THE INTEGRATIVE STUDY ON THE STRUCTURE OF BIODIVERSITY FROM LACUSTRINE ECOSYSTEMS IN THE FLOODPLAIN OF THE DANUBE

CIOBOIU Olivia, CISMAŞIU Carmen-Mădălina, GAVRILESCU Elena, BREZEANU Gheorghe

Abstract. The flooded area of the Danube is one of the most important wetlands in Europe, which is characterized by ecosystemic structures that are complex, aquatic and terrestrial, having a major role in regulating and balancing of climatic processes (temperature variations, humidity, hydrological regime), ecological processes (by localization of a great biodiversity) and economic processes – the production of natural resources. The researches carried out on the floodplain of the Danube, in the Cetate - Dăbuleni sector, are part of a national program for knowing the structure of biodiversity of specific ecosystems of wetlands from the southwest of Romania. The physical chemical characteristics of the water, the structure of the planktonic and benthic biocenoses were highlighted. The greatest diversity belongs to algae, the most abundant being cyanophycean, bacillariophytes and chlorophylls. Marsh and aquatic macrophytes occupy an important place in the bioeconomy of ecosystems. One of the main ecological factors in the structure of the communities of organisms in the flood zone is the Danube, and the interdependence between them contributes to ensuring the structural-functional peculiarities of the biocenosis. The river waters that periodically enter the lakes represent the main source of the biological production of the lake ecosystems, determining the development of the primary producers and consumers in correlation with its specific ecological particularities. The fauna specific to the floodplain of the Danube includes 24 groups of invertebrates, with the prevalence of protozoa, rotifers, copepods, cladoceres, oligochaetes, gastropods, bivalves, amphipods, odonates, chironomids. Gastropod populations are an important component of the biological production of eutrophic lake ecosystems and a total number of 37 species was identified. The analyses performed by the mineralization process in the lacustrine ecosystems from the studied sector illustrate the capacity of lung snail species such as *Radix balthica* and *Lymnaea stagnalis* to accumulate metal ions of Mn^{2+}, Fe^{2+}, Cu^{2+} and Zn^{2+} type in direct correlation with the chemical peculiarities of the soil in the flooded area of the Danube. Also, enzymological studies have shown that dehydrogenase, catalase and phosphatase are found in irrelevant amounts in the sediments of the Bistreț, Maglavit and Desa-Ciuperceni lakes in this sector.

Keywords: biodiversity, lacustrine ecosystems, the Danube, the flooded area, Oltenia.

Rezumat. Studiu integrativ privind structura biodiversității ecosistemelor lacustre din zona inundabilă a Dunării. Zona inundabilă a Dunării este una dintre cele mai importante zone umede din Europa, caracterizată prin structuri ecosistemice complexe, acvatice și terestre, având rol major în reglarea și echilibrarea proceselor climatice (variațiile de temperatură, umiditate, regim hidrologic), ecologice (prin localizarea unei mari biodiversități) și economice – producția resurselor naturale. Cercetările efectuate asupra zonei inundabile a Dunării, în sectorul Cetate - Dăbuleni, fac parte dintr-un program național de cunoaștere a structurii biodiversității unor ecosisteme specifice zonelor umede din sud-vestul României. Au fost puse în evidență caracteristicile fizico-chimice ale apei, structura biocenozelor planctonice și bentonice. Diversitatea cea mai mare aparţine algelor, cele mai abundente fiind cianoficeele, bacilarioficeele şi cloroficeele. Macrofitele palustre şi acvatice ocupă un loc important în bioeconomia ecosistemelor. Unul dintre factorii ecologici principali ai structurii comunităților de organisme din zona inundabilă este Dunărea, interdependenţa dintre acestea contribuind la asigurarea particularităţilor structural-funcţionale ale biocenozei. Apele fluviului care pătrund periodic în lacuri reprezintă sursa principală a producţiei biologice a ecosistemelor lacustre, determinând dezvoltarea producătorilor primari şi consumatorilor în corelaţie cu particularităţile ecologice specifice acestuia. Fauna specifică zonei inundabile a Dunării cuprinde 24 grupe de nevertebrate, dominante fiind protozoare, rotifere, copepode, cladocere, oligochete, gasteropode, bivalve, amfipode, odonate, chironomide. Populaţiile de gasteropode reprezintă componenta importantă a producţiei biologice a ecosistemelor lacustre eutrofe, fiind identificate un număr de 37 specii. Analizele realizate prin procesul de mineralizare în ecosistemele lacustre din sectorul studiat ilustrează capacitatea speciilor de melci pulmonaţi *Radix balthica* și *Lymnaea stagnalis* de a acumula ioni metalici de tip Mn^{2+}, Fe^{2+}, Cu^{2+} și Zn^{2+} în corelaţie directă cu particularitățile chimice ale solului din zona inundabilă a Dunării. De asemenea, studiile enzimologice au evidenţiat faptul că dehidrogenaza, catalaza și fosfataza se găsesc în cantități irelevante în sedimentele lacurilor Bistreț, Maglavit și Desa-Ciuperceni din acest sector.

