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The Salty Lakes of Ocna Sibiului. Past. Present. Future

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Abstract. At the center of the Transyvanian Plateau lies Ocna Sibiului, with its salt deposits which, in places, run up to one thousand meters below the surface. The presence of these deposits has been favored, due the extraction of salt throughout the years causing the formation of the now famous salt lakes. Due to different environmental conditions, lacustrine cuvettes and water quality differ from one lake to another. The studied lakes are considered to be in conection with the salt deposits exposed through minig activities carried on in different time periods. Other lakes in the area already are isolated from salt deposits due to natural sedimentation proceses. The study adresses the lakes which still present a high degree of salinity and are used for balnear purposes, and present, due to various factors, variation of physical-chemical composition throughout the year. Water samples were collected from the main six lakes in Ocna Sibiului (Ocnița – Avram Iancu; Rândunica; Negru; Fără Fund; Brâncoveanu and Gura Minei). Surveys were carried out in four periods (March-November) during 2012.Water temperature, electrical conductivity (at 25°C) and pH were measured *in-situ*. The water pH changed from a lake to another. Generally it is within the range of 6.78 to 8.8 highlighting the neutral to slightly alkaline lake water. Salt lake water conductivity values, in the upper layers vary within a wide range, from more than 200 mS cm^{-1} to 45.7 mS cm^{-1}, with different values from the different lacustrine units. The salt water lakes are characterized by high content of sodium and chlorine ions. The other major ions are present in a small amount. This paper aims to compare the past and present evolution, characteristics and environment of these lakes, , and, based on this and current research, to project a vision of their future and how it will affect the lives of future generations living besides them.

Keywords: Ocna Sibiului, salty lake, Transylvania, physico-chemical characteristics

INTRODUCTION

Throughout the Transylvanian Plateau numerous artificial salt lakes formed in derelict salt mines are widely distributed (Alexe, 2010). At the center of the Transyvanian Plateau lie the salt deposits of Ocna Sibiului which, in places, run up to one thousand meters below the surface. The presence of these deposits favored the formation of the now famous salt lakes, formed due the extraction of salt throughout the centuries. These anthropic, or more specifically, anthropic-salted lakes, have a small surface area of a few thousand square meters, yet feature great depths and contribute to a specific landscape, representing the main source of income for the local economy.

Ocna Sibiului is a tourist resort located in Sibiu County. In the southern hills of the Transylvanian Plateau (north-west of Sibiu Depression) 15 km north of Sibiu, in the Visa valley, a region surrounded by cenntenial oak forests and rich in salt deposits. The presence of these deposits favoured the formation of the now famous salt lakes. The first spa was established in 1845 and since then, Ocna Sibiu has attracted a reputation for heliothermic treaments.

The town has a high historical significance and has been populated since Roman when was Ocna Sibiului included in a salt extraction network in the so-called “salt route”. Salt extraction remained the main activity in the following centuries, for example in the 13th century when the miners were given legal rights and privileges and in 1346 when the settlement was declared a burgh. Gradually the salt mines were abandoned one by one and in time, under the influence of the climactic factors, the walls collapsed and the salt mines turned into today’s lakes.

The majority of the salt lakes emerged in the last centuries following the collapse and flooding of the abandoned salt mines. In the 16th century their healing effects became famous in the entire Transylvanian area. In mid-19th century the burgh was transformed in a spa resort upon the opening of the hot and cold baths. The resort entered a period of stagnation or even degradation, in the late '90s. In 1997 all activites are ceased.

In 2002 the spa is reopened on a permanent basis but at a diminished capacity, the treatment centre using the premises and facilities of Hotel Salinas.

Ocna Sibiu Mayorality received in 2010, 4.5 million PHARE funds and another 3.5 million government funds for rehabilitation and modernization of the Salt Lakes Complex and of the Ocna Sibiu resort.

Presently the Ocna Sibiului Health & Spa has been completely rehabilitated following an intensive restoration process which closely respected the original architectural syle imprinted by the Austrian architects (only the central pavilion was demolished given its advanced state of degradation, its restoration being impossible).

The lacustrine complex currently includes a total of 14 lakes (all located in the eastern part of the village on the salt massif). From the lakes, only 2 are carstosaline, the remaining 12 being antropic. Lakes were divided in three areas:

- lakes from the Ş trand Bathing Complex: Horea, Cloşca, Crişan.
- lakes from Station Park: Pânzelor, Mâţelor and Fără Fund.
- outer lakes: Ocniţa-Avram Iancu, Gura Minei (Ignaţiu), Balta cu Nămol, Mihai Viteazu, Brâncoveanu, Rândunica (Sf. Ioan), Austel, Verde (Poporului).

