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Evaluation and Evolution of the Physico-Chemical Parameters of Ocnei and Rotund Lakes Located near the "Salina Turda" Mine, Romania

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Abstract: The present research brings an input of information regarding the evolution of several physico-chemical parameters of two salt lakes (Lake Ocnei and Lake Rotund), part of the "Salina Turda" resort, Cluj County, Romania, by means of on-site determinations. Measurements were carried out at six depths for each sampling point. We attempted to describe the behaviors of the two lakes under different natural conditions, in order to identify the impact of anthropogenic activities on the quality parameters of the two lakes. Our studies showed that the qualitative parameters of the water fluctuate as an effect of anthropogenic activities. A comparative analysis of the results gathered during three monitoring campaigns in 2016, 2018, and 2020 indicated that water quality was affected by anthropogenic activities such as mixing water layers which were characterized by different salinity values. The lakes tended to lose basicity, pH values varying between 9 at the surface level and 7 at −4 m. The thermal stratification phenomenon was only evident in the first year of monitoring; later on, the waters of both lakes appeared thermally homogenous down to the depth of −2 m. It was determined that the lakes had an uppermost freshwater layer, which disappeared during the bathing season because of vertical mixing. Interestingly, the two lakes showcased different behaviors at depths beyond −3 m. In addition, the infiltration of meteoric water that was polluted with nitrites and nitrates demonstrated the fact that anthropogenic activities that take place in the vicinity of the lakes generate negative effects on water quality. The presence of the heliothermal phenomenon was confirmed by the measurements made in the upper segment of the lakes. This layer of water consists of a mixture of fresh and salt water. The purpose of the research was to evaluate the water quality of the lakes, monitor its evolution during the bathing season and update the situation regarding the water quality of the two salt lakes by testing specific parameters.

Keywords: physico-chemical parameters; water quality; anthropogenic activities

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1. Introduction

Salt lakes are a distinctive component of the Transylvanian Basin landscape; they have been extensively studied, monitored and exploited over time. The physico-chemical peculiarities of the saltwater (e.g., heliothermy) and the therapeutic value of organic-rich sediments (or "sapropels") are the most relevant features of salt lakes in Transylvania, which spark early interest, both scientifically and economically, for such formations [1].

The curative effects of salt lakes in Transylvania (mainly those in Turda, Ocna Sibiului, and Sovata) are being mentioned since the 16th century. Treatments involving water and sapropelic mud from these lakes were hailed as to aid in treating various conditions such as infertility, skin problems, or rheumatic ailments [1,2]. The first studies considering the therapeutic quality of the salt lakes in Turda date from 1844 and were carried out by Hanko [3]. The author mentions that the two lakes are used for bathing and that they are warmer than other nearby saline water bodies. He also states that their temperature is directly related to the atmospheric temperature.

Generally, salt lakes in Transylvania tend to be small and quite deep, thus offering ideal conditions for stratification (forming of permanent density water layers) [4]. Natural and anthropic factors have generated massive transformations of the entire area, with touristic exploitation being an important risk factor [5]. One such transformation led to the disappearance of one lacustrine unit and structural modifications of other ones. If left undisturbed, the lakes tend to be meromictic [6,7]. The characteristic of meromictic lakes is the presence of two physico-chemically distinct water layers, the upper mixolimnion and the lower monimolimnion, separated by an intermediate stratum termed chemocline [8,9]. The persistence of this phenomenon is returned by the huge differences in water density [10]. Salt lakes are very sensitive to climate changes due to a significant evaporation potential that can lead to their drying [11]. A further peculiarity of these water bodies is that the lack of vertical movement leads to a natural settling of suspended matter, making the water both clearer and less sensitive to weather conditions.

Thermal stratification, corroborated with the significant depth and with a mineral stratification, results, in summer and autumn, in an almost total lack of vertical water circulation. This leads, in turn, to a decrease of the dissolved oxygen towards the bottom of the lake.

The quality of any surface water is a function of either or both natural influences and human activities [12–14]. In order to establish the water quality assessment, the helpful tools used are the water quality indices [15]. Recreational water quality standards are focused on the prevention of waterborne infections [16]. Spatio-temporal changes in sedimentation is the result of declining water quality, temperature, pH, nutrients, heavy metals, toxic organic compounds, and pesticides [17].

It is very important to understand the physico-chemical properties in the water bodies, because is an important issue to determine the pollution assessments [18]. Open access and inadequate conservation generate the decline of ecosystem goods and services of the water bodies where they face change in wetland hydrology and habitat loss of catchment areas adjacent to urban growth, increasing runoff of nutrients and pollution [19]. The destruction of the ecological status of water is caused by pollution of the water environment. The repercussions of this phenomenon are as follows: water bodies lose their functions, which in turn has restricted human development, and the ecological function of water bodies will be restored by reducing pollutants discharge and water diversion [20]. The economic effects of pollution are much more obvious, when the pollution has settled despite of the cost of pollution prevention which is relatively lower, generating a reduction in the value of production or consumption activities [21]. Costs and cost-savings are sensitive to alternative allocation, inflow, and cost assumptions [22]. In addition, global warming and changes in rainfall will have major consequences for salt lakes and other ecosystems [23,24]. Global warming has already begun to influence the natural state of lakes [25,26].

