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ORIGINAL RESEARCH PAPER

ASSESMENT OF THE WATER QUALITY IN SIRET HYDROGRAPHIC BASIN

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Abstract: The current study is focusing on the evaluation of the quality of surface water from the Siret hydrographic basin. For this purpose, was used the Global Pollution Index (I^*_{GP}), which was calculated for eleven water sampling points from Siret Basin. The sampling was performed for a period between the years 2010 and 2014. In the study were considered the following physicochemical parameters: *p*H, dissolved oxygen, chemical and biochemical oxygen demand, nitrogen compounds, phosphorus, iron, manganese, cadmium, mercury, nickel, lead, copper, zinc, and chromium. A specific quality index was calculated by considering the provisions of the law and an evaluation score was determined for each of the monitored water parameters. Finally, the global pollution indexes were determined, and based on these values could be evaluated the water pollution state. The results show that the situations when the pollution is creating discomfort effects on the environment are below 20 % (18 %), while the situations when is observed distress on some life forms are around 2 % (based on 474 collecting days, during the studied period).

Keywords: *general pollution index, quality index, physicochemical parameters, specific evaluation index, surface water*

INTRODUCTION

Water is considered as one of the basic needs for all of the living organisms, therefore, it is necessary to sustainably use this resource [1]. Nowadays, the necessity to evaluate the quality of the water bodies is growing as the world population is increasing, and as a consequence, increased anthropogenic activities are registered. All of these are leading to increased pressure for the permanent evaluation of the quantity and quality of the water resources [2].

In the last years, the most studied environments are rivers and lakes, as these are representing the most accessible sources of freshwater for the population [3].

Moreover, the importance of evaluating the quality of the water from the rivers is also due to its multiple uses, out of each should be mentioned the domestic and residential supplies, agricultural activities, recreational use, transportation, electric power supply as well as for other industrial processes [4].

In general, for the establishment of the suitability of the water for various uses is used the term of water quality management [5]. An important key in water quality management is monitoring the quality of water resources. The monitoring is performed by collecting all the relevant information on the physicochemical and biological water parameters [6]. In the case of the river water, the collection of all of the parameters of interest is followed by the assessment of the compliance with the permissible limit values as defined in the water quality national regulations [7]. This assessment leads to information for the national authorities, and based on these are taken the decisions for future action plans [8]. However, this procedure for the evaluation of the water quality parameters at different sampling points (*i.e.* at the points entering a river basin) is laborious and expensive which makes it difficult [9].

When a hydrographic basin is considered for water quality management, the situation is getting even more complicated. These complications are arising because several parameters are influenced by the flow rate of the water of the river during an entire year [10].

Therefore, it is necessary to be able to use a single value which will create the possibility to have a simple data interpreting and in the same time that reduces the number of parameters that are used for the evaluation of the water quality [11, 12]. Such a possibility is offered by the environmental impact assessment method developed by the Romanian researchers that is based on the use of the global pollution index (I^*_{GP}) [13-16].

In the present paper is presented the evaluation of the water quality of some of the important water sampling points from the Siret Hydrographic Basin. The evaluation methodology is based on the use of the global pollution index [15] and was applied for 10 sampling points from the above-mentioned basin by taking into account 17 physicochemical parameters.

MATERIALS AND METHODS

Sites

Eleven sampling sites were selected within the Siret Hydrographic Basin. The sampling locations are Argestru, Mihoveni, Ostra, Fundu Moldovei, Durau, Candreni, Ciobanus, Slanic, Crucea, Baia, Sendreni.

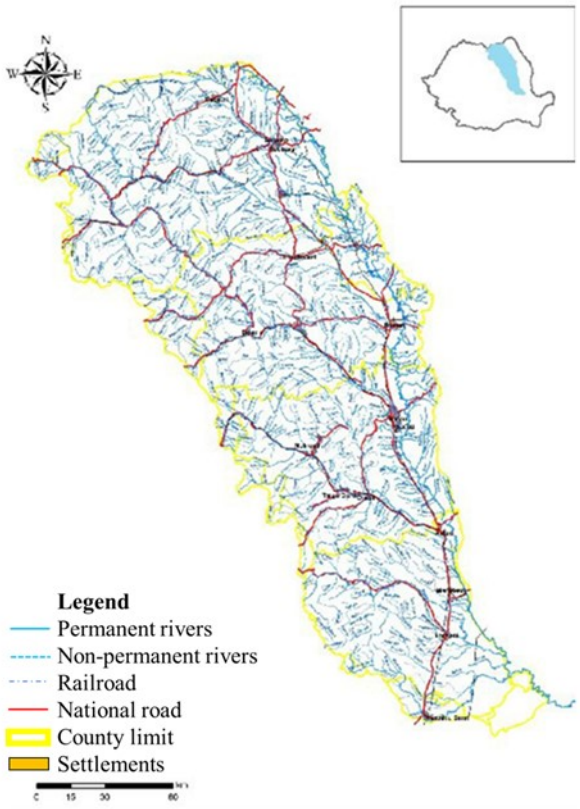


Figure 1. *Siret Hydrographic Basin*

Methods

In this study were collected the values for the following parameters: *p*H, dissolved oxygen, chemical and biochemical oxygen demand, nitrogen compounds, phosphorus, iron, manganese, cadmium, mercury, nickel, lead, copper, zinc, and chromium. The sampling was performed for five years, during 2010-2014, on a monthly base. The determinations were performed according to the officially approved methods [17].

Methodology for the evaluation of the environmental impact

For the calculation of the general pollution index, the methodology presented by Zaharia [15] was applied.

Firstly, was calculated the quality index according to the following equation:

$$EQ_i = \frac{C_i, measured}{MAC_i} \quad (1)$$

where EQ_i is the quality index for the parameter *i*, C_i is the measured value for the considered parameter, and MAC_i is the maximum admissible limit for the parameter *i*. After the calculation of the EQ_i, an evaluation score is assigned to each parameter according to the values presented in Table 1.

Table 1. *Correlation scale between the quality index, evaluation score, and pollution level for the monitored sites from Siret Basin, adapted from [15]*

Quality index, EQ_i	Evaluation Score, ES_i	Environmental impact
0	10	The water body is not affected by economic activities
$0.0 < EQ_i \leq 0.2$	9	The water body is affected by economic activities but the impact cannot be quantified
$0.2 < EQ_i \leq 0.7$	8	The water body is affected by economic activities but below the established maximum admissible limits - level 1. Alert level: potential effects.
$0.7 < EQ_i \leq 1.0$	7	The water body is affected by economic activities but into the established maximum admissible limits -level 2. Intervention level: potential effects.
$1.0 < EQ_i \leq 2.0$	6	The water body is affected, above the maximum allowed limit - level 1. The effects are pronounced.
$2.0 < EQ_i \leq 4.0$	5	The water body is affected, above the maximum permissible limit - level 2. The effects are harmful.
$4.0 < EQ_i \leq 8.0$	4	The water body is affected, above the maximum allowed limit - level 3. The harmful effects are pronounced.
$8.0 < EQ_i \leq 12.0$	3	Degraded water body - level 1. The effects are lethal at the average exposure time.
$12.0 < EQ_i \leq 20.0$	2	Degraded water body - level 2. The effects are lethal shortly after exposure.
$EQ_i > 20.0$	1	The water body is not appropriate for life

After the assignment of the evaluation scores, based on equation (2) is calculated the global pollution index [13-16] for each of the samples of this study.

$$I_{GP}^{*} = \frac{100 * n}{ES_1 * ES_n + \sum_{i=1}^{n-1} ES_i * ES_{i+1}} \quad (2)$$

where *n* is the number of the parameters, and *ES* is the evaluation score.

RESULTS AND DISCUSSION

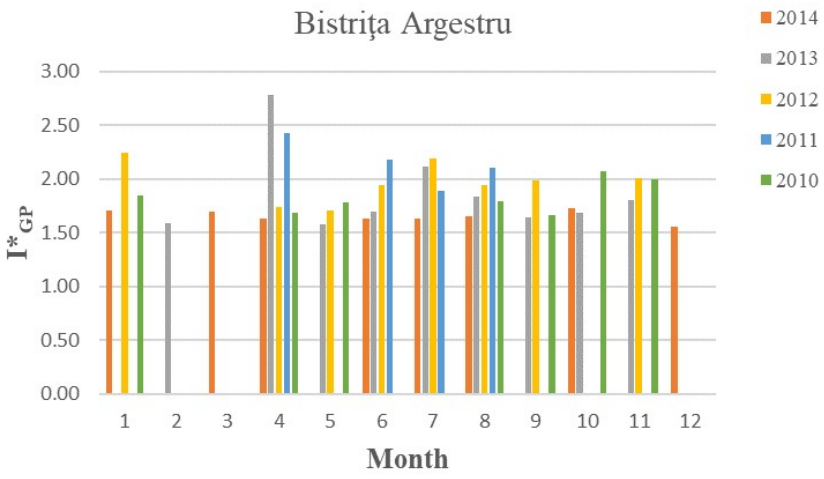
The Water Framework Directive requires continuous monitoring of the water resources with the identification of the anthropogenic factors that have any potential impact on the quality of the water bodies.
To assess the quality of the water sampled in different sampling points from the Siret Hydrographic Basin, for the period 2010-2014, the general pollution indexes were

