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THE DETERMINATION OF THE DEGREE OF TROPHICITY OF THE LACUSTRINE WETLANDS IN THE EASTERN CARPATHIANS (ROMANIA)

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Abstract

The lakes over Romania's territory are relatively uniformly distributed within most physico-geographical regions. A low density is specific to the West, where significant drainage works have been realized, while the highest density is characteristic to the North-East, with numerous ponds, registered since the 14th-15th centuries. Most of the lakes within the Romanian territory, especially those analyzed in the present study, are anthropic. Most of the natural lakes are small-dimensioned and they do not have a special ecologic or economic importance. Although situated in different physical-geographical conditions, the analyzed lakes are mostly included in the category of good waters from a qualitative point of view, and within the eutrophic, mesotrophic or hipertrophic category, from a trophic point of view. Because of the fact that most lakes are anthropic, it is obvious that they are artificially maintained at this stage. Most of the mountain lakes and those in the volcanic areas are ultra-oligotrophic and oligotrophic. The lacustrine wetlands in the mountainous units are relatively meagrely developed, as their distribution is limited by the morphology of the landforms.

Keywords: *lacustrine wetlands, geographic distribution, genetic type, water quality, pollution.*

Rezumat

*Determinarea gradului de troficitate a zonelor lacustre umede din Carpaţii Orientali (România)***.** Lacurile de pe teritoriul României sunt relativ uniform distribuite, în majoritatea regiunilor fizico-geografice. O densitate redusă este specifică vestului ţării, unde au fost realizate lucrări de desecare semnificative, în timp ce densitatea cea mai mare este caracteristică nord-vestului, cu numeroase iazuri, înregistrate încă din secolele XIV-XV. Marea majoritate a lacurilor de pe teritoriului României, şi în special cele analizate în acest studiu sunt antropice. Cele mai multe lacuri naturale sunt reduse ca dimensiuni şi nu posedă o importanţă ecologică sau economică deosebită. Deşi situate în condiţii fizico-geografice diferite, lacurile analizate sunt incluse în categoria apelor bune din punctul de vedere al calităţii şi în categoriile eutrofic, mezotrofic sau hipertrofic, din punctul de vedere al troficităţii. Din cauza faptului că majoritatea lacurilor sunt antropice, este evident că sunt menţinute în mod artificial în acest stadiu. Cele mai multe dintre lacurile de munte şi cele situate în arii vulcanice sunt ultra-oligotrofice şi oligotrofice.

Cuvinte-cheie: *mlaştini lacustre, distribuţie geografică, tip genetic, calitatea apei, poluare.*

INTRODUCTION

The interdisciplinary studies regarding wetlands in Romania are almost inexistent. This is why, at a local level, the analysis of water quality in the main lake basins and their correlation with the existence of the main wetlands of national and local ecological importance, is being done.

In the present study all the great natural lakes (lacustrine wetlands) and most of the artificial lakes from almost all river basins have been analysed. We wanted to emphasize, for each region, river basin and aquatic surface, the quality of the lacustrine waters in order to use them in different fields of activity as well as a life support for the biologic component.

The major difficulty, for such a study, was represented by the relatively big dimension of the surface of Romania, the relatively great number of lakes (136), and the extremely varied and fragmented landforms. Some lakes are situated in hardly accessible places, and as a result, the present study could not be realized during one single year. For the Eastern Carpathians the most representative 19 lacustrine wetlands have been analyzed.

We performed a complex analysis of the physico-chemical characteristics of the lacustrine waters and of their role in maintaining life. Such a study, for the whole territory of Romania

(especially for the Eastern Carpathian Mountains), has rarely been done, and even then, there were important gaps for some river basins and for the isolated lakes. In places where the lakes within a small area had the same characteristics, only the most important aquatorium was mentioned, as being typical and representative for that territory and for those types of lakes.

Within the rich literature in the field, only the materials referring strictly to the issues concerning the lakes in the Eastern Carpathians or water trophicity worldwide have been mentioned: Brenner et al., 1996; Daraba, 2008; Dumitran, 2002; Dumitran et al. 2005; Dumitran et al., 2006; Godeanu and Galatchi, 2007; I.N.M.H., 2000, 2006; Jonasson, 1996; Jorgensen, 1996; Karatayev, 1995; Neagu and Miron, 2008; Porumb, 1986; Romanescu, 2006; Romanescu and Romanescu, 2008; Romanescu et al., 2005, 2008; Shchur, 2009; Zanovschi and Porumb, 1979 etc.