Cuvinte cheie: biodiversitate, ecosisteme lacustre, zona inundabilă a Dunării, Oltenia.

INTRODUCTION

The floodplain of the Danube is one of the most important wetlands in Europe, characterized by complex aquatic and terrestrial ecosystems, having a major role in regulating and balancing climatic processes (temperature variations, humidity, hydrological regime), ecological (by locating a high biodiversity) and economic - production of natural resources (ANTIPA, 1910; PĂCEȘILĂ et al., 2008; BREZEANU et al., 2011).

The researches carried out on the floodable area of the Danube, in the Cetate - Dăbuleni sector, are part of a national program for knowing the structure of biodiversity of some ecosystems specific to the wetlands in southwestern Romania (Fig. 1). This sector, with an area of 56,425 ha is a sample of the flood zone that has disappeared and which preserves the biocenotic structures specific to wetlands (CIOBOIU & CISMAŞIU, 2016). The main ecosystem components in the area between Cetate-Dăbuleni are: lakes (Maglavit, Desa-Ciuperceni, Bistreț), ponds (Manginița, Țarova, Balta Lată), ravines (Milu's ravine), a series of swamps and canals (Fig. 2). These ecosystems are subject to the anthropogenic process of eutrophication and industrial pollution.

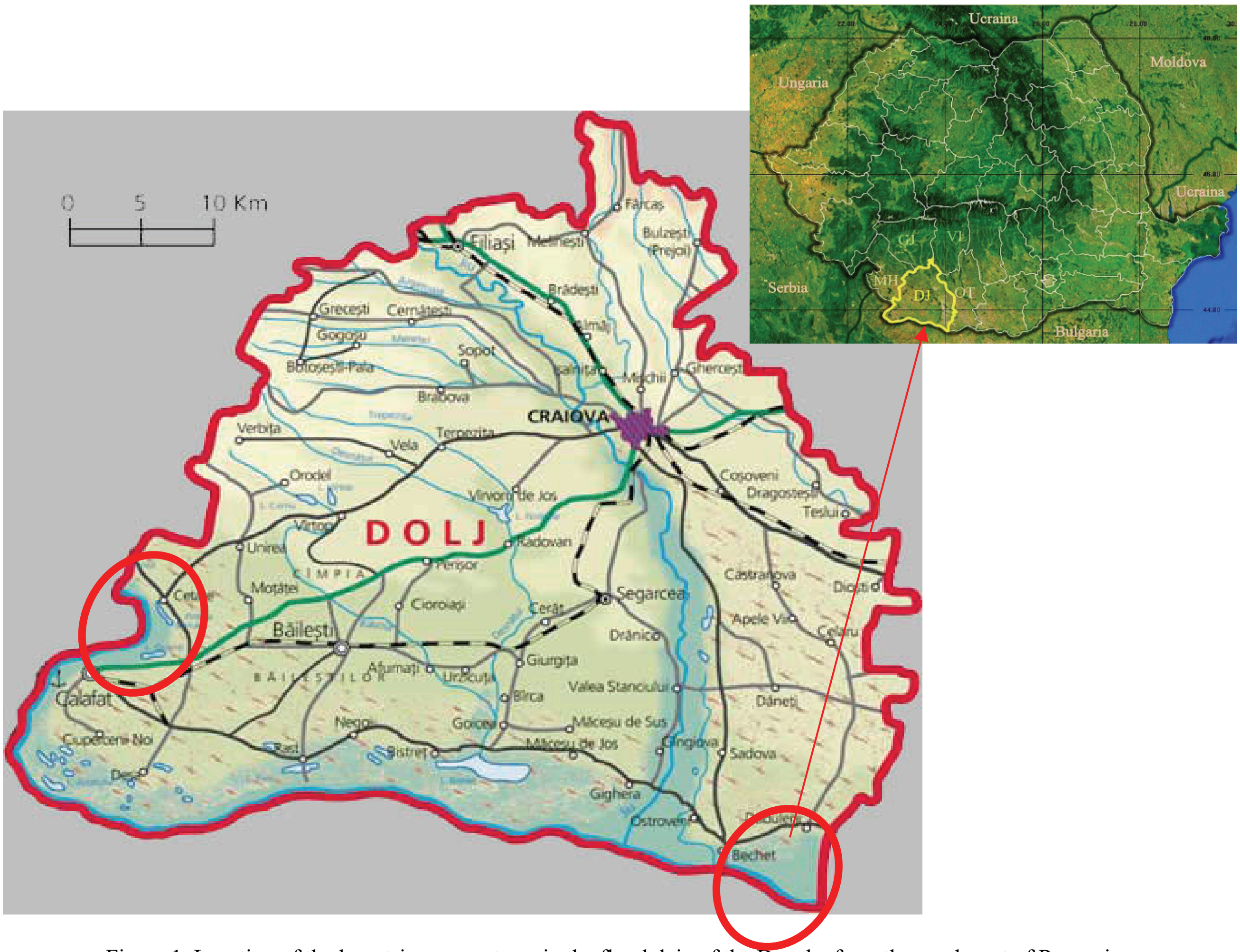

Figure 1. Location of the lacustrine ecosystems in the floodplain of the Danube from the southwest of Romania (from Google Earth, accessed: March 11, 2020).

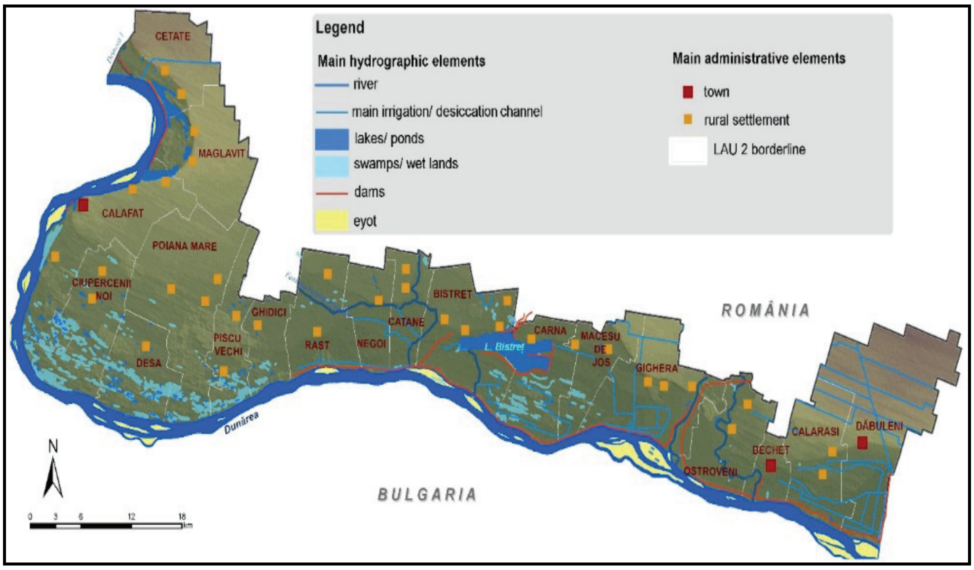

Figure 2. Main hydrographical characteristics of Danube Floodplain in the Sector Cetate - Dăbuleni (after POPESCU et al., 2015).

Understanding the mechanisms by which the acidophilic bacteria of the genus *Acidiphiilium* are involved in the fixation of heavy metals is very important in terms of the development of microbial processes of concentration and removal of these metals from aqueous solutions. Thus, the knowledge of the chemical reactions that take place during the fixation of metal ions leads to the achievement of an efficient control of the parameters of the bioremediation process of the industrially polluted areas from Oltenia, as well as from the neighbouring areas (CISMAŞIU, 2014).

MATERIAL AND METHOD

In order to evaluate the hydrobiological characteristics, an extensive research program was carried out. Based on the existing data in the literature and our own research, a synthesis was made that allowed monitoring the biodiversity of lake ecosystems in the studied sector (CIOBOIU, 2008; BREZEANU et al., 2011; CIOBOIU & BREZEANU, 2014). Samples were taken in order to establish the physico-chemical characteristics of water, the planktonic and benthic structures, as well as enzymatic activity.

Enzymological studies consisted in determining the quantitative enzymatic activity as follows: phosphatase activity (AF) - Kramer and Erdei method (PUSKÁS et al., 2005), catalase (AC) - Kappen method and dehydrogenase activity. Because different categories of sediments may have a different water content, the degree of humidity of each sample was established, which may influence the expression of microbial load and enzymatic activity related to gram dry sediment (CUŞA, 1996; GAVRILESCU et al., 2017).

RESULTS AND DISCUSSIONS

Water chemistry is characteristic of eutrophic ecosystems. The ph values range from 6.5-8.5 (weakly alkaline range) (table1). The large amount of nitrates and nitrates is due to the intake of nutrients as an effect of the administration of mineral and organic fertilizers on neighbouring agricultural lands. Among the cations, first of all, calcium (Ca^{2+}) stands out, whose origin is considered to be the sedimentary rocks of the lake basin, but also the amendments applied to the agricultural lands in the area (CIOBOIU & PLENICEANU, 2005; CIOBOIU, 2011).

Table 1. Physico-chemical composition of water (average values).

No.	Indicators analysed	Measured values	Permitted values	Method of analysis	Equipment used
			Order 161/2006 Class II		
1.	Conc. hydrogen ions (pH), unit. pH	7.2	6.5 – 8.5	STAS 6325-75	pH meter WTW 330i, series 08090178
2.	Electrical conductivity µS/cm, max.	1100	-	STAS 7722-84	Cond WTW 340i, series 08082507
3.	Total hardness, German degrees, max	27.50	-	STAS 3026-76	-
4.	Fixed residue, mg/dm3, min./max.	550	750	STAS 3638-76	Analytical balance type KERN 770 Series 17308244
5.	Ammonia (NH_4), mg/dm^3, max.	0.102	1.0	STAS 6328-85	Spectrophotometer DR 2000, no. series 930700025411
6.	Calcium (Ca^{2+}), mg/dm^3, max.	55	100	STAS 3662-62	-
7.	Magnesium (Mg), mg/dm^3, max.	87	50	STAS 6674-77	-
8.	Nitrates (NO_2), mg/dm^3, max.	<0.01	0.1	Method 571	Spectrophotometer Lovibond PC spectro Series 100510
9.	Nitrates (NO_3), (mg/dm^3, max.	108	13	Method 355	Spectrophotometer DR 2000, no. series 930700025411
10.	Chlorides (Cl), mg/dm^3, max.	64	50	STAS 3049-86	-
11.	Oxidizable organic matter CCOCr (O_2) mgO_2/dm^3,max	4.3	25	STAS 3002-85	-

The floristic and faunal structure of the lake ecosystems is particularly diverse. The greatest diversity belongs to algae, the most abundant being bacillariophytes and chlorophylls, and during the summer they have an intensive development and cyanophyceae. The most common species are: *Diatoma elongatum, D. vulgare, Synedra acus, S. ulna, Amphora ovalis, Ceratoneis arcus, Gyrosigma acuminatum, Scenedesmus quadricauda, S. acuminatus, Pediastrum duplex, P. boryanum, P. simplex, Cymatopleura solea, Navicula cineta, Cymbella affinis, C. lanceolata, Microcystis aeruginosa, Euglena viridis,* with an average numerical density of over 80 thousand specimens / L (MOLDOVEANU & FLORESCU, 2013).

Macrophyte swamp and water play an important role in the bioeconomy ecosystems, the dominant species is *Phragmites communis, Typha angustifolia, Nuphar luteum, Nymphaea alba, Rorippa Amphibia, Polygonium amphibium, Iris pseudacorus, Equisetum arvense, Euphorbia palustris, Scirpus lacustris, Carex riparia, Ranunculus aquatilis , Salvinia natans, Stratiotes alloides, Myriophylum spicatum, Hydrocharis morsus-ranae* (DIHORU & ARDELEAN, 2009). An overall assessment of biomass demonstrated that they can get 85200 Kg / ha / year wet biomass. It is a proof of trophic ecosystems (CIOBOIU & CISMAŞIU, 2016).

As with phytoplankton, zooplankton is an important part of biological production. Its development correlates with that of phytoplankton, the latter being the main source of food for zooplankton. The dominant groups are rotifers, copepods and cladocerans (BREZEANU et al., 2011). In the case of rotifers, whose numerical density exceeds 86 thousand specimens / L, the dominant species are: *Brachionus angularis, B. calyciflorus, Keratella cochlearis, Polyarthra vulgaris, P. major, Filinia longiseta, Asplanchna priodonta, Synchaeta pectinata*. Copepods that have a significant contribution to zooplankton production (over 20 thousand specimens / l in Lake Maglavit) are frequently represented by the species *Acathocyclops vernalis, Cyclops vicinus, Eudiaptomus gracilis, Mesocyclops leukarti* (CIOBOIU, 2015). Cladocera are a group with a large share in the zooplankton of eutrophic lakes. The dominant and common species are: *Diaphanosoma brachiurum*, *Moina micrura, Bosmina longirostris, Leptodora kindi, Sida cristalina, Daphnia cucullata, Chydorus sphaericus, Leydigia acanthoscelidis.*

One of the main ecological factors of the structure of the communities of organisms in the flood zone is the Danube, the interdependence between them contributing to ensuring the structural-functional peculiarities of the biocenosis. The river waters that periodically enter the lakes represent the main source of the biological production of the lake ecosystems, determining the development of the primary producers and consumers in correlation with its specific ecological particularities. The structure of the benthos is determined by the structure of the benthic facies (CIOBOIU & CISMAŞIU, 2018). The main benthic groups are: oligochaetes (dominant species *Limnodrilus sp., Peloscolex ferox, Stylaria lacustris, Branchiura sp.),* chironomides *(Chironomus plumosus, Tendipes semireductus, Polypedilum sp., Cricotopus sp., Procladius sp.),* plecopteres *(Amphinemura standfussi, Capnia bifrons, Leuctra fusca, L. nigra, Nemoura cambica, N. cinerea, Perla marginata*, *Protonemura intricata*), bivalves (*Unio pictorum, Anodonta piscinalis, Sphaerium lacustre, Dreissena polymorpha*), hirudinees (*Piscicola geometra, Hirudo medicinalis*), ephemeroptera (*Palingenia* sp.), odonata (*Gomphus pulchellus*), choleoptera (*Hydrophilus sp*.), trichoptera (*Hydropsyche ornatula, Setodes sp*.), gamarides (*Pontogammarus crasus*, *Dicherogammarus vilosus*). An important role in the biological production of the lake ecosystems in the area is played by the populations of gastropods, predominantly benthic organisms that actively respond to the heterogeneity of the microhabitats they populate. A number of 37 species have been identified, including *Viviparus acerosus, Radix balthica, Physella (Costatella) acuta, Lymnaea stagnalis, Planorbarius coneus* are characteristic of eutrophic lake ecosystems in the floodplain (Table 2) (GROSSU, 1993; CIOBOIU, 2015).

Table 2. The taxonomic diversity of gastropods.

CLASS GASTROPODA Cuvier 1798	
SUBCLASS PROSOBRANCHIA Milne Edwards 1848	
ORDER CYCLONERITIDA Rafinesque 1815	
Family Neritidae Rafinesque 1815	*Theodoxus danubialis* C. Pfeiffer 1828 *Theodoxus fluviatilis* Linnaeus 1758 *Theodoxus transversalis* (C. Pfeiffer 1828)
ORDER MESOGASTROPODA (Thiele 1925)	
Family Viviparidae Gray 1847	*Viviparus acerosus* Bourguignat 1870 *Viviparus viviparus* Linnaeus 1758
Family Valvatidae Thomson 1840	*Valvata cristata* (O. F. Muller 1774) *Valvata (Cincina) piscinalis* O. F. Muller 1774 *Borysthenia naticina* (Menke 1845)
Family Lithoglyphidae Troschel 1857	*Lithoglyphus naticoides* C. Pfeiffer 1828
Family Bithyniidae Gray 1849	*Bithynia tentaculata* Linnaeus 1758 *Bithynia (Codiella) leachii* (Sheppard 1848)
Family Thiaridae Troschel 1857	*Esperiana esperi* (Ferussac 1829) *Esperiana (Microcolpia) daudebardii* (Prevost 1821) *Esperiana (Microcolpia) daudebardii acicularis* Ferussac 1823
SUBCLASS PULMONATA Cuvier 1817	
ORDER BASOMMATOPHORA A. Schmidt 1855	
Family Physidae Fitzinger 1833	*Physa fontinalis* (Linnaeus 1758) *Physella (Costatella) acuta* (Draparnaud 1805) *Aplexa hypnorum* (Linnaeus, 1758)
Family Lymnaeidae Rafinesque 1815	*Lymnaea stagnalis* (Linnaeus 1758) *Stagnicola palustris* (O. F. Muller 1774) *Stagnicola corvus* Gmelin 1788 *Radix auricularia* (Linnaeus 1758) *Radix ampla* (Draparnaud 1805) *Radix balthica* (Linnaeus 1758) *Galba truncatula* (O. F. Muller 1774)
Family Ancylidae Rafinesque 1815	*Ancylus fluviatilis* O. F. Muller 1774
Family Acroloxidae Thiele 1931	*Acroloxus lacustris* (Linnaeus 1758)
Family Planorbidae Rafinesque 1815	*Planorbis planorbis* (Linnaeus 1758) *Anisus (Anisus) septemgyratus* (Rossmassler 1835) *Anisus (Anisus) spirorbis* (Linnaeus 1758) *Anisus (A.) vortex* (Linnaeus 1758) *Bathyomphalus contortus* (Linnaeus 1758) *Gyraulus albus* (O. F. Muller 1774) *Armiger crista* (Linnaeus 1758) *Segmentina nitida* (O. F. Muller 1774) *Hippeutes complanatus* (Linnaeus 1758) *Planorbarius corneus* (Linnaeus 1758)
ORDER STYLOMMATOPHORA A. Schmidt 1855	
Family Succineidae Beck, 1837	*Oxiloma elegans* (Risso 1826)

It is noted that the largest number of species inhabit the bottom of the slurry-detritus (24 species) in the vicinity of the banks in shallow areas. These areas have the best food conditions. The smaller species diversity was determined in the areas where the substrate is predominantly sand (10 types) (Table 3).

Table 3. Taxonomic composition according to the benthal facies.

Species	Benthal facies		
	Sandy	Muddy	Detritus
Theodoxus danubialis	+	+	
Theodoxus fluviatilis	+		
Theodoxus transversalis	+		
Viviparus acerosus		+	+
Viviparus viviparous	+	+	
Valvata cristata		+	
Valvata (Cincina) piscinalis		+	+
Borysthenia naticina			+
Lithoglyphus naticoides		+	+
Bithynia tentaculata		+	
Bithynia (Codiella) leachii			+
Esperiana esperi	+	+	
Esperiana (Microcolpia) daudebardii		+	+
Esperiana (Microcolpia) daudebardii acicularis	+	+	+
Physa fontinalis			+
Physella (Costatella) acuta		+	+
Aplexa hypnorum			+
Lymnaea stagnalis		+	+
Stagnicola palustris	+	+	
Stagnicola corvus			+
Radix auricularia		+	+
Radix ampla		+	+
Radix balthica	+		+
Galba truncatula	+	+	
Ancylus fluviatilis	+		
Acroloxus lacustris		+	
Planorbis planorbis		+	+
Anisus (A.) septemgyratus			+
Anisus (A.) spirorbis		+	
Anisus (A.) vortex		+	+
Bathyomphalus contortus			+
Gyraulus albus		+	
Armiger crista			+
Segmentina nitida			+
Hippeutes complanatus		+	+
Planorbarius corneus		+	+
Oxiloma elegans		+	+

Regarding the presence of bivalent heavy metals in sediments and the shell of freshwater snails, it was found that they can accumulate higher levels of $Mn^{2+,}$ Fe^{2+} and Cu^{2+} than the allowable environmental values (0.001 - 0.01 mg / l), according to Ord 161 / 2006. The analyses performed in the Maglavit Lake illustrate the capacity of the lung snail species *Lymnaea stagnalis* to accumulate metal ions of Mn^{2+}, Fe^{2+} and Cu^{2+} type in direct correlation with the concentration of the respective ions in the soil (Table 4).

Table 4. Concentrations of the metals in the soil and lungs snail shells of *Lymnaea stagnalis*.

No.	Analysed indicator (mg / Kg / SU)	Maglavit (soil)	Snails (shells)	Method analysis	Equipment used
1	Iron	0,27	180	Specific working method from the GBS-Avanta Atomic Absorption Spectrometer User Manual	Avanta GBC flame atomic absorption spectrometer, SN A 5378
2	Manganese	0,008	187		
3	Nichel	< SLD	0.475		
4	Crom	< SLD	4.07		
5	Cupru	< SLD	8.1		
6	Zinc	0.006	0.115		
7	Cadmium	0.0015	0.1		
8	Plumb	< SLD	0		

Note: SLD - below the detection limit

Also, the studies performed showed the increased tolerance of these snail species (e.g. the species of gill snails *Viviparus acerosus* and lung snails *Radix balthica*) to the presence in the environment of bivalent metal ions from industrial solid waste processing activities (CISMAŞIU et al., 2015). These species are bioindicators of industrially contaminated environments in the studied sector because they signal early the occurrence of negative changes in lacustrine ecosystems (CIOBOIU et al., 2019).

An important component of the studied lake ecosystems lies in the local microorganisms. Studies have shown that microorganisms in these environments have an increased resistance to the metal ions existing in them, having a greater capacity to reduce and oxidize organic and inorganic compounds in industrial habitats. This type of extracellular metabolic adaptation could be used in the bioremediation processes of industrial contaminant sites in Romania (BALOUCT et al., 2007; VOICU et al., 2009; KATYAL & PETRIŞOR, 2012; CISMAŞIU et al., 2016).

The researches imposed conservative approaches materialized in declaring the lake ecosystems in the studied sector as sites of community importance (Maglavit, Calafat - Ciuperceni - Danube, Bistreţ, Jiu-Danube Confluence) within the European Ecological Network Natura 2000 (POPESCU et al., 2015; CIOBOIU & CISMAŞIU, 2018).

Monitoring the enzymatic activity of sediments in the studied lakes. The grouping of lakes according to the phosphatase activity of sediments is as follows:

- the Desa-Ciuperceni lakes have a low phosphatase potential of sediments - phosphatase activity varies between 61.22 µg phenol / g sediment and 95.21 µg phenol / g sediment, the average value being 72.60 µg phenol / g sediment;
- the Maglavit Lake has a moderate phosphatase activity, the minimum phosphatase value being 78.5 µg phenol / g sediment, the maximum value being 120.03 µg phenol / g sediment. The average annual phosphatase activity of sediments for this lake is around 100 µg phenol / g sediment;
- the Bistreț Lake falls into the category of those with intense phosphatase activity — the average annual value of phosphatase was 134.43 µg phenol / g sediment, and seasonal fluctuations fall between 117.5 µg phenol / g sediment and 232.24 µg phenol / g sediment.

Depending on the catalase enzymatic activity, we have the Desa-Ciuperceni lakes with low catalase activity. The seasonal variation and the difference between the enzymatic potential of these lakes was 0.15 - 1.1 mg H_2O_2 / g dry matter sediment, and the average annual value recorded was up to 0.5 mg H_2O_2 / g dry matter sediment.

The Maglavit Lake has medium catalase activity. The sediments showed a mean catalase potential of 0.87 mg H_2O_2 / g dry matter sediment, ranging from 0.21 mg H_2O_2 / g sediment, dry matter to 2.1 mg H_2O_2 / g dry matter sediment.

The Bistreț Lake has intense catalase activity - the minimum catalase activity being 0.36 mg H_2O_2 / g dry matter sediment in the sediment, and the maximum value of 2.17 mg H_2O_2 / g dry matter sediment.

Dehydrogenase activity can be considered an overall indicator of the biological activity of organisms, but it has also been used as an ecotoxicological test to evaluate the effects of pollutants on the soil or sediment microbiota.

Lakes with very low dehydrogenase enzymatic activity in the sediment denote poor microbial activity. Seasonal fluctuations are relatively low, the minimum value was 0.13 µg, formazan / 1g dry sediment at Desa-Ciuperceni and approximately 0.37 µg formazan / 1g dry sediment, maximum value. Lake Maglavit has a moderate dehydrogenase activity, with high seasonal fluctuations - between 0.67 µg formazan / 1g dry sediment and 1.70 µg formazan / 1g dry sediment, and the average value recorded during the monitored period was approximately 1.00 µg formazan / 1g dry sediment.

The variation of the dehydrogenase activity in the sediments of Bistreț Lake is of 0.60 - 1.99 µg formazan / 1g dry sediment. The lake shows the maximum annual dehydrogenase activity of the dry sediment of 1.89 µg formazan / 1g sludge (dry matter).

CONCLUSIONS

The floodplain of the Danube in the Cetate-Dăbuleni sector is characterized by a diversity of types of ecosystems specific to wetlands. Specific floristic and faunal structures are characteristic to this ecosystem diversity. One of the fundamental factors of the life of the flood zone is the Danube, and the interdependence between them contributes to the structuring and functioning of the planktonic and benthic populations.

The fauna includes 24 groups of invertebrates, dominant being protozoa, rotifers, copepods, cladoceres, oligochaetes, gastropods, bivalves, amphipods, odonates, chironomids.

Gastropod populations are an important component of the biological production of eutrophic lake ecosystems in the area. They have a special role among consumers, because they represent an important factor in the process of accumulation of metal ions in water and sediment, as well as mass transfer to higher order consumers represented by fish.

Gastropod species are bioindicators of industrially contaminated environments in the floodplain of the Danube in the Oltenian sector because they signal early the emergence of negative changes in lake ecosystems.

The monitoring of the enzymatic activity of the sediments from the lakes located in the Cetate-Dăbuleni sector highlights the presence of the three enzymes studied in irrelevant quantities (dehydrogenase, catalase and phosphatase), especially in the sediments of the Bistreț lake followed by the Maglavit and Desa-Ciuperceni lakes. It can be concluded that the Bistreț Lake falls into the first quality category.

ACKNOWLEDGMENT

The data are the result of the collaboration conventions between The Institute of Biology of Bucharest and The Oltenia Museum of Craiova with numbers 39 / 05.01.2018, respectively 18 / 08.01.2018, with research theme: *The integrative study regard to biodiversity specific to industrial polluted ecosystems from Oltenia, as well as limitrofe areas*. Also, some of the presented data are results of project no. RO1567-IBB05 / 2020 developed at the Institute of Biology of the Romanian Academy.

REFERENCES

ANTIPA GR. 1910. *Regiunea inundabilă a Dunării. Starea ei actuală și mijloacele de a o pune în valoare.* Institutul de Arte Grafice. Edit. Acad. R. P. R. Bucureşti. 320 pp.

BALOUCT J. C., OUDIJK G., PETRIŞOR IOANA, MORRISON R. D. 2007. Emerging forensic techniques. *Introduction to environmental forensies*. Elsevier. Paris. **15**: 678-722.

BREZEANU GH., CIOBOIU OLIVIA, ARDELEAN A. 2011. *Ecologie acvatică*. Vasile Goldiş University Press. Arad. 406 pp.

CIOBOIU OLIVIA. 2008. The distribution of the gastropoda populations from the Danube and Danube Delta. *Verhard Internationale Verein Limnological*. Elsevier. Stuttgart. **30**(2): 295-296.

CIOBOIU OLIVIA. 2011. Biodiversity of a protected lacustrine complex within the lower hydrographical basin of the Jiu. *International Journal of Ecosystems and Ecology Sciences (IJEES)*. University Press. Tirana. **1**(1): 56-62.

CIOBOIU OLIVIA. 2015. Hydrobiological particularities of Maglavit Lake (Romania) – the place and role of Gastropod populations. *Oltenia. Studii și comunicări. Ştiinţele Naturii*. Muzeul Olteniei. Craiova. **31**(1): 221-229.

CIOBOIU OLIVIA & PLENICEANU OTILIA. 2005. Implications of lacustrine ecosystems eutrophization the Preajba River. *Environment & Progress*. University Babeș-Bolyai Publisher. Cluj-Napoca. **5**: 89-95.

CIOBOIU OLIVIA & BREZEANU GH. 2014. The restauration of the Danube Floodplain, a fundamental ecological issue for Romania. *International Journal of Ecosystems and Ecology Sciences (IJEES)*. University Press. Tirana. **4**(1): 141-146.

CIOBOIU OLIVIA &. CISMAŞIU CARMEN-MĂDĂLINA. 2016. Structural and functional characteristics of biocoenoses in the flooded area of the Danube for the biotope reconstruction from industrial contaminated habitats. *Oltenia. Studii și comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **32**(1): 122-131.

CIOBOIU OLIVIA & CISMAŞIU CARMEN MĂDĂLINA. 2018. Impact of eutrophication and industrial pollution on biodiversity evolution of the lacustrine ecosystems from the Romanian Sector of the Danube River. *The 42nd IAD Conference Smolenice*. Geomorphologia Slovaca et Bohemica. Bratislavia: 32-38.

CIOBOIU OLIVIA, CISMAŞIU CARMEN-MĂDĂLINA, GAVRILESCU ELENA, MITITELU-IONUȘ OANA. 2019. Monitoring the structure of biodiversity of lacustrine ecosystems in southwestern Romania. Abstract Book. *International Conference Lakes & Reservoirs: Hot Spot and Topics in Limnology*. University Poznan Publishing. Mikorzyn: 70-71.

CISMASIU CARMEN-MĂDĂLINA. 2014. The effect of salts compositions on the extracellular amylases activity from *Acidiphilium* populations isolated from mining effluents. *Oltenia. Studii şi comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **30**(1): 185-191.

CISMAȘIU CARMEN-MĂDĂLINA, CIOBOIU OLIVIA, CÎRSTEA DOINA MARIA, PAHONŢU JANINA MIHAELA, ŞTEFĂNESCU M. C. 2015. Structural and functional characteristics of microorganisms involved in processes of metal ions controlled bioreduction in order to reconstruct biocenotic structures. *Oltenia. Studii și comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **31**(2): 176-182.

CISMAȘIU CARMEN-MĂDĂLINA, CIOBOIU OLIVIA, PĂCEȘILĂ I. 2016. An integrative synthesis about the biodiversity research related to the decontamination processes of the natural ecosystems affected by the industrial pollution from Romania. *Oltenia. Studii și comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **32**(2): 164-173.

CUŞA V. 1996. The metodological instruction for microbiological analysis of the acvatic sediments. *Research and Environmental Engineeering Institute*. University Press. Bucharest. 4: 14-20.

DIHORU GH. & ARDELEAN G. 2009. *Cartea roşie a plantelor vasculare din România*. Edit. Academiei Române Bucureşti. 630 pp.

GAVRILESCU ELENA, CIOBOIU OLIVIA, CISMAŞIU CARMEN-MĂDĂLINA. 2017. Characterization of waters and sediments from Lacustrine Complex Adunații of Geormane. *Oltenia. Studii şi comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **33**(2): 153-160.

GROSSU AL. V. 1993. *Compendiul gasteropodelor din România.* Edit. Litera. Bucureşti. 525 pp.

KATYAL A. K. & PETRIŞOR IOANA. 2012. Innovative Sustainable Drought Management Strategy Incorporating Forensic Techniques and Policy Framework. *Environmental Forensics*. Taylor & Francis Publisher. London. **13**(2): 122-139.

MOLDOVEANU MIRELA & FLORESCU LARISA. 2013. Long-term analysis of cyanobacterial blooms in lake Roşu (Danube Delta). *Oltenia. Studii şi comunicări. Ştiinţele Naturii*. Craiova. **29**(1): 252-260.

PĂCEȘILĂ I., IONICĂ DOINA, COMAN CRISTINA ALINA. 2008. Activitatea dehidrogenazică – instrument de evaluare a metabolismului comunităților microbiene din sedimentul golfului Musura (Delta Dunării). *Rezumat Sesiunea Anuală a Institutlui de Biologie București al Academiei Române*. Edit. Ars Docendi. București: 15 (www.ibiol.ro/sesiune/2008/eco.pdf) (accessed March, 2020).

POPESCU LILIANA, LICURICI MIHAELA, BĂDIȚĂ AMALIA. 2015. Ecotourist resources – premise for the economic diversification of settlements in the Danube Floodplain (Dolj County). *Oltenia. Studii și comunicări. Ştiinţele Naturii*. Muzeul Olteniei. Craiova. **31**(2): 228-238.

PUSKÁS ÁGNES, ŞEULEAN MANUELA, DRĂGAN-BULARDA M., SAMUEL ALINA. 2005. Microbiological and enzymological studies on the water and sediments of the Ochiul Mare Lake (1 Mai baths, Bihor County). *Analele Universităţii Oradea. Fascicula Biologie*. Edit. Universitaria. Oradea. