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WATER QUALITATIVE PARAMETERS OF FLUVIATILE LIMANS LOCATED IN THE SOUTH - WEST OF DOBROGEA (ROMANIA)

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Abstract

The fluviatile limans in the south-west of Dobrogea are the most characteristic forms of this type, with an exclusive development on the territory of Romania. In time, they were interpreted as fluvio-maritime limans or even as fluvio-lacustrine limans. As a result of the fact that they are situated close to the Danube, bordering one of the driest regions of Romania, they have had diverse usage since ancient times. Because the fluviatile limans in Dobrogea are mostly used in pisciculture, the water qualitative parameters have to be monitored permanently. They also have a role in attenuating floods, acting as a tampon against flash floods. Consequently, they have a special local importance even today, feeding as much of the population as possible (directly or indirectly). From a geomorphological point of view the fluviatile limans in Dobogea were formed as a result of the withdrawal of the Romanian (Levantine). The decrease in depth may cause the flood waves to pass over the dams. In this case, the periodical drainage of lake cuvettes is required. The physical parameters of water (depth, transparency and temperature) as well as the chemical parameters (pH, dissolved oxygen, nitrates, nitrites, phosphates and the Ca/Mg ratio) have been analyzed. From an ecological viewpoint, the fluviatile limans in the south-west of Dobrogea are suitable for fish breeding and for developing an adequate lacustrine life.

Keywords: *fluviatile limans; geomorphological parameters; management; qualitative parameters.*

Introduction

The lake is a high-complexity open ecosystem. The disappearance or alteration of one component leads to the inevitable modification of the others. For this reason, the present study has a chapter about the geomorphological parameters, with direct influences upon water quality. Over the course of time, most large lakes have had complex uses. After 1989, the important lacustrine waters became private properties, for exclusive use in pisciculture. This is why monitoring campaigns control the quality parameters of lacustrine waters over the course of time. As consequence of long-term droughts, frequent floods, the use of fertilizers in the agriculture, etc., the Dobrogea waters can be easily polluted. If a quality parameter is rapidly detected when the normal limit is exceeded, the ecosystem may be saved.

Even though most lacustrine cuvettes have become private properties, they must keep their flood-preventing characteristics. Given the great water volume they can comprise, these

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lacustrine cuvettes act as perfect tampons in attenuating floods. In this sense, technical monitoring maintains the morphographic and morphometric characteristics of the cuvette and, at the same time, the perfect functioning of dams.

The physico-chemical water parameters are influenced by factors in two categories: non-climatic and climatic. Among the non-climatic factors, we underline, on the one hand, the bedrock lithology of the lacustrine cuvette and of the receiving cuvette, and, on the other, the morphographical and morphometrical characteristics. The climatic factors are determinant, mostly through precipitations and temperature. The relationship between the precipitations and water evaporation – according to the geographical area of the lacustrine cuvette – is materialized by the presence or absence of leakages in and towards the lake [1]. The origin of the fluviatile limans in the south-west of Dobrogea has been debated in the Romanian field literature [1-9]. Nevertheless, it is certain that their origin is fluviatile.

At present, the lakes are intensely used in fish farming, This is why the water level and water quality should be checked permanently. A high degree of silting is recorded at the outlet of the main brooks and during the Danube River flooding, at levels exceeding 7 hydrogrades.

Along the right bank of the Danube, the following fluviatile limans are present: Bugeac (Garlita), Oltina, Dunareni (Marleanu) and Vederoasa.

Successive measurements, in different years, have been carried out on the following characteristics: depth, transparency, temperature, pH, O_2, PO_4^{3-}; P, NO_3^-, NH_4^+, Ca^{2+}/Mg^{2+}. A synthetic table of the most important parameters defining the water quality was created, after which the main lacustrine cuvettes were globally analyzed.

Information on the physico-geographical conditions, on the whole, is extremely generous, but data on the physico/chemical parameters of water are rare and inconclusive. Only in some papers of a general character can indirect reference to water physico-chemical parameters be found [5, 10-17].

Geographical location

The Danubian fluviatile limans occupy the south-west of Dobrogea, situated as they are between the border with Bulgaria, in the south, and the locality of Cernavoda, in the north. The four fluviatile limans: Bugeac (Garlita), Oltina, Dunareni (Marleanu) and Vederoasa, are located in the south-western sector of Dobrogea, next to the Bulgarian border. Sometimes, these lakes have different names on different maps: Bugeac Lake is also known as Garlita. Lake Oltina includes a smaller part known as Iortmac. Dunareni Lake, nicknamed Marleanu, has its cuvette upstream. A small lake called Beilic and Vederoasa Lake includes a smaller cuvette in the north-east, known as Baciu (Fig. 1).

