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ASSESSMENT OF WATER QUALITY FROM BRĂTENI LAKE, BISTRIȚA-NĂSĂUD COUNTY

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Abstract: The Brăteni Lake is used for fishing and leisure. A lot of fish species grow in this lake and many birds and ducks live and nest in this area. A total of 12 sets of surface water samples were collected from three representative points from Brăteni Lake, during 2015 and 2016 for three seasons (autumn, winter and spring). The samples were taken bi-monthly. *In situ*, using a portable multiparameter WTW Multi 350i, were determined the physico-chemical parameters like: pH, EC, TDS, ORP, and salinity. In laboratory by using an ion chromatograph (IC500 Dionex) were analysed the following cations: NH_4^+, Mg^{2+}, Ca^{2+}, Li^+, Na^+, K^+ and anions F^-, Cl^- , NO_2^-, Br^- , NO_3^- , PO_4^{3-} , SO_4^{2-}. The content of heavy metals (Cd, Pb and Fe) was analysed using an atomic absorption spectrometer (ZEEnit 700 Analytik Jena). The cations concentration varied between: 56.31 – 75.97 mg/L for Na^+, 20.44 – 26.66 mg/L for K^+, 35.92 – 54.80 mg/L for Mg^{2+}, 67.83 – 144.22 mg/L for Ca^{2+}. N-NH_4^+ was found only in one sample (0.3 mg/L) and Li^+ was found in three samples (0.25 – 0.26 mg/L). The anions concentration varied between: 26.78 – 48.93 mg/L (Cl^-), 0.20 – 0.51 mg/L (F^-), 0.19 – 4.07 mg/L (N-NO_3^-), 124.77 – 193.51 mg/L (SO_4^{2-}). Lead ranged between 3.98 and 33.01µg/L and iron had levels between 0.02 and 0.6 mg/L. Using the obtained results, sodium adsorption ratio (SAR) and Kelley's index (KI) were calculated, in order to determine if the water is suitable for irrigation.

Keywords: Brăteni Lake, water quality, major ions, lead, irrigation

1. INTRODUCTION

Water plays an essential role in many process and physical or chemical reactions (Awanga et al., 2015). Water provides society both environmental and economic benefits: irrigation, fisheries, recreation, climate regulation and shipping (Moss, 1999). Water is an important resource but at the same time it is limited. Natural water quality gradually deteriorated mainly due to urbanization and intensification of human activities. One of the major causes of such water pollution is change of land use, which can produce various effluents in domestic, agricultural, and industrial areas (Tallar & Suen, 2015). Aquatic ecosystems have been affected by different types of contaminations in the recent period (Nazeer et al., 2014). Nutrient losses from agriculture are a major constituent of diffuse water pollution (Zhang et al., 2015). Other relevant studies for this topic are: Zhai et al., (2010); Mohamed et al., (2014); Effendi (2016). The investigated water body (Brăteni Lake) is approximately 25 hectares; water is retained with one dam. The lake is located in the Transylvanian Plain and the around lands are used for agriculture. On the lands near the lake, farmers used pesticides, chemical and natural fertilizers. Currently the lake is famous for fishing and recreation.

2. MATERIALS AND METHODS

2.1. Study area

Brăteni Lake is located in Transylvania Depression, more exactly sub-unit in Transylvania Plain (Fig. 1). From geologically point of view the area is characterized of: marl clays, sands and tuffs from Bessarabian and Volhynian (Bâca & Onofreiu, 2016). The area is characterized by a moderate continental climate. The average annual temperature is >8ºC and the rainfall varies between 600 - 650 mm/year.

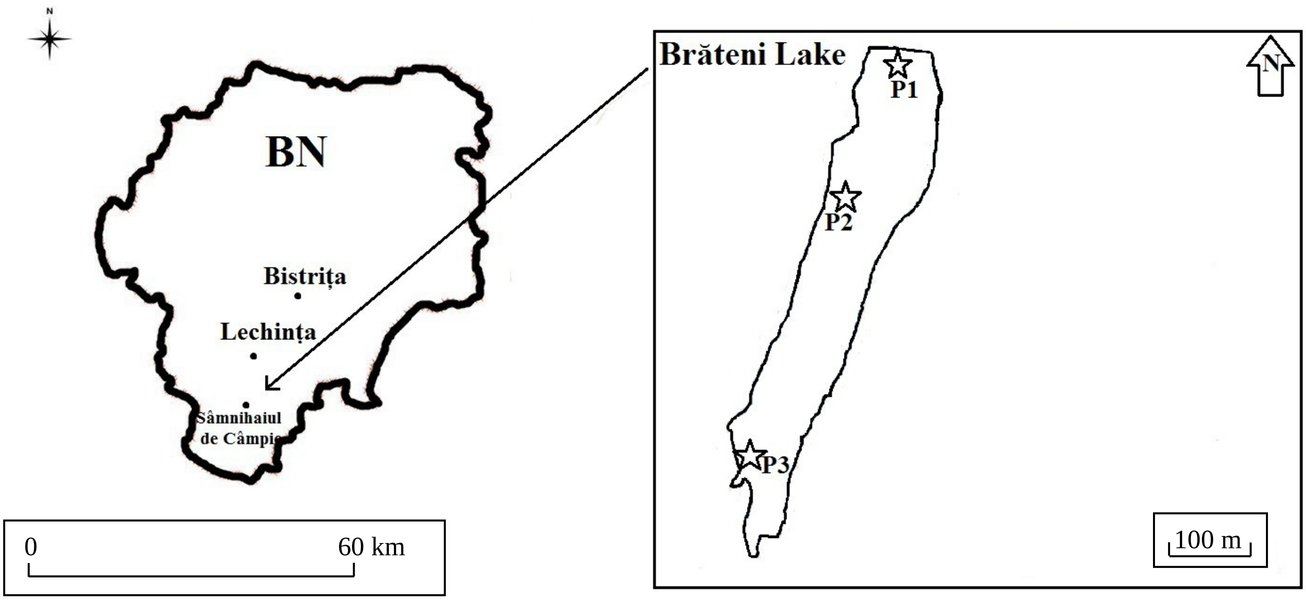

Figure 1. The study area with sampling points.

Regarding the vegetation there can be found meet steppe and forest steppe elements and othe highest hills specific elements of oak area (Bâca & Onofreiu, 2016). On the lake can be found a rich herpetofauna represented by frogs (*Rana* species) and water snakes. Fishes are present in large number in the lake water, the most common fish species are: *Cyprinus carpio, Aristichtys nobilis, Silurus glanis, Lepomis gibbosus, Hipophtalmychtis mollitrix, Carassius gibelio, Scardinius erythrophthalamus.*

2.2. Methodology

Water samples were collected bi-monthly between November 2015 and April 2016. For this study, a total of 12 sets of samples were collected, each set containing three water samples P1, P2 and P3. Water samples were collected in PET bottles, each containing 500 ml of water. Subsequently, water samples were analysed in the laboratories of the Faculty of Environmental Science and Engineering. Analyses focused on determining the physico-chemical parameters. There have been 3 major types of analyses: multiparameter, ion chromatography and heavy metals. The analyses performed with multiparameter WTW 350i were: pH, total dissolved solids (TDS), electrical conductivity (EC), oxido-reduction potential (ORP), and salinity (Nicula, 2016). Those parameters were determined *in situ*. The dissolved ions (Li^+, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}) were analysed by ion chromatography (IC500 Dionex). The heavy metals (Fe, Pb and Cd) were analysed by using an atomic absorption spectrometer ZEEnit 700 Analytik Jena. The devices were calibrated using standard solutions before each determination. The analyses were performed according to Romanian standard methods and the results were compared with Romanian legislation.

3. RESULTS AND DISCUSSIONS

The obtained results for the analysed samples are presented in figure 2, tables 1 and 2. The obtained results were compared with the national guidelines (Order no. 161 of February 16th 2006), but not all analysed parameters are regulated by the Romanian legislation. Generally, the pH values were within 6.5-8.5, thus within the normal limits imposed by the Romanian legislation. The only value, which was not within the limits, was recorded at the beginning of November, a pH of 6.06 being recorded at sampling point P3 (Nicula, 2016). With the exception of a few inaccuracies it can be observed that the lake water is homogeneous on the pH values distribution. Generally, the ORP values were negative. TDS values were constant during the monitoring period, thus the homogeneity of the lake water can be observed. The values variation for all sampling points is not significant. At the beginning of February a strong decrease of TDS was observed especially for sampling points P2 and P3 (Nicula, 2016). This decrease can be due to the low temperatures recorded in the sampling period. Electrical conductivity is directly correlated with TDS. The electrical conductivity values have shown higher values with the increase of the temperature. In the last part of the monitoring interval the values for all points are higher. Due to the frost in February, very low values of EC were recorded especially for sampling points P2 and P3 (Nicula, 2016).

