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Evolution of water quality in the Blue Lagoon from Aghireșu

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Abstract. The Blue Lagoon Lake is the result of anthropic activity in Aghires area, boeing Ander the action of natural factors, since the beginning. The area is rich in caolino quartz sands which were intensively exploited for a while. The lake inpoundment is formed in an excavation followed by the collaps of the galleries. This study incluyes an assessment of physical and chemical lake water quality in the summer of 2009 and a comparison of measurements made during 2008-2009. The water physical and chemical properties varied within narrow limits in both their spatial and temporal variation, with significantly lower values in year 2009. The comparisons were made vertically, horizontally and in time. In time it can be observed a reduction of the dissolved oxygen which cause a decrease of the lake water quality including in terms of aquatic life.
Key words: lacustrine units, physical characteristics, hydrochemistry, vertical variation, temporal variation.

Zusamenfassung. Die Eingriffe des Menschen haben das Blauen Haffes-Gebiet verändert; die natürlichen Faktoren und Prozesse wirken bis Heute im Zusammenspiel und auf der Grundlage dieser Eingriffe. Das Gebiet ist reich in Quarz Caolino Sand, welche früher intensiv genutzt genutzt wurden. Das Seemulde entstand in einer Baugrube und auch durch Zusammenbruch Prozesse gebildet wurde. Diese Studie umfasst eine Bewertung der physikalischen und chemischen Seewasserqualitat im Sommer 2009 und einen Vergleich dieser zu den Messungen des Zeitraumes 2008-2009. Selbst in den engen zeitlichen und räumlichen Grenzen schwankte die physikalischen und chemischen Beschaffenheit des Wassers stark, mit deutlichem Trend zu geringeren Werten im Jahr 2009. Die Vergleiche wurden sowohl vertikaler, horizontale und temporale durchgeführt. Die Abnahme der Wasserqualität korreliert mit der Reduktion von Sauerstoff und hat entscheidenten Einfluss auf das Leben im Wasser.
Schüsselwörter: lacustrine Einheiten, physikalische Eigenschaften, hydrologische Eigenschaften, vertikale Variation, zeitliche Variation.

Tartalom. A Kek Lagúna tórendszer antrópikus behatások eredményeképpen jött létre melyeket a környezeti tényezők tovább alakitottak. És alakitanak a továbbiakban is. Geológiai felépités szempontjából kvarchomokban és kaolinban gazdag melyek kiaknázása több évtizedig intenziven folyt. A tómedrek a kaolin-kvarchomok kitermelése során jöttek létre, melyekhez a paretok beomlása is hozzájárult. A jelen tanulmány a viz fizikai és kémiai összetevöit vizsgálja a 2009-as év nyári periodusában, összehasonlitva azokat a 2008-2009-as években végzett vizsgálatok eredményeivel. A fizikai és kémiai vizsgált paraméterek térben és időben, szűk korlátok között változtak, és jelentösebben alacsonyabb értéket mutattak a 2009 üas évben. A vizsgált paraméterek, függőleges és időbeni változásai a viz oxigéntartalmának a csökkenését mutatták ki, melyek kihatással vannak a vizminőségére valamint az élővilágra is.
Kulcsszavak: tavi egységek, fizikai, hidrokémiai jellemzők, függőleges,változások, időbeli eltérés.

Rezumat. Lacul Laguna Albastră este rezultatul acțiunii antropice din zona Aghireș, supusă acțiunii factorilor naturali, procese care se continuă și în prezent. Zona este bogată în nisipuri caolino-cuarțoase care au fost într-un timp exploatate intensiv. Cuveta lacului s-a format într-o excavație dar s-au produs și procese de prăbușire. Prezentul studiul cuprinde o evaluare din punct de vedere fizic și chimic a calității apelor lacului în perioada de vară a anului 2009 cât și o comparare a măsurătorilor efectuate în anii 2008-2009. Elementele fizice și chimice ale apei au variat în limite strânse atât în variația lor spațială și temporală, cu valori semnificativ mai mici în anul 2009. Comparațiile s-au efectuat atât în plan vertical, orizontal cât și temporal, observându-se o diminuare a oxigenului dizolvat în timp fapt ce determină o scădere a calității apei lacului inclusiv în ceea ce privește viața acvatică.
Cuvinte cheie: unităţi lacustre, caracteristici fizice, caracteristici hidrochimice, variație verticală, variație temporală.

Introduction. The area surrounding Aghireşu, situated in the western part of the Someşan Plateau, was shapped through the influence of the aerial agents and that of the mining activities (Pop 2001). The first ones are very diverse and consequently the resulting relief shapes are varied, both at a large scale as well as at micro scale, with evolutions sometimes spectacular in time. The antropic influence is focused in the areas of mining and stock-piles and above the artificially created relief new natural processes got imprinted. Consequently a varied relief resulted, sometimes chaotic and where the aerial moulding processes are active even in the present moment.

Along its geologic evolution the area faced several immersions and accretions due to which deposits from several geneses and stratigraphic-petrographic features were gathered. The succession of the marine and continental characteristics underline these features through lito-stratigraphic entities which stand for horizons; this is due to the fact that tectonic activities have slightly affected the region (Savu 1963). The area emerged definitely at the end of the Oligocene, after which it started to be submitted to the aerial moulding. The main draining systems were formed, leading to the shaping of valleys, flanks, torrents, cloughs, glacis, etc. During the glacial periods the periglacial processes were more active. The last mouldings date from the Holocene and are even nowadays active, through the erosions and the deposits along the alluvial plains, in the river beds and on the versants.

Given such geologic conditions, in the underground were deposited some useful resources, that can be exploited (Pandi & Berkessy 2008; Pandi 2004). In the Oligocene-Aquitanian deposits, relatively thin layers of brown coal were fixed, alternating with clays and marls. The eocene-oligocene chalk stones are used as construction materials. The gypsum is used as raw material to fabric the plaster; the kaolinous-quartzous sands from the Aghireş area are very important that is why they will be studied in more details.