Regional setting

The Eastern Carpathians represent the Eastern segment of the Carpathian Mountains, and they are situated between the Ukrainian border (in the North) and Prahova Valley (in the South) (Fig. 1).

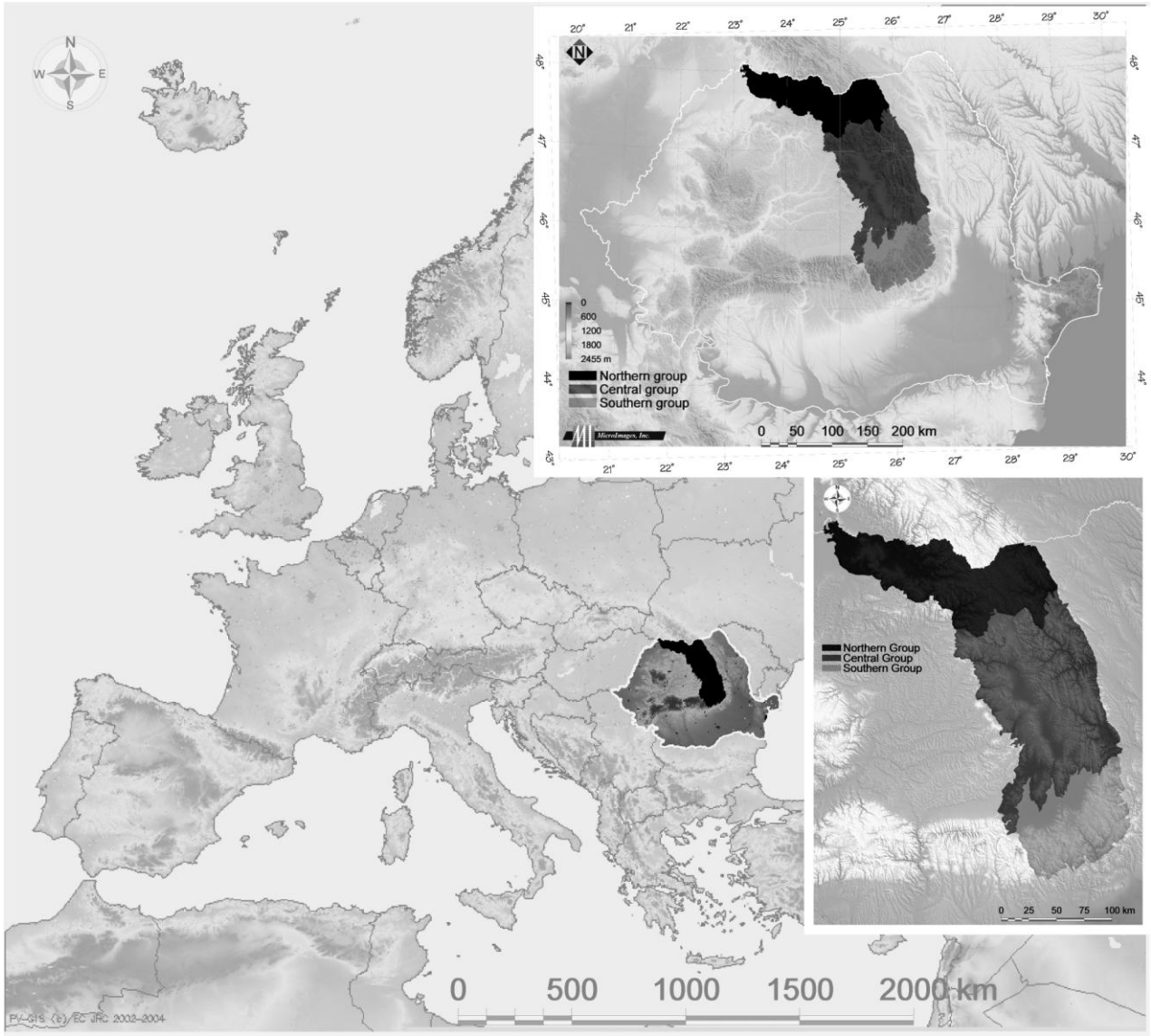

Fig. 1 Geographical location of the Eastern Carpathians in Europe and Romania

They are divided in three main groups: the Northern Group, between the Ukrainian border and Tihuța Pass, the depression corridor Vatra Dornei-Câmpulung Moldovenesc (in the South); Central Group, between Tihuța Pass, the depression corridor Vatra Dornei-Câmpulung Moldovenesc (in the North) and Oituz Pass and Brasov Depression (in the South); Southern Group, between Oituz Pass

and Braşov Depression (in the North) and Prahova Valley (in the South) (Fig. 2).

It is the largest Carpathian sector on the territory of Romania and the second highest after the Southern Carpathians.

From a geological point of view, it is made up of three distinct stripes, with a NW-SE orientation: the volcanic stripe (in the West), the crystalline stripe (in the centre) and the sedimentary stripe (in the East).

METHODOLOGY

There are 3450 lakes in Romania, with a cumulated surface of 2,620km^2, covering 1.1% of the total surface of Romania. Unfortunately, most of the lakes are anthropic, while the natural lakes, apart from being fewer, they have an insignificant surface (Gâstescu, 1971; Romanescu, 2006).

The seasonal campaign during a four-year period (2003, 2004, 2005, 2006, 2007, and 2008) had as a main purpose the complex characterization of lacustrine waters quality, by interpreting the results of the field measurements, with reference to their classification in quality classes. A complex measurement set (Multisampler HACH) was used for the measurement of the physico-chemical parameters, and at the same time, we took samples of phytoplankton, specific to the lacustrine waters.

The trophicity of the lacustrine waters (wetlands) required the characterization of several physico-chemical and biological indicators, having determined and favoured its evolution: pH, CCO-Cr, CC=-Mn, CBO_5, total mineral nitrogen, total phosphorous, temperature, dissolved oxygen, transparency, nutrients, structure of aquatic biota (value of phytoplankton biomass, percentile value V90% of the plankton biomass, coli form bacteria).

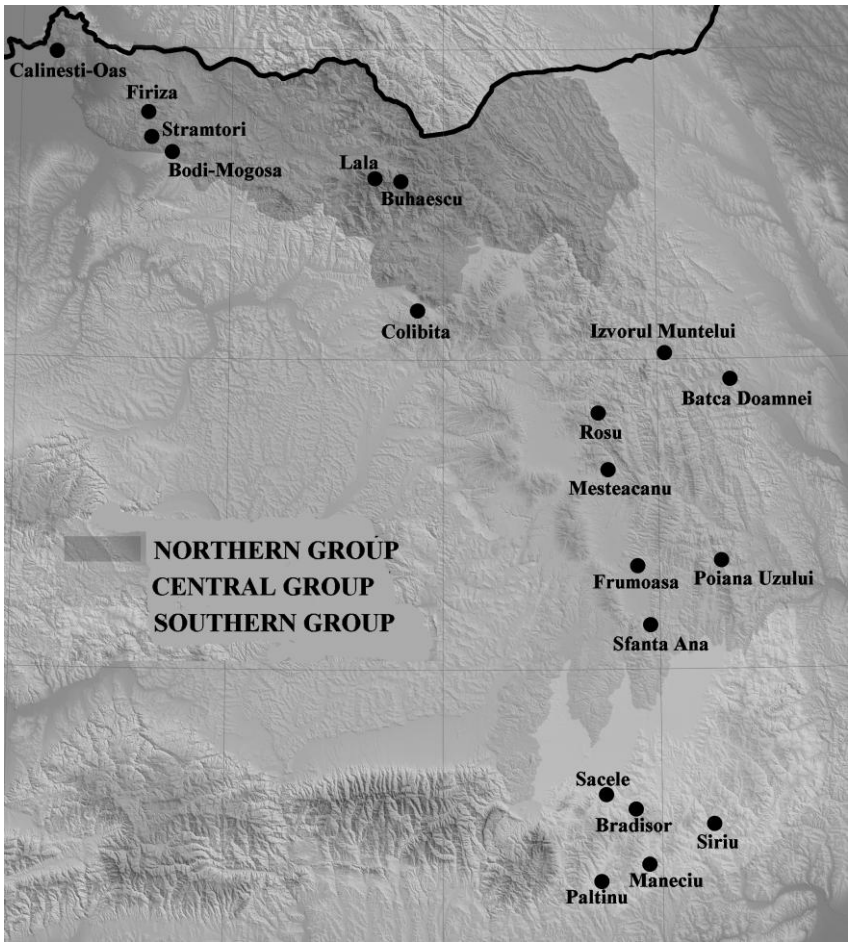

Fig. 2 Geographical position of the main lakes in the Eastern Carpathians

The global characterization of water quality was made by interpreting the results obtained during the seasonal campaigns, with reference to the establishing of the quality categories. The water trophicity degree was determined by following the evolution of the physico-chemical and biological indicators: temperature, transparency, oxygen regime, nutrient regime, biocenosis evolution (phytoplankton biomass and trophicity degree) according to the limits stipulated by the standards.