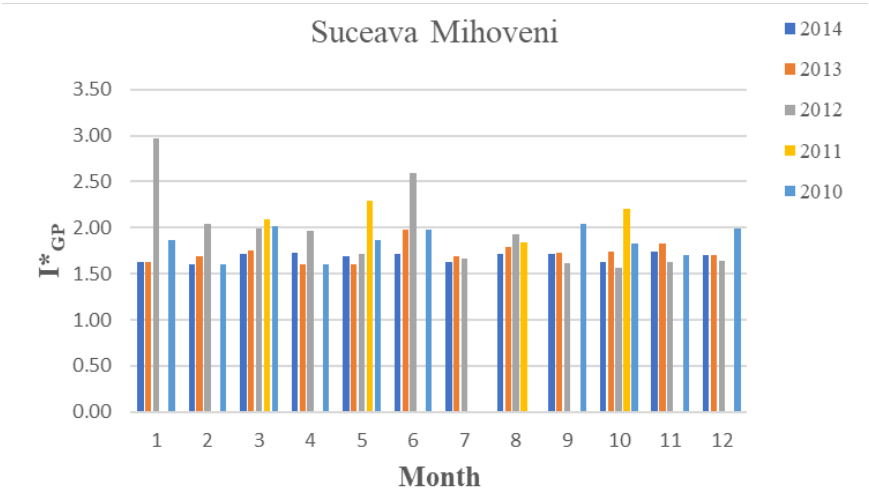
calculated according to the methodology presented above. For each sample can be evaluated the pollution state according to Table 2.

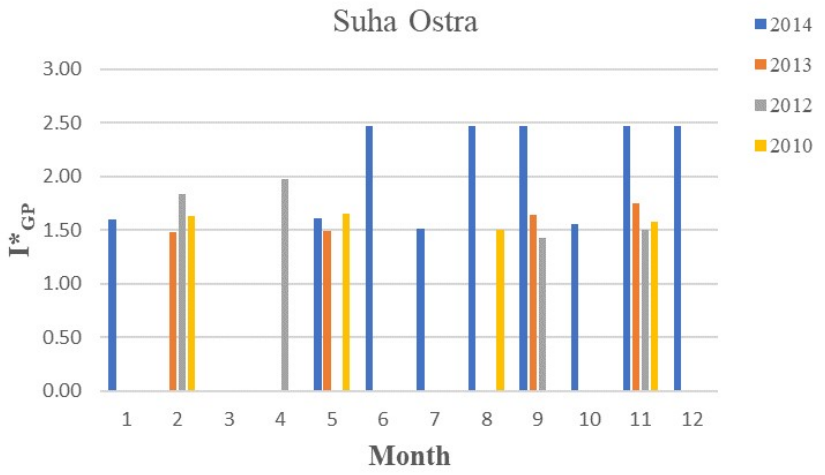
Table 2. *Correlation of the water pollution state with the general pollution index*

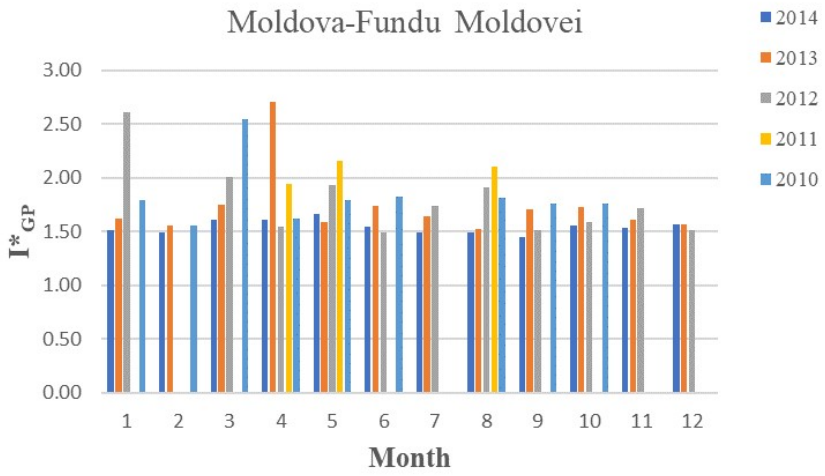
Values for I^*_{GP}	Effects on the water body
1	Water body, unaffected by human activity
$1 \leq I^*_{GP} < 2$	Water body subject to human activity within the permissible limits
$2 \leq I^*_{GP} < 3$	Water body subject to human activity, causing discomfort to the forms of life
$3 \leq I^*_{GP} < 4$	Water body subject to human activity, causing disturbance to the forms of life
$4 \leq I^*_{GP} < 6$	Water body severely affected by human activity, dangerous to the life forms
$I^*_{GP} \geq 6$	Degraded water body, unappropriated to any life form