The "Salina Turda" resort in Turda, Cluj County, Romania, was established around an old out-of-use salt mine. The resort underwent a period of intense development in 2004−2006, following the implementation of a project with European funding that stated "increasing the touristic attractivity of the Durgau–Valea Sarata and Salina Turda areas, based on the local salt lakes with balneary potential" as its main objective. However, the history of using the local saltwater resources is much older.

Once the project was implemented and natural saltwater resources began to be exploited to a touristic end, the whole area, including part of the infrastructure, started to evolve, in order to support the ever increasing number of tourists.

The salty lakes from Turda formed in place of ancient salt mine chambers, which were probably exploited in the 15th and 16th centuries. One of them is located at some distance from the southern end of the mines to the West. Lake Ocnei was formed by the collapse of the "Ocna cea Mare" excavation around 1800, and Lake Rotund was formed by the collapse of the "Ocna cea Mica" excavation [4].

The present research aimed to monitor the evolution of the water quality in two salt lakes (Lake Ocnei and Lake Rotund), in order to establish the impact of anthropic activities, thus allowing a durable exploitation of this natural resource.

The two anthropo-saline lakes that make the object of our study are actively used for recreation and therapy. These lakes are heavily exploited during summer. Hence, our interest in determining the evolution of parameters over time has been attracted, because they have been found to be beneficial for human's health.

Given that the lakes have been open for leisure and treatment since 2009, the flow of tourists has increased exponentially. Before it was a point of interest only for people who lived around the area or for those who knew the existence of these lakes, since 2009 the presence of tourists during the summer has increased significantly. This was one of the main reasons why we chose to study these lakes in order to observe the evolution over time of their quality parameters.

Due to their therapeutic importance, the lakes in the natural reserve "Saraturile Ocna Veche" near Turda represent a point of interest during the warm season. Their quality status has to be monitored in order to implement the concept of sustainable development on this activity segment as well. Our research will give an overview of the parameters and their evolution in time, making it possible to apply timely remediation measures for any non-conformities.

The purpose of the present research was to evaluate the water quality of the lakes and to monitor its evolution during the bathing season, in order to ascertain whether anthropogenic activities impact the studied parameters. In addition, the aim of the present study was to update the situation regarding the water quality of the two salt lakes by testing specific parameters, so as to give the owners a chance to address possible non-compliances by taking measures to preserve and protect the therapeutic potential of the water. Investigations in 2018–2020 were based on data gathered two years before, in 2016, with the intention to see if and how water quality changed in the approximatively 10 years since the new resort involving the two lakes was opened to the public.

2. Materials and Methods

2.1. Study Area

The area is part of the "Sărăturile Ocna Veche" natural reserve, with an average altitude of 360 m. Figure 1 shows a satellite view of the area, including the lakes.

Figure 1. Satellite view [27].

Lake Ocnei is located to the North of Lake Dulce ("The Freshwater Lake"), with on the same line the two water bodies being separated by a 45–50 m wide threshold [4]. Lake Ocnei is one of the largest neutral, hypersaline lake of anthropic origin in Transylvania [28] and a representative lacustrine unit for the Turda area, mainly because of its considerable depth and volume (ca 26,000 m^3 by 2001) [4,5].

The chemistry of Lake Ocnei speaks of a hypersaline environment of sea salt origin (thalassohaline), a habitat very likely to be populated by halotolerant eukaryotes and bacteria, as well as by halophilic bacteria and archaea; in addition, it is a meromictic lake (saline epilimnion and monimolimnion) [28–30].

During late summer, the upper water layer reaches temperatures of over 30 °C, a phenomenon called heliothermy [29–32]. The water in the lake finds its way towards NNW through a channel (pipe) that allows excess water to drain into the Salt Valley. Although the banks are fairly steep, they are relatively smooth and covered with vegetation (especially the Eastern shore). The Northern bank, although lower, is rugged, and the streams do not allow vegetation to catch on it. The southern and southeastern shores have sliding areas, revealing the salt massif in the southeast corner. The surface of the lake in 2001 was 2045.25 m^2. Following the bathymetric measurements in May 2006, a maximum depth of 33 m was determined [4].

Lake Rotund is located to the NE side of Lake Ocnei. The lake appears circular in shape, and hence, the name "rotund" means round). It is located to the western end of a flat-bottomed ditch with steeper shores to the N and the S. The lake has a depth of 16 m (May 2006) and a surface of 460 m^2. In a ranking according to the salinization degree, it comes in second, after Lake Ocnei [4].

2.2. Data Collection

The study was carried out during summertime, when bathing was a current and massive occurrence.

As part of the 2016 determinations, measurements were made at several analysis points (17 for Lake Ocnei and 9 for Lake Rotund). For the measurements taken in 2018, the number of sampling points was decided considering the diameter of the two water bodies (Figure 2): two points for Lake Rotund and three for Lake Ocnei. Sampling points farther away from the shore were reached by boat. Samples targeted six depth intervals: 0.2, 0.3, 1, 2, 3, and 4 meters. Measurements in 2020 were carried out for both lakes at a single point close to the shore, where the sensor reached a maximum depth of 1 m. Only three depth intervals were targeted: 0.2, 0.3, and 1 m. All the analysis campaigns took place in the middle of the day.

(**a**) (**b**)

Figure 2. Sampling points for Lake Ocnei (**a**) and Lake Rotund (**b**) in 2018.

The rationale for reducing the number of sampling points in 2020 was that results of the previous campaigns showed that the lakes have an uppermost freshwater layer, which disappears during the bathing season because of vertical mixing; further on, the physico-chemical properties of the water vary by depth but are relatively constant throughout the lake within a given depth layer, so that there is no justification for so many sampling points.