The most important resource from the area is represented by the kaolinous-quartzous sands the most important from Romania, which were intensely exploited for some time. The origin of the kaolin from Aghireşu is secondary, the floating material being deposited in a combined structure, in a lake and lagoon-like environment. The resource was exploited both in the underground and on the surface, in quarries. This led to the production of kaolin for fine ceramics as well as kaolin used in the refractory industry (Pandi et al 2009).

The Microdepression of the Blue Lagoon. In some of the negative relief shapes resulted from the antropic activities rain water gathered and lakes were formed. Surely the initial antropic relief was moulded sometimes very aggressively by the aerial agents. The geomorphologic processes are active even nowadays.

The most representative lake unit is the Blue Lagoon. The basin of the lake was formed in a digging area where there also took place collapsing processes. The soft material deposits and the lack of vegetation was in favour of the very active presence of the moulding processes caused by the external agents. It is a depression with obvious risk processes, both on the versants, through areal and linear processes, and through the deposits of the lake basin.

The Blue Lagoon Microdepression has a North-Eastern – South-Western orientation. It has two very distinct parts, the most north-eastern, where the lake was formed and another smaller one in the south-western direction, which is higher. The microdepression is surrounded by an abrupt area having various heights of several meters, which is often chipped by forms of the linear erosion, in regression.

A wider opening exists in the north-eastern side to which the access way also contributed. In the south-east the cornice is continuous being the highest in the area. On the slope the active processes of the areal erosion are represented by land slides and collapses, from which the most developed has already entered the lake’s water. The linear erosion is active through the numerous cloughs of diferrent dimensions. A similarly abrupt, but much shorter, limits the depression in the south-western part. Above it there is a small wood that restricts the retreat. The north western limit has two distinct parts. In the shortest one a micro valley of erosion was developed, on which the draining in torrential beat transports large quantities of deposits into the lake, forming a strong peninsula. The other side is crossed by different forms of the linear erosion, but there are also mass movements of small dimensions. In a part the abrupt approaches the margins of the forest. Besides these processes there are also obvious the alteration and erosion processes in the aerial domain; they contribute to the general draining of the area.

The two parts of the depression are separated by a less obvious abrupt. From the smaller part starts a torrential organism, in parallel with the one from the north-western limit, having a strong deposits transport. It leads to the formation of another peninsula in the lake. The two peninsulas will soon be joined, they will close the already almost blocked gulf and will separate a part of the lake, decisively contributing to the retreat of the water surface.

The areal and lineary transport of the deposits in the lake basin as well as the renewal of the deposits by the mechanical movements of the water intensively contribute to reducing the depth, developing the vegetation, the appearance of the eutrophic processes, thus to the regression of the physical, chemical and biological qualities of the lake's water.

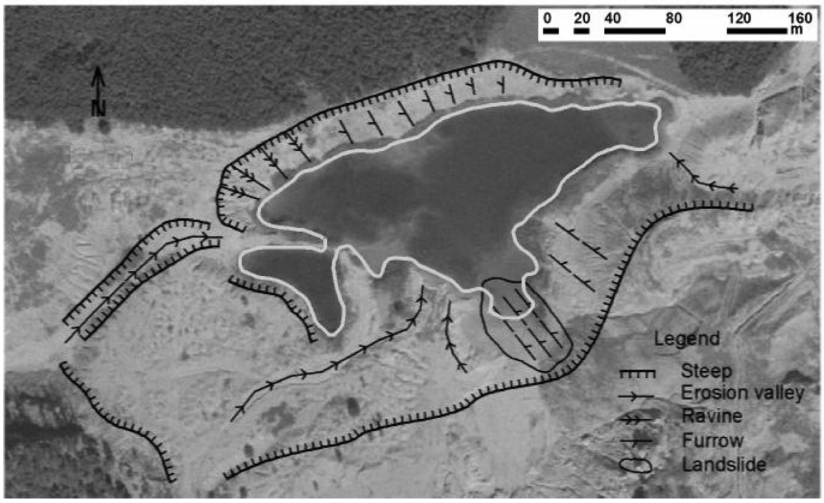


Figure 1. The geomorphologic processes active in the microdepression.

The microdepression is almost 500m long and over 200m wide resulting into an approximative surface of 100000 m^2. The lake's dimensions excluding the gulf, that is almost separate, are as follow:

-the surface of the water: 22000 m^2
-the water volume: 50000 m^3
-the length: 255 m
-the width: 132 m
-the maximum depth: 7 m

The Climatic Conditions in Shaping the Lake. In a negative relief form a lake is formed if the depression has no infiltration conditions, if the water supply is rich enough and if the potential evaporation is not larger than the quantity of rain water (Fodorean 2007). In the Blue Lagoon depression the kaolinous bed that is the connection between the sands, forms a relatively water-proof coverage through which the losses by infiltration are insignificant.

The multi-annual medium quantity of rain-water is 566 mm, calculated based on the data from the meteorologic stations from Cluj and Huedin. The medium number of rainy days is 130-140. The split of rain quantities is not even, the regime curve having the shape of a pyramid, growing until June and followed by a decrease until November. The maximum monthly value registered is in June (87 mm) while the minimum is in February (23 mm). The most rainy season is summer, that leads to a decrease in the number of hot days, thus the quantity of water evaporated.

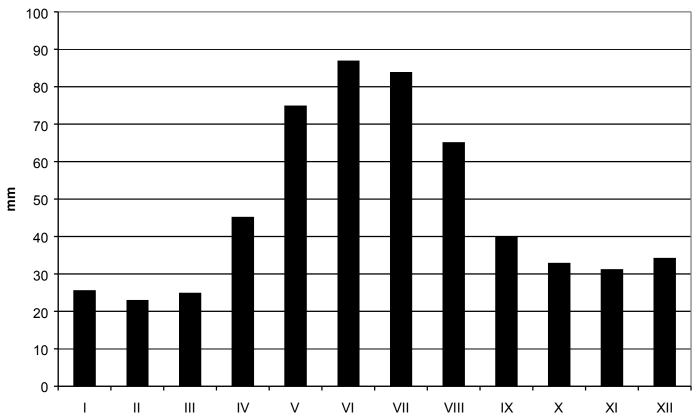


Figure 2. The raining conditions.