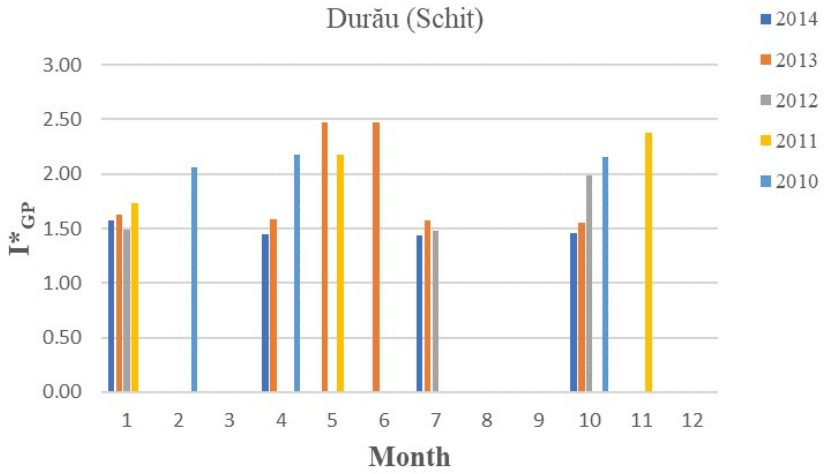
Based on the obtained general pollution indexes, were prepared graphs for each sampling point considered in the present study (Figure 2).

