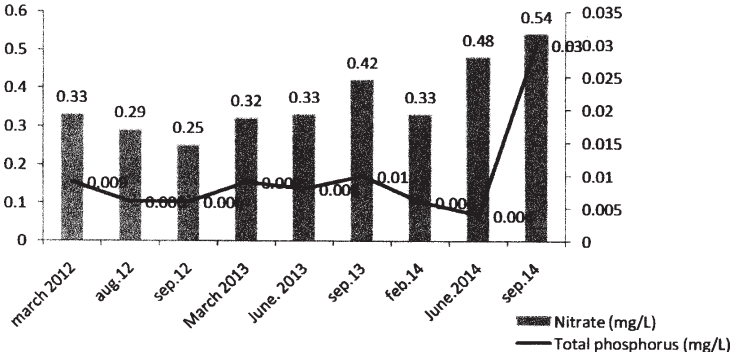

Fig.2. NO_3^- and total phosphorus content for Motru River in section S1

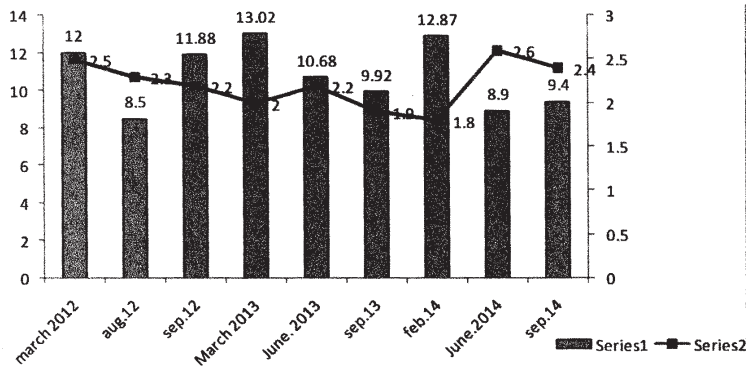

Fig.3. Dissolved oxygen and biochemical oxygen demand variation for section S1

Monitored parameters	Great Valley – downstream of accumulation section (S2)								
	2012			2013			2014		
	March	Aug.	Nov.	March	June	Sept.	Febr.	June	Sept.
Temperature (^{0}C)	6	18	6	3	10	15	2	19	10
Suspended solids (mg/L)	26	23	26	24	27	19	19	24	25
pH	7.16	7	7.41	7.3	7,35	7.27	6.93	7.2	7.1
Nitrates (mg/L)	0.37	0.30	0.26	0.35	0,34	0.43	0.34	0.38	0.53
Total phosphorus (mg/L)	0.01	0.007	0.006	0.01	0,009	0.012	0.008	0.03	0.006
Dissolved oxygen (mg/L)	11.8	8.6	12	12.78	10,36	9.62	12.73	8.3	9.8
Oxygen saturation (%)	94.55	86.82	96.15	94.73	91,27	94.49	91.91	88.58	86.34
BOD_5 (mg/L)	2.8	2.6	2.4	2.3	2.5	2.1	2	2.9	2.6

Table 2
MOTRU RIVER PHYSICO-CHEMICAL PARAMETERS FOR GREAT VALLEY – DOWNSTREAM OF ACCUMULATION SECTION (S2)

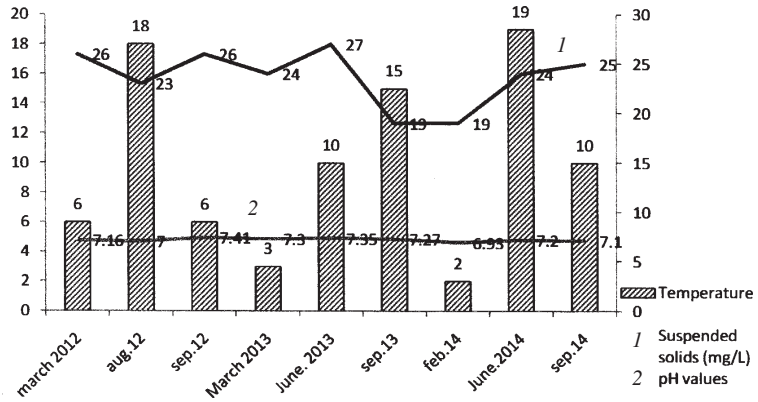

Fig.4. The physico-chemical parameters variation for section S2

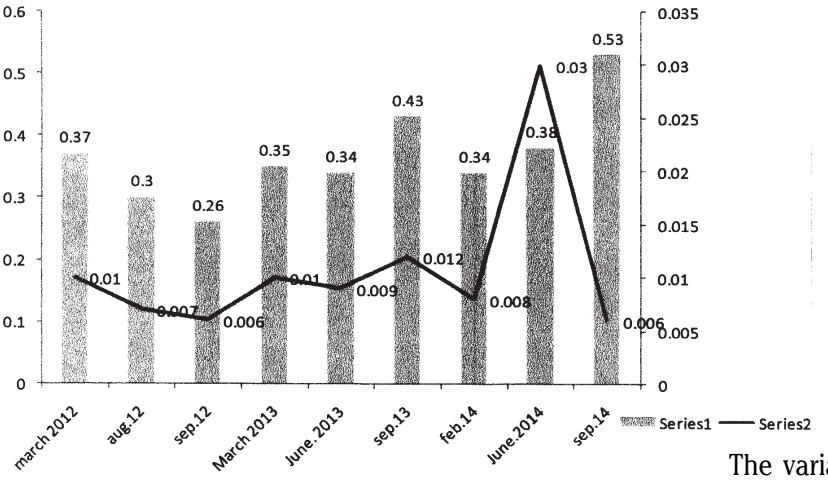

Fig.5. NO_3^- and total phosphorus content for Motru River in section S2

With regard to oxygen during the monitored period for section S1, there was a variation of dissolved oxygen between a minimum value of 8.5 mg/L registered in August 2012, corresponding to a Class II water, and a maximum value of 13.02 mg/L in March 2013, corresponding to a Class I. (fig. 3). Biochemical oxygen demand had a variation in the range 1.8 mg/L in February 2014 and 2.6 mg/L in June 2014 characteristic for a I Class water (fig. 3).

Table 2 presents the values of quality parameters for Motru river, in 2012-2014, in the downstream of accumulation Great Valley section (S2).

The variation of temperature in the downstream of accumulation Great Valley section (S2) is between 2-19°C, the *p*H values are in the reference conditions of Norm 161/2006 (*p*H 6.5-8.5), and suspended matter are between 19-27 mg/L (fig. 4).

The data presented in figure 5, revealed that the nutrient regime evaluated in downstream of accumulation Great Valleyof River Motru section (S2) corresponds to Class I water according to Norm 161/2006 (nitrate limit value (LV) = 1 mg/L).

Dissolved oxygen concentration in the period monitored, for downstream of accumulation Great Valley section (S2),

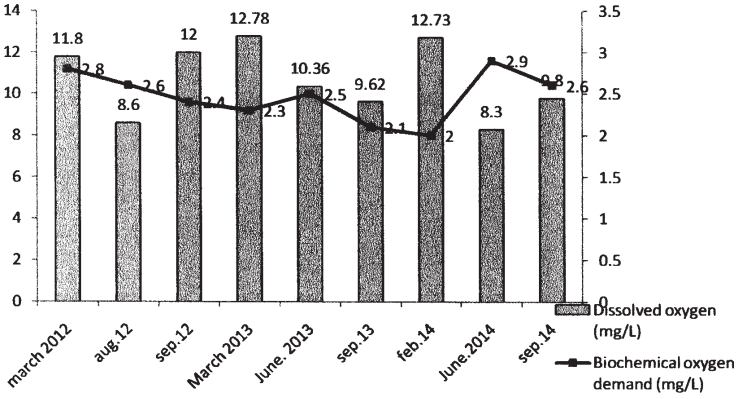

Fig.6. Dissolved oxygen and biochemical oxygen demand variation for section S2

Monitored parameters	Upstream of Motru Sec village section (S3)								
	2012			2013			2014		
	March	Aug.	Nov.	March	June	Sept.	Febr.	June	Sept.
Temperature (^{0}C)	4	16	5	3	10	15	3	20	11
Suspended solids (mg/L)	27	24	24	24	27	20	24	27	26
pH	7.30	7.10	7.40	7.01	7.35	7.05	6.89	7.3	7.2
Nitrates (mg/L)	0.50	0.40	0.29	0.4	0.34	0.5	0.41	0.53	0.38
Total phosphorus (mg/L)	0.016	0.006	0.007	0.016	0.009	0.019	0.008	0.009	0.008
Dissolved oxygen (mg/L)	12.4	8.6	12.1	12.7	10.36	9.26	12.28	8.2	9.6
Oxygen saturation (%)	94.36	86.25	94.45	94.14	91.27	90.96	91.03	89.22	86.48
BOD_5 (mg/L)	2.2	2.4	2.2	2.4	2.5	2.2	2.1	2.6	2.2

Table 3
MOTRU SEC RIVER PHYSICO-CHEMICAL PARAMETERS FOR UPSTREAM OF MOTRU SEC VILLAGE SECTION (S3)

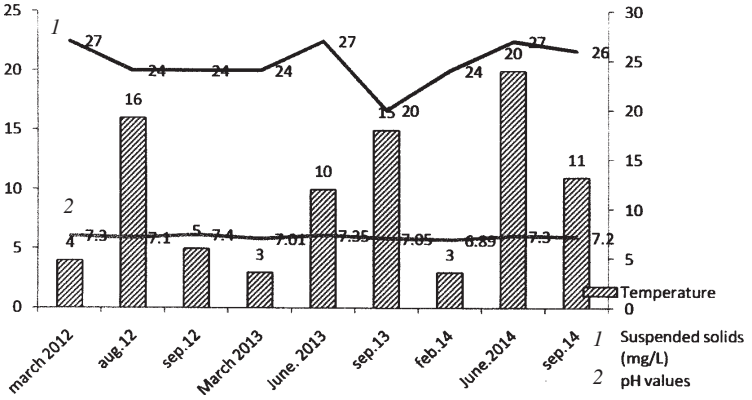

Fig.7. The physico-chemical parameters variation for section S3

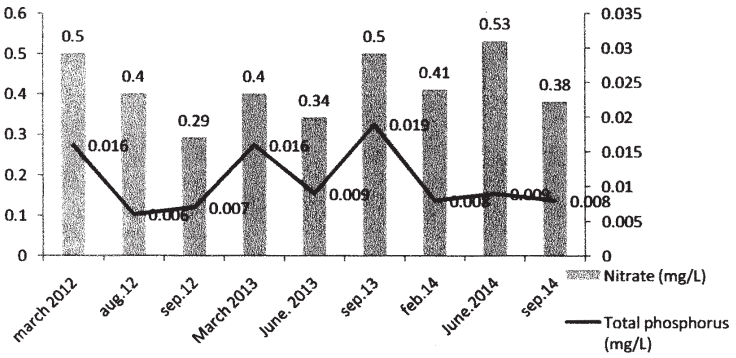

Fig.8. NO_3^- and total phosphorus content for Motru Sec River in section S3

recorded a variation between a minimum value of 8.3 mg/L registered in June 2014, corresponding to a Class II quality water and a maximum value of 12.78 mg/L recorded in March 2013, corresponding to a Class I quality water, according to Norm 161/2006 (fig. 6). Biochemical oxygen demand had a variation in the range 2 mg/L in February 2014 and 2.9 mg/L in June 2014. This variation includes the river Motru in Class I quality water (BOD LV = 3 mg O_2 /L).

Table 3 shows the quality water parameters monitored in 2012-2014 for Motru Sec river, in upstream of Motru Sec village section (S3).

In figure 7-9 are presented the variations of monitored parameters for section S3 of Motru Sec river.

For upstream village Motru Sec section (S3) it was observed that Motru Sec river water temperature varies depending on the thermal condition of air with a minimum value of 3°C in March 2013 and February 2014 to a maximum value of 20°C in June 2014. From the chart of *p*H and particulate matter (fig. 7) for the section S3 it can be observed that all values of these paparenters are according to reference conditions from normative 161/2006. The contents of nitrate and total phosphorus (fig. 8) of Motru Sec river correspond to Class I. In case of oxygen

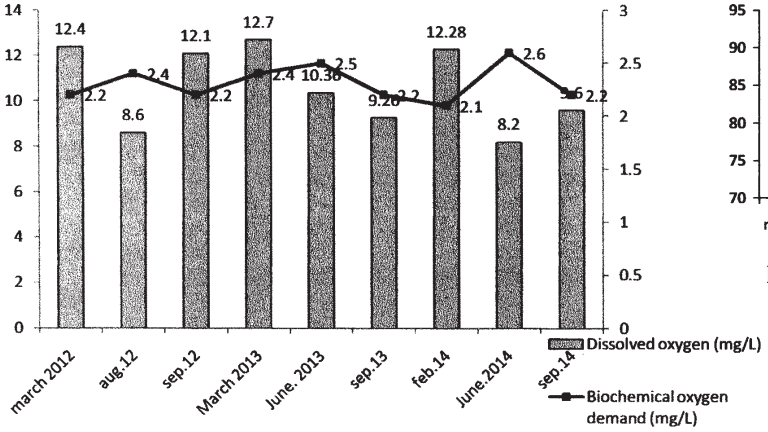

Fig.9. Dissolved oxygen and biochemical oxygen demand variation for section S3

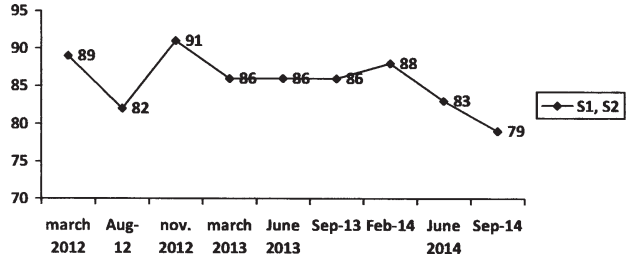

Fig.10. Variation quality index for Motru river, in the period 2012-2014 for sections S1, S2

regime in the monitored period, there was a variation between a minimum value of 8.6 mg/L registered in August 2012 corresponding to Class II water quality and a maximum value of 12.07 mg/L in March 2013 corresponding to Class I quality water (fig. 9). Biochemical oxygen demand had a variation in the range 2.1 mg/L in February 2014 and 2.6 mg/L in June 2014. This variation corresponds to a Class I water quality (fig. 9).

Water Quality Index of Motru river

Water Quality Index is a tool to describe the general situation of water bodies by changing water quality parameters values into a numerical score using mathematical equations [15]. It was firstly determined according to a methodology which was described by the Environmental Protection Agency, Region 10 US. The above mentioned methodology uses different value ranges to determine the importance of each parameter in calculating the index, and then it provides the establisment for a single value corresponding to index value [16, 17]. Primary values of each quality parameter should be compared to the standard limit values to calculate the index to establish the quality assessment. Formula for calculating the quality index is:

$$WQI = 1/100\left(\sum_{i=1}^{9} q_i \cdot W_i\right)^2$$

where i is the parameter of quality; qi - the value recorded; Wi - degree of involvement (share) parameter in the formula for calculating the index

Since 2000, the environmental research centers have used an easier method of calculation, with the help of a programme available online: WQHYDRO, *Monitoring the quality on surface waters*. Index values thus obtained are divided into several ranges. These values indicate the water quality and its uses field: 0-25% means a very polluted water, 25-50% corresponds to a polluted water, 50-70% represents a moderate polluted water, 70-90% corresponds to a good water, and 90-100% very good water.

The method that we have chosen for calculating water quality index, according to Field Manual for Water Quality Monitoring includes the following steps:

- selection of parameters was performed according to global quality classes established in accordance with the foreknowledgement of Order 161 of 16 February 2006;

- bringing the units of measurement at the same scale and establishing the weight of each parameter depending on its importance in the state of sanogenesis of aquatic ecosystem. According to the methodology of water quality index calculation, the weights of monitored parameters are: temperature 0.10; suspended solids 0.07; *p*H 0.11; nitrates 0.10; total phosphorus 0.10; dissolved oxygen (oxygen saturation,%) -0.17, 0.11 biochemical oxygen demand;

- calculation of the quality and determination of the purpose was performed online [18].

Calculation of Motru river water quality index was based on the selection of the following parameters stipulated by the methodology of calculation: temperature, suspended solids, pH, nitrate, total phosphorus, dissolved oxygen/ oxygen saturation, biochemical oxygen demand. Since microbiological parameter (Total Coliforms) was not monitored in the sections analyzed, it was not taken into account. Motru River Water Quality Index values were calculated by the programme *Monitoring the quality surfacewaters*, based on monitored parameter values and their weight in the index calculation are presented in figure 10.

Water Index Quality (WIQ) value recorded in November 2013 (WIQ = 91) recommends Motru river water for all kinds of recreational activities and convenient for all species of fish and aquatic animals. Water can be used without treatment in industry. For values in the range 70-90% (good) Motru river water is uncertain for water sports that provide direct contact with water and for fishing, in this case water only supports populating with freshwater fish. Regarding use in industry, for this range of values WIQ, water requires a minor treatment if it is needed one quality or no treatment for most type of uses.

The water quality of the Jiu river in Rovinari was studied in [19[.

Conclusions

Assessment of quality status of rivers Motru and Motru Sec was achieved by monitoring quality parameters such as temperature, *p*H, dissolved oxygen, biochemical oxygen demand, total phosphorus, nitrates, suspended solids, in the period 2012-2014. The values obtained were reported to normative 161/2006 regarding the classification of surface waters in order to determine the ecological status of water bodies. For sections monitored, it was established that Motru and Motru Sec rivers are in Class I ecological status for all parameters analyzed, except for dissolved oxygen in the summer months.

The higher values of oxygen concentration in winter months may be ascribed to factors such as temperature, phytoplankton and others, and the lower values of oxygen concentration in summer months can be partially due to organic substances and bacterial load.

All parameters monitored in the period 2012-2014 indicated that Motru and Motru Sec rivers were not affected by contamination with domestic sewage, agricultural run-off or industrial wastewater.

There was also conducted surface water quality assessment using water quality index which shows a number of advantages, namely: totaling more variables into a single number, it brings at the same unit of measure several parameters of water quality, gives the possibility to compare temporal and spatial the quality of several/one water bodies, and sets the usability of water in different areas or purposes.

Quality assessment by calculating the Motru river water quality index highlighted its adequate framing in terms of good and very good condition.

The Water Quality Index is simple, flexible, stable and trustworthy indexing system and can be used as suitable tool for assessment of water bodies quality at national and international level.

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