ASSESSING THE LOWER DANUBE WATER QUALITY USING THE WATER POLLUTION INDEX

Călmuc Mădălina[1], Călmuc Valentina-Andreea[1], Iticescu Catalina[1], Georgescu P. Lucian[1], Timofti Mihaela[1], Arseni Maxim[1], Țopa Maria Cătălina[1], Roșu Adrian[1]

[1] *Faculty of Science and Environment, European Center of Excellence for the Environment, "Dunarea de Jos" University of Galati, 111, Domneasca Street, RO-800201, Galati, Romania, calmucmadalina@yahoo.com, valentinacalmuc@yahoo.ro, catalina.iticescu@ugal.ro, lucian.georgescu@ugal.ro, timoftimihaela@gmail.com, maximarseni@yahoo.ro, catalina_topa@yahoo.com, rosu_adrian_90@yahoo.ro*

Abstract: *The main aim of this paper is to establish the Lower Danube water quality near the Galati City, Romania, by using Water Pollution Index method (WPI). In order to calculate the WPI index, 12 physico-chemical indicators from five sampling stations, were monthly monitored for the period between June 2018 and May 2019. To analyze these indicators, electrochemical methods and spectrophotometric methods provided by Merck-Millipore kits were used. The results obtained from the application of Water Pollution Index conclude that the Danube water, in most of the cases, was majority classified in second class of quality (except SS3 station in summer season). Furthermore, at sampling stations corresponding to confluence areas of Danube with Siret and Prut Rivers (SS2 and SS5) were recorded a higher values of WPI compared to the other three stations. This outcome demonstrates the contribution of the main tributaries to the Danube water quality. Regarding seasonal variation of WPI values, the highest values were recorded in the summer and autumn seasons.*

Keywords: *Water Pollution Index, Lower Danube river, physico-chemical indicators.*

1. Introduction

The industrial and domestic wastewaters which are treated insufficiently, the use of fertilizers and herbicides on agricultural land, navigation or permitted and illegal discharges of waste are some sources of the Danube water pollution. The main aquatic pollutants caused by these activities are: nutrients, organic material and hazardous substances (heavy metals and organic compounds) [1,2].

The Lower Danube sector near the Galati City represents a source of drinking water for over 600000 people. For this reason, it is necessary the permanent monitoring and assessment of the Danube water quality [3].

An efficient tool used for watercourse quality assessment is the quality index method. This concept involves the aggregation of water quality parameters measurements into a single value that establishes the quality status of the monitored aquatic ecosystem [4]. One such example is the Water Pollution Index (WPI) that was used for the evaluation of water quality of some rivers from the Serbia and Latvia hydrographic network [5-8]. Furthermore, the WPI was also used to assess the water quality of Serbian Danube and according to the WPI results, the water quality in 2014 was moderately polluted (quality class III) [9]. On the Romanian Danube, the Water Pollution Index has not been used until now.

The main aim of this paper is to assess the water quality in the Lower Danube-Galati area (Romania) using the Water Pollution Index (WPI). The seasonal variation of water quality through WPI and the contribution of each parameter to WPI results were also envisaged.

2. Study area

In order to assess the Danube water quality in adjacent sector of the Galati City, the water samples were monthly taken from five sampling stations for the period between June 2018 and May 2019. The sampling stations are as follows:

- SS1 - Priza Dunarii - the area where water is pumped for the drinking water supply of Galati;
- SS2 - the confluence area of the Danube with Siret River;
- SS3 - Libertatea - area with commercial activity (restaurants) on the left bank of the Danube;
- SS4 – station far from the urban area;
- SS5 - the confluence area of the Danube with Prut River (Figure 1).

