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MONITORING THE PHYSICOCHEMICAL PARAMETERS OF WATER QUALITY FROM LAKE HERĂSTRĂU BUCHAREST - 2015 -2020

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Abstract

Water is the most valuable natural resource and the protection of its quality is necessary. Water is a unique vital resource, without which life as we know it could not exist. Water is also a transport corridor and a very efficient climate regulator. The aim of this paper is to evaluate the effects of physicochemical indicators on water quality of Herăstrău Lake from Bucharest. Water samples were taken bi-monthly, from 2015 to 2020, 12 samples from each point and were monitoring 8 parameters, in order to design a monitoring network. Physicochemical analyzes of water samples are performed according to standardized methods. The analyzed parameters are: pH, EC, NTU, DO, BOD, COC-Mn, the concentration of nitrites and nitrates by spectrophotometry. Following the statistical analysis, a significant difference was found between the values of the studied parameters, and their correlation was verified by determining some regression functions. The results of the analyzes obtained can be used to generate thematic models on water quality monitoring and management to improve and protect biodiversity and quality of life.

***Key words**: monitoring, physicochemical indicators, thematic models, water quality.*

INTRODUCTION

Water is a renewable but vulnerable and limited natural resource. It is an indispensable element for life and society, and at the same time a raw material for productive activities, a source of energy and a means of transport, and finally a determining factor in maintaining ecological balance.

Water is an excellent biological fluid. This is not only an environment containing gases, minerals or organic substances in solution, but also a living environment. All life forms need water, and through oxygen, carbon dioxide and the mineral salts it contains, it makes animal and vegetable life possible. Human activities have a profound impact on aquatic ecosystems. The result is a change in the chemical composition of natural waters and a disruption in the stability of biocenosis.

All this has led to the need to monitor the quality of surface waters, the current ecological status of surface waters, determine the sources of pollution and develop new methods of treatment, which has become a priority. Consequently, maintaining water quality is becoming more and more important (Smuleac et al., 2017).

Regardless of their location, the quality of groundwater resources is influenced by various natural and anthropogenic factors, especially if hydro geomorphological settings allow pollutants to reach the aquifer from the ground surface. Previous studies have shown that the quality of groundwater parameters may vary greatly as a result of natural conditions and human activities. (Zereg et al., 2018; Bhurtun et al., 2019).

Among the ecological problems in the aquatic environment, a major problem is eutrophication, which represents secondary pollution (Stachelek, J. et al., 2018). The major cause of water eutrophication is the supplementation, beyond the water body calibration capacity and often beyond permitted legal limits, of nutrients containing phosphorus and nitrogen. Their excess determines the abnormally increased production of algae and higher plants, leading to increased turbidity and lower dissolved oxygen concentrations,

phenomena which are accompanied by the disappearance of aquatic fauna. It is generally accepted that the eutrophication of surface water bodies is a major problem of water quality because it affects both economic and social environments (Violeta M.R. et al., 2019).
Water quality monitoring is important and is of increasing global concern with respect to the quality and quantity of water resources available for multiple purposes. Collecting reliable water quality data is one of the most important aspects of protecting and developing robust management plans for our rivers and lake systems. Environmental data monitoring can also be used to understand the type and severity of water quality impairments and to help decision-makers set achievable targets for improving water quality (Daniela Cîrțînă et al., 2011).
Dissolved oxygen concentration (DO) is one of the most important water quality parameters, as it reflects the balance between oxygen-producing processes (e.g. photosynthesis) and oxygen-consuming processes (e.g. chemical oxidation). DO itself depends on many interacting factors such as salinity, temperature and other water quality parameters (Liu et al., 2012; Missaghi et al., 2017) and is clearly an important element in the assessment and sustainability of complex ecological systems.
The main aim of the present work was to monitor water quality indicators that influence surface water quality.
To monitor the evolution of surface water quality in Herăstrău Lake - Bucharest, the main indicators such as pH, electrical conductivity (EC), Turbidity (NTU), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen consumption COC-Mn, nitrite (NO_2-N) and nitrate (NO_3-N) were used and analysed in the period 2015-2020.
The results obtained were interpreted according to legal standards in order to classify Herăstrău Lake into a suitable quality class and allowed to estimate the vulnerability of water resources and predict the water quality in the studied area for the period mentioned above.