The total surface of the four lakes is 60.52km^2: Bugeac (13.86km^2), Oltina (30.36km^2), Dunareni (10.22km^2), and Vederoasa (6.08km^2). All four lakes are used in pisciculture. This is the reason why natural environmental conditions can be easily altered in a negative manner. The whole lacustrine complex comprises two other swampy cuvettes – Baciu and Cochirleni. They are clogged as result of natural developments and they represent environments typical of the preservation of biodiversity (flood plain wetlands).

Methodology

Geomorphological observations consisted of taking sediment samples from the bottom of the lakes, examining their particle size and undertaking chemical analysis in order to determine the genesis of the limans. At the same time, research involved an analysis of the development of the lacustrine cuvettes, changes in the shoreline, the silting degree etc. The topographic measurements were done by using LEICA TCR 1201 Total Station. For the bathymetric measurements the Valeport Midas Surveyor echosounder was used.

The number of collection points for hydrobiological samples attempted to cover all the representative zones: the junction between supply channel – brook, the centre of the brook – the area of its own springs, „the tail" of the brook and the zones with macrophite vegetation. In this way, three or four stations were rehabilitated, depending on the area of each liman. The observations were carried out in the period 2000 - 2004, 2 - 3 times a year, from March to November. The physic-chemical and water quality analyses were done in the field and in the laboratories of the Natural Science Museum in Tulcea and the Faculty of Geography and Geology, Iasi (Geo-archaeology Laboratory).

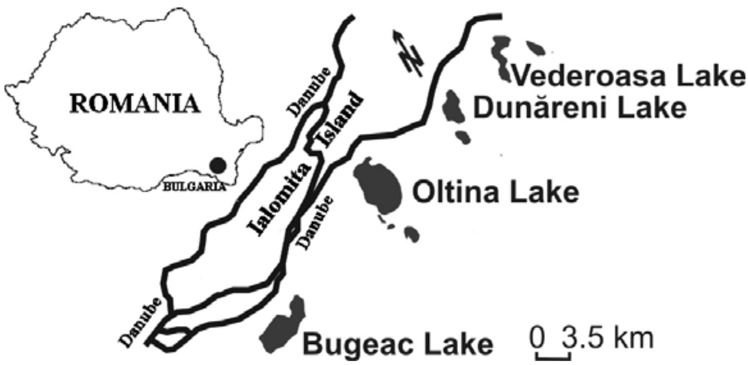

Fig. 1. Geographic location of the 4 fluviatile limans in the south-western sector of Dobrogea

The values of the physico-chemical parameters of water were determined by using Sechi disk (transparency, depth), the portable apparatus MultiLine P3 – WTW (pH, temperature, dissolved oxygen) and the photo-colorimeter Photolab S6 – WTW (nitrates, nitrites, phosphates, Ca/Mg). As for the ecological indicator, we used the Botnariuc-Beldescu transparency index (T/A = transparency/water depth). The measurements for the physical parameters were done in the stations for collecting the phyto-plankton and zoo-plankton samples, while these samples were being taken. In order to determine the chemical parameters, the water sample taken from the central part of the marsh was generally used. The soil samples were taken and analyzed according to the standards applied in the chemical analysis laboratory of the Romanian Railway National Society, Bucharest.

Results and discussions

Geomorphological parameters

The geomorphological parameters (lithology, mineralogy, morphography, morphometry, etc.) determine a part of the physico-chemical characteristics of the lacustrine water [1, 18, 19]. In (Levantine) Romania a large lake existed on the present Romanian Plain. It played an important role in the initial carving of the gulf-depressions in which the fluviatile limans were formed later [7-9]. The great size of the mouths of these relatively small valleys reveals the fact that they evolved as gulfs of the (Levantine) Romnian Lake. The terrace which extends between Ostrov and Cernavoda represents the most obvious G.M. Murgoci [8] mentions it for the first time, and C. Bratescu [3] and P. Cotet [4, 5] later.

As for the genesis of the limans in the south-west of Dobrogea, they were formed as a result of the spasmodic character of the Danube waters. The fluvial sandbars were built during the floods. The sandbars are more developed upstream (on the left of the limanic valleys) and less developed downstream (on the right). These fluviatile sand bars flood when 7 hydrogrades are exceeded. The valleys were deepened while the Romanian (Levantine) lake was retreating. The loess and the loessoide deposits are younger, from the Pleistocene era, deposited during the glacial periods [6, 20, 21] (Fig. 2). The present shape of the valleys, wide and flat, is a result of an erosive surface.

Fig. 2. Oltina lake basin cut in the loessoide deposits

The relief energy has values of between 100 and 120 m. The valleys present alternations of narrow and wide sectors (of the bassinette type). The general flowing direction of the valleys is SE – NW. This explains their origin, initially epirogenetic, and then the antecedent [3]. The gulf-depressions on the Romanian terrace are home to the enlarged fluviatile limas, with a highly alluviated bottom. Their shapes can be: elongated (Baciu Lake, Cochirleni Lake, Seimeni Lake), meander-valley (Vederoasa Lake), oval-elongated (Marleanu Lake), oval-polygonal (Bugeac Lake), oval-circular (Oltina Lake). The intense aggradation of the valleys is determined by the existence of a high alluviation rate [2, 22].

The change in the bathymetric parameters, through the decrease in depth, may determine which flood waves pass over dams and barriers. In this case, periodical drainage is required in order to maintain optimal depths.

Physico-chemical parameters as ecological indicators

The economic importance of the lacustrine units in the south-west of Dobrogea requires serious research of the quality parameters of water. The physico-chemical water parameters in the ecosystems studied are influenced, to the greatest extent, by water exchange [23, 24]. This is done over time, according to the supply sources and depending on the water loss of the marshes (hydrological balance). The Danube represents the supply sources, precipitation falls directly over the surface of the marsh, water flows from the slopes, and, in the case of some marshes, from their own sources. Water loss in the marshes takes place during evaporation (which leads to a concentration of salts), and during superficial flow in other aquatic basins (nurseries, the Danube).

Water depth varies according to the supply possibilities of marshes, to the intensity of evaporation, and to the necessities required by exploitation by fishing [25]. When the water supply comes from the Danube, the maximum depth registered by the marshes reaches values of 1.65 - 1.70 m (Bugeac marsh) (Table 1).

After the concession of the Bugeac marsh in 2005, much greater depths are assured, up to 2.50 - 2.70 m. The depths are justified by the configuration of the marsh cuvette, and by the fact that these no longer supply the nursery, in the summer months (there are two distinct fishing units from an administrative point of view) [26].

During dry periods (when the supply during spring high waters is insufficient in summertime as well), the nurseries are supplied from marshes. Water depth reduces to 0.40 –

0.65 m, which is below the optimum fishing limit. The Dunareni marsh represents a special situation. It was not supplied by the Danube in the period the analysis was conducted (2001 - 2003), the water coming from rainfall and other sources.

In Vederoasa march, the seasonal variation of water depth, measured at the same stations, is relatively low, due to the independence of this marsh from the water level in the river. The Dunareni, during wintertime, when the ice bridge is formed on the marsh, causes a decrease of water depth up to 0.95 - 1.10 m, in order to prevent the destruction of the perimetral dam by the ice floes. For the period studied, the average water depth registered values between 78 - 128 cm (spring), 86 - 150 cm (summer) and 79 - 132 (autumn).

The factors influencing *water transparency* are represented by the development of the plankton organisms, especially phyto-plankton, and also by the solid suspensions brought by the Danube in spring, when the marshes are supplied with water. It can also be influenced by the strong winds agitating the fishing waters. This last factor is not to be neglected in the case of several marshes (Bugeac, Oltina, Dunareni, Baciu), as, before they were leased in 2004, there was fishing activity almost all year round (except the days with ice bridge). At the same time, due to relatively small average depth, and the frequency of the winds in the area, for several months a year, the silt strata is brought in suspension, and the bottom of the marshes becomes less stable, with consequences for the benthonic organism and submerged life.

Table 1. The physical characteristics of the aquatic ecosystems in the south - west of Dobrogea (2001 - 2004)

Aquatic ecosystem	**Collecting station**	**Data**	**Physical parameters**			**Observations**
			Water depth (cm)	**Transparency (cm); T/A**	**T_{water} (^0C)**	
Bugeac	SW	17.07.01	155	20; 0.12	28.3	Calm
	CA		100	15; 0.15	28.2	
	NE		170	25; 0.14	28.3	
	NW		155	23; 0.14	28.7	
Oltina	E	18.07.01	145	18; 0.12	25.8	Moderate SW-NE wind
	Center		155	25; 0.16	26.1	
	NW		150	24; 0.16	26.2	
Dunareni	NW	18.07.01	100	46; 0.46	28.7	Weak SW-NE wind
	Center		120	30; 0.25	28.6	
	S		95	40; 0.42	28.4	
Vederoasa	N	19.07.01	40	40; 1.00	24.9	Calm; submerse aquatic vegetations all over the layer surface
	NW		50	50; 1.00	23.9	
	SW		100	100; 1.00	25.9	
	E		100	100; 1.00	25.3	
Bugeac	W	12.09.01	40	12; 0.30	17.6	Slightly waved water surface
	E		105	9; 0.08	16.7	
Oltina	NW	11.09.01	90	13; 0.14	19.1	High turbidity
	SW		100	15; 0.15	19.5	
Dunareni	W	12.09.01	65	6; 0.09	19.0	High turbidity
	S		60	8; 0.13	19.1	
	E		45	5; 0.11	20.3	
Vederoasa	NE	13.09.01	90	90; 1.00	16.9	Underwater vegetation fallen on the bottom; agglomeration of *Viviparus* sp. in the NE
	W		100	100; 1.00	17.4	
	SW		95	85; 0.89	17.3	
Bugeac	NE	21.03.02	100	13; 0.13	9.6	Cloud cover; weak NE-SW Wind
	Center		105	12; 0.11	8.5	
	E		50	20; 0.50	8.9	
Dunareni	Center	22.03.02	95	77; 0.81	11.3	Calm
	N		55	55; 1.00	12.1	
	S		65	45; 0.69	11.6	
Dunareni	W	06.06.02	90	40; 0.44	23.5	Wind
	E		75	40; 0.53	24.8	
Oltina	Center	06.06.02	65	10; 0.15	24.5	Wind

Bugeac	NE Center SW	27.06.02	80 120 95	11; 0.13 12; 0.10 10; 0.10	23.0 23.2 22.9	Calm
Dunareni	W S E	26.06.02	80 55 70	20; 0.25 8; 0.14 12; 0.17	22.7 22.4 22.8	Calm
Vederoasa	NE E SW	25.06.02	100 70 110	100; 1.00 70; 1.00 110; 1.00	27.4 27.0 27.3	Strong H_2 S smell in the NE station
Bugeac	NE Center SW	03.10.02	60 80 60	5; 0.08 4; 0.05 4; 0.06	17.9 18.1 17.3	Calm; high turbidity
Oltina	NW Center E	03.10.02	60 115 115	0 0 0	13.5 14.7 15.2	High turbidity
Dunareni	NW Center SE	04.10.02	80 100 95	20; 0.25 15; 0.15 15; 0.15	15.1 15.0 14.9	Weak NE-SW wind
Vederoasa	NE E SW	04.10.02	95 80 100	80; 0.84 80; 1.00 75; 0.75	17.3 16.8 17.2	
Bugeac	NE Center SW W	24.04.03	150 165 145 150	5; 0.03 5; 0.03 5; 0.03 6; 0.04	10.9 10.9 10.6 10.6	Grey colour; high turbidity
Oltina	NE Center SW E	23.04.03	120 155 155 120	21; 0.17 27; 0.17 25; 0.16 35; 0.29	10.9 11.4 11.2 11.2	Clear sky; yellow-green colour
Dunareni	NW Center SW E	24.04.03	95 105 95 80	32; 0.33 32; 0.30 20; 0.21 34; 0.42	13.06 14.4 14.4 13.6	Grey-green colour
Dunareni	NW Center S NE	08.08.2003	60 55 50 45	3; 0.05 3; 0.05 6; 0.12 8; 0,17	26.3 27.1 28.4 28.5	Algae
Bugeac	SW SE Center NE	05.08.04	150 165 170 160	18; 0,12 20; 0.12 22;0.129 25; 0.15	22.7 23.6 23.0 23.8	Covered sky, weak SW-NE wind; algae
Oltina	NE Center SE	05.08.04	125 160 160	24; 0.19 24; 0.15 24; 0.15	24.5 25.2 25.8	Algae
Dunareni	NW Center S NE	04.08.04	90 100 80 85	20; 0.22 18; 0.18 30; 0.37 18; 0.21	25.9 26.0 26.3 25.0	Algae
Bugeac	NE Center SE SW	04.11.04	140 165 140 160	24; 0.17 24; 0.14 27; 0.19 28; 0.17	13.4 13.3 13.3 13.4	Calm
Oltina	NE Center SW	05.11.04	100 150 155	23; 0.23 27; 0.18 23; 0.14	13.0 13.0 13.5	Calm
Dunareni	NE Center S	04.11.04	90 115 110	32; 0.35 31; 0.26 34; 0.30	13.2 13.3 13.3	Calm

CA- supply channel; T/A –Botnariuc-Beldescu transparency index; P **–** total phosphorous (mg/L)

In order to see the biological influence of the transparency parameter in the ecosystems studied, the ***Botnariuc - Beldescu transparency index*** (***T/A*** = transparency/water depth) was computed (Table 1). Thus, the maximum values of this index were recorded in Vederoasa marsh (0.89 – 1.00). Transparency, correlated to the reduced turbidity and water weak circulation in this marsh, is reflected in the development of the submerged macrophytes (ie. vegetal association made up of species belonging to the genus *Chara*, *Myriophyllum*, *Hippuris*, *Stratiotes*). From the observations conducted it was concluded that for values of the transparency index lower than 0.80, calculated for Bugeac, Oltina and Dunareni marshes, the submerged vegetation does not develop. The causes can be generated by the very high turbidity, caused by the factors mentioned above, and weak capitalization of the primary production, the phytoplankton, respectively, by the peaceful zooplankton which appears weakly developed, much under the available energetic potential. The efficiency of using the production of phytoplankton and bacterioplankton by the peaceful zooplankton is also reduced due to the high eutrophization degree of those marshes. The lowest value of the transparency index was 0, recorded in Oltina, in October 2002.

The thermal regime of water depends on the climatic conditions of the area in which the marshes are located (i.e. air temperature, mechanical wind action), on the density and degree of mineralization of water in these marshes. As the aquatic units studied have low depths, the classical thermal structure characteristic to a lake cannot be formed. It only presents a water layer strongly influenced by the daily variation of air temperature or by wind action. Water circulation is total. This fact leads to the oxygenation, temperature homogenization and the development of the trophic base in the whole aquatic mass (Table 1).

Water temperature registers values which are relatively similar at the sample collection stations in each marsh, the differences varying between 0.2 and 2ºC, depending on the season and on the aquatic ecosystem. These thermal differences appear due to the particular conditions in which the marshes function (depth, presence of macrophyte vegetation, wind direction). In this respect, it was noticed that the temperatures recorded in Oltina marsh are slightly lower than the temperatures recorded in other marshes. The large area, the relatively small water depth, the reduced presence of the macrophyte veneration, the large number of windy days etc, are factors which favour the thermal exchange into a dynamic rhythm. The data resulted from recordings in different periods of the year. They show minimum values in March 2002 in Bugeac (8.5ºC), November 2004 in Dunareni (13.2ºC) and maximum values in July 2001 in Dunareni and Bugeac (28.7ºC) and August 2003 in Dunareni (28.5ºC).

The value of *pH* varies between 7.30 and 10.01, indicating slight variations within each ecosystem (Table 2). pH values higher than 8.3 units (admitted in fishing waters) give the water a strongly alkaline character, which means that the basic reserve of the environment is high. The values exceeding the maximum limit accepted by fishing industry were recorded in the following marshes: Dunareni (9.70 - 10.01 in August 2003 – close to the lethal limit for cyprinides, which is 10.8, Bugeac (9.28 - 9.40 in October 2002) and Oltina (9.38 in August and 9.22 in November 2004). The high values of pH are caused by the free carbon dioxide consumption in the phytoplankton photosynthesis process, but also by the lime and carbonates content in the soil. (The marshes are located on carbonatic chernozem soils). In Vederoasa marsh, values close to those favourable to fish were registered (7.30 - 8.65). This situation is due to the phenomenon of biogenic decalcification, a consequence of the massive development of aquatic submerged vegetation, especially of macrophyte algae from the *Chara* genus. These algae cover almost the entire surface of the marshes, like a carpet. They have the property of keeping the calcium salts under the form of precipitates, and this makes them rough when touched.

Table 2. Chemical characteristics of the lacustrine ecosystems in the south-west of Dobrogea (2001-2004)