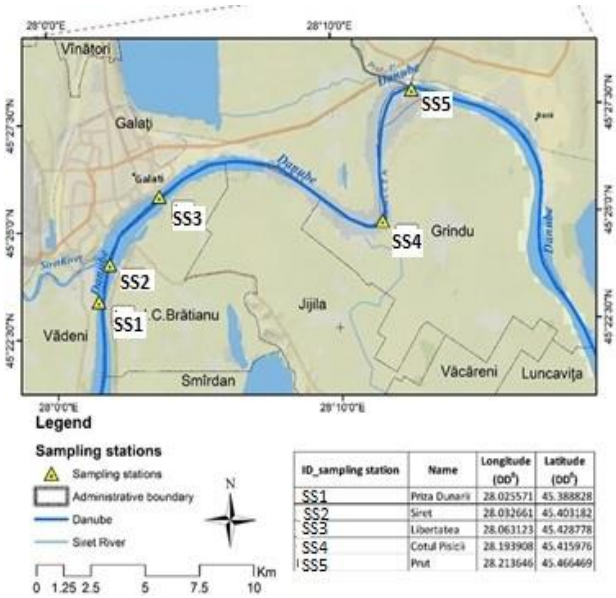


Figure 1: *The geographic distribution of the sampling stations*

3. Materials and methods

To calculate the Water Pollution Index, 12 physico-chemical indicators were analyzed at the Regional Centre of Research and Monitoring the Environment Quality of "Dunarea de Jos" University of Galati-Romania using spectrophotometric methods provided by Merck-Millipore (COD, $N\text{-}NH_4^+$, $N\text{-}NO_3^-$, SO_4^{2-}, Cl^-, TN, TP, Fe, Zn^{2+}) and electrochemical methods (pH, DO, BOD_5). The 12 analyzed indicators and standard threshold values according to Order 161/2006 for the second quality class are summarized in Table 1.

Table 1: *Analyzed indicators and standard threshold values*

Indicator (Abbreviation)	Standard threshold value (mg/L)	Unit
pH	8,2	(u pH)
Dissolved Oxygen (DO)	>7	(mg O_2/L)
Biochemical oxygen demand (BOD_5)	5	(mg O_2/L)
Chemical oxygen demand (COD)	25	(mg O_2/L)
Ammonium nitrogen ($N\text{-}NH_4^+$)	0,8	(mg N/L)
Nitrate nitrogen ($N\text{-}NO_3^-$)	3	(mg N/L)
Sulphate (SO_4^{2-})	120	(mg/L)
Chloride (Cl^-)	50	(mg/L)
Total nitrogen (TN)	7	(mg N/L)
Total phosphorus (TP)	0,4	(mg P/L)
Total iron (Fe)	0,5	(mg/L)
Zinc (Zn^{2+})	0,2	(mg/L)

WPI was calculated according to formula 1:

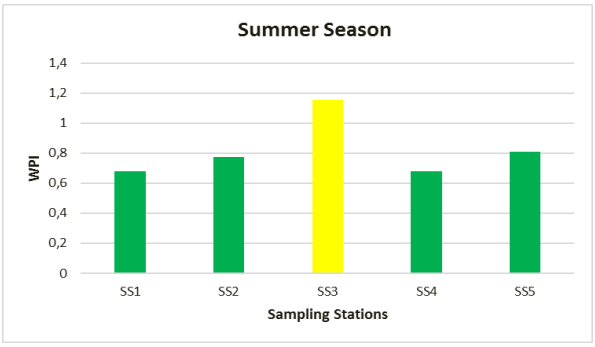
$$WPI = \frac{1}{n}\sum_{n=1}^{n}\frac{Ai}{T} \quad . \qquad (1)$$

where, Ai represents seasonal average value of parameters concentration, *n* represents number of the analyzed indicators and T is standard threshold values according to Order 161/2006 for the second quality class. The water quality classes according to WPI is shown in Table 2 [7,10].

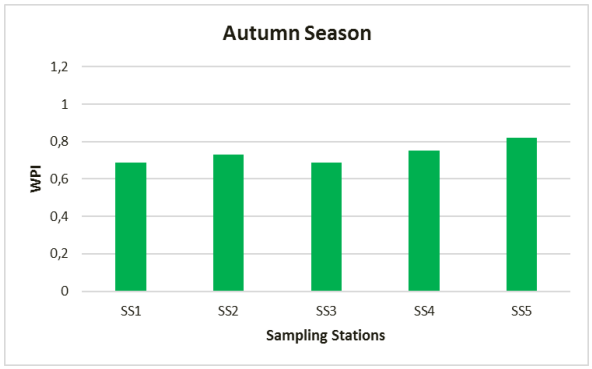
Table 2: *Water quality classification based on the WPI*

WPI value	Water quality class
≤0,3	I-Very pure
0,3-1,0	II-Pure
1,0-2,0	III-Moderately polluted
2,0-4,0	IV-Polluted
4,0-6,0	V-Impure
≥6,0	VI-Heavily impure

3. Results and discussions



(a)



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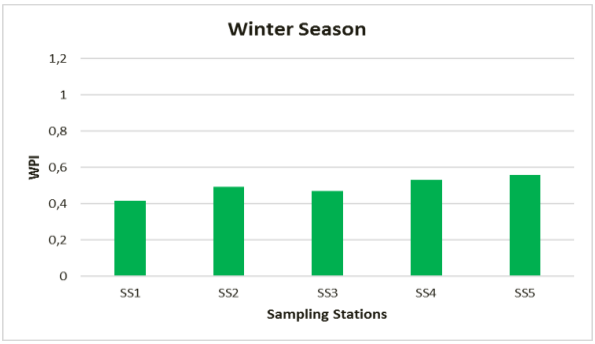

