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THE ECOLOGICAL CHARACTERISTICS OF THE ROMANIAN LITTORAL LAKES – THE SECTOR MIDIA CAPE - VAMA VECHE

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Abstract

In the present study we have taken into account only the lakes between Midia cape and Vama Veche, and only those that have directly communicated with the sea. As origin, the littoral lakes from the south-eastern part of the Black Sea are of three categories: fluvio-marine (Corbu - Gargalâc, Taşaul, Tăbăcariei, Agigea, Techirghiol, Costineşti, Tatlageac, Mangalia); lagoons (Siutghiol, Comorova, Hergheliei - Mangaliei Moor); man-made (Belona, partially Costineşti, the three lakes of the Comorova complex and Hergheliei). The littoral lakes, due to their geographical position and to the climatic conditions of the area, are subject to water salinization processes. In the last period, as a consequence of the economical activities specific to agriculture, the freshwater input has been supplemented, and thus it begins to be felt a strong phenomenon of water freshening. The phenomenon must be stopped in the case of the lakes that accumulate therapeutically mud (Agigea, Techirghiol). In the case of the other lakes the water may be used, where is needed, in irrigations (Corbu -Gargalâc, Tasaul etc.) or for fish hatching (Corbu -Gargâlc, Taşaul, Tatlageac, Mangaliei). In the case of the lakes created for recreation, the water's salinity degree is not so important (Belona, Costineşti, Neptun, Jupiter, Tismana, Venus).
Keywords: lake, the physico-chemical properties, littoral, Blak Sea.

1. INTRODUCTION

For the present study we have taken into analysis the physico-chemical properties of the littoral lakes between Midia Cape and Vama Veche. In fact, these are the lakes of the abrasive sector of the Romanian littoral.

In the category of the littoral lakes some authors (Gâştescu, 1971, Breier, 1976) include and the lagoon complex Razim-Sinoie. In the present paper this complex will be

analyzed separately, because the geographical position and the water physico-chemical characteristics strongly differ from those situated in the southern sector of the Romanian littoral. This complex may be included, from a genetic and hydrologic viewpoint, in the Danube Delta (Gâştescu 1976, 1992, 1993, 1997, 2006, 2008).

The lakes studied include the lacustrine complex Corbu (Gargalâc) – Taşaul – Siutghiol - Tăbăcăriei and the Agigea, Belona, Techirghiol, Costineşti and Tatlageac lakes; and the Comorova complex (three man managed lakes - Venus, Hergheliei, Mangaliei (Figure 1).