The situation of the global quality, the establishing of the quality category and trophicity quality of the lakes in Eastern Carpathians was done by cumulating the results obtained in each river basin.

The physico-chemical parameters were interpreted at the Hydrology Laboratory of the Faculty of Geography and Geology, University "Al. I. Cuza" in Iaşi, while the biological parameters were interpreted by the Natural Sciences Museum in Tulcea.

At first, some data were missing from our analysis, in the cases of some lakes mentioned above, but they could eventually be taken from the Headquarters of Water Supply in Bucharest or from the regional hydrologic offices (I.N.M.H. – the National Institute of Meteorology and Hidrology, 2006).

The data we obtained were reported to Order 1146/2002 into five quality classes, and the classification of the lakes was established by using the percentile system V (90%).

RESULTS AND DISCUSSIONS

The analysed area refers to the whole territory of Romania (especially to the East Carpathian Mountains), especially to the natural lakes with ecologic and economic importance, as well as the most important anthropic lakes.

While in the Western part of Romania hydro-technical works have been built and a large part of the flood plain lakes were eliminated, in the Eastern part of Romania the situation is reversed. In Moldova, some of the oldest and most numerous anthropic lakes are registered, most of them having small dimensions. Still, some of these lakes cover significant areas and they have a complex role (Romanescu et al., 2005).

Fig. 3 Izvorul Muntelui reservoir on the Bistrița river

As a result of the fact that Romania's landforms are very diverse (delta, extended flood plains, arid and wet plains, hills with high fragmentation, low and high mountains etc.), the genetic types of lakes and the hydrologic balance specific to these areas are various as well.

The complex analysis of the lakes was done on the following river basins: Tisa (Buhăescu, Călineşti-Oaş); Someş (Colibița, Firiza, Lala, Strâmtori, Bodi-Mogoşa), Olt (Mesteacănu, Sfânta Ana, Frumoasa, Săcele, Bradişor); Ialomița (Paltinu, Măneciu); Siret (Izvorul Muntelui, Bâtca Doamnei, Poiana Uzului, Siriu, Roşu).

The most important lakes within all river basins were analysed. The present study does not refer to the salt lakes in the salt massifs (natural and

anthropic) as they present different characteristics and they are used only therapeutically (Ocna Şugatag, Coştui, Telega, Slănic Prahova etc.).

Analysing the distribution of the lakes within Romania's territory, one can notice their absence in the Western part of the country and an increased number in the East (Moldova, Bărăgan, and Dobrudja). The absence of lakes in the Someşului, Crişurilor and Timişului Plains is caused by the drainage hydro-technical works having been used in order to convert the land into agricultural fields.

The great number of lakes in Moldova (the Siret and the Prut river basins) is explained by the reduced hydrological resources and the need to preserve them. For that reason, artificial lakes were built since antiquity; they had small dimensions and multiple usage. In the 15^{th} -16^{th} centuries, about 3,500 ponds were recorded, while nowadays their number decreased to 350 (the Romanian Academy, 1983). Some of them were abandoned, others were silted because of the high rate of soil erosion (friable sub-stratum) (Romanescu et al., 2008).

Table 1 Morphometric characteristics and trophicity of the lakes in Romania (data processing, I.N.M.H. Bucharest, 2006)

Lake	Genetic type	Water course	Usage	Volume Mln.m^3	Surface ha	Maximum depth	Water quality (category)	
							Nutrients (total nitrogen, total phosphorous)	Biology
Tisa river basin								
Buhăescu	Glacial	-	-	0.004	0.2	5	M-E	O
Călineşti-Oaş	Human made	Tur	complex	29.0	160	9	E	E
Someş river basin								
Colibiţa	Human made	Bistriţa	complex	101.2	314	50	E-H	O
Firiza	Human made	Săsar	complex	-	110.0	37.5	E	O
Lala	Glacial	-	-	-	0.6	2	UO	UO
Strâmtori	Human made	Firiza	complex	16.6	113.0		E	M
Bodi-Mogoşa	Floodplain	Săsar	complex	0.3	1.6	7	E-H	UO
Olt river basin								
Mesteacănu	Human made	Olt	Water supply	1.1	15	16	M-E	UO
Sfânta Ana	Volcanic	-	Tourism	0.250	19.5	7.5	M	M
Frumoasa	Human made	Frumoasa	Water supply	10.6			O-M	UO
Săcele	Human made	Târlung	Water supply	18.3	-	37	M-E	UO
Brădişor	Human made	Lotru	Complex	38.0	-	-	M	H
Ialomiţa river basin								
Paltinu	Human made	Doftana	Water supply	62.3	215	107	E-H	O
Măneciu	Human made	Teleajen	Complex	58.0	192	-	H	O
Siret river basin								
Izvorul Muntelui	Human made	Bistriţa	Complex	1230.0	3000	90	M	M
Bâtca Doamnei	Human made	Bistriţa	Energy	10.0	235	16	E	O
Poiana Uzului	Human made	Uz	Water supply	90.0	335	75	E-H	M
Siriu	Human made	Buzău	Complex	158.0	360	-	E	O
Roşu	Natural barrage	Bicajel	Tourism		13	7.5	M-E	UO

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

The trophicity degree of the lakes within Romania's main river basins was determined by the analysis of the chemical aspects (according to the value of the nutrients) and the evolution of the aquatic cenoses (according to the value of the phytoplankton biomass). The given qualifications range among the following categories: hypertrophic, eutrophic, mesotrophic, oligotrophic and ultraoligotrophic, intermediate categories being added.