For the salinity parameter the values were normal, the maximum being recorded at the end of April with a value of 0.5 ‰. The highest variations were recorded for sampling points P2 and P3. Measurements from sampling point P1 have recorded both the highest and the lowest value within the whole monitoring interval.

The content of dissolved ions is shown in Table 1. The results presented for ions are only for the first 3 months of monitoring. Li^+ was identified in three samples, the highest concentration was found in P1.6. (0.26 mg/L). Na^+ was identified in all samples with an average concentration of 62.94 mg/L, thus the water belongs to 3rd water quality class. An increasing trend can be observed with the increase of water temperature. $N\text{-}NH_4^+$ was identified only in P3.1 sample (0.3 mg/L), belonging to 1st water quality class. K^+ was determined in all water samples with an average concentration of 22.29 mg/L.

Another important cation investigated in the present study was Mg^{2+}, with an average concentration of 40.20 mg/L, corresponding to 2nd water quality class. Significant Ca^{2+} concentrations were determined, especially for the last samples set, belonging to 2nd water quality class. NO_2^-, Br^- and PO_4^{3-} anions were not identified in any samples. Low concentrations of F^- (0.31 mg/L average) were identified in the water samples.

Moderate concentrations of Cl^- were identified in all samples, with an average of 32.53 mg/L. According to this concentration the water monitored is within the 2nd water quality class. Moderate concentrations of $N\text{-}NO_3^-$ were determined, being higher especially for the last set of samples with an average concentration of 1.40 mg/L. considering the $N\text{-}NO_3^-$ levels, most of the analysed water samples belong to 2nd water quality class.