The physical properties determined were as follows: pH, conductivity, resistivity, specific density, temperature, total dissolved solids (TDS), and turbidity. Chemical characteristics determined were as follows: dissolved oxygen, salinity, chlorides, nitrites, and nitrates.

On-site determinations were performed by means of a portable Hanna HI 9829 multiparameter, which had the ability to monitor 14 essential water quality parameters. The device was portable, being equipped with a multi-sensor probe that made measurement possible. With the help of this multiparameter, determinations for pH, conductivity, resistivity, specific density, temperature, total dissolved solids, turbidity, dissolved oxygen, and salinity were made. The immersion cable of the instrument was marked every meter, ensuring very good depth precision.

A multiparameter Almemo 2390-5 instrument was used for climatological determinations. This multiparameter was equipped with 3 sensors: the sensor for measuring the light intensity, the sensor for measuring the air speed, and the sensor for determining humidity and temperature.

In order to determine the amount of nitrites, nitrates, and chlorides the sample collection was carried out using sterilized collection containers, thus avoiding any external contamination. The determination of nitrites and nitrates was performed by spectrophotometry of molecular absorption according to SR EN 26777:2002/C91:2006 [33], and the determination of chlorides was performed using Mohr method according to SR EN ISO 15682:2002 [34].

Following the experiments carried out in order to determine the concentrations of nitrites and nitrates, respecting the measures stipulated by the standards, the calculation equations were written as follows:

$$N\text{ - }NO_2\ (mg/L) = \mu g\ N/V - \textit{determination of nitrites},$$

$$N\ (mg/L) = m(N)/V \times (40/Vdil) - \textit{determination of nitrates},$$

where μgN is the concentration value read on the calibration curve, V is the volume used (V = 40 mL) [33], $Vdil$ is the volume of the sample to be analyzed that is diluted, and N represents 0.226 mg/L [33].

After determining the amounts of nitrates, the pollution index (NPI) was calculated by using the following relation [35]:

$$\text{NPI} = (\text{Cs-HAV})/\text{HAV},$$

where Cs is the analytical concentration of nitrate in the sample and HAV is the threshold value of the anthropogenic source (human-affected value) taken as 20 mg/L [35].

The water quality was classified into five types based on the NPI values: <0 (unpolluted), 0–1 (light pollution), 1–2 (moderate pollution), 2–3 (significant pollution), and >3 (very significant pollution) [35]. Based on the same principle, we applied the calculation method for nitrites.

In order to determine the amount of chlorides, the equation used for calculating the concentration was described as follows:

$$\rho Cl = (Vs - Vb)\cdot c\cdot f/Va\ (mg/L),$$

where Vs is the volume of the silver nitrate solution for sample titration; Vb is the volume of the silver nitrate solution of the control sample; c is the real concentration of the solution; f is the conversion factor (3543 mg/mol); and Va is the sample volume (100 mL) [34].

The climatological measurements on the sampling day were as follows: in 2016—air humidity of 33.1%, atmospheric temperature of 26.5 °C, wind speed of 3.8 ÷ 5.6 m/s, clear sky; in 2018—air humidity of 55%, atmospheric temperature of 28 °C, wind speed of 0.15 ÷ 0.5 m/s, clear sky; in 2020—air humidity of 43.9%, air temperature of 26.9 °C, and wind speed of 0.37 ÷ 0.9 m/s.

3. Results and Discussion

3.1. Water Quality Monitoring for Lake Rotund

Results are shown separately for each of the two lakes, aggregating data from all three campaigns. Values shown on charts are the averages of measurements collected from each depth.

The recorded pH values (Figure 3) showed little fluctuation from one measuring campaign to the other, staying in the neutral range (6.5 ÷ 8.5) [8], with exception for the determinations made in 2018 when a higher value of pH between 0.2 and −2 meters was recorded. In 2016 and 2018, water showed a tendency to lose basicity with an increasing depth, while in 2020 a uniformization of the pH at various depth points was noticed.

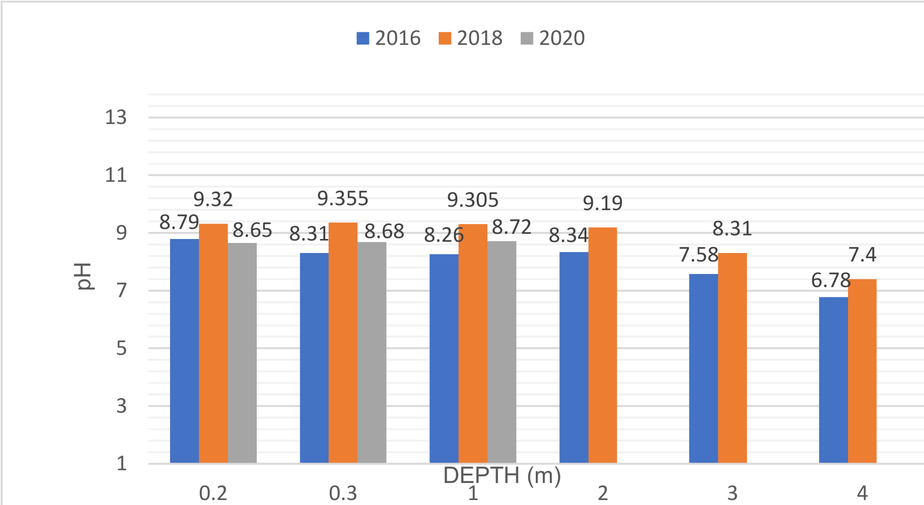

Figure 3. pH values at several depths of Lake Rotund.

The measurements in 2016 showed a strong thermal stratification. The average measured temperature at −0.2 m was 25.39 °C; values were highest (39.17 °C) at −1 m and decreased very markedly at −4 m, going as low as 22.84 °C (Figure 4). In 2018, the measured temperature was highly constant down to −3 m (highest value 28.94 °C at −1 m; lowest value 27.77 at −3 m). The same phenomenon was noted in 2020. Due to meteorological conditions and a longer bathing season in the subsequent campaigns, a marked heliothermy was only noted in 2016.

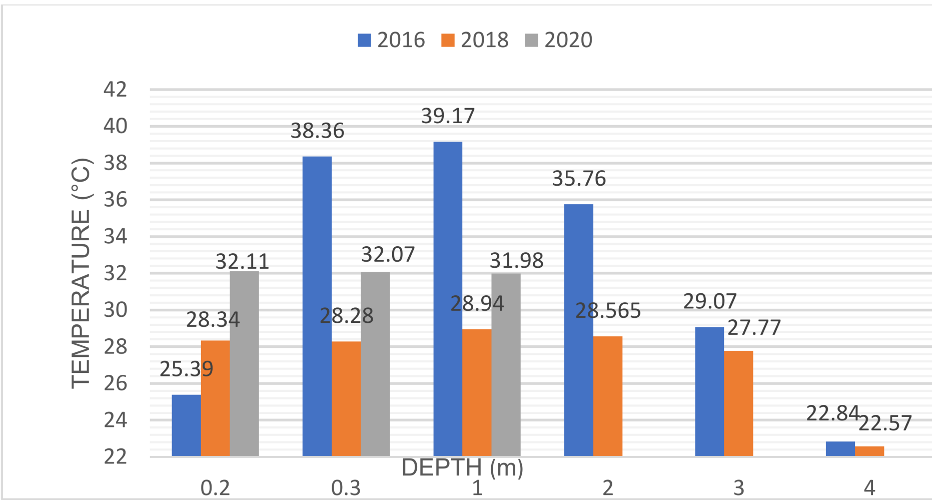

Figure 4. Temperature values at several depths of Lake Rotund.

Water conductivity increased, starting with the first depth segment (Figure 5). The results in 2016 showed that the conductivity increased from 72.18 mS/cm at −0.2 m to la 226.46 mS/cm at −4 m, highlighting the stratification process. The measurements in 2018 showed a relatively constant conductivity of about 134 mS/cm down to the depth of −2 m, followed by an increase up to the value measured in 2016 at −4 m. The measurements in 2020 highlighted a similar uniformization process down to the depth of −1 m, with an average value of conductivity of 175.3 mS/cm, 40 mS/cm higher than in 2018.

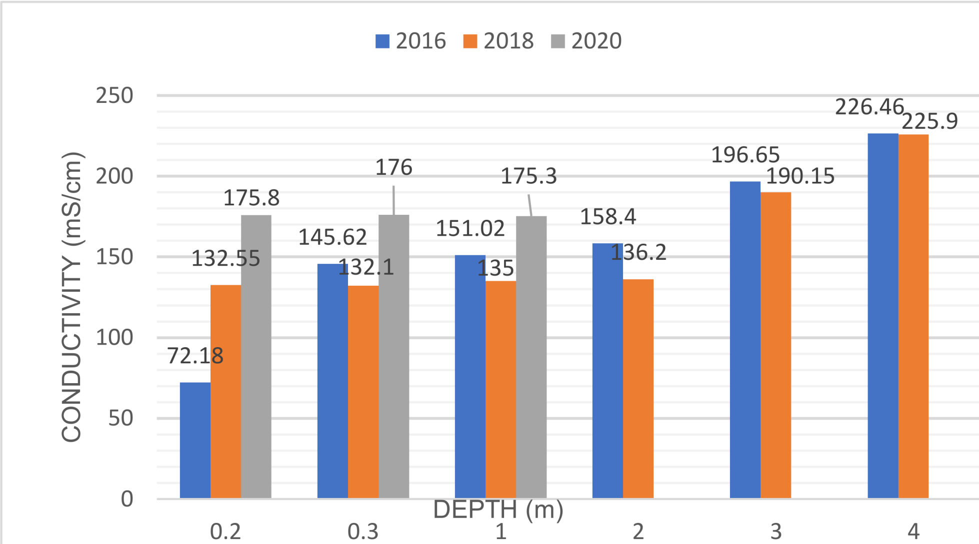

Figure 5. Conductivity levels at several depths of Lake Rotund.

The TDS in the water of Lake Rotund (Figure 6) in the summer of 2016 increased from 32.9 mg/L at −0.2 m to 117.7 mg/L at −4 m. TDS showed increasing values from one campaign to the other: 54.5 mg/L in 2016, 63 mg/L in 2018, and 77.53 mg/L in 2020 (values at −0.2 m).