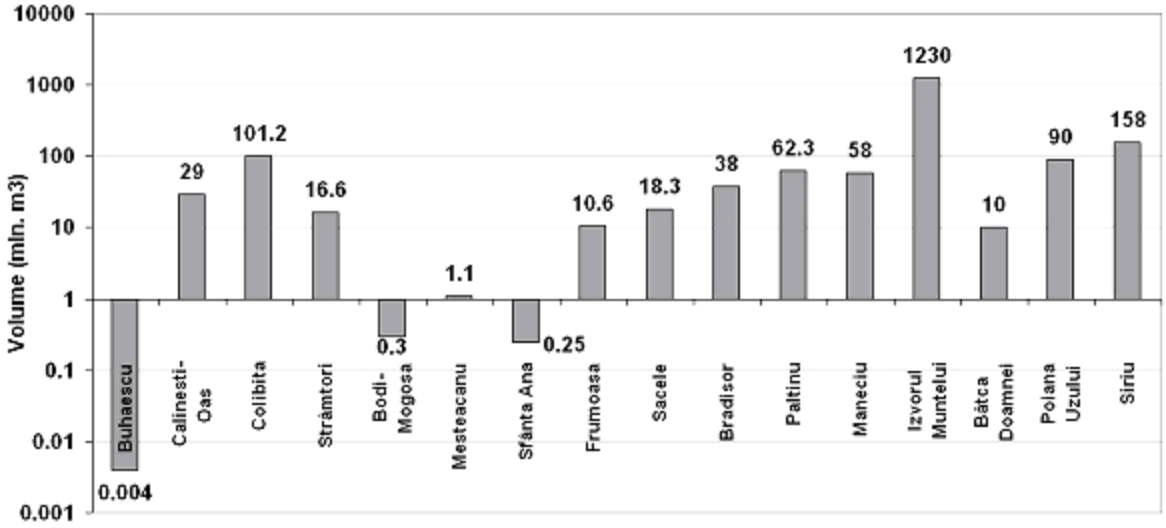

Fig. 4 Size of the lakes in the Eastern Carpathians according to water volume

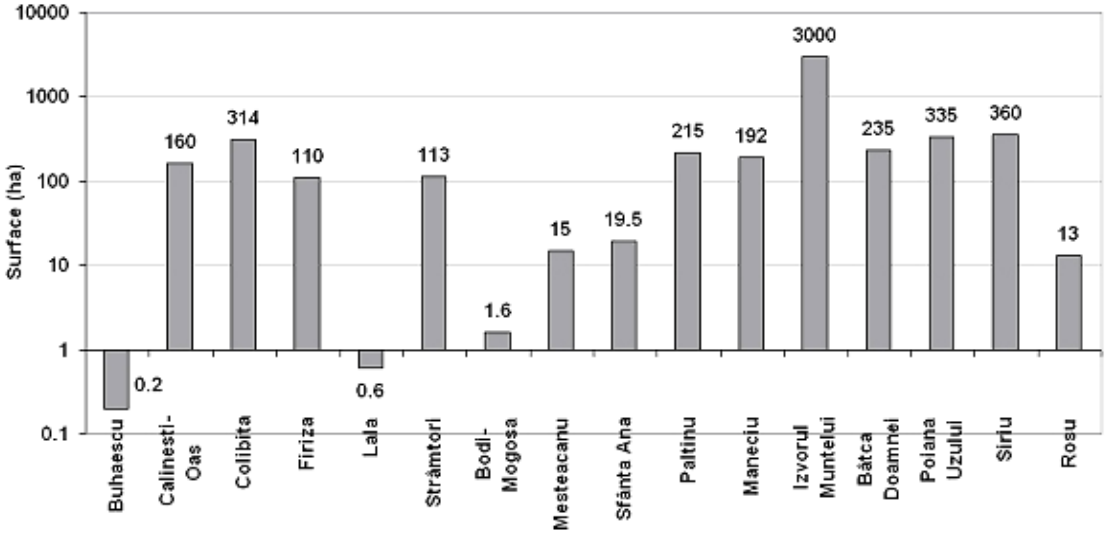

Fig. 5 Size of the lakes in the Eastern Carpathians according to surface

The eutrophic lakes are characterized by an important primary productivity, resulting in a high nutrient content. On the other side, the oligotrophic lakes have very reduced nutrient content, resulting in a low productivity. The mesotrophic lakes are situated between the two categories, with intermediate productivity. The hypertrophic and ultraoligotrophic lakes are situated at the two extremes.

Table 2 Lacustrine waters trophicity according to the nutrients value (Nutrients - total nitrogen, total phosphorous)

River basin	Total number of lakes	Trophicity degree															
		UO		O		O-M		M		M-E		E		E-H		H	
		Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Tisa	2	-	-	-	-	-	-	-	-	1	50.00	1	50.00	-	-	-	-
Someş	5	1	20.00	-	-	-	-	-	-	-	-	2	40.00	2	40.00	-	-
Olt	5	-	-	-	-	1	20.00	2	40.00	2	40.00	-	-	-	-	-	-
Ialomiţa	2	-	-	-	-	-	-	-	-	-	-	-	-	1	50.00	1	50.00
Siret	5	-	-	-	-	-	-	1	20.00	1	20.00	2	40.00	1	20.00	-	-

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

The geographical location of the lakes within distinct landform units (mountains, hills and plains, littoral) creates a different background for the manifestation of the trophicity. We can notice the fact that, according to the value of the nutrients, most of the lakes (wetlands) are situated within the mesotrophic, meso-eutrophic, eutrophic, eutro-hypertrophic, and hypertrophic categories (17 of 19, meaning 88.49%). It is only in the mesotrophic category that 3 lakes (wetlands) are included (15.78%). Within the two extreme categories, 1 lake (wetland) is ultraoligotrphic (5.26%) and 1 lake (wetland) is hipertrophic (5.26%).

Fig. 6 Lala Lake in Rodna Mountains

Table 3 Trophicity of lake waters according to the phytoplankton biomass value (Biology)

River basin	Total no of lakes	Trophicity degree															
		UO		O		O-M		M		M-E		E		E-H		H	
		Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Tisa	2	-	-	1	50.00	-	-	-	-	-	-	1	50.00	-	-	-	-
Someş	5	2	40.00	2	40.00	-	-	1	20.00	-	-	-	-	-	-	-	-
Olt	5	3	60.00	-	-	-	-	1	20.00	-	-	-	-	-	-	1	20.00
Ialomiţa	2	-	-	2	100.00	-	-	-	-	-	-	-	-	-	-	-	-
Siret	5	1	20.00	2	40.00	-	-	2	40.00	-	-	-	-	-	-	-	-

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

According to the phytoplankton biomass value, a large number of lakes are included in the categories: ultraoligotrophic, oligotrophic and oligo-mesotrophic (13 of 19, representing 68.42%). In the mesotrophic category, 4 lakes are included (21.05%). A number of 6 lakes are included in the ultraoligotrophic category (31.57.5%) and 1 lake in the hypertrophic category (5.26%).