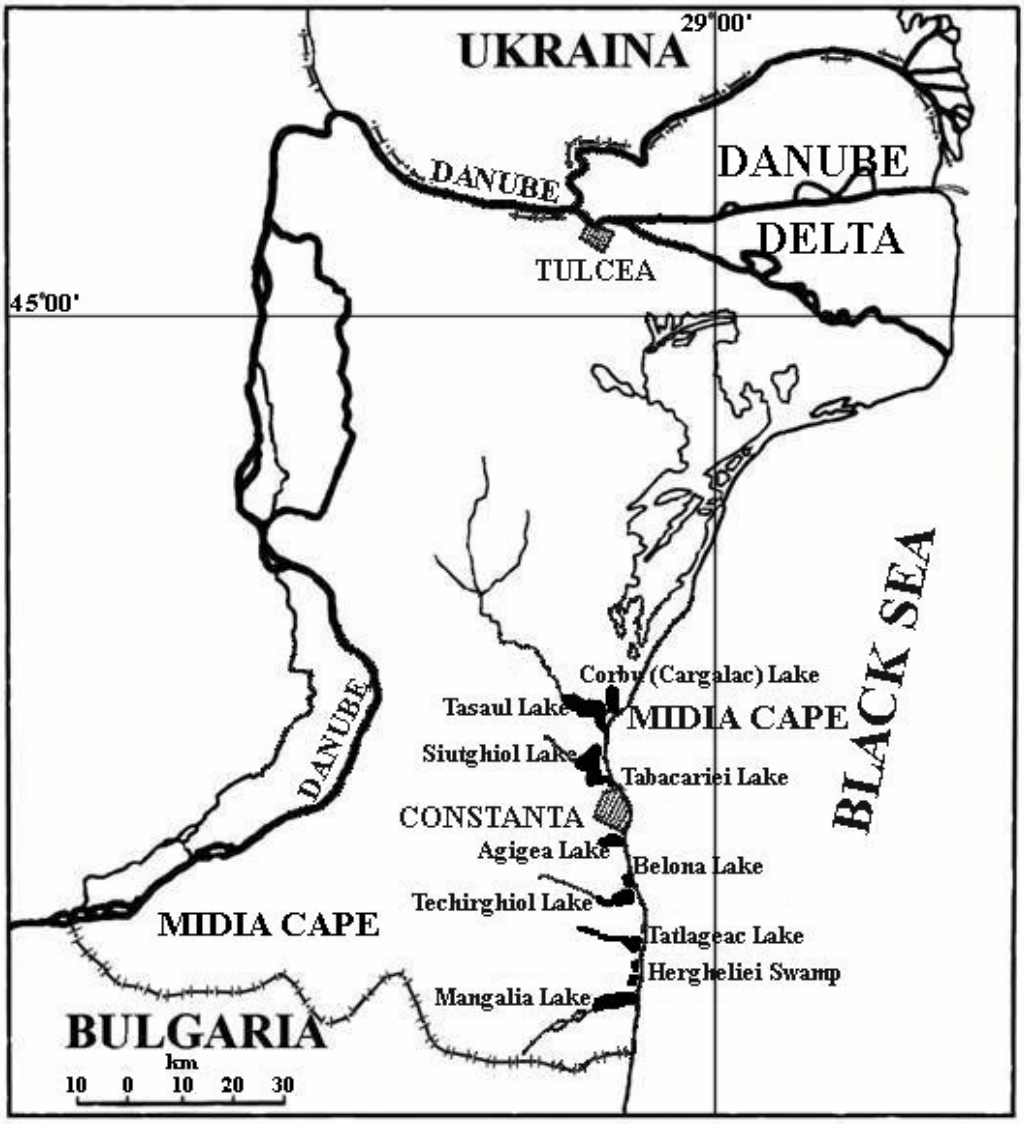

Figure 1 The geographical location of the littoral lakes from the abrasive sector of the Black Sea (Romania)

From a genetic point of view, the Black Sea littoral lakes occurred as a consequence of the marine abrasion and accumulation. They owe their apparition to the recent paleo-geographical evolution, specific to the adjacent marine basin. They depend on the variations of the marine level, and on the local epeirogenesis movements. Their evolution may be separated in three stages: the valley stage (during Neoeuxin, when the sea's level was 80 m lower than the present one), the gulf stage (when the sea level was 3-5 meters higher than the present one), ant the lake stage (specific to the historical times, most probably the half of the first millennia AD, when the conditions occurred for the formation of the sandy belts.

As genesis, the littoral lakes form the south of the Black Sea Romanian littoral are separated into three categories: fluvial-maritime lakes (Corbu-Gargalâc, Taşaul, Tăbăcăriei, Agigea, Techirghiol, Costineşti, Tatlageac, Mangalia); lagoons (Siutghiol, Comorova, Hergheliei); artificial lakes (Belona, partially Costineşti, the three lakes of the Comorova complex, Venus and Hergheliei).

Because of the fact that the lagoons are situated on valleys, the slopes are high and the general form of the lake is elongated. The upper stream sectors present accumulative formations such as alluvia cons, frequently vegetation covered. They often present a sinuous form. The lagoons, similar to the previous, are flanked by high calcareous slopes, while the demarcation to the sea is done by low and often unstable sand cordons. The artificial lakes have been constructed on old basins partially or completely clogged, in a recreational purpose.

Although Dobroudja presents the highest aridity index from Romania, (K= Zmm/Pmm) – 2.2 (Ujvari, Gâştescu, 1958; Donciu, 1959; Breier, 1976), on the littoral there are many lakes that owe their existence to the geomorphologic and hydrologic factors specific to the littoral.

For the majority of the littoral lakes the hydrographical network input is low. The flow character imprints them some regime particularities. In our case remarkable is only Casimcea River, which charges the Taşaul Lake, and Corbului stream, which flows into Corbul-Cargalâc Lake. The majority of the rivers from southern Dobroudja have a temporary character, with very high level and discharge variations.

The littoral lakes are alimented from the precipitations that fall directly on their surface, from the superficial flow of the drainage basin and from subterranean sources. According to the climatic characteristics of the southern littoral, the lakes have acquired an azonal feature. In this case the alimentation may have a supplement source that may be assured by an inflow from outside the superficial reception basin, meaning a rich subterranean alimentation facilitated by the favorable litologic and tectonic conditions (carstifiable rocks and many fractures and fissures).