MATERIALS AND METHODS

Herăstrău Lake is an anthropogenic lake placed in the northern part of Bucharest, with a surface area of 77 hectares, with 2.3 million cubic meters of water with depths up to 5 meters. Located upstream of Băneasa Lake and downstream of Floreasca Lake, it is disposed on the Colentina River and is used for fishing, irrigation, flood mitigation, recreation. Presented in Figure 1 is the map of Herăstrău Lake - Bucharest, Romania and the points used for sampling the water.

Figure 1. Map of sampling points - Herăstrău Lake, Bucharest

The water samples points from Herăstrău Lake, showed in Figure 1, were taken from six different points, in glass containers, every March between 2015 and 2020. The water samples were taken about 30 cm below the surface layer. The samples were then stored in mobile cold rooms at 4°C for transport as soon as possible to the place of analysis in order to minimize physical and chemical changes (Mala-Maria Stavrescu-Bedivan et al., 2016). Water sampling was done according to ISO 5667-6:2009 (Panaițescu et al., 2013).
The location of the 6 points was determined based on geographical coordinates, and in this way the water samples could be taken from the same place in order to maintain the accuracy of the results from a comparative point of view. This was done using a handheld GNSS receiver by determining the coordinates of the corresponding points, the points being marked by paint in the field at the lakeshore.
The geographical coordinates (longitude and latitude) of the 6 points are as follows:

- Point 1
  - Latitude: 26004’37,74114’’N
  - Longitude: 44028’35,32287’’E
- Point 2
  - Latitude: 26004’16,14375’’N
  - Longitude: 44028’21,08029’’E
- Point 3
  - Latitude: 26005’10,82811’’N
  - Longitude: 44028’38,61264’’E
- Point 4
  - Latitude: 26004’42,47064’’N
  - Longitude: 44028’44,20116’’E
- Point 5
  - Latitude : 26004’58,56988’’N
  - Longitude: 44028’58,69324’’E
- Point 6
  - Latitude: 26004’38,35277’’N
  - Longitude: 44028’55,24198’’E

The geographical coordinates were transformed into the Stereographic 1970 national coordinate system using the TransDatRO version 4.06 transcalculation program, which resulted in the following points:

- Point 1
  - East (m): 585812.10
  - North (m): 331316.96
- Point 2
  - East (m): 585340.68
  - North (m): 330871.03
- Point 3
  - East (m): 586541.88
  - North (m): 331428.30
- Point 4
  - East (m): 585912.95
  - North (m): 331592.37
- Point 5
  - East (m): 586262.69
  - North (m): 332044.41
- Point 6
  - East (m): 585817.41
  - North (m): 331931.91

The analysis was performed according to current standards using the appropriate equipment and devices, as the pH was potentiometrically determined using the pH meter, electrical conductivity (EC) with conductivity meter WTW MULTI 340i, turbidity was determined using a turbidimeter whit unit of measurement NTU (nephelometric turbidity units), dissolved oxygen (DO) - Winkler titration, biochemical oxygen demand (BOD) 5-days incubation - Winkler titration and chemical oxygen consumption COC-Mn-permanganate titration. The concentrations of nitrite (NO_2-N) and nitrate (NO_3-N) were determined by the spectrophotometric means, for nitrates was used phenoldisulphonic method and nitrites was quantified by the Griess reaction (the sample was treated with sulphanilic acid and naphthyl-1-amine in acidic medium).

To represent the evolution over time of the values of the parameters studied, thematic maps have been created using the QGIS software. QGIS is an open-source desktop geographic information systems application that supports visualization, editing and analysis of geospatial data.