Lacul fără Fund (*Bottomless Lake*) has an area of 0.2 ha., being declared a natural reserve. It has a depth of 34.5 m a diameter of 50 m, the shape is oval and was born following the collapse in 1775 of Ocna Francis.

Previous studies of the lakes from Ocna Sibiului have mainly focused on their origin, physico-chemical parameters of the water and microbial characteristics of the mud. The first chemical analyses were attested in 1820 by Dr. Pataky Samuel in “Descriptio aquarum mineralium Transilvaniae” published in Sibiu. Due to these analyses, it was discovered that the salted water at Ocna Sibiului has therapeutic properties (Horotan, 2010). In 1885, Schnell made his first notes regarding the physical properties of Ocna Sibiului salt lakes. Friedenfels (1880) undertook an ample study of the biological elements in these waters, noticing the existence of *Artemia Salina.* Rigler (1902) and Rozsa (1910), observed the stage and evolution in time of the water temperatures and concentrations (Alexe and Şerban, 2008). Maxim (1958, 1931) presented some data about the optical properties of the water (transparency and color). Bobeică (1969) studied the vertical distribution of temperatures in the salt lakes. Recent researches are those of Alexe and Şerban (2008), Poplăcean (2009), Alexe (2010), Horotan (2010), Ciobanu and Costea (2009) and Ianuş (2010).

According to analyzes conducted in 1963 by Costin-Deleanu, the chloride content of some lakes in Ocna Sibiu varies from the category of low chloride lakes (Popular Lake with 12.96 g L^{-1} to lakes with higher chloride content (Brâncoveanu, 79.8 L^{-1}) and strongly chlorinated water lakes (Ocniţa Lake, 138.7 g L^{-1} and Avram Iancu, 107.2 g L^{-1}) (Horotan, 2010).

Poplăcean (2009) classifies the Ocna Sibiului lakes in three main categories: lakes with high salinity (over 200 g L^{-1}, Negru; Brâncoveanu), lakes with moderate salinity (around 100 g L^{-1}, Fără Fund, Gura Minei, Ocniţa, Balta cu Nămol) and lakes with low salinity (around 50 g L^{-1}, Horea, Cloşca, Crişan, Rândunica, Mâţelor, Auster and Pânzelor).

Another important characteristic of the lakes water is the heliothermal phenomenon, due to the stratification of the salinity in the water. As a result, during the summer months at water surface the temperature is 24.5°C and at depths of only 1 m. 31.4°C and at 1.5 – 2 m 40°C afterwards it decreases. (Ianuş, 2010). Heliothermy was observed even during winter, under the ice sheet, as a result of the maintenance during the warm season (Fără Fund Lake), or as a result of thermal reorganization of the epilimnion, due the cooling of the surface water (Alexe and Şerban, 2008, Ianuş, 2010).

Various type of local tourism activities and buisnesses mainly depend on the salt-water characteristics of the lakes, weather conditions often allowing outside bathing from April to October. The inflow is mainly rain water. Most of these lakesNatural and anthropic factors can influence the water properties. Events such as heavy rains and droughts can lead to alteration of the normal water characteristics. To these are added anthropic uncontrolled pressures such as water extraction in huge quantities in order to supply the numerous treatment centers as well as impacts derived from the presence of an excessive influx of tourists, even the presence of livestock in the protected saliferous environment can exercise and major impact. These entire factors can influence the state of the local environment and ultimately its most valuable resource, the salt lakes.

MATERIALS AND METHODS

Water samples were collected in sterile polyethylene (PE) containers from the six main salt lakes situated in Ocna Sibiului (Tab. 1 and Fig. 1). Surveys were carried out in four periods (March-November) during 2012.

Water temperature, electrical conductivity (at 25°C) and pH were measured *in situ* (using the InoLab Multi 720 multimeter, WTW, Germany). The water samples were taken from about 50 cm beneath the water surface.

Standard laboratory procedures and appropriate conservation criteria (cooler storage boxes, filtration through a 0.45 µm membrane filter Millipore, to remove particulate materials etc.) were used for water sample analysis. Samples were transferred to the laboratory using a thermo box under dark conditions for further analyses.