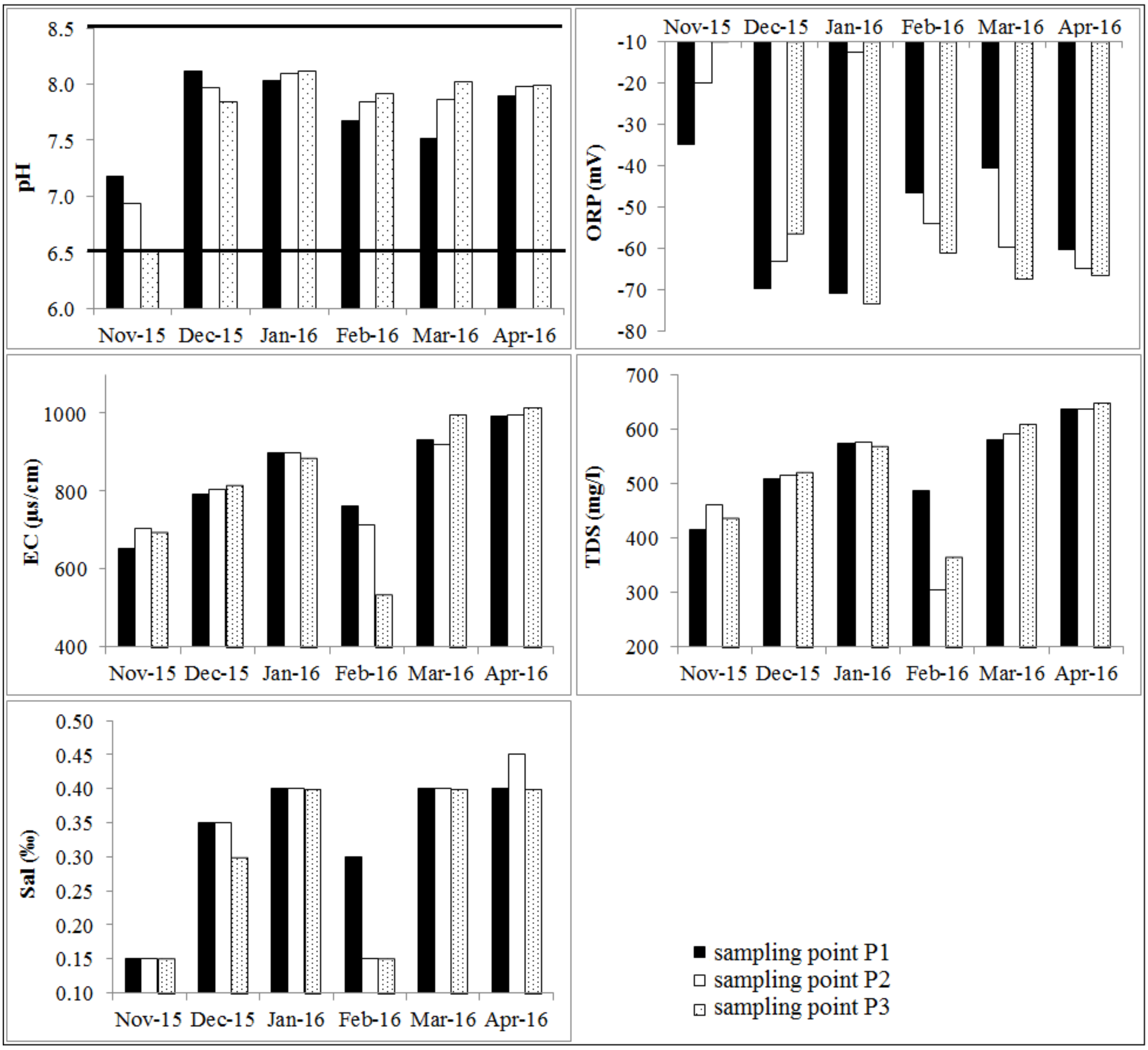

Figure 2. The physico-chemicals parameters values, depending on the sampling point.

Table 1. Dissolved ions concentrations in the analysed water samples.

No.	Sample	Li^+	Na^+	K^+	Mg^{2+}	Ca^{2+}	F^-	Cl^-	$N\text{-}NO_3^-$	SO_4^{2-}
		(mg/L)								
1	P 1.1	nd*	59.9	21.44	37.45	69.47	0.22	27.58	0.82	133.28
2	P 2.1	nd	58.61	21.22	37.14	70.16	0.31	27.61	0.97	129.25
3	P 3.1	nd	57.73	21.25	37.48	70.74	0.23	27.75	0.21	125.57
4	P 1.2	0.25	57.83	22.43	35.92	67.83	0.32	29.4	1.31	124.77
5	P 2.2	nd	57.76	22.07	36.26	68.09	0.30	28.58	1.35	127.91
6	P 3.2	nd	59.38	21.76	36.06	75.19	0.34	29.03	0.19	141.02
7	P 1.3	nd	57.64	21.18	36.10	69.73	0.25	27.44	2.31	130.12
8	P 2.3	nd	57.93	20.75	36.05	69.27	0.20	27.61	1.56	130.8
9	P 3.3	nd	56.31	20.51	36.63	70.79	0.27	26.78	2.11	131.81
10	P 1.4	nd	63.52	21.28	36.54	70.52	0.20	32.03	0.40	137.79
11	P 2.4	nd	60.75	20.44	36.63	71.11	0.28	29.07	0.39	136.05
12	P 3.4	nd	60.07	20.56	36.54	71.66	0.21	28.41	0.39	136.9
13	P 1.5	0.25	66.61	22.45	41.67	77.31	0.41	32.92	0.34	149.76
14	P 2.5	nd	66.44	22.42	41.13	76.62	0.26	32.01	0.42	148.22
15	P 3.5	nd	65.71	22.74	39.62	74.55	0.27	34.13	0.44	145.27
16	P 1.6	0.26	75.97	25.99	53.78	142.98	0.46	48.93	3.96	193.24
17	P 2.6	nd	75.05	26.66	54.80	144.22	0.51	47.95	4.02	193.51
18	P 3.6	nd	75.8	26.06	53.88	142.64	0.49	48.41	4.07	193.22
Average ± SD**		**0.04 ±0.1**	**62.94 ±6.6**	**22.29± 1.9**	**40.20 ±6.6**	**83.49 ±27.6**	**0.31 ±0.1**	**32.53 ±7.6**	**1.40 ±1.3**	**144.92 ±23.5**
1st quality class***		-	25	-	12	50	-	25	1	60
2nd quality class		-	50	-	50	100	-	50	3	120
3th quality class		-	100	-	100	200	-	250	5.6	250
4th quality class		-	200	-	200	300	-	300	11.2	300

*nd – not detected; **SD – Standard Deviation; *** - – limits imposed for different water quality classes (Order 161/16 February 2006)

For SO_4^{2-} a significant increase in concentration can be observed in the last set of samples, with an average concentration of 144.91 mg/L, corresponding to 3rd water quality class.

For water sample collected in 2 and 3 sampling campaign were determined the heavy metal concentrations as well. For all water samples the cadmium concentration was under the detection limit, thus the obtained results contain only iron and lead concentrations. Table 2 presents the heavy metal concentrations for the analysed samples.