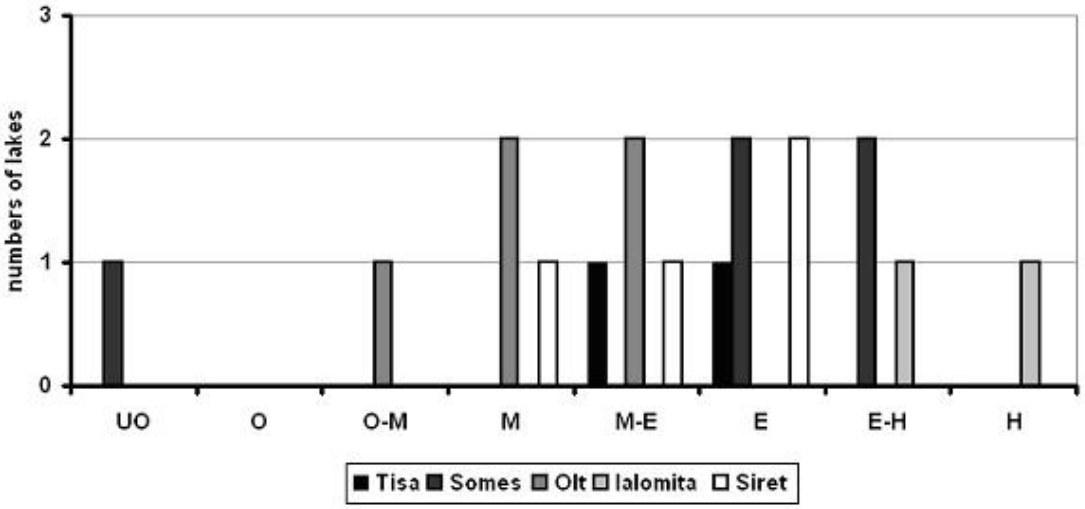

Fig. 7 The number of lakes distributed on river basins

Fig. 8 Roşu (Red) Lake in Hăghimaş Mountains

Most hypertrophic lakes are situated in low landform units, where temperatures are high and quantity of nutrients is extremely high (Maneciu). The most favourable area for a high trophicity is represented by the Danube flood plain (Romanian Academy, 1967).

The most ultra-oligotrophic lakes are found in the high mountain area. All the glacial lakes are included in this category (Lala). To these, the reservoirs with cold water, developed on hard rocks can be added.

In the area with the highest density of lakes there are lakes (aquatoriums) with good and very good trophicity (see the Siret and Olt river basins). Because of this reason, many of the accumulation lakes in the Siret and Olt basins are the most important aquatoriums for fishing industry.

Besides the climate, the trophicity is strongly influenced by the nature of rocks within the drained river basin, by the erosion rate, by transparency and turbidity etc.

From the point of view of trophicity, according to the data obtained by I.N.M.H. (2000), out of 95 lakes on the whole territory of Romania, 20 (21.05%) were oligotrophic, 20 (21.05%) oligo-mesotrophic, 33 (34.74%) mesotrophic, 11

(11.57%) meso-eutrophic and 11 (11.5%) eutrophic. As compared to the average value for Romania, the lakes in Eastern Carpathians include a higher proportion of the oligo-mesotrophic and mesotrophic category.

Fig. 9 Sfânta Ana Lake in Ciomatu Mountains

The general analysis of the lakes on Romania's territory (especially from the Eastern Carpathian Mountains) clearly demonstrates the fact that they are included, to the greatest extent, into the category of lakes with medium and high trophicity.

CONCLUSIONS

The number of the lakes (wetlands) in Romania and the Eastern Carpathian Mountains is relatively great, but their area is often reduced. Most lakes are anthropic, being mainly situated in the Northern Moldova and Transylvania. The most important analysed lakes (wetlands) were limited within river basins. In the present study the salty lakes in the salt massifs were not analysed, as they present different characteristics and they are used only therapeutically (Ocna Şugatag, Coştui etc.).

The trophicity degree is given by 5 main qualifications (hypertrophic, eutrophic, mesotrophic, oligotrophic, ultraoligotrophic) and separates the lakes on the territory of the Eastern Carpathian Mountains according to landform units and climate. The trophicity can also be influenced by the nature of rocks. According to the value of the nutrients, most of the lakes are included in the mesotrophic, mesoeutrophic, eutrophic, eutro-hypertrophic and hypertrophic categories. The lakes with the best trophicity are used for fishing as well.

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