The high intensity rains take place from the west-northern direction, on the Nadăş Valley. The rains lead to areal and concentrated torrential drainings. The water infiltration leads to land slides on the versants where the soil is not stabilized by vegetation. The climatic droughts are not frequent and last for maximum 10-20 days, at the end of the summer.

The rain quantities and their temporal split allows the accumulation of a sufficient quantity of water to ensure the existance of the lake.

The medium annual temperature is 8.4 ^{o}C, in the most hot months approaching to 20 ^{o}C while in January is almost -4 ^{o}C. The hot days are important for the existance of the lake, in what regards the determination of the evaporation. Thus the number of days with medium temperatures over 30 ^{o}C is 14-17 per year, registered during the months of July and August. The hot days are not that frequent as to determine special intensities of the evaporation from the surface of the lake.

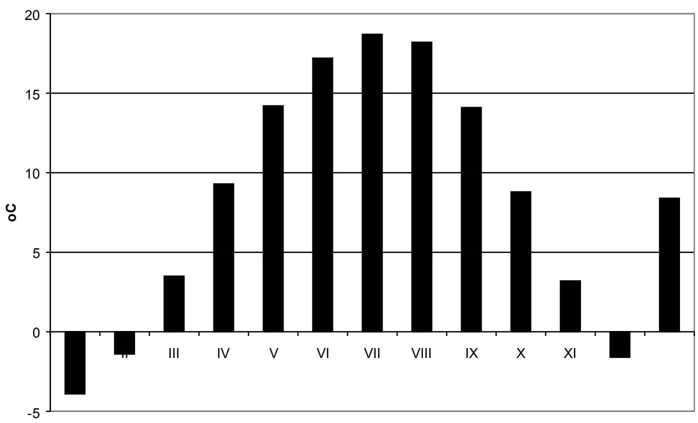


Figure 3. The temperature conditions.

Materials and Methods. With the purpose of re-evaluating the state of the environment in the Blue Lagoon expeditionary measurements were organized in the summer of 2009. They repeated the determinations made in the previous year and extended over other parameters as well.

Firstly a detailed geomorphologic charting of the depression was performed, setting on map the position of each process and microform of relief. Then the measurements referring to the physical-chemical parameters of the lake were repeated. For this operation were used the multiparameter HI 9828 analyses and turbidimeter HI 98713 case. The determinations were made in several characteristic points at the surface of the lake and at different depths (Roșu 2007).

Figure 4. The Blue Lagoon.

Results and Discussions. The water lake parameters present a spacial-temporal variety due to the natural agents: the geologic stratum, the climatic, the geomorphologic and vegetation conditions that influence the hydrologic and thermic conditions of the water. In time, most changes of the quality of water have as support the internal processes.

Table 1

Pozition of the reference points for trials

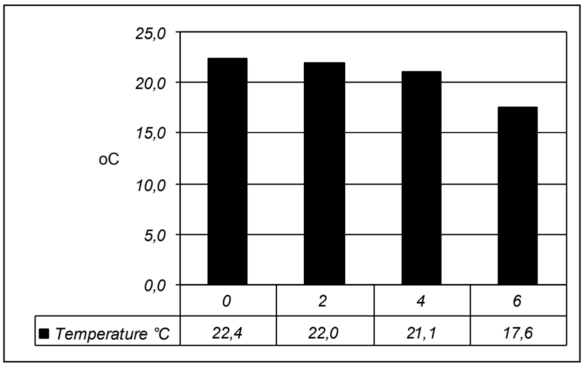
The sampling vertical	*Position*		*The depth of sampling (m)*			
	Lattitude N	Longitude E				
1.	46.89011	23.29229	0	2	4	6
2.	46.89008	23.29135	0	2	4	6
3.	46.88969	23.29062	0	2	4	4.3
4.	46.88974	23.29010	0	2	4	5
5.	46.89036	23.29080	0	2	4	6

The physical and hydro-chemical description of the Blue Lagoon water

The physical markers of the water

The variation of the water temperature is directly related to the thermic variations of the air above the lake. Within this experiment the variations of the temperature on the vertical were followed in the 5 sampling verticals indicated in table 1. From the analysis of the trials from the surface results an insignificant variation of the temperature, the values being almost identical. This is due to the relatively reduced dimension of the lake. In what regards the tendency of the temperature values on the vertical this indicates almost linear decreases in verticals 3 and 4, as well as stronger decreases between the last 2 points of sampling in verticals 1, 2 and 5 (Figure 5). The differences between the surface temperatues and those from the basin of the water range between 2.9 ^{o}C in vertical 3 and 5.6 °C in vertical 5 (Figure 5).

The water turbidity is influenced by the concentration of the substances dissolved and the substances in suspension. The samples used for the evaluation of the turbidity were taken from the five points of sampling, at the surface of the lake. The values determined are high to medium, taking into consideration the fact that in the hot season the turbidity is higher due to the torrential rains that wash the versants of the basin. In comparison to the sampling site no significant variations were discovered, slightly rangig between 22.5-33.0 g/m^3 (Figure 6).