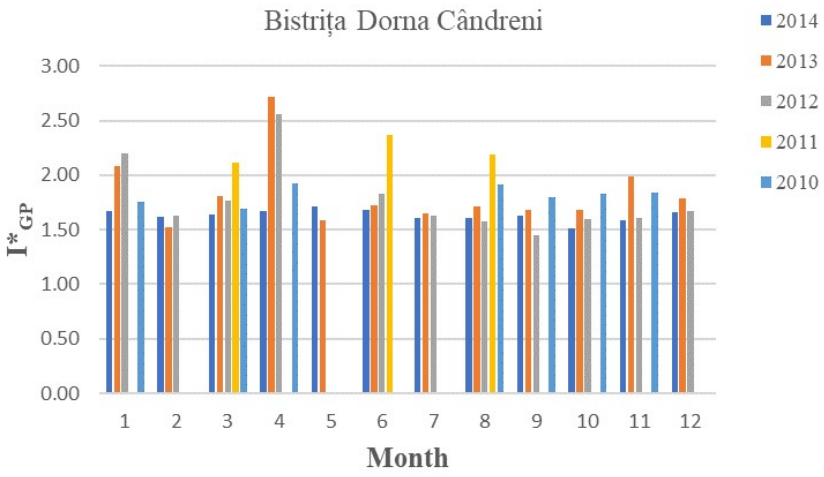


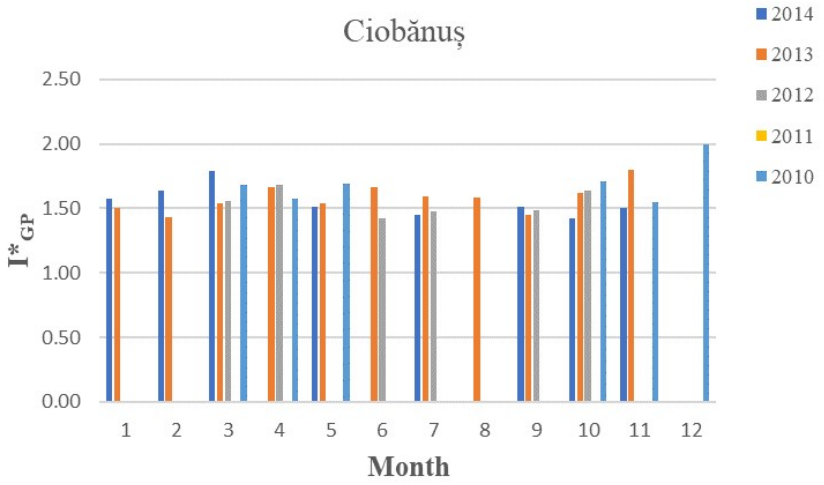


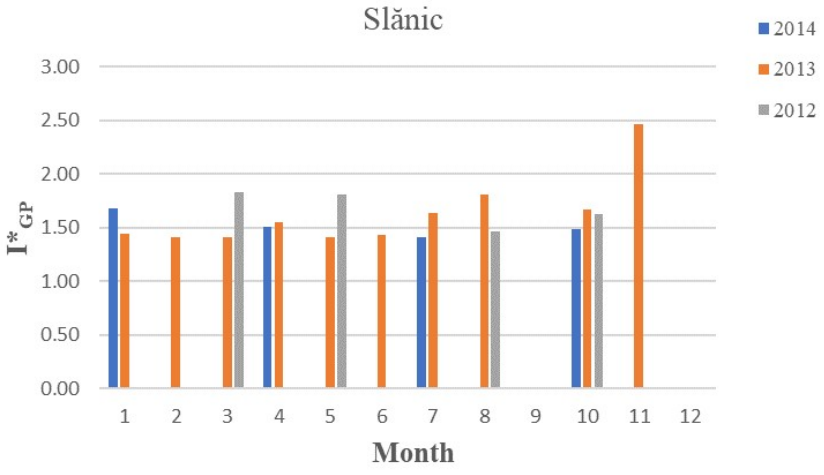

Suha Ostra
2014
2013
2012
2010
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month


Moldova-Fundu Moldovei
2014
2013
2012
2011
2010
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month


Durău (Schit)
2014
2013
2012
2011
2010
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month


Bistrița Dorna Cândreni
2014
2013
2012
2011
2010
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month


Ciobănuș
2014
2013
2012
2011
2010
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month


Slănic
2014
2013
2012
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I*GP
1 2 3 4 5 6 7 8 9 10 11 12
Month

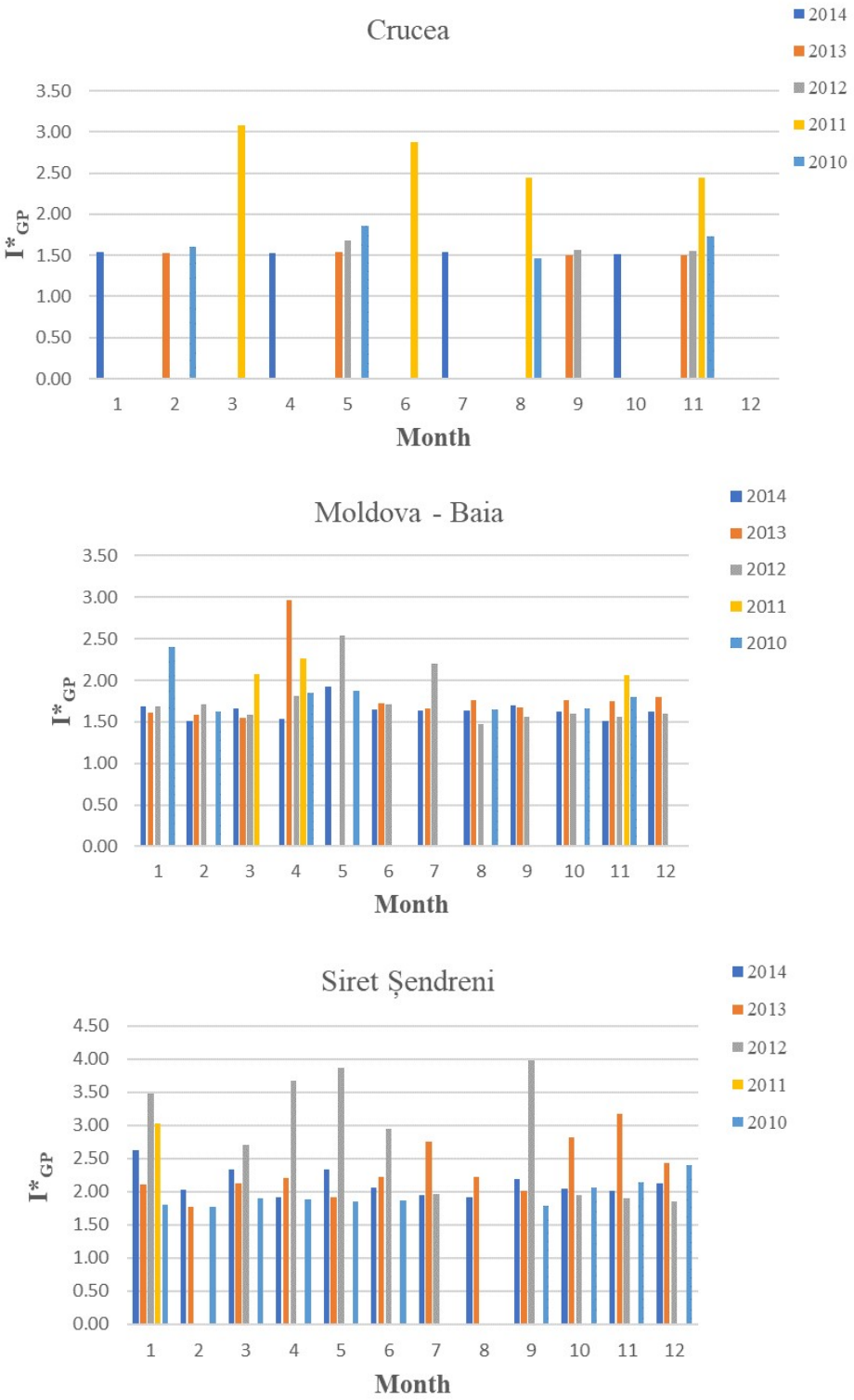


Figure 2. *Variation of the general polluting indexes for the sampling points from Siret Basin. The evaluation was performed for the monthly collected samples for five years*

As it can be observed from Figure 2, in all of the considered sampling sites during the monitored period there are situations when the values of the general pollution index are located between 2 and 3, which means that the anthropogenic activities are producing discomfort to the aquatic life forms. The number of values of I^*_{GP} that are higher than is presented in Table 3, for each of the sampling points.

Table 3. *Evaluation of the data presented in Figure 1*

Sampling point	Number of cases with I^*_{GP} higher than 2	
	$2 \leq I^*_{GP} < 3$ (Water body subject to human activity, causing discomfort to the forms of life)	$3 \leq I^*_{GP} < 4$ (Water body subject to human activity, causing disturbance to the forms of life)
Argestru	8	-
Mihoveni	8	-
Ostra	5	-
Fundu Moldovei	6	-
Durau	7	-
Candreni	7	-
Ciobanus	1	-
Slanic	1	-
Crucea	3	1
Baia	7	-
Sendreni	23	6

Based on the results presented in Table 3 it can be observed that the calculated general polluting indexes for the sampling point Sendreni, indicate that in this part of the Siret Hydrographic Basin the impact of the human activities is the highest from all of the studied sampling points from this region.
As can be seen from Figure 2, considering the entering in force of the provisions of the national and European regulations, it can be observed that these positively contributed to the reduction of the number of situations when exists a discomfort or a disturbance on the water forms of life. As a consequence, in 2014 are registered just a few isolated cases of a higher pollution impact on the water of the river, that can be seen in the case of Ostra and Sendreni.
For the evaluated sampling points on the rivers from Siret Hydrographic Basin, it can be concluded that in the Sendreni and Suha regions there is necessary to adopt appropriate measures to reduce the impact of the agricultural, industrial, domestic and residential activities.

CONCLUSIONS

The present study is based on a previously developed method [15, 16] for the calculation of a global polluting index that can be used for the evaluation of the quality of the water from the rivers of Siret Hydrographic Basin. For this purpose, the physicochemical parameters for water samples from eleven different locations from Siret Basin were monthly collected during five years.

The results show that the situations when the pollution is creating discomfort effects on the water from the river are below 20 % (18 %), while the situations when is observed distress on some life forms are around 2 % (based on 474 collecting days).
Nevertheless, the worst quality of water is registered in Ostra and Sendreni, and the global polluting indexes are showing that the situations were not changing even in 2014, after the implementation of the provisions of national and European regulations. Therefore, especially for these two regions, a sustainable water management plan should be rigorously implemented.

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