Tab. 1

The sampling points and the morphometric characteristics of the studied lakes

Sampling points	Lake	Latitude	Longitude	Lake area*, m^2	Max. depth*, m
P1	Ocniţa – Avram Iancu	45°52′28.56"N	24° 3′59.80"E	12106.4	127.1
P2	Rândunica	45°52′22.45"N	24° 3′59.28"E	2149	46.54
P3	Negru	45°52′25.32"N	24° 3′54.63"E	4400	3
P4	Fără Fund	45°52′34.18"N	24° 4′3.27"E	1700	34.5
P5	Brâncoveanu	45°52′18.83"N	24° 3′55.18"E	388.7	14.5
P6	Gura Minei	45°52′23.91"N	24° 3′52.71"E	969.33	27

*Alexe, M. (2010)

Fig. 1. Sampling point location

The concentrations of major anions and cations were measured using ion chromatography (Shimadzu system), equipped with a conductivity detector, Allsep Anion 7u column (150 x 4.6 mm) and Universal Cation 7u column (100 x 4.6 mm).

Water samples were analysed for a pre-defined set of physical and chemical indicators in order to allow the build-up of a meaningful database that can be used for comparative assessment and trend delineation. Analyses were made in triplicate and the mean values were reported. The samples with ion concentrations exceeding the calibration range were diluted accordingly and re-analysed. Unpreserved water samples were transferred to the laboratory in a thermo box under dark conditions for further analysis.

All reagents were of analytical-reagent grade type and all solutions were prepared using ultrapure water with a specific resistance of 18.2 MΩ cm^{-1}.

Data were expressed as mean ± SEX (Standard Error of Mean). The level of statistical significance was established as $p < 0.05$.

RESULTS AND DISCUSSIONS

Water composition depends on physical and geographical conditions, on the composition of inflowing waters, on the size and shape of the lake and on wind directions. In summer, lake water is well mixed due to the intensive bathing, while in winter, lakes are highly stratified.

At surface, water pH is within the range 6.78 to 8.8, varying from neutral to slightly alkaline in all the studied lakes (Tab. 2).

With increasing depth, lakes pH decreases with increasing amounts of carbon dioxide, the degree of mineralization and the oxidation-reduction. Seasonal variation of pH values measured is influenced by increasing the water temperature. Overall it was noted that an increase of water temperature causes a decrease in the pH of the water.

Salt lake water conductivity values vary within a wide range, from more than 200 mS cm^{-1} to less than 50 mS cm^{-1}. In most sampling sites, lake water was well mixed in summer. Near the water surface, the specific conductance was usually lower (45.7–231 mS cm^{-1}) in

winter than in summer (53–256 mS cm^{-1}) due to the intensive bathing (Tab. 2). The great concentration in salt (almost to saturation) is given by the sodium chloride found in direct contact with water.

Tab. 2

Mean results of *in-situ* measurement

Sampling point	Lake	pH (unit. pH)		EC (mS cm^{-1})		TDS (g L^{-1})	
		Mean ± $SE_{\bar{x}}$	Range	Mean ± $SE_{\bar{x}}$	Range	Mean ± $SE_{\bar{x}}$	Range
P1	Ocniţa – Avram Iancu	7.62±0.09	7.4÷7.8	156.8±2.26	150.2÷160.3	132.37±2.50	126.79÷137.68
P2	Rândunica	8.01±0.09	7.8÷8.2	49.4±1.61	45.7÷53	34.10±1.00	31.16÷36.59
P3	Negru	7.15±0.18	6.78÷7.5	244.6±5.31	231÷256	282.65±3.50	266.9÷295.82
P4	Fără Fund	7.93±0.17	7.53÷8.3	171.5±7.53	153÷189	150.43±2.50	129.16÷172.7
P5	Brâncoveanu	8.5±0.29	7.4÷8.6	233±5.37	220÷246	269.24±3.50	240÷284.27
P6	Gura Minei	8.7±0.07	8.5÷8.8	113.6±1.21	110.5÷116	88.13±1.50	85÷90

Mean values of 2012, SEX – Standard Error of Mean, EC – Electrical Conductivity, TDS – Total dissolved solids

The salt water lakes are characterized by high content of sodium and chlorine ions (Na^+, Cl^-) (Tab. 3). The other major ions are involved within a small amount. Of these, sulfates, have a larger share coming from the transformation processes that occur within the lakes.

Tab. 3

The content of major ions in the studied lakes (mean ± S.E. in meq L^{-1})

Parameter, meq L^{-1}	P1	P2	P3	P4	P5	P6
	Ocniţa – Avram Iancu	Rândunica	Negru	Fără Fund	Brâncoveanu	Gura Minei
Cl^-	3019.7±15.2	1664.8±13.3	3907.4±17.1	1757.5±11.6	2247.9±16.3	1045.07±12.4
NO_3^-+ NO_2^-	0.07±0.06	0	0	0.36±0.05	0.01±0.03	0
SO_4^{2-}	23.75±2.32	15.71±1.52	18.35±2.02	39.58±3.12	25.54±2.3	21.27±1.67
HCO_3^-	2.20±0.17	2.27±0.17	2,81±0.2	2,5±0.25	2±0.12	2.26±0.27
Na^++K^+	3017.39±14.6	1656.52±12.7	3917.39±15.5	1743.48±10.1	2239.13±17.4	1034.78±12.6
NH_4^+	0,98±0.15	0,1±0.063	0	1,08±0.21	0,66±0.1	0
Ca^{2+}	29.94±1.62	23.50±2.12	21.95±2.32	38.48±2.9	33.58±1.98	19.15±1.65
Mg^{2+}	3,64±0.7	3,33±0.57	1,21±0.35	17,86±1,3	4,66±0.52	12,67±1,24

Lake water biogenic substances are present as ions or colloids coming from the vital activity of aquatic organisms. These substances are based on nitrogen compounds (ammonium, nitrite, nitrate), but their concentrations are reduced below 10 mg L^{-1}.

The high mineralization of these lakes includes them in salted water category, with mineralization over 24.5 g L^{-1}.

CONCLUSION

The salty lakes represent the most important hydrologic factor of the Ocna Sibiului area and the main element of tourist and therapeutic attraction. A characteristic feature of the salt lakes is represented in the water stratification, the salinity and the temperature. Besides the sodium chlorine (which is the main element of the lakes water), there other elements like: bromine, iodine, iron, magnesium, manganese, aluminium, calcium, and so on are to be found in different concentrations. This proves the mineral richness of the salt deposit that gives them certain therapeutic qualities.

Salt lakes can be considered an important tourist resource given the multiple valences of use, both for recreational purposes and to treat some diseases. The tourism in Ocna Sibiului was and still is mainly centered on curing functions in the treatment center or in the swimming pools. In most cases, the existing arrangements were made more for financial reasons rather than to protect lacustrine environment.

The revitalization of the area must be based on specific studies to propose concrete solutions in conjunction with measures to protect sources. A deep mentality change is necessary, as well as the application of concepts like sustainable development and ecodevelopment, because environmental protection and tourism should coexist.

It would require a more active involvement of local authorities, county and government highlighting the potential of the lakes as well as the formulation of strategies to ensure sustainable development of the environs.

Therefore, it is appropriate to implement education programs that besides tourist and visitor related information, motivate them to act responsibly when conducting tourist activities.Ocna Sibiu can become a ”shining” spa as it was in the inter-war epoch.

REFERENCES

1. Alexe, M. (2010). A study on the salt lakes of the Transylvanian Basin. Cluj University Press, Cluj-Napoca (in Romanian).
2. Alexe, M. and Gh. Şerban (2008). Considerations regarding the salinity and water temperature of salty lakes of Sovata and Ocna Sibiului. Studia Universitatis “Vasile Goldiş ”, Life Sciences Series 18:305-311.
3. Bobeică, A. (1969). Cercetări privind lacurile de la Ocna Sibiului. Hidrotehnica, Gospodărirea apelor, Meteorologia, 14(4):179-187.
4. Ciobanu, R. and M. Costea (2009). Favourable and restrictive elements of the saliferous environment in tourism: Case study Ocna Sibiului. Brukental. Acta Musei IV.3:529-542 (in Romanian).
5. Horotan, A.R. (2010). Hydrobiological study for the exterior lakes at Ocna Sibiului. Brukental. Acta Musei V.3:543-553.
6. Ianuş, L. (2010). Contributions to the study of the influence heliothermy phenomenon on stratified fluid, PhD thesis abstract, UTCB, Bucureşti (in Romanian).
7. Maxim, A.I. (1931). Contribuţii la explicarea fenomenului de încălzire a apelor lacurilor sărate din Transilvania (II). Lacurile de la Ocna Sibiului. Rev. Muz. Geol.–Min. al Universităţii Babeş-Bolyai IV(1):47-111.
8. Maxim, A.I. (1958). Lacurile fără fund de la Ocna Sibiului, Rev. Natura, 3:13-25.
9. Poplăcean, M. (2009). Caracterizarea microbiologică şi enzimologică a apelor şi nămolurilor din lacurile sărate de la Ocna Sibiului, PhD thesis abstract, USAMV Cluj Napoca.
10. Poplăcean, M. and L. Oprean (2009). Microbiological and enzymological characterization of water and sapropelic muds in the lakes of Ocna Sibiu. Acta Universitatis Cibiniensis Series E: FOOD TECHNOLOGY XIII (2):49-56.