The analysed water samples proved to have high lead levels, heaving an average of 20.86 µg/L. Regarding the lead concentration, most of the waters can be classified as 2nd water quality class. The iron concentration was relatively low, belonging to 1st water quality class. Only in the case of P3.3 sample, the Fe content was higher, belonging to 3rd water quality class. Iron is not as harmful as lead for aquatic life. The obtained data offers the possibility to determine whether the water is proper for irrigation.

In order to assess if the lake water can be used for irrigation we calculated the following indicators:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$ (Richards, 1954; Harront et al., 1983; Sisir & Anindita, (2012)

Table 2. Lead and iron concentrations for analysed water samples.

Sample	Pb (µg/L)	Fe (mg/L)
P 1.2	3.98	0.02
P 2.2	16.68	0.05
P 3.2	33.01	0.51
P 1.3	31.69	0.06
P 2.3	19.26	0.12
P 3.3	20.57	0.60
Average ± SD*	**20.86±10.7**	**0.23±0.3**
1st quality class**	5	0.3
2nd quality class	10	0.5
3th quality class	25	1
4th quality class	50	2

*SD – Standard Deviation; * – limits imposed for different water quality classes (Order 161/16 February 2006)

The results are presented in figure 3. Based on the standard values (Tables 3 and 4), both methods indicate that the water of Brăteni Lake can be used for irrigation. The salts concentration is low therefore there is no risk of soil salinization.

Table 3. SAR scale (Richards, 1954; Sudhakar şi Narsimha, 2012)

Category	Range
Excellent	<10
Good	10 – 18
Doubtful	18 – 26
Unsuitable	>26

$$KR = \frac{Na^{+}}{Ca^{2+}+Mg^{2+}}$$ (Reddy, 2013)

Table 4. Kelley's Ratio (Kelley,1951)

Category	Range
Good	≤1
Not good	>1

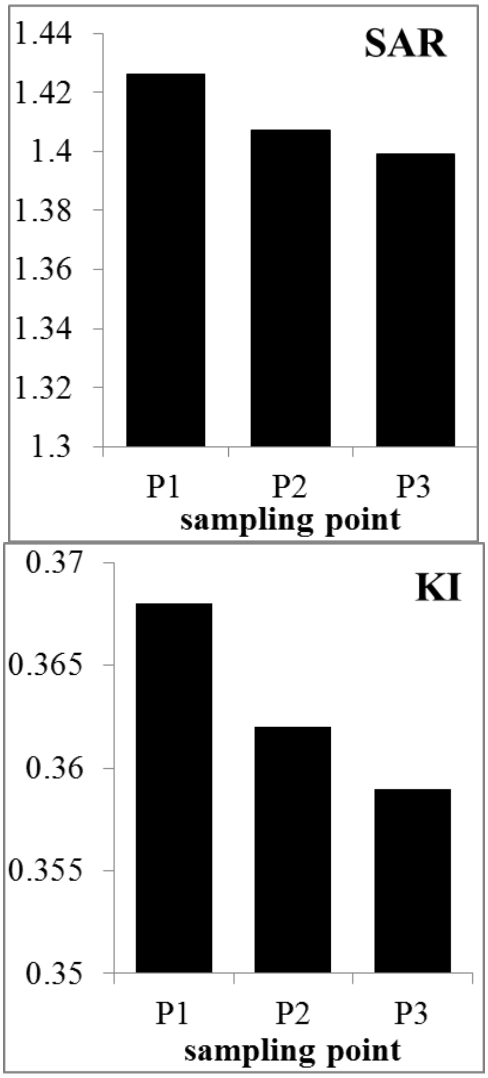

Figure 3. The SAR and KI values, depending on the sampling point.

4. CONCLUSIONS

The present study proved that in the investigated lake water was found a dynamic for monitored parameters. The investigated quality parameters change their concentration depending on the temperature (samples were taken from the same depth). Temperature increasing leads to biological activity increasing and changes parameters significantly. The results were not particularly worrisome values, but there are a few parameters that can cause problems, like lead.

Based on Ca^{2+}, Mg^{2+}, Cl^{-}, $N\text{-}NO_3^{-}$ and Pb content, most of the water samples belong to 2nd water quality class. Considering the Na^{+} and SO_4^{2-} levels, most of the analysed water samples belong to 3rd water quality class.

After the calculation of SAR and KI we could demonstrated that the water is excellent for irrigation.

For the future it is essential to monitor the lead concentration and to assess the impact of intensive agriculture on water quality.

The present study was a screening in order to assess the Brateni Lake water quality. Based on the obtained results a future study will be develop in order to include more sampling points for water and for sediments as well.

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