Thematic maps have been developed for the first and last water sampling years (2015 and 2020 respectively). The variation of the parameters for the entire period monitored is presented in the graphs which show the evolution recorded in the 6 points throughout the period analysed.

The annual average parameter values were compared using confidence levels (significance level alpha = 0.05), which were calculated using the Microsoft Excel Data Analysis Module. Some important statistical differences between the years analyzed have been observed. The 2D and 3D regression curves were determined in Excel, and the 3D charts were created in the 3D plotter from the website https://academo.org/.

RESULTS AND DISCUSSIONS

The physico-chemical results of the analysed samples from Herăstrău Lake - Bucharest, Romania are presented in Table 1 and are compared with the maximum permissible values provided by the national and European legislation in force.

The approach to the surface water quality objectives was carried out through the assessment according to the provisions of Regulation 161/2006, which classifies surface waters from a chemical and ecological point of view, and the European Parliament and Council Directive 2000/60/EC establishing a framework for Community action in the field of water policy.

Table 1. Outcomes of water quality parameters in Herăstrău Lake between 2015 and 2020

Parameter	CMA	Points / years	P_{1m}	P_{2m}	P_{3m}	P_{4m}	P_{5m}	P_{6m}
pH	6.5÷8.5	2015	7.68	7.73	7.59	7.63	7.65	7.69
		2016	8.03	8.15	7.85	7.93	7.73	7.91
		2017	9.24	9.21	9.08	9.18	8.93	9.15
		2018	9.15	9.18	9.13	9.21	9.11	9.16
		2020	8.67	8.62	8.68	8.60	8.58	8.65
		Interval	7.59 ÷ 9.24					
EC (µS/cm)	250	2015	385	393	365	378	369	381
		2016	425	416	395	421	411	423
		2017	436	438	437	438	435	438
		2018	476	474	470	471	469	473
		2020	508	510	506	508	505	507
		Interval	365 ÷ 510					
Turbidity (NTU)	≤ 5	2015	5.45	5.68	5.35	5.42	5.32	5.51
		2016	5.73	5.82	5.65	5.59	5.71	5.81
		2017	5.79	6.20	5.62	5.45	5.34	5.43
		2018	5.85	6.10	5.98	5.85	5.92	6.10
		2020	6.10	5.92	6.40	6.35	6.21	6.15
		Interval	5.35 ÷ 6.40					
DO (mg O_2/l)	9 ÷ ≤ 4	2015	4.56	4.34	5.35	5.89	4.63	5.24
		2016	4.72	4.65	5.63	6.05	4.82	5.92
		2017	4.65	4.24	5.67	6.15	5.35	5.82
		2018	8.65	9.35	8.83	9.65	8.74	9.24
		2020	9.29	11.50	9.50	11.30	10.21	10.45
		Interval	4.24 ÷ 11.50					
BOD (mg O_2/l)	3 ÷ >20	2015	7.15	6.83	7.64	7,22	7.55	6.95
		2016	7.43	7.10	7.22	7,13	7.34	7.25
		2017	6.88	7.22	8.67	7,35	7.64	8.15
		2018	6.74	6.33	7.84	7,05	6.82	7.43
		2020	6.54	5.77	7.15	6,92	6.75	6.93
		Interval	5.77÷ 8.67					
COC-Mn (mg O_2/l)	5 ÷ >50	2015	14.8	16.5	15.6	17.3	15.3	16.8
		2016	15.8	16.9	15.4	16.8	15.2	16.5
		2017	16.3	17.1	16.6	17.9	16.8	17.3
		2018	11.3	12.6	11.6	14.6	12.4	13.2
		2020	9.7	8.7	9.3	8.3	8.8	9.4
		Interval	8.3 ÷ 17.9					
NO_2-N (mg/l)	0.5	2015	0.02	0.01	0.3	0.3	0.05	0.1
		2016	0.3	0.02	0.3	0.2	0.2	0.3
		2017	0.01	0.03	0.3	0.3	0.3	0.3
		2018	0.2	0.2	0.3	0.2	0.3	0.2
		2020	0.33	0.33	0.31	0.30	0.32	0.31
		Interval	0.01 ÷ 0.33					
NO_3-N (mg/l)	25-50	2015	58.23	57.45	59.05	58.68	57.25	58.15
		2016	59.15	58.63	58.85	59.15	58.23	58.05
		2017	61.04	61.32	61.18	61.32	59.86	60.75
		2018	68.35	65.45	63.58	66.45	64.53	65.35
		2020	71.12	70.56	68.86	69.58	69.68	70.25
		Interval	57.45 ÷ 71.12					