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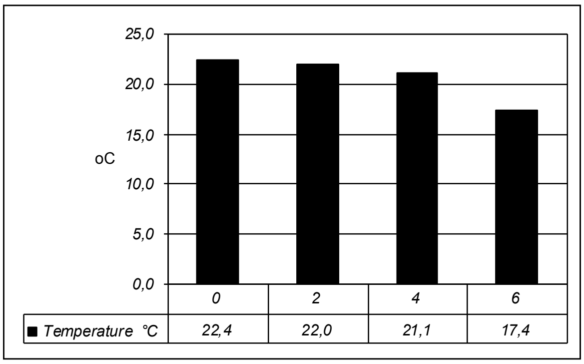

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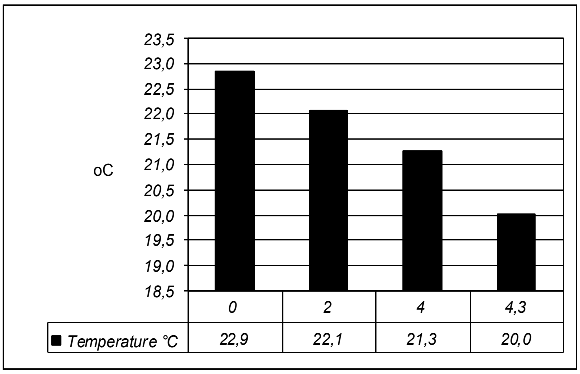

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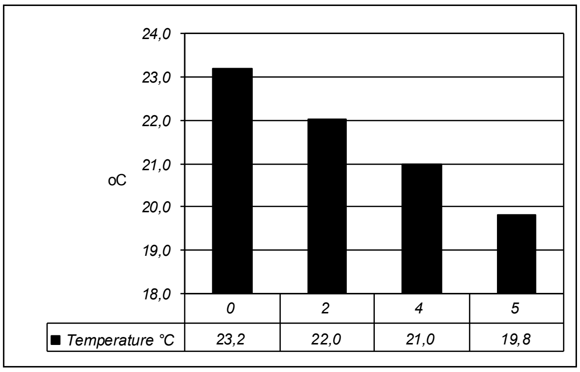

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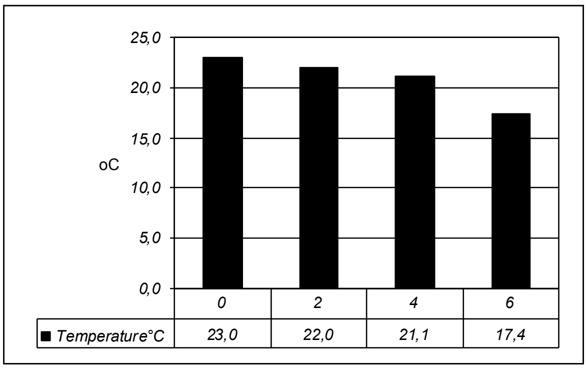


e. Vertical 5

Figure 5. The variation of the temperature values amongst the 5 verticals.

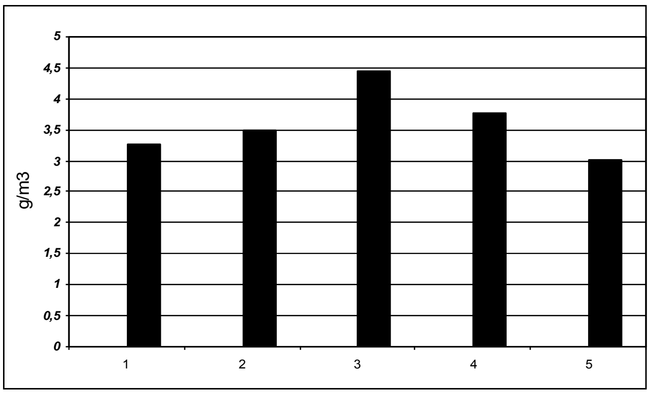
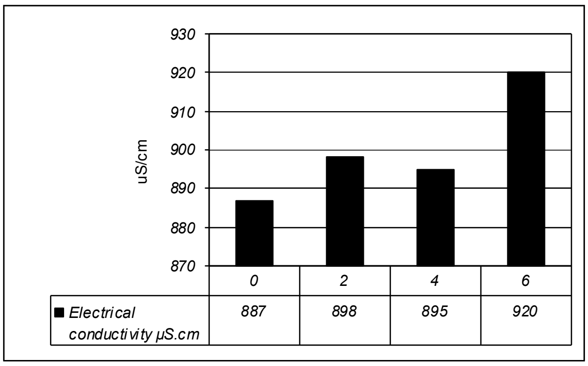


Figure 6. The variation of the values of turbidity.

The electric conductivity. The values of the electric conductivity revealed a medium level of the concentration of dissolved salts. The determinations were made on trials sampled from the surface of the water and three levels in depth. The values of the conductivity at the surface varied between 884-894 µS/cm, being the lowest from all the sampling points. In depth the conductivity increases in all cases as a consequence of the charging with dissolved salts. In all the verticals the maximum values were registered in the deepest sampling points. The variation gap here was between 898-920 µS/cm. The differences between the conductivity in depth and that from the surface are around 30 µS/cm in verticals 1,2, 5, and 4 µS/cm in vertical 3, respectively 15 µS/cm in vertical 4. More important leaps between the lake basin and the points from above are noticed in verticals 1,2, and 5. It is interesting to notice that in all verticals the value from a 2 meters depth is higher or equal to 4 m (Figure 7).



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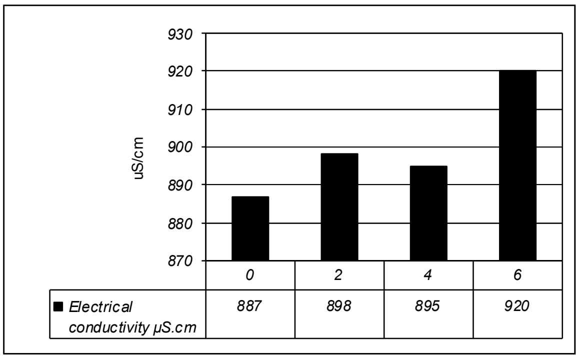

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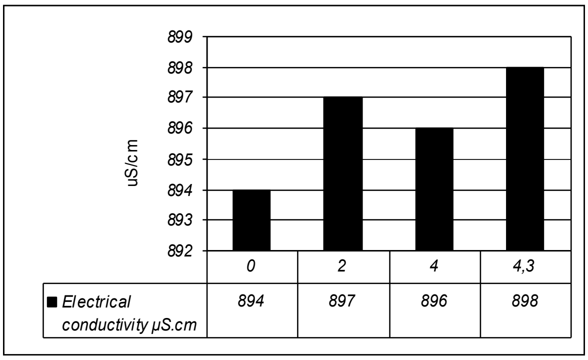

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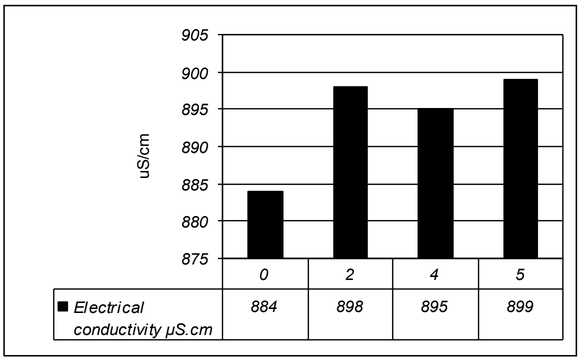

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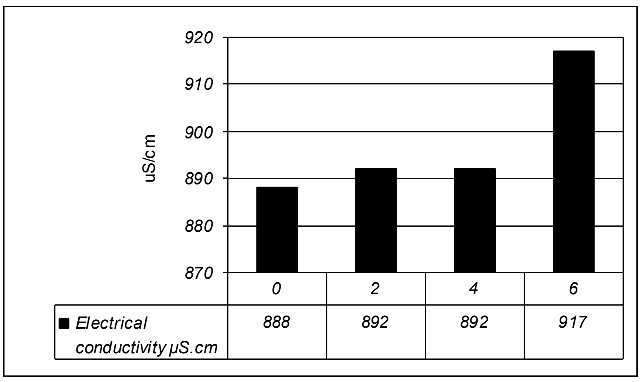
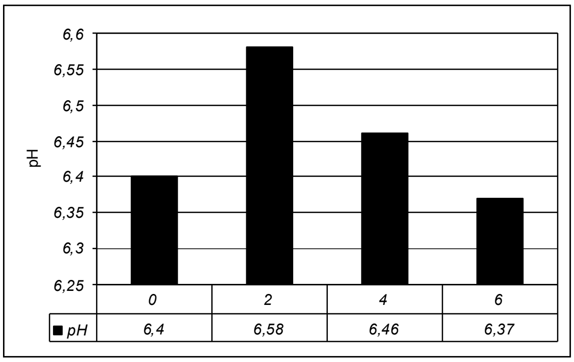


d. Vertical 5

Figure 7. The variation of the electric conductivity values amongst the 5 verticals.

Hydrochemical characteristics. The main factor that determins the composition and the chemism of the water lake is the petrography, the surface washes on the versants, as well as the the morphologic and morphometric particularities of the lake basin.

The concentration of the hydrogene ions. The concentation values of the hydrogen ions are relatively small. They are due to the waters coming from the mining exploitations as well as from the natural washing of the stock-piles. The tendencies of variation of the pH according to depth are diminishing in verticals 2,3,4 and 5. There is an exception for vertical 1, where the maximum value is registered at a depth of 2meters, instead of at the surface. The highest pH (6.76) was measured at the surface of the vertical 1, and the lowest (6.34) in depth in vertical 5. The maximum gap of decrease, of 0.35, is in vertical 1. The lowest values of the pH lead to the decrease of the oxygen quantity from the water, and consequently to the deterioration of the life conditions for the aquatic organisms (Figure 8).



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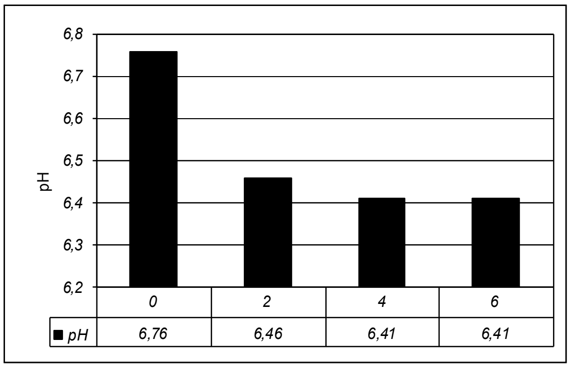

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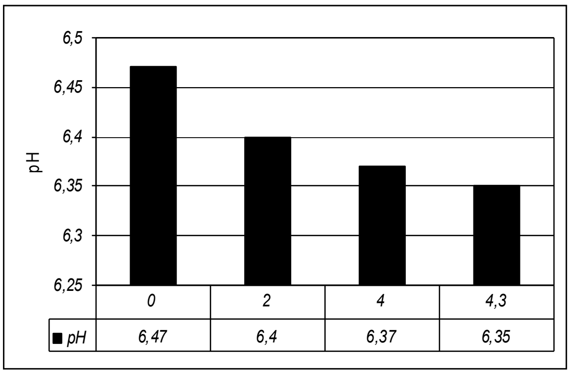

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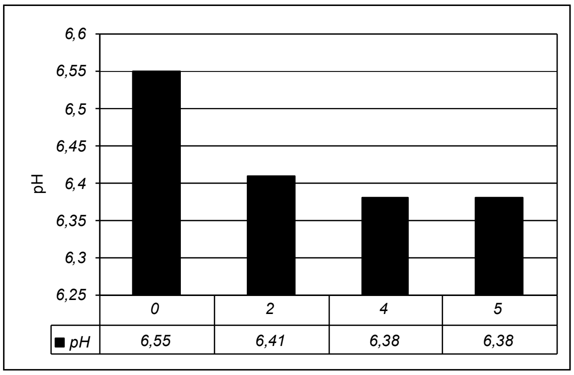