					Chemical parameters					
Aquatic ecosystem	**Collecting station**	**Data**	**pH**	**O_2 (mg/L)**	**PO_4-; P (mg/L)**	**NO_3- (mg/L)**	**NO_2- (mg/L)**	**NH_4- (mg/L)**	**Ca/Mg (mg/L)**	**Observations**
Bugeac	SW CA NE NW	17.07.01	8.46 8.89 8.39 8.35	6.56 7.01 6.85 6.96	0.52; 0.16	0.95	0.155	0.998	128/97	Calm
Oltina	E Center NW	18.07.01	8.80 8.73 8.80	3.93 4.25 4.02	0.49; 0.15	1.30	0.082	0.175	115/93	Moderate SW-NE wind
Dunareni	NW Center S	18.07.01	8.86 8.82 8.85	8.13 7.80 8.10	0.80; 0.28	1.27	0.046	0.082	148/117	Weak SW-NE wind
Vederoasa	N NW SW E	19.07.01	8.31 7.60 8.65 8.41	2.89 2.28 3.93 7.32	0.05; 0.01	1.90	0.03	0.149	78/65	Calm; submerse aquatic vegetations all over the layer surface
Bugeac	W E	12.09.01	8.31 8.44	9.30 8.89	0.81; 0.27	1.40	0.16	0.307	95/72	Slightly waved water surface
Oltina	NW SW	11.09.01	8.56 8.62	10.15 9.50	0.75; 0.24	1.70	0.020	0.476	115/101	High turbidity
Dunareni	W S E	12.09.01	8.42 8.52 8.56	12.80 12.40 13.25	0.21; 0.06	1.80	0.057	0.126	107/83	High turbidity
Vederoasa	NE W SW	13.09.01	7.69 8.11 8.17	6.25 6.34 5.89	0.09; 0.02	2.80	0.018	0.021	150/98	Underwater vegetation fallen on the bottom; agglomeration of *Viviparus* sp. in the NE
Bugeac	NE Center E	21.03.02	8.77 8.76 8.80	11.77 11.33 10.89	0.13; 0.04	0.9	0.078	0.22	109/70	Cloud cover; weak NE-SW wind
Dunareni	Center N S	22.03.02	8.49 8.35 8.45	9.41 8.65 9.36	0.02; 0.006	0.4	0.021	0.132	108/74	Calm
Dunareni	W E	06.06.02	8.55 8.36	8.51 10.44	0.09; 0.02	2.4	0.020	0.093	95/71	Wind
Oltina	Center	06.06.02	8.42	11.23	0.39; 0.12	1.4	0.079	0.250	105/83	Wind
Bugeac	NE Center SW	27.06.02	9.16 9.02 8.95	13.76 13.70 10.86	0.67; 0.21	0.8	0.122	0.132	117/91	Calm
Dunareni	W S E	26.06.02	8.32 8.45 8.36	5.57 6.44 6.25	0.83; 0.27	2.3	0.157	0.675	145/112	Calm
Vederoasa	NE E SW	25.06.02	9.07 9.20 8.07	9.19 8.52 7.17	0.03; 0.009	2.2	0.021	0.133	89/70	Strong H_2 S smell in the NE station
Bugeac	NE Center SW	03.10.02	9.40 9.35 9.28	14.50 13.70 13.41	0.32; 0.10	3.5	0.069	0.249	98/84	Calm; high turbidity
Oltina	NW Center E	03.10.02	8.85 8.74 8.77	11.45 11.40 10.40	0.53; 0.17	3.9	0.077	0.144	126/106	High turbidity

Dunareni	NW Center SE	04.10.02	8.91 8.80 8.76	14.60 12.95 12.94	0.37; 0.12	2.4	0.078	0.276	119/95	Weak NE-SW wind
Vederoasa	NE E SW	04.10.02	7.30 7.49 7.43	6.46 6.25 6.70	0.07; 0.02	3.4	0.016	0.025	147/97	Calm
Bugeac	NE Center SW W	24.04.03	8.83 8.80 8.82 8.81	12.19 11.98 12.26 12.26	0.05; 0.01	0.18	0.075	0.135	105/70	Grey colour; high turbidity
Oltina	NE Center SW E	23.04.03	8.55 8.86 8.87 8.78	11.06 11.37 11.40 12.19	0.09; 0.02	0.13	0.05	0.130	109/72	Clear sky; yellow-green colour
Dunareni	NW Center SW E	24.04.03	8.64 8.57 8.53 8.45	11.23 10.94 10.80 10.52	0.23; 0.07	0.80	0.102	0.193	128/94	Grey-green colour
Dunareni	NW Center S NE	08.08.03	9.70 9.94 10.01 9.98	13.35 13.72 12.20 15.26	0.83; 0.27	1.35	0.159	0.077	147/114	Algae
Bugeac	SW SE Center NE	05.08.04	8.60 8.80 8.72 8.82	5.56 7.24 6.86 7.80	0.45; 0.14	1.27	0.125	0.032	115/88	Covered sky, weak SW-NE wind; algae
Oltina	NE Center SE	05.08.04	9.38 9.32 9.31	11.27 10.64 10.63	0.72; 0.22	1.94	0.087	0.145	116/90	Algae
Dunareni	NW Center S NE	04.08.04	9.00 8.80 8.97 8.77	11.31 11.23 9.08 7.09	0.80; 0.26	1.52	0.153	0.084	132/109	Algae
Bugeac	NE Center SE SW	04.11.04	8.94 8.80 8.82 8.83	10.50 11.20 11.18 10.89	0.11; 0.03	0.50	0.040	0.134	193/150	Calm
Oltina	NE Center SW	05.11.04	9.22 9.13 9.06	12.03 11.70 11.40	0,12; 0,03	0.30	0.049	0.078	218/181	Calm
Dunareni	NE Center S	04.11.04	8.70 8.63 8.77	12.10 12.25 12.95	0.30; 0.09	0.2	0.039	0.06	231/172	Calm

CA- supply channel; T/A –Botnariuc-Beldescu transparency index; P –total phosphorus (mg/L)