The alimentation of the lakes is related and to the dimension of the reception basins of each lake.

Table 1 The coefficient of the lake surface

Nr.	Lake	Genetic type	Surface km^2		The coefficient of the lake surface	
			Lake (f_o)	Reception basin (F)	$K=f_o/F$	$K=F/f_o$
1	Corbu (Cargalâc)	Littoral lake	5.20	64.25	0.081	12.1
2	Taşaul	Littoral lake	23.35	830.70	0.028	36.0
3	Siutghiol	Lagoon	19.00	71.65	0.26	3.88
4	Tăbăcăriei	Littoral lake	0.98	9.56	0.10	9.75
5	Agigea	Littoral lake	0.65	39.25	0.016	61.5
6	Techirghiol	Littoral lake	11.61	160.00	0.072	13.8
7	Costineşti	Littoral lake	0.07	21.25	0.003	303.5
8	Tatlageac	Littoral lake	1.38	144.00	0.009	104.3
9	Mangalia+ Hagieni	Littoral lake	3.11	784.00	0.004	252.0

2. THE HYDROCHEMICAL CHARACTERISTICS

Initially, the littoral lakes have communicated with the sea, and the waters were identical or even saltier than those of the Black Sea. In time, their hydrochemical evolution has been guided by the continental alimentation, by the maintenance or interruption of the connection with the sea and by the conditions of lake water freshening. The salts alimentation sources coincide with those of water inflow. A secondary mineralization source in represented by the salts contained in the marine deposits from the bottom of the previous gulfs, those around the lakes, but also by the particles existent in air and transported by winds (Gâştescu 1971, Breier, 1976).

A common alimentation source for all the lakes is rainfall. They contribute to water dilution, especially in the small lakes. The littoral lakes between Midia Cape and Vama Veche are alimented mainly subterranean and are loaded with different elements washed from rocks. Foe the chemical evolution we must held in mind the communication of the lakes with the sea, as well as the direction of this communication. The lakes of positive water balance generally present a flow towards the sea; those of negative or neutral balance receive at the sea level or under, temporarily or permanently, salted marine waters. The index of sea communication depends on the morphology of the littoral belts. The salted marine waters flowed into all the littoral lakes, while today this phenomenon is specific only to the Techirghiol, Costineşti and Mangalia lakes. In the lakes with irreversible flow to the sea occurs a permanent elimination of the salts. The intensity of the process depends on the quantity of water flowed from the lakes, which nowadays is human-controlled. This is specific to the Corbu (Gargalâc), Taşaul, Siutghiol and Tăbăcăriei lakes. Practically, this lake system is controlled through hydro-technical conditionings.

In the lakes with flow towards the sea water is lost exclusively through evaporation, having place a process of intense salt accumulation. Salts can be eliminated through wind or through water sampling in different purposes (irrigation, balneotherapy, animal drinking, mud exploiting etc). The phenomenon occurs in the Agigea, Techirghiol, Costineşti and Tatlageac lakes. Nowadays, the chemistry of the lake waters is strongly influenced by the human activities, especially through irrigations. In this case we have to analyze the evolution of the hydrochemical characteristics from the initial phase till the actual.

Regarding the evolution of the hydrochemical characteristics of the littoral waters have been edited many papers, some of them of a medical thematic: Bernard, 1890; Saligny, Georgescu, 1893; Brătescu, 1928; Petrescu, 1924, 1927-1928; Crasu, 1925,1928,1935; Trandafirescu, 1931; Cernătescu, 1933-1934; Grimalschi, Hohor, 1937; Ziemiankovski, 1951; Teodorescu-Leonte et al. 1956,1960; Ţuculescu, 1965; Bondar, 1965; Gâştescu, 1971; Breier, 1971,1976 etc.

Adjacently are mentioned, as secondary ecological indicators, the electric conductivity, pH, tension and dissolved oxygen. All the measurements data are from the summer of 2004.

For the present study we had in view the most important parameters of the littoral waters: the chemistry and the total content of dissolved salts (TDS).

The Black Sea waters at Mamaia have a salinity of 16.6 g/l, higher than those in north, but lower that than of the southern waters.