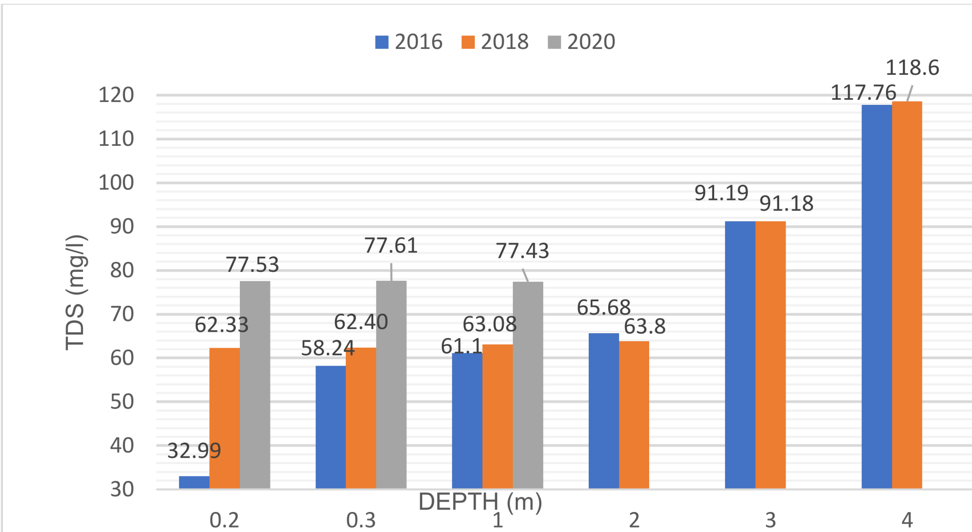

Figure 6. TDS values at several depths of Lake Rotund.

Both TDS and conductivity values emphasized the same phenomenon: vertical water mixing, with the disappearance of the characteristic layering. During the second measurement campaign, there was a longer bathing period prior to the sampling day, and thus, the mixing was even more marked.

Salt lakes range from 3 to 300 g per kg TDS, with many regional differences in their chemical composition, in contrast to fresh waters, which are mostly dilute calcium bicarbonate systems [36].

The value of dissolved oxygen was on average 0.082 mg/L, with very little fluctuations over the whole depth range, in both measuring campaigns. This was a direct influence of water mixing due the intense bathing activity.

Dissolved oxygen is one of the most important indicators of water purity; low oxygen concentrations indicate higher levels of pollution [37], but considering the high salinity of the lake water, it is to be expected that this indicator will be in its lower range.

The salinity values in Lake Rotund (70 PSU units) at all depth segments were determined. The same happened with the specific density, which exceeded the maximum sensor detection limit (50 σt).

During the research, the analyses showed a nitrites concentration of 49 mg/L in 2018 and 0.4 mg/L in 2020. In addition, the analyses showed a nitrates concentration of 6.5 mg/L in 2018 and 5.8 mg/L in 2020. The results are expressed in Table 1.

Table 1. Determinations of nitrites, nitrates, and NPI values for Lake Rotund.

Year	2018		2020	
	Determined Value (mg/L)	**NPI**	**Determined Value (mg/L)**	**NPI**
Nitrites	49	1.45	0.4	−0.98
Nitrates	6.5	−0.67	5.8	−0.71

The results showed that in 2018 there was moderate pollution in Lake Rotund (NPI = 1.45).

The value of turbidity for Lake Rotund after determination was 40.6 FNU. In terms of the amount of chloride, a concentration of 101 g/L was determined. It is then easy to understand that the conductivity increased with the concentration of dissolved salts. The determination for turbidity and chlorides was made in the monitoring campaign carried out in 2020.

3.2. Water Quality Monitoring for Lake Ocnei

Regarding Lake Ocnei, the pH measured near the surface was basic; a slight acidification occurred towards the depth. Figure 7 shows the pH variation with depth. A comparative view showed that the pH had a relatively minor fluctuation in time.

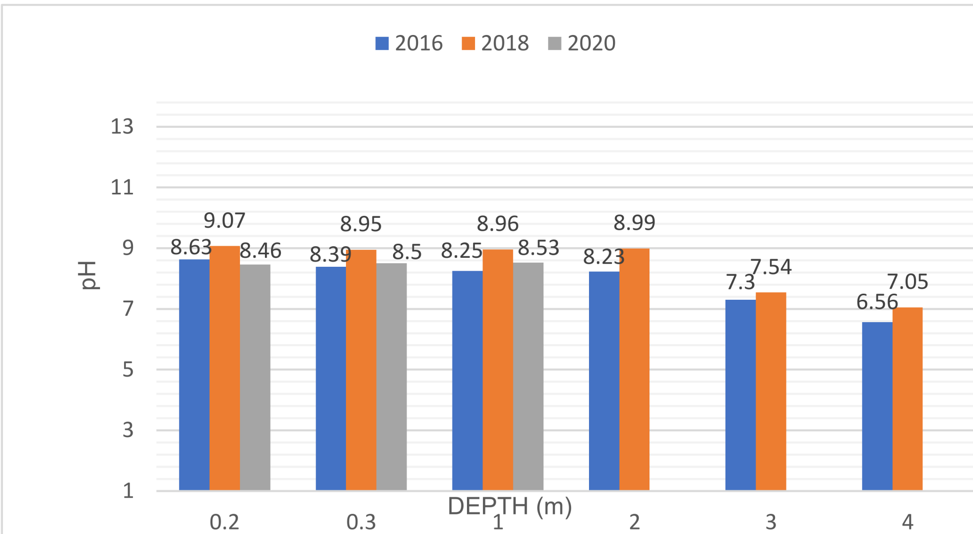

Figure 7. pH levels at several depths of Lake Ocnei.

Figure 8 shows the temperature variation in Lake Ocnei. The measurements taken in 2016 showed a clear stratification. The temperature increased from 22.66 °C at −0.2 m to a maximum of 35.49 °C at −1 m and then fell to 30.95 °C at −4 m. In 2018, the surface temperature was 28.43 °C, increasing to 37.82 °C at −3 m. In 2020, the thermal regime was quite constant, with fluctuations not exceeding 1 °C. The variation of temperature with the depth was directly influenced by the meteorological conditions, by the heliothermy phenomenon and by the presence of bathers, which resulted in the mixing of water layers.

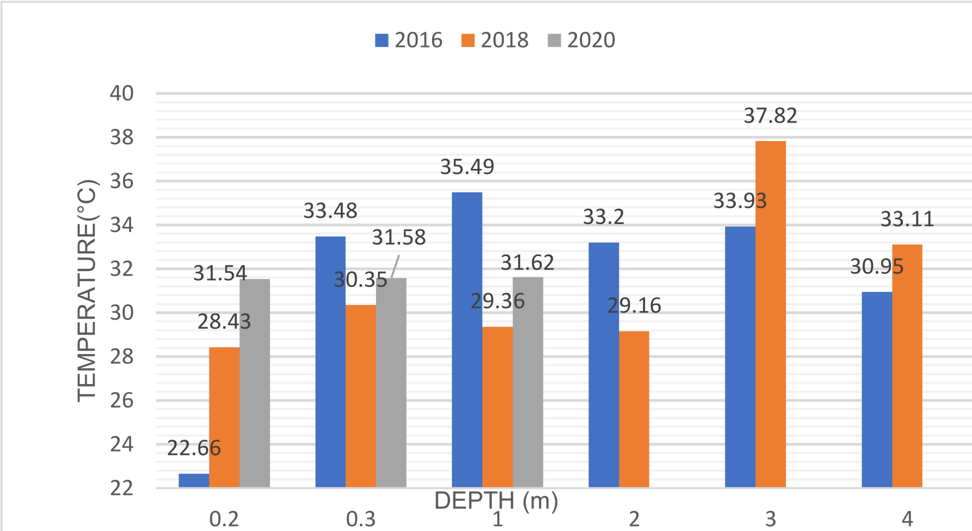

Figure 8. Temperature levels at several depths of Lake Ocnei.

In 2016, the water conductivity of Lake Ocnei varied from the minimum of 85.8 mS/cm at −0.2 m to the highest value of 264.1 mS/cm at −4 m. In June 2018, the conductivity had a recorded value of 148.23 mS/cm at the surface level. A constant increase of the conductivity was recorded down to the last depth interval, where the sensor reached its maximum value of detection. The conductivity stayed relatively constant down to the depth of −2 m; an abrupt increase occurred at −3 m, and the same high values was found at −4 m. Similar to Lake Rotund, a tendency towards increasing values from one campaign to the other was noted. The evolution of the conductivity is shown in Figure 9.

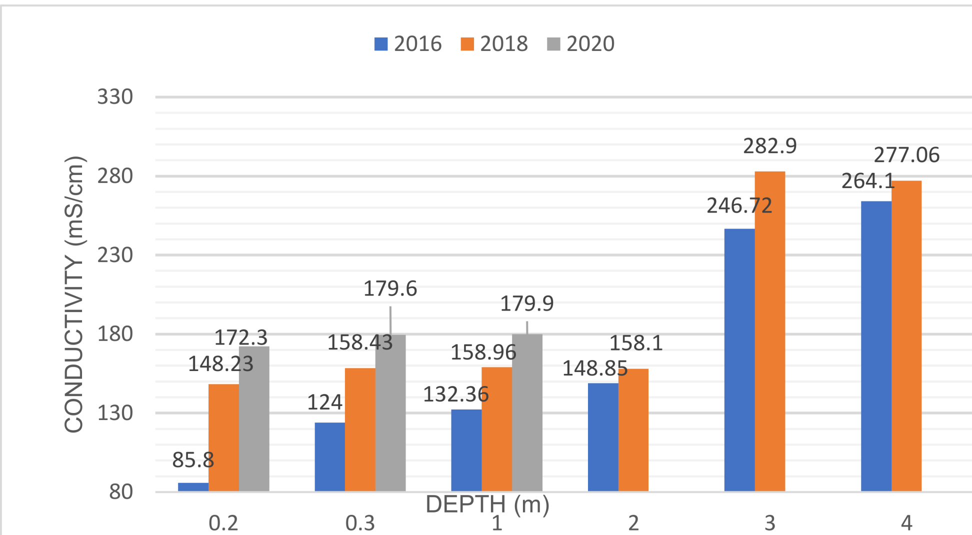

Figure 9. Conductivity levels at several depths of Lake Ocnei.

As shown in Figure 10, TDS values in the water of Lake Ocnei increased with the depth. The measurements carried out in showed that TDS varied little down to the depth of −2 m (average value: 61 mg/L) and increased to an average of 112 mg/L at −3 m.