The *dissolved oxygen* content is enriched through phytoplankton photosynthesis, in the first place, and macrophyte vegetation photosynthesis, water supply from winter high floods, and mechanical action of wind on the water mass [27] (Table 2). In general, except few situations identified in Oltina and Vederoasa, recorded values indicate an over-saturation in oxygen of the waters from the aquatic ecosystems studied, recording a maximum in Dunareni marsh (13.25 - 14.60mg/L in September 2001, and October 2002) and Bugeac marsh (13.41 - 14.50mg/L in October 2002). The minimum values were recorded in Vederoasa marsh (2.28 - 2.89mg/L in July 2001). The significant oxygen deficit was generated by the small water depth (40 - 50cm), the lack of any form of water dynamics, the decomposing macrophite vegetation, under the conditions of high water temperatures (24.9 - 25.9ºC). In August 2004, Bugeac marsh also recorded a significant decrease of the amount of dissolved oxygen due to the high temperatures, but this did not generate a deficit (5.56 - 6.86mg/L, while T_{water}= 23.6 - 23.8ºC). The lowest values are recorded towards the end of autumn and in winter.

Nitrates represent the main nutrition source for the aquatic vegetation. These are generally included in the limits admitted by fishing industry (1.00 - 5.00mg/L) (Table 2). Values higher than 3mg/L (maximum optimum value), determined in the month of October 2002 in Oltina, Bugeac and Vederoasa marshes, indicate a high decomposition degree of the chemical compounds. The minimum recorded values are situated between 0.13 - 0.18mg/L (Oltina and Bugeac, April 2003) and indicate high nitrates consumption. In the summertime, even if algae blossom was noticed, the nitrites values were situated in several cases over 1mg/L (Bugeac, Oltina and Dunareni in August 2004). These blossoms were generated by the cyanophite algae which are great atmospheric nitrogen consumers. This is the explanation.

Nitrites represent a more advanced stage of the decomposition processes of the organic substances containing nitrogen. Consequently, their presence demonstrates an older, less dangerous pollution (Table 2). The values determined are situated between 0.016mg/L (Vederoasa, October 2002) and 0.159mg/L (Dunareni, August 2004), higher than the optimum values for the fishing waters, which is 0.005mg/L, but not exceeding the maximum admitted limit (0.20mg/L).

Phosphates are situated in the optimum limits admitted by the fishing waters, with values between 0.02mg/L (Dunareni, March 2002) and 0.83mg/L (Dunareni, June 2002) (Table 2). For the determination of the total phosphorus, the coefficient 0.3263 was multiplied by the values recorded for the phosphates content (Table 1), this is written with bold figures). From the results of the analyses, it was noticed that this chemical parameter registers values much over 0.10mg/L, characteristic of the eutrophizate aquatic ecosystems with unclear waters, a fact confirmed by the analysis of the phytoplankton and of water transparency (Oltina, Dunareni). The lowest values were recorded in Vederoasa (0.009 - 0.02mg/L, in June 2002, and September 2001), due to its consumption by the macrophyte plants, a phenomenon also reflected in the limitation of the development of planktonic organism.

The ratio Ca^{2+}/Mg^{2+} has values between 1.16 - 1.51, varying from one month to another and from one ecosystem to another (Table 2). The chemical composition and the mineralization degree of water in the marshes are influenced by the following factors:

- The lithological structure of the marsh cuvette proper and of the adjacent reception basin influences the accumulation of salt in the water;
- The morphological and morphometrical characteristics of the marsh cuvette and of the adjacent river basin influences salt stratification and their circulation;
- The amount of precipitation which falls in the area of the marsh and its surface;
- Air temperature influences the evaporation from the surface of the marsh.

The marshes contain fresh water with mineralization a little higher than the Danube water (between 250 - 400mg/L in Bugeac and Oltina). The increase of concentration corresponds to the periods when the connection to the river is interrupted. Vederoasa and Iortmac marshes have a higher salt content (600 - 700mg/L Vederoasa and over 1000mg/L Iortmac) due to the underground supply. Due to its chemical properties, the water in all marshes belongs to the class of bicarbonated waters – calcium group, when they are supplied by the Danube, and the natrium group, when the connection with the river is interrupted (and a chemical metamorphosis process takes place - Bugeac, Oltina, Dunareni marshes), or in the magnesium group, when the supply is assured by its own sources (Vederoasa, Iortmac, Baciu marshes).

Due to the location of the marshes in a flood area, the soil covering the layers of these aquatic basins result from the alluvia transported by the Danube waters and by the meteoric waters, rich in sand and clay in a colloidal state, with calcium, potassium and phosphates salts (Table 3). To these, the organic and inorganic matter, coming from the aquatic mass capable of maintaining life, are added. They are raw soils, in a primary state, with no distinct profile (limonsoils in the initial stage). The soil samples were taken in September 2001, from Bugeac, Dunareni and Vederoasa marshes, and a single set of analyses were done. In order to point out the influence of soil on water chemism, the same table presents the values of the physical-chemical parameters of water, recorded in the places from which the soil samples were taken.