The Corbu (Gargalâc) lake is alimented by the Corbului and Valea Vetrei rivers. In this case the water chemistry is influenced by the water inflow from different sources, by year period, by water extraction for different time intervals. This case is also available for all the littoral lakes between Midia Cape and Vama Veche.

Table 2 Physico-chemical parameters of the Black Sea water at Mamaia

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
16.6 Mezohalin	28	28	8.25 Alkaline	71.4	6.75	80.6	159

The salinity of Corbu (Gargalâc) lake has evolved in the following manner: 1957 - 3.1 g/l; 1970 – 1.7 g/l; 2004 – 2.0 g/l. The fact that the lake is somehow isolated from the Taşaul and Siutghiol lakes has favored a relative preservation of the inherited salinity, between 2-3 g/l. This is the lake that suffered the weakest salinity variations.
At the moment the lake is used for fish and a part of the water for irrigations.

Table 3 Physico-chemical parameters of the Corbu (Gargalâc) lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
2.0 Oligohalin	44.0	4.4	9.10 Alkaline	119.8	5.86	11.4	22.8

Table 4 Physico-chemical parameters of the Taşaul lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
0.6 Oligohalin	1541	1541	9.12	122.6	5.14	14.7	30

Taşaul Lake is alimented by the Casimcea stream and secondarily by other streams of low dimensions and temporary character (Dalufac, Dalufacul Mic, Valea Adâncă, Caracvila). The salinity has evolved as following: 1906-1907 – 25.63 g/l; 1924 – 30.09 g/l; 1927 - 25 g/l; 1928 - 10 g/l; 1957 – 2.4 g/l; 1970 – 1.5 g/l; 2004 – 0.6 g/l. The construction of the Taşaul-Siutghiol pipe has led to a strong decrease in water concentration. A big part of the continental waters comes from irrigations, through the subterranean inflow, and more rarely through the surface waters. The water surplus that comes from the Siutghiol Lake is fresh compared to the old inheritance of the lake.

Table 5 Physico-chemical parameters of the Siutghiol lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
1.1 Oligohalin	248	2.42	8.87	106.4	5.20	15.3	30.4

The streams that flow into the **Siutghiol** Lake are of small dimensions and of temporary character. The most important alimentation way is the subterranean one. For the Siutghiol lake very important is the sampling place, because at water salinization contributes two factors, continental and marine. In this case, for the same water body the fluctuations are may be quite high. On years, the salinity varies in low limits: 1933 – 0.5 g/l; 1957 – 0.5 g/l; 1960 – 0.7 g/l; 1961-1.0 g/l; 1963 – 1.0 g/l; 1969 – 0.9 g/l; 2004 – 1.1 g/l. The mineralization of the lake waters is close to those of the streams that flow into them. The littoral cordon with friable substratum favors the inflow of marine waters in certain

conditions, which complete the water deficit from the Corbu (Cargalâc), Taşaul and Tăbăcăriei Lake.

Table 6 Physico-chemical parameters of the Tăbăcăriei Lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
0.7 Oligohalin	1659	1659	9.60	150.3	4.4	255	215

It does not present a properly reception basin. The **Tăbăcăriei Lake** has the same alimentation characteristics as Siutghiol Lake. Through a system of channels Tăbăcăriei Lake is connected with Siutghiol. It is conditioned for recreational activities. The salinity evolves in relatively low parameters: 1933 – 0.5 g/l; 1957 – 0.8 g/l; 1961 – 1.4 g/l; 1963 – 0.8 g/l; 2004 -0.7 g/l.

Table 7 Physico-chemical parameters of the Agigea Lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
1 Oligohalin	14	2.22	9.10	119.1	6.47	18.3	37

The Iuncatan, Agigea rivers aliment in a very small measure the waters of the lake. The most important inflow is the subterranean one, through fresh water streams. The reed formations occur at the end of the lake, near the inflowing river. The substratum is formed from a diluvium with limestone boulders. Agigea lake has supported the largest salinity variations: 1929 - 52 g/l; 1963 – 6.9 g/l; 1969 – 2 g/l; 1970 – 1.9 g/l; 1972 – 1.5 g/l; 2004 – 1.0 g/l. The high salinity from the past has favoured the formation of the therapeutic mud, whose fabrication is stopped at the moment.

Table 8 Physico-chemical parameters of the Black Sea at Eforie Nord

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
17.2 Mezohalin	29	29	8.32 Alkaline	71.4	6.89	10.7	21.8

The waters of the Black Sea at Eforie Nord have a salinity of 17.2 g/l, value close to the average of this basin, but higher than those of the northern sector.