The pH values ranged from 7.59 to 9.24 pH units (Figure 2), which are in the slightly neutral to moderately alkaline range and show a slightly increasing gradient from 2015 to 2020. pH values above 8.5 can be disturbing to aquatic life and the basic environment could lead to decreased fecundation in some fish species. These values indicate pollution with inorganic compounds and correlated with high salinity content, while turbidity ranged from

5.35 to 6.40 (Figure 3) that places the water from the lake under investigation in Quality Class III.

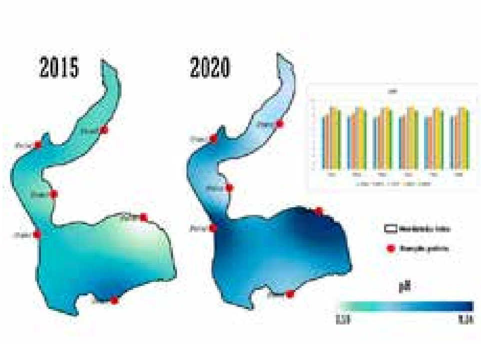

Figure 2. Results of pH and generated model maps

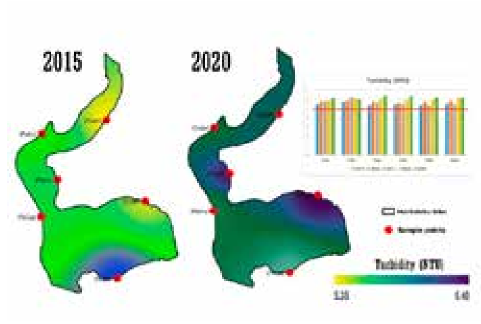

Figure 3. Results of Turbidity and generated model maps

The conductivity of water is one of the indicators used in assessing the degree of mineralization of waters by the determination of dissolved salts in the water.
Quality indicators specific to salinity, such as calcium, magnesium, sodium, and potassium, are substances of natural origin and are not related to pollution. It is proportional to the mineralization of the water, so the richer the water is in ionized mineral salts, the higher the conductivity (Derwich et al., 2010).
Following the measurements, with electrical conductivity values between 365 and 510 µS/cm, the water of Herăstrău Lake is considered to be mineralised (Figure 4) and falls into the second quality class of surface water, as EC values of 250 µS/cm are considered optimal and the water is in good condition.
Quantifying the concentration of dissolved oxygen DO (Figure 5) in the water of a hydrological system is a rather important factor because it is involved in most of the chemical and biological processes in these aquatic environments (Rodier et al., 1984; Brahimi and Chafi, 2014).