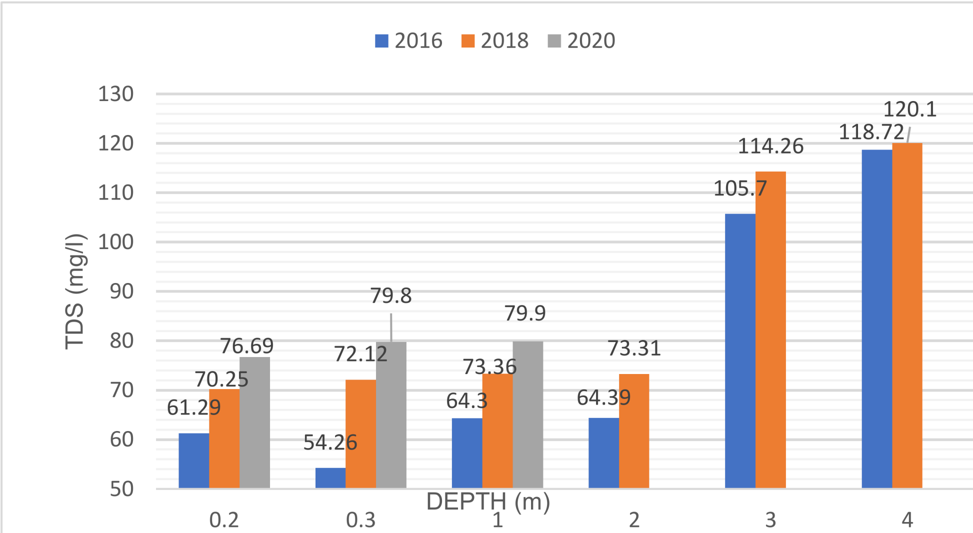

Figure 10. TDS levels at several depths of Lake Ocnei.

The measurements in June 2018 indicated a value of 70.25 mg/L at the surface level and a value of 120.1 mg/L at the 4 m depth. The TDS values in 2020 were found to be a larger amount. That aspect was certainly influenced by the prolonged bathing period, by the number of bathers in the lake, and by the meteorological conditions.

The measurements showed a continuous increase of TDS levels over the whole evaluation interval.

Hypolimnion was characterized by high salinity.

In general, if the concentration of salinity is very high, the conductivity will be higher.

The determined salinity in the waters of Lake Ocnei exceeded 70 PSU units (maximum sensor detection limit) at every depth segment. Salinity increased with depth in the limits of 8–26% NaCl [38].

The specific density exceeded the detection limit of the multiparameter sensor (50 σt).

The determinations regarding the amounts of nitrites and nitrates were made in 2018 and 2020. Table 2 presents the results of the measurements.

Table 2. Determinations of nitrites, nitrates, and NPI values for Lake Ocnei.

Year	2018		2020	
	Determined Value (mg/L)	NPI	Determined Value (mg/L)	NPI
Nitrites	35	0.75	0.184	−0.99
Nitrates	7	−0.65	3.5	−0.82

After determining the pollution index, the results showed that the water of the lake was slightly polluted (NPI = 0.75). The presence of the nitrogen point towards fertilizers used in nearby fields is a possible source of water pollution.

The value of turbidity for Lake Ocnei after determination was 6.51 FNU. In addition, in terms of the amount of chloride, a concentration of 175 g/L was determined. The determination for turbidity and chlorides was made in the monitoring campaign carried out in 2020.

3.3. Presentation of the Results Related to the Two Salty Lakes Studied

A study carried out in 2017 reported a decrease of the percentage of bathing areas with excellent water quality [39]. Our results confirmed this conclusion.

Our measurements carried out in June 2018 showed that the water of Lake Ocnei and Lake Rotund had a neutral or slightly alkaline character, with pH values varying between 9 at the surface level and 7 at −4 m; there were no major discrepancies in terms of the pH level, neither over time nor with the depth.

The active reaction of the water (pH—main ecological factor) was followed at each lake, finding that during the study period, near the surface (at a depth of 0.3 m), the pH was 8.8 in the study carried out by Mera [29]. Achieving a comparative situation resulted in the fact that the lakes have a slight tendency to lose basicity.

The salinity of the lakes exceeded the value of 70 PSU units at every depth, proving that these waters had a considerable amount of salt. With sodium chloride being a thermophilic molecule, NaCl levels and conductivity increase, when the water becomes warmer during daytime [40].

Considering the amount of dissolved oxygen, both water bodies fell into the category of oligotrophic lakes which are defined as lakes with low primary productivity due to the low nutrient content [41]. An extreme environment, as is this case, is defined by a low presence species diversity and where the whole taxonomic groups are missing. The action of the environmental factors is the reason why the obtained values are far from the average in the biosphere. The hypersaline ecosystem, such as these two lakes, shows a great variability in total salt concentration, ionic composition, and pH. These salterns provide a diversity of environments where different conditions of salinity, pH, temperature, light intensity, oxygen, and nutrient concentrations are found [42].

TDS values increased with the depth. In addition, over time, TDS in the lake waters were found to be a larger amount, proving that the salinity of the lakes also increased.

If TDS levels are high, especially due to dissolved salts, many forms of aquatic life are affected. The salts affect the skin of animals by dehydrating it. Another fact is about unplanned tourism activities without systematic planning and regulation that proved to be another major threat to urban water bodies [41].

In both lakes, a comparative analysis for the −2 m interval showed a constant increase of TDS over time. Compared to the situation in 2016, the average TDS increase in Lake Rotund was of 11.5 mg/L/year, while in Lake Ocnei it was of 8.8 mg/L/year. The two measurement campaigns in 2016 and 2018 showed a difference of about 10 mg/L TDS between the two lakes; this difference practically disappeared in 2020, becoming only 1 mg/L.

A similar comparison regarding water conductivity at −2 m also showed a larger increase for the 2016–2018 interval and a smaller one in 2020. Compared to in 2016, the average conductivity increases for Lake Rotund were 51.4 mS/cm/year and 27.3 mS/cm/year for Lake Ocnei. The difference in conductivity between the two lakes decreases over time, from 50.5 mS/cm in 2016 to 19.6 mS/cm in 2018 and to only 2.2 mS/cm in 2022.

The results gathered from the measurements carried out in July 2020 suggested that the lakes's water was mixed due to a longer bathing period prior to the moment of testing (the bathing season had been open for a longer time). This showed the values of all studied parameters had a marked homogeneity over the whole depth range.

The salinity decreased due to sedimentation of the terrigenous material brought into the lake basin from the active grazing area upstream [43]. These salterns provide a diversity. Sediments play an important role in determining the type of pollution that will affect an aquatic system; they act both as a carrier and as a storage tank for pollutants, reflecting the history of the contaminant [44]. The presence of urbanization and agricultural activities taking place near water resources affects the water quality, behaving like large pollution generators [28]. Pollution with nutrients (nitrates and phosphates) induces eutrophication of smooth running waters, lakes, or seas [45].

Comparing the results for nitrites and nitrates in 2018 and 2020, it was proved that there were infiltrations with polluting substances in the water of the lake. In the upstream area, there was a riding center and an animal farm. Studies carried out between 2005 and 2006 [46,47] showed that the amounts of nitrates (74.14 mg/L for Lake Ocnei and 78.05 mg/L for Lake Rotund) in the water of the lakes are above the standards limits, with an obvious tendency of decreasing the concentration with the increasing water depth. The study conducted by Mera reports a possible source of pollution with substances used to fertilize cultivated soils near the lakes, and this aspect was also determined in the current research [46]. If bathing water is polluted, it causes undesirable effects not only on water quality parameters, but also on swimmers [48]. Evaluation of water quality over time can only be performed through periodic monitoring. Regarding the study conducted by Zessner [49], it is expressed that monitoring is based on establishing the empirical basis by providing space- and time-dependent information on substance concentrations and loads, as well as boundary conditions for assessing water quality trends.

The amount of chlorides is due to the presence of NaCl in large quantities. In addition, it was observed, by following the determinations for turbidity, that for Lake Rotund this parameter was very high.

4. Conclusions

The present research brings a body of data necessary in order to evaluate and monitor the water quality levels of Lake Ocnei and Lake Rotund in the Saraturile Turzii area, setting a ground upon which durable exploitation strategies of these natural resources can be put in place.

Following the testing campaigns carried out during the 2016–2020 interval, a number of conclusions could be drawn.

Although in close vicinity, the two lakes behave distinct, though interacting ecosystems. Their water underwent constant change and suffered under the influence of nearby human activities. Negative effects of in-water activities, specifically bathing, were noticed down to the depth of −2 m, with cummulative effects from one year to the other, as shown by parameters such as TDS and conductivity. At greater depths, TDS and conductivity values stayed relatively constant in time.

The water was slightly alkaline (pH 8.5–9) down to the depth of −2 m and decreased to 6.5–7.5 at −3 m and below, conforming to the norms of a water defined as neutral.

The highest measured temperature occurred in the water of Lake Rotund at −1 m (39.17 °C), during the 2016 campaign. The results showed that the heliothermy process was stronger in this period. The thermal stratification phenomenon was only evident in 2016; later on, the waters of both lakes appeared thermally homogenous down to the depth of −2 m, most probably due to the lakes being used for bathing. There was a ±1 °C difference in temperature between the two lakes. In addition, the water temperature increased from one testing to the next (+2 °C for Lake Ocnei and +3 °C for Lake Rotund).

Interestingly, the two lakes showcased a different behavior at depths beyond −3 m: the temperature of Lake Rotund went down (T_{av} = 28.42 °C at −3 m; T_{av} = 22.7 °C at −4 m), while the one in Lake Ocnei went up (T_{av} = 35.87 °C at −3 m; T_{av} = 32.03 °C at −4 m).

Although −0.2 m is not a standard sampling depth, it appears to be an important target, because the freshwater layer forming at the lake surface was not equally high between the two lakes and also varied in time, going from 0.15 to 0.2 m. This characteristic freshwater layer, important for the heliothermy process, was higher and better defined in Lake Ocnei.

The evaluation of the amounts of nitrites and nitrates showed that the source of pollution was certainly in the upstream area and through the water flow and these substances reached the lakes.

The concentrations of nitrites and nitrates in water were very high for a surface water.

The chlorine levels determined in 2020 were high, because the water was hypersaline and perfectly normal. In addition, turbidity indicated that in 2020 Lake Rotund was better preferred for bathing compared with Lake Ocnei.

The constant testing of the water quality at 0.2, 0.3, 1, 2, 3, and 4 m depths was required in order to monitor the lakes behavior and to attain a sustainable management of this natural resource located within a protected area.

Human activities involving the lakes also generate a contamination of the water. The water supply system must follow a few simple rules that ensure compliance with the WHO view on the microbiological quality of water, which is considered a priority compared to risk factors of chemical origin.

In order to preserve their therapeutic properties, the two lakes need to maintain a high level of salinity, as well as other specific parameters. The comparative results over the three monitoring campaigns suggested that in-water human activities have a negative impact on the saltwater. Thus, specific parameters have to be constantly monitored and bathing activities should be organized such as preservation of the quality of the water, possibly limited or otherwise restricted, in order to allow the stratification of the water to occur.

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