Table 3. Values of physical-chemical parameters of soil (September 2001)

SOIL INDICATORS		**Bugeac**	**Dunareni (center)**	**Dunareni (east bank)**	**Vederoasa (west bank)**	**Vederoasa (center)**
pH		7.8	8.09	7.3	7.6	7.6
Conductivity(μS)		55	82	76	66	75
Humidity (%)		54.94	73.46	59.34	67.76	63.63
Dry substance (%)		45.06	26.54	40.66	32.24	36.37
Phosphorus	(%)	13.65	8.28	22.64	5.8	27.29
	mg/L	7.22	5.36	15.58	3.34	18.2
Nitrogen	(%)	1.67	11.13	10.70	2.4	7.63
	mg/L	0.9	5.9	6.1	1.2	4
Calium	(%)	21.82	47.92	45.34	19.25	29.26
	mg/L	6.7	12.7	10.7	5.1	7.2
Calcium	(%)	0.36	0.44	0.28	0.48	0.44
	mg/L	18	22	14	24	22
WATER INDICATORS		**Bugeac**	**Dunareni (center)**	**Dunareni (east bank)**	**Vederoasa (center)**	**Vederoasa (west bank)**
Depth (cm)		105	57	45	95	98
Transparency (cm)		9	8	5	85	98
Temperature (°C)		16.7	19.1	20.3	17.3	17.4
pH		8.44	8.52	8.56	8.17	8.11
Phosphorus (mg/L)		0.84	1.02	0.21	-	-
Nitrates (mg/L)		1.4	1.7	1.8	-	-
Nitrites (mg/L)		0.161	0.207	0.057	-	-

The geomorphological factor influences the water quality and also its dynamics. The calcareous layer and the existence of the loessoid deposits offer an important carbonates supply to the lacustrine waters. As a result of the existence of these deposits, erosion is high as well. This leads to a rapid, even accelerated silting, especially after a large proportion of the surrounding fields have been used for crops.

During winter, most of the lakes freeze on almost all their surface. Total frost is only missing in the warmer winters. Due to frost, fish breeders have to empty the lakes in autumn and exploit the whole quantity of fish.

In the sectors with small depths and still waters, total frost appears. This phenomenon leads to a “sterilization” of waters. The temperature directly influences the amount of dissolved oxygen. The highest values are recorded in spring and autumn, and the lowest in summer. The maximum values may exceed 14mg/L, and the minimum values reach 6 - 7mg/L. Because of frost, no samples were collected in winter.

There is no direct relation between the depth and the value of transparency. This fact is due to the reduced depth existing in all the lacustrine cuvettes, to the important lateral alluvia supply, to the phenomenon of water blossom, and the existence of an abundant hygrophile and hydrophile vegetation etc.

The physical-chemical qualities of the waters in the lacustrine cuvettes specific to the south-west part of Dobrogea are very appropriate for the practice of a fishing industry. All four lakes are used for fish breeding, with high productivity in Bugeac and Oltina, and a little lower in Vederoasa and Marleanu. In fact, in the two lakes, fish breeding is semi-wild. Only in the other lakes is it totally controlled by humans. Carp, silver carp, bighead carp, crucian carp, etc., give optimum production. Pike perch, salmon and pike, which are more demanding species, appear sporadically, and they are more expensive.

Conclusions

The main fluviatile limans in the south/western part of Dobrogea were created as a result of the significant floods recorded on the Danube. They occupy the former gulfs of the Romanian lake on the Romanian Plain. The detailed morphology, with higher places on the left (upstream of the Danube) and lower places on the right (downstream of the Danube) betrays this origin.

The siltage of the limans is rapid because loess represents the basic rock. The dry climate and the rains of a torrential character cause powerful erosion of the rock. The resulting material contributes to the aggradation of the lacustrine bottoms. The decrease in depths may make the flood wave pass over the dams. It is mandatory to periodically drain the basins in order to maintain proper depths.

Local factors determine the physico-chemical water parameters: climatic, lithological, anthropic, etc. Man’s influence, even though the water basin is used exclusively in pisciculture, did not cause alterations in quality parameters. The large dimensions of the lakes and the abundant vegetation create a semi-natural system for the fish. A large proportion of the nourishment is taken from the natural environment.

The physico-chemical analyses (pH, dissolved oxygen, nitrates, nitrites, phosphates and the Ca/Mg ratio), on the water in the most important lake basins along the Danube revealed the fact that they have an appropriate quality and they are optimum for pisciculture.

Biodiversity in vegetation and fauna determines a semi-artificial nourishment for most of the fish population (the nourishment is supplemented only during the temporary deficit periods). It is in the owners’ interest to maintain quality parameters to normal standards. Lately, there has been a substantial increase in demand for fish for sportfishing: – zander, luce, indigenous carp.

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