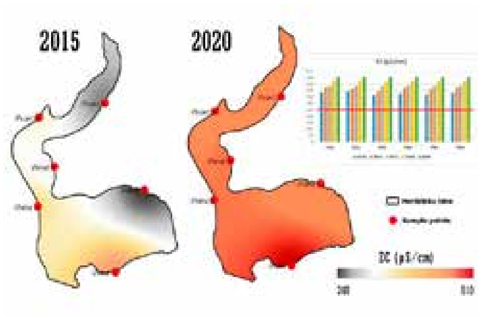

Figure 4. Results of EC and generated model maps

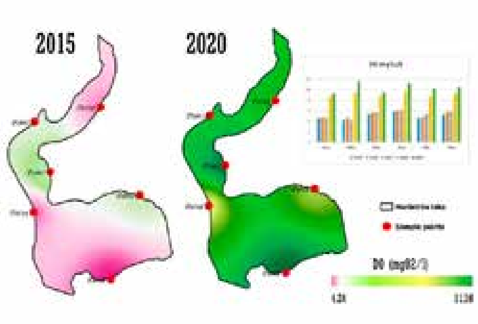

Figure 5. Results of DO generated model maps

The evolution of dissolved oxygen in the water Herăstrău Lake samples shows a significant degradation of the quality of this water during 2015-2017 correlated with high turbidity values, but improving for the following years (Figure 5).
The BOD values in the analyzed samples fall in the third quality class indicating a poor ecological status of the water (Figure 6). Biochemical and chemical oxygen analyses are low, with values obtained ranging from 5.77-8.67 mg O_2/l BOD and 8.3-17.9 mg O_2/l COC-Mn therefore (Figure 7), these parameters classify the studied water body in quality class III in 2015 compared to the values obtained in 2020, which falls in quality class II.

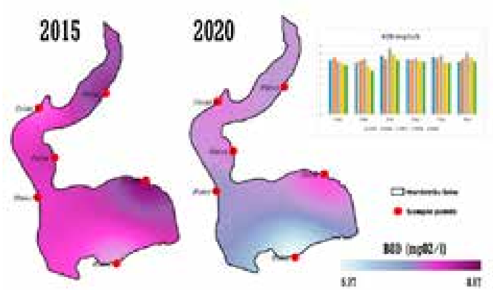

Figure 6. Results of BOD and generated model maps

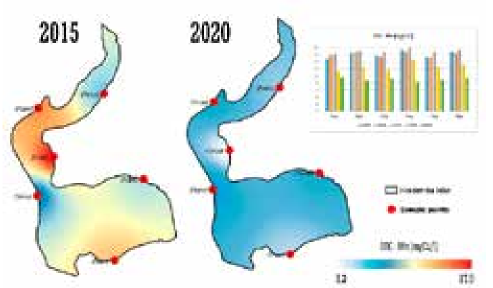

Figure 7. Results of COC-Mn and generated model maps

The assessment of nitrite concentration led to a classification of the monitored water as quality class I, according to MO 161/2006, and from the graphical representation (Figure 8) of the nitrate variation, it can be observed the increasing trend of NO_3-N concentration which recorded a maximum of 71.12 mg O_2/l in 2020.

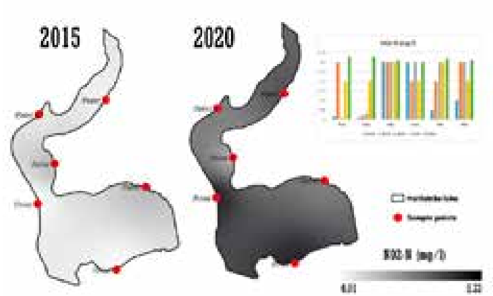

Figure 8. Results NO_2-N and generated model maps

The variation of nitrate (Figure 9) content in the water of Herăstrău Lake was also monitored, where it recorded high values between 57.45-71.12 mg NO_3-N/l, indicating the final mineralization phase of organic nitrogen compounds and a high degree of eutrophication. As a result of this process, the balance of aquatic organisms is deteriorating and the quality of surface waters is decreasing.