Table 9 Physico-chemical parameters of the Belona lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
2.2 Oligohalin	16	4.27	9.11 Alkaline	119.8	5.84	11.1	22.5

Belona Lake has lower dimensions and is connected to a series of channels that influence its level and salinity. The relation with the sea is done by subterranean waters flow. The lake's level in 0.65m above the sea. The salinity varies frequently according to the complexity of the factors: 1969 – 17.3 g/l; 2004 – 2.2 g/l. The higher initial level shows that the lake has a subterranean or artificial alimentation.

Table 10 Physico-chemical parameters of the Techirghiol lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
65.1 Hiperhalin	92	92	8.40 Alkaline	77.7	5.63	8.1	16.4

The Muratan, Dereaua, Izvoarelor streams bring a low water inflow from precipitations. Techirghiol is the lake that suffered the most important level variations and implicitly of salinity. The proof of the level variations is given by succession of abrasive lake terraces. During time the salinity of these waters has varied between very large limits: 1893-71.6 g/l; 1931-110 g/l; 1936 – 99.6 g/l; 1956 – 75.6 g/l; 1969 – 81.4 g/l; 1970-78.6 g/l; 197-1974 - 50 g/l; 2004 – 65.1 g/l. The water inflow from irrigations has determined the present freshening, which may be negative because the therapeutic mud is difficultly restored.

Table 11 Physico-chemical parameters of the Costineşti I lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
10.7 Mezohalin	205	17.96	9.99 Alkaline	170.9	4.45	96.2	193.4

It is alimented by the Cealac Dere stream. Through the limestone deposits situated under the surface loessoide ones transits a very important quantity of subterranean water. The old blocked lake has been converted into a recreational one, which haplessly is wrongly managed and the waters strongly eutrophiated. It comprises a system of two lakes, the upper stream one being isolated from the main basin. The upper stream lake is strongly clogged and totally covered with vegetation, and on the banks with reed and cat tail. In this case, the main lake has been named Costineşti I, and the lower stream one Costineşti II. The salinity varies between relatively high limits: 1963 - 27 g/l; 1969 – 17.1 g/l; 2004 – 10.7 g/l: the freshening of the water is due to the subterranean and urban inflow, strongly varying within seasons. Taking into account that the lake's waters have salinity close to that of the sea, it is considered that from this viewpoint the modifications are not radical.

The salinity of the Costineşti II Lake is reduced, because the surface continental alimentation and the subterranean one are dominant. Although close, the two lakes detain totally different salinity values. In the case of Costineşti II Lake, the clogging is high and the organic mud dominates. We only have one analysis data - 2004: 0.3 g/l.

Table 12 Physico-chemical parameters of the Costineşti II Lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
0.3 Fresh	1050	1050	9.10	118.2	3.16	37.3	76.6

Table 13 Physico-chemical parameters of the Tatlageac lake southern sector

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
1 Oligohalin	211	211	8.49 Alkaline	79.4	7.10	84.1	168.3

The main inflow is represented by the Tatlageacul Mic stream. In the upper stream sector of the lake has developed a prominent alluvial fan covered with hydrophile vegetation. A large part of the Tatlageac Lake suffered modifications through repeated closures on isolated sectors and their transformation in ponds. From this motive these areas evolve relatively different from the main lake. The isolated sectors, exposed to continental inflows, have a lower salinity. For the proper lake, with a very large opening to the sea, the situation is different and as a consequence the salinity is higher. Such a sector presents in 2004 a salinity of 1.0 g/l.

Table 14 Physico-chemical parameters of the Tatlageac lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
2.3 Oligohalin	50	4.36	8.71	96.8	5.83	71.4	145.5

The variations in chemistry vary between low limits: 1960 – 0.79 g/l; 1961 – 1.3-1.9 g/l; 1963 – 1.3-1.4 g/l; 1969 – 1.3-1.4 g/l; 1970 – 1.3 g/l; 1972 – 0.6 g/l; 2004 - 1-2.3 g/l. The clogging is high in the upper stream sector of the lake and the bottom is filled with Limnosols (organic deposits).