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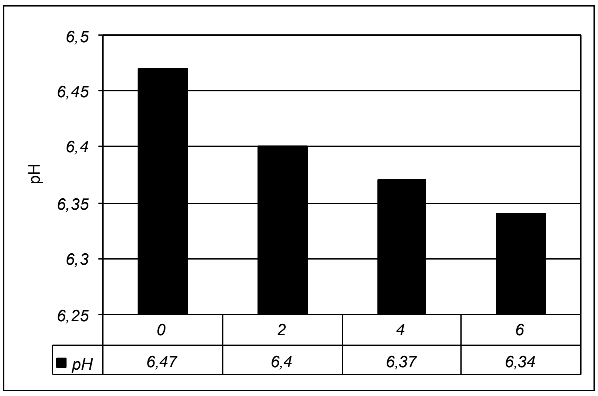
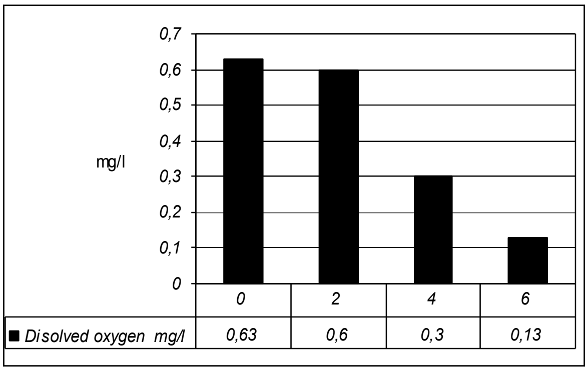


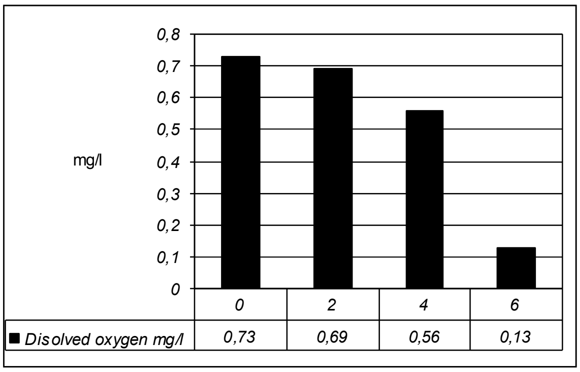
e. Vertical 5

Figure 8. The variation of the pH values amongst the 5 verticals.

The dissolved oxygen. The analysis of the values obtained in the 5 verticals indicate low quantities of dissolved oxygen. The maximum values were registered at the surface of the water, from where they decrease towards depth in all the verticals. The oxygen concentration is maximum in vertical 4, both at the surface (1.7 mg/l), as well as in depth (1.0 mg/l). The maximum gap (1.0 mg/l) of variation was measured in vertical 1, while the minimum (0.10 mg/l) in vertical 3. The trend of decrease of the dissolved oxygen is almost linear in verticals 4 and 5. In verticals 2 and 3 a discrepancy between the values from the bottom of the lake and those from the surface can be noticed (Figure 9).



a. Vertical 1



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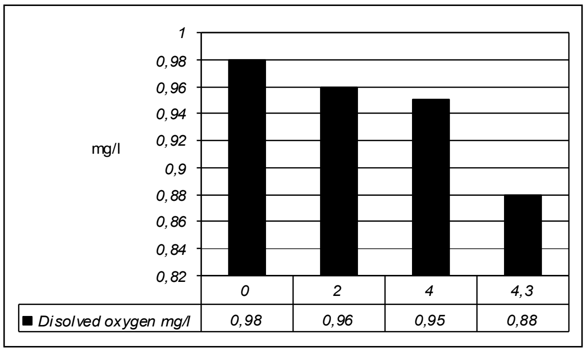

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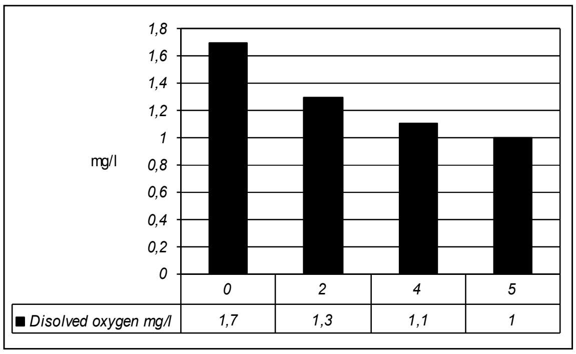

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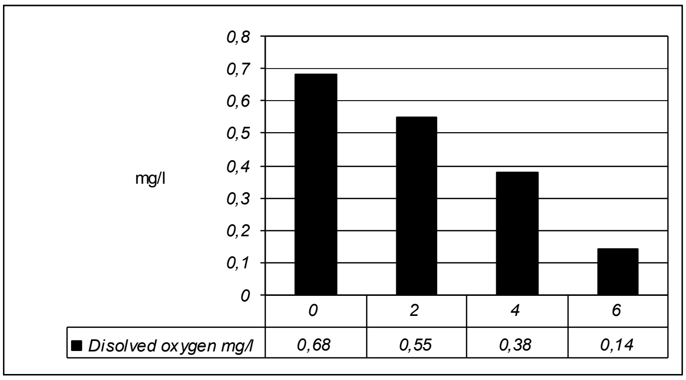
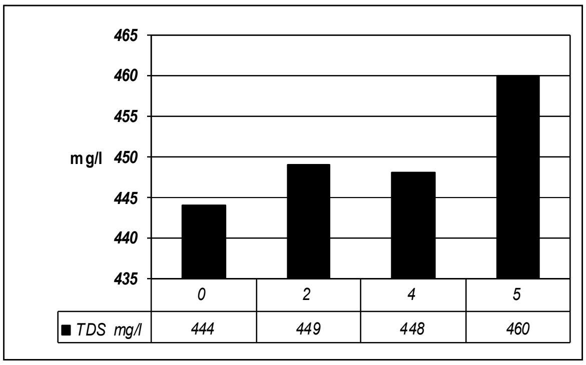


e. Vertical 5

Figure 9. The variation of the dissolved oxygen values amongst the 5 verticals.