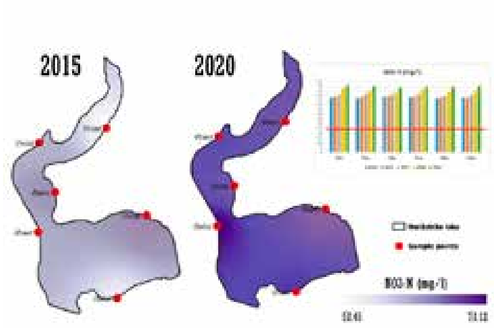

Figure 9. Results of NO_3-N and generated model maps

To conclude, overall, the values of the parameters monitored progressively increased between 2015 and 2020, with an upward trend. Regarding these data, univariate and multivariate statistical analyzes (similarity tests) were performed for the main components, to determine the different correlations between these studied parameters.

Regarding the parameters pH and EC, from one year to another the confidence interval did not intersect, the differences between the means are significant. At the same time, the differences between the means of turbidity are significant berween the years 2015-2016 (Figure 10).

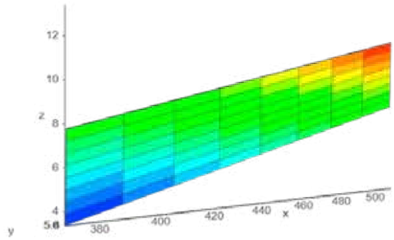

Figure 10. Correlation between pH, EC and Turbidity parameters

In the case of the DO parameter the differences between the means are significant between the years 2015-2016, 2017-2018. Analyzing the

BOD_5 was found that the differences between the means are nonsignificant from one year to another (Figure 11).

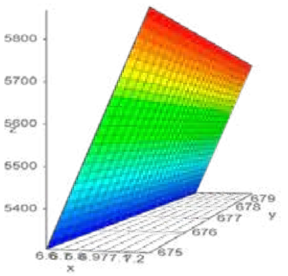

Figure 11. Correlation between DO, BOD_5, COC-Mn parameters

Further, the following analyzed parameters showed significant differences between the means as follows: COC-Mn between the years 2017-2018, 2018-2020 (Figure 11), NO_2 between the years 2018-2020 and NO_3 between the years 2016-2017, 2017-2018, 2018-2020 (Figure 12).

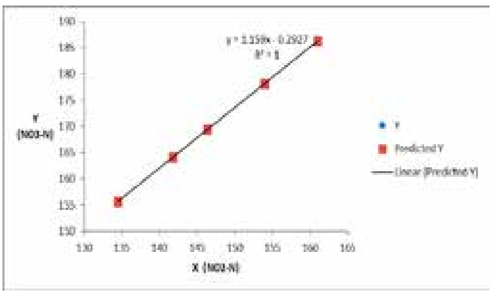

Figure 12. Correlation between NO_3-N and NO_2-N parameters

CONCLUSIONS

Based on the quality parameters evaluated, their structure was analyzed in quality classes for the lake being evaluated. It has been found that the monitored indicators are generally included in the quality classes II and III according to MO 161/2006, although the concentration of nitrates in Herăstrău Lake are specific to values of quality class IV according to the above-mentioned order. Comparing the national legislation in force (Order of the Minister of the Environment and Water Management no. 161/2006 for the approval of the Regulation on the classification of surface waters in order to determine the ecological status of water bodies) with the results obtained on the water quality of Herăstrău Lake, led to the following conclusions: - for the dissolved oxygen indicator, DO, values were recorded below the DO content corresponding to quality class a-II (O.D.=7 mg/l); - for the indicator chemical oxygen consumption, COC-Mn (maximum allowed concentration is 50 mg/l, quality class III), no exceedances were recorded; - for the indicator electrical conductivity, EC, no exceedances were recorded (EC (µS/cm) = 250, quality class II); - for the indicator nitrates NO_3-N/l, exceedances were recorded (mg NO_3-N/l=50, quality class IV).

Other quality indicators showed similar values for the six sampling points. As a result of this study, Herăstrău lake was classified as a mesotheutrophic lake.

Water quality in this lake is influenced by human activities along the shoreline, including residential areas not connected to the sewer system and small industrial units. Sources of water degradation include vegetation or pesticides produced by park treatments.

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