Table 15 Physico-chemical parameters of the Neptun lake (ancient Comorova swamp)

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
0.5 Oligohalin	1332	1332	8.82 Alkaline	101.3	7.50	111	223

Through conditioning, the Comorova swamps have been transformed into anthropic lakes with recreational purpose in the Saturn, Neptun and Venus resorts. The salinity of the Tismana, Jupiter and Neptun lakes has varied this way: 1970 – 1.3 and 1.0; 2004 – 0.5. These are lakes controlled by human and the influence of the sea has reduced as a consequence of the man-made conditioning. The Venus Lake presents similar values.

Table 16 Physico-chemical parameters of the Mlaştina Hergheliei (Mangaliei) Lake)

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
0.6 Oligohalin	1568	1568	8.85 Alkaline	103.7	5.1	193	270

The previous Hergheliei swamp has been transformed through adequate hydro-technical improvements into a lake, strongly covered in reed and cat tail. The salinity varies between reduced limits: 1906 – 0.9 g/l; 1935 – 1.3 g/l; 2004 – 0.6 g/l. The waters have

reduced depths and the vegetation is abundant. The organic soil is dominant and favours the development of wetland specific vegetation.

Table 17 Physico-chemical parameters of the Mangaliei Lake

Chemistry g/l	total content of dissolved salts TDS mg/l	Electric conductivity (µs/cm mS/cm)	pH	Tension U mV	Dissolved oxygen O_2		
					mg/l	%	mbar
13.3 Mezohalin	23	23	8.29 Alkaline	69.3	7.83	9.8	20.6

It is alimented by Albeşti stream. On its superior valley have been conditioned two lakes: Hagieni and Limanul. Mangaliei Lake has had a different evolution compared to the other homonyms. Its relation with the sea is limited and the marine exchanges reduced. After the cutting of the sand belt and the transformation of this lagoon like lake into a gulf, the salinity of the waters radically changed. Nowadays the lake is separated through a embankment on which the Constanţa -Vama Veche railway was built. Its mouth welcomes Mangalia harbour. The salinity variations following the mentioned modifications and the fact that the underground streams detain an important role, have evolved strongly: 1906 – 3.9 g/l; 1933 – 1.6 g/l; 1970 – 15.8 g/l; 2004 – 13.3 g/l.

Human intervention, mainly in the last years, is very important especially regarding water chemistry modifications. The first geographical paper of an applicative character has been elaborated by C.Brătescu (1922) and implied the construction of a relating channel between Taşaul and Siutghiol lakes. At the moment the whole lake complex Corbu (Gargalâc) - Taşaul -Siutghiol - Tăbăcăriei is related through channels. Their waters communicate with the sea through artificial openings.

Tatlageac's mouth has been closed, Mangalia's lake opened; the Comorova and Hergheliei swamps transformed into recreational lakes, and Costineşti and Belona embanked.

Taking into account that the area's climate, the most arid of the country, the lakes should have evolved to a salinity concentration. The comparative results demonstrate the opposite – a sometimes radical freshening, directed by the direct or indirect human activity. The most important factor that acts upon lake water chemistry is the irrigations. The freshening of the lake waters has consequences on the therapeutic mud production. Optimum conditions have existed in the Agigea and Techirghiol lakes. Haplessly, now they are produced only in Techirghiol Lake, where water chemistry should be preserved so as to protect it from the claying process.

The littoral lakes between Midia Cape and Vama Veche are part of the following categories:

- lakes with a continuously increase of level and salinity through the increase in fresh water inflow: Corbu (Gargalâc), Taşaul, Agigea, Belona, Techirghiol.

- lakes with a relatively constant salinity where the activity of the coastal processes is reduced to minimum as a consequence of the weak level variations: Siutghiol, Tăbăcăriei, Costineşti, Tatlageac, Neptun, Jupiter, Tismana, Venus, Mlaştina Hergheliei, Mangaliei (after the conditioning of the gulf).

3. CONCLUSIONS

The littoral lakes, through their geographical position and the climatic conditions of the area, are the object of water salinization processes. During the last period, as a consequence of the economical activities specific to agriculture, water inflow has been supplemented and a strong process of water freshening is felt. The phenomenon must b stopped in the case of the lakes that produce therapeutic mud (Agigea, Techirghiol). In the case of the other lakes the waters may be used at irrigation, (Corbu, Taşaul etc.) or for fish raising (Corbu, Taşaul, Tatlageac, Mangaliei). In the case of the lakes created for recreation water salinity does not present a high importance (Belona, Costineşti, Neptun, Jupiter, Tismana, and Venus).

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