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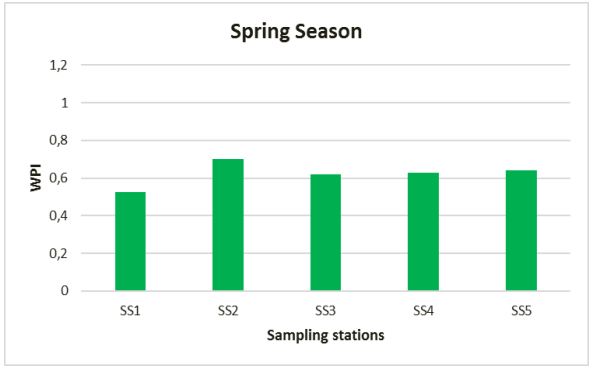
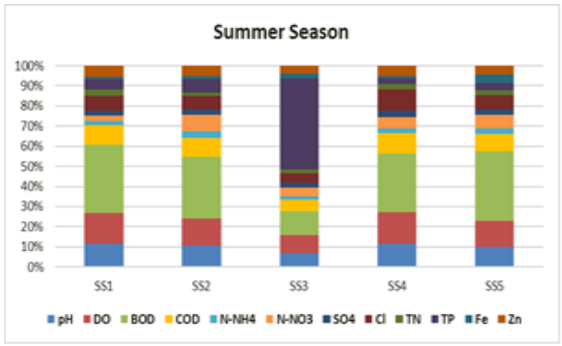
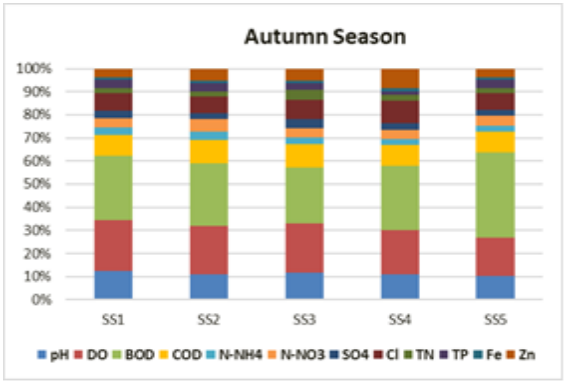


(d)

Figure 2: *Seasonal and spatial variation of WPI values: Summer (a), Autumn (b), Winter (c), Spring (d)*



(a)



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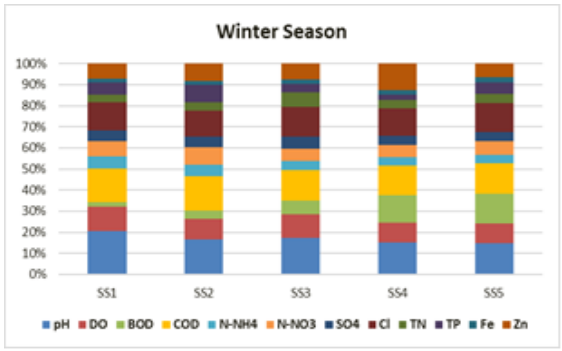

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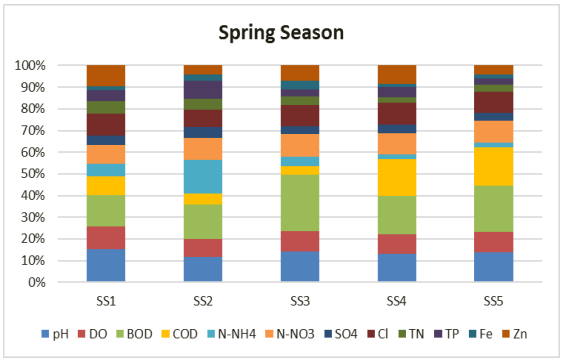

(d)

Figure 3: *Contribution (weight) of each parameter to the WPI seasonal value: Summer (a), Autumn (b), Winter (c), Spring (d)*

Surface water quality varies seasonal due to the natural (i.e. water flow variation) and anthropogenic factors (i.e. agricultural activities). For example, the low concentration of pollutants recorded during the flood periods can be due to the high water flow that dilutes them significantly [11].

Figures 2 and 3 illustrate seasonal variation of Water Pollution Index (Fig. 2) and the contribution (weight) of each monitored parameters to the WPI seasonal value (Fig. 3) in the 5 sampling stations.