The degree of mineralization varies within normal limits. The dynamics of the natural water due to the wind and the artificial one due to the touristic activity, leads to the relative homogenization of the mineralization, within a relatively small lake basin. The general tendency is of increase of the mineralization towards depth. This phenomenon is more obvious in verticals 1, 2 and 5. In verticals 2 and 3 at a depth of 2 m the values of the mineralization indicate a leap. The highest value of the mineralization degree is of 460 mg/l in vertical 1, and the lowest of 442 mg/l in vertical 4. The maximum gaps are indicated in verticals 1 and 5: 16 mg/l, respectively 15 mg/l. The gap is very small, only 1 mg/l, in vertical 3 (Figure 10).



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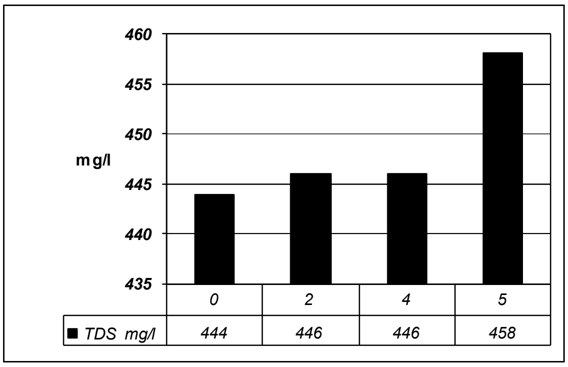

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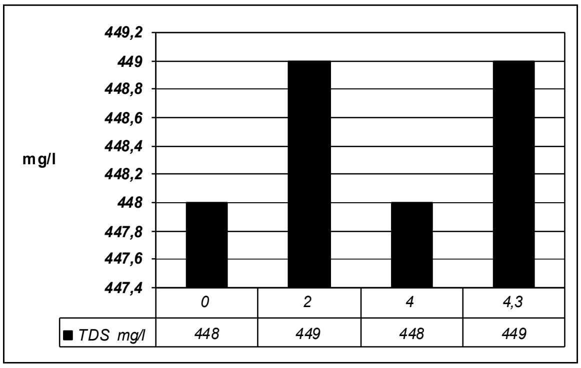

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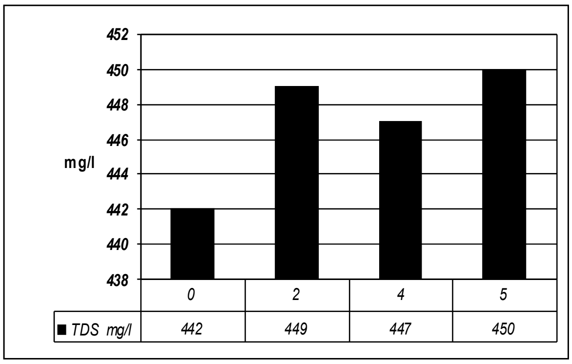

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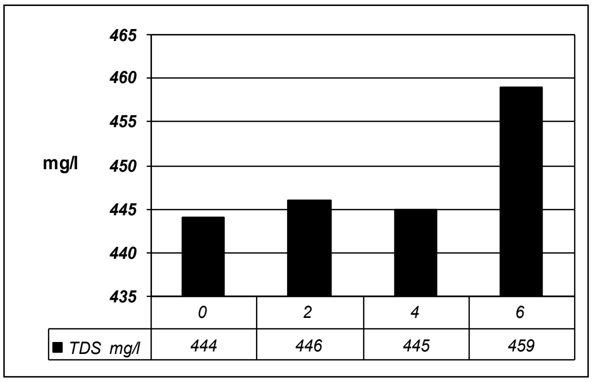

d. Vertical 5

Figure 10. The variation of the mineralization degree values amongst the 5 verticals.

The comparison of the measurements between years 2008 and 2009. In order to underline the evolution of the quality of the lake water some parameters measured in 2008 are compared with similar parameters from 2009. In these 2 years that we are talking about the measurements were made during summer in similar topoclimatic conditions.

The temperature from the surface of the water is higher than in 2009. Generally the positive deviation is below 1 ^{o}C, however in vertical 4, the warmest, it reaches to 1.4 ^{o}C. In the basin the situation is viceversa. In 2009 the temperatures are lower with a few degrees. The closest temperatures are in verticals 3 and 4, only 0.9 ^{o}C, respectively 1.2 ^{o}C. These variations are due to a shorter but more sudden period of warmth in 2009. Due to this fact the upper water layer was more heated, but the speed of the phenomena did not allow the heat waves to infiltrate to the lower layer (Figure 11).

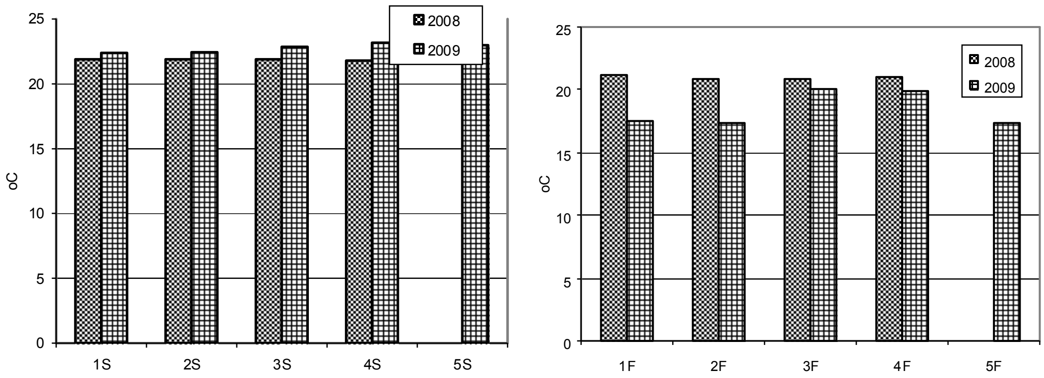

Figure 11. Comparison of the temperature values
at the surface and at the bottom of the lake.

The electric conductivity is not significantly different in the 2 years. In 2009, both at the surface as well as in the basin the values are slightly lower than is the previous year. The deviation percentages are not higher than 5 %, on any of the verticals. The quantity of dissolved salts from the water has not significantly changed which also results in the very similar values of the conductivity.

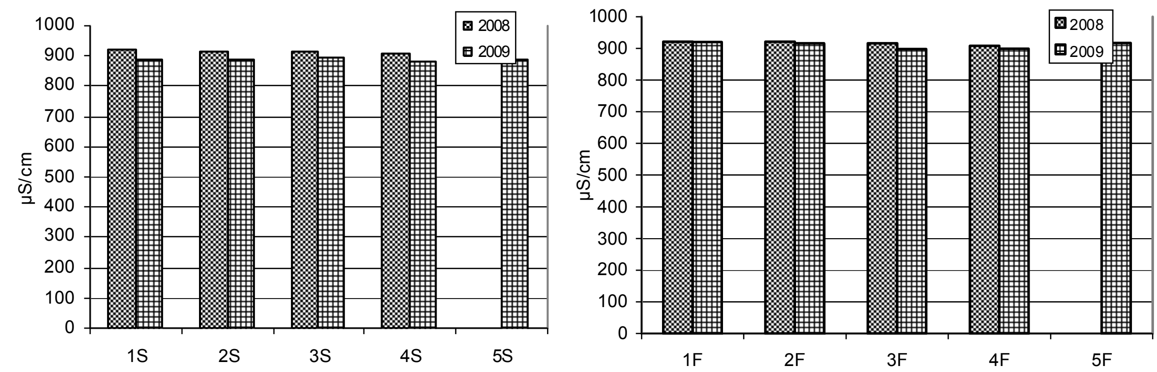

Figure 12. Comparison of the electric conductivity
at the surface and in the basin of th water.

The concentration of the hydrogen ions is more uniformely split in 2009 than in the previous year. Surely the differences are not that large here either, but a slight increase of the values on all the verticals can be noticed. If in 2008 the values were below 6.0, in 2009 they all vary between 6.0 and 7.0. In both years the general rule of slight decrease of the pH value in depth is maintained (Figure 13).

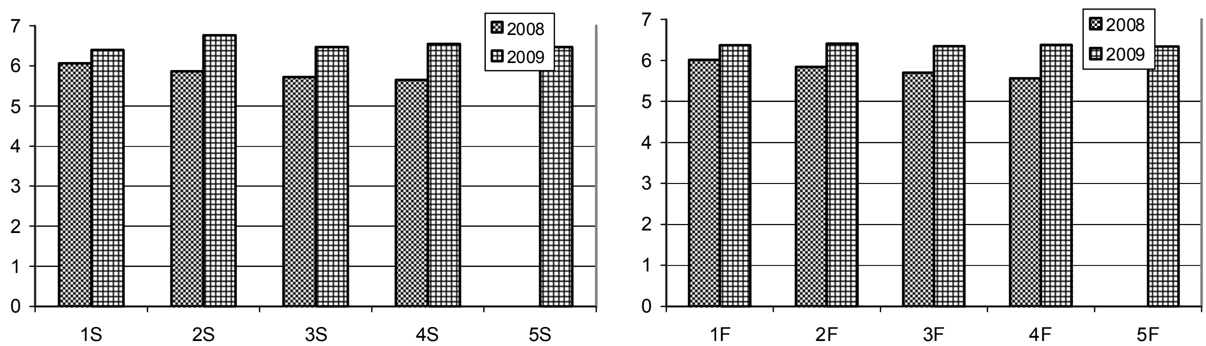

Figure 13. Comparison of the ph at the surface and in the basin of the lake.

The dissolved oxygen indicates large variations both between different verticals as well as from year to year. The numerous inffluencial factors are reflected in the value variance. However in 2009 the gap of variation was lower than in 2008. The sudden heating previously mentioned led to the general decrease of the values in 2009. It is worth remembering that in both years the maximum values were registered in vertical 4, and the minimum in verticals 1, 2 and 5, both at the surface as well as in the basin of the lake (Figure 14).

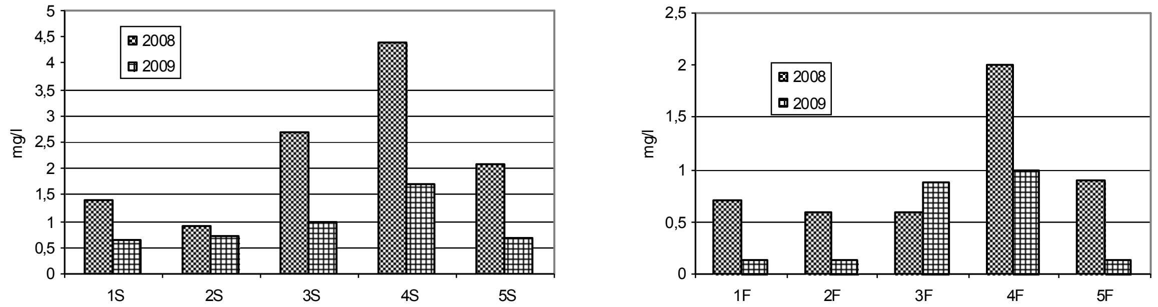

Figure 14. Comparison between the dissolved oxygen concentration at the surface and in the basin of the lake.

Conclusions. The characteristics of the water from the Blue Lagoon vary according to the local geologic, geomorphologic, climatic and antropic agents. Between 2008 and 2009 most of the factors remained slightly different.

Thus some parameters of physical chemical quality were modified within narrow boundaries. The observation is valid both for the values from the upper layer of water as well as in the basin of the lake water. The most obvious changes are noticed in the case of dissolved oxygen. Even if the natural laws of variation are respected, the values from 2009 are significantly lower than those in 2008.

The decrease of the dissolved oxygen concentration has direct impact upon the quality of the lake water including what regards the aquatic life.

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