The obtained values of the WPI varied between 0,41 - 1,15 and according to these results, the Danube water quality was majority classified in second class of quality ("pure" status), except the maximum value (1,15) that corresponds to third quality class ("moderated polluted" status). The maximum value of WPI (1,15) was recorded in summer season at the SS3 station (Fig. 2.a*)* and this event was due to the high concentration of total phosphorus, that significantly exceeded the maximum allowable concentration (0,4 mg P/L) set by Order 161/2006 for the second quality class. This fact can be also observed in Figure 3 (a), where the total phosphorus was the parameter with the highest contribution to the WPI value.

Analyzing the seasonal variation of WPI values (Fig. 2. a, b, c, d), can be observed that the highest values were recorded in summer and autumn, when the water flow is lower than winter and spring. According to Fig. 3 a, b, BOD_5 and DO were the parameters that significantly influenced the water quality. The low level of dissolved oxygen can be explained by the high biochemical oxygen consume, which is due to the presence of large organic matter content in water [12]. During winter and spring seasons, each parameter contributed approximately in the same ratio, except $N\text{-}NH_4$ (in SS2) and BOD (in SS3) values that exceeded the standard threshold value in spring season (Fig. 3.c, d).

Regarding the spatial variation of the WPI, the highest values of WPI were found in the stations SS2 and SS5. These results are due to the pollutants transported from upstream by the main tributaries of the Danube, the Siret and the Prut Rivers.

4. Conclusions

Taking into account the results obtained by using Water Pollution Index, the Danube water near Galați city was majority fallen into quality class II. The "moderately polluted" status of water quality recorded in SS3 station in summer period was an exceptional situation probably due to a phosphorus compound pollution event in this area (i.e. domestic waste, detergents and fertilizers).

The results of the spatial distribution of water quality illustrated the contribution of the main tributaries (the Siret and the Prut Rivers) to the Danube water quality and the Danube self-treatment capacity.

Regarding seasonal variation of WPI values, the highest values were recorded in the summer and autumn seasons due to the high contribution of BOD_5 and DO parameters and due to the low water flow.

References

[1] Apetrei, C., Iticescu, C., Georgescu, L.P., *Multisensory System Used for the Analysis of the Water in the Lower Area of River Danube*, Nanomaterials, 2019.

[2] Gasparotti, C., *The main factors of water pollution in Danube River basin*, Euro Econ., 2014.

[3] Iticescu, C., Georgescu, L.P., Topa, C.M.,2013, *Assessing the Danube Water Quality Index in the City of Galati, Romania*, Carpathian Journal of Earth and Environmental Sciences, 2013.

[4] Sutadian, A.D., Muttil, N., Yilmaz, A.G., Perera, B.J.C, *Development of river water quality indices — a review*, Environ Monit Assess, 2016.

[5] Lyulko, I., Ambalova, T., Vasiljeva, T., *To integrated water quality assessment in Latvia, In: MTM (Monitoring Tailor-Made) III*, Proceedings of International Workshop on Information for Sustainable Water Management-Netherlands, 2001.

[6] Milijašević, D., Milanović, A., Brankov, J., Radovanović, M., *Water Quality Assessment of the Borska Reka River using the WPI*

(Water Pollution Index) method, Arch. Biol. Sci., 2011.
[7] Popović, Z. N., Đuknić, J. A., Čanak Atlagić, Z. J., Raković, M. J., Marinković, N. S., Tubić, B. T., Paunović, M. M., *Application of the Water Pollution Index in the Assessment of the Ecological Status of Rivers: a Case Study of the Sava River, Serbia*, Acta Zoologica Bulgarica, 2016.
[8] Brankov, J., Milijašević, D., Milanović, A., *The assessment of the Surface water quality using the water pollution index: A case study of the Timok River (The Danube River Basin), Serbia*, Archives of Environmental Protection, 2012.
[9] Takić, L., Mladenović-Ranisavljević, I., Vasović, D. și Đorđević, L., *The Assessment of the Danube River Water Pollution in Serbia,* Water, air, and soil pollution, 2017.
[10] Milanović, A., Milijašević, D., Brankov, J., *Assessment of polluting effects and surface water Quality using Water Pollution Index: A case study of Hydro – system Danube – Tisa – Danube, Serbia,* Carpathian Journal of Earth and Environmental Sciences, 2011.
[11] Iticescu, C., Georgescu, L.P., Murariu, G., Topa, C., Timofti, M., Pintilie, V., Arseni, M., *Lower Danube Water Quality Quantified through WQI and Multivariate Analysis*, Water, 2019.
[12] Iticescu, C. Georgescu, L. P., Topa, C., Murariu, G., *Monitoring the Danube Water Quality near the Galati City*, Journal of Environmental Protection and Ecology 15, 2014.

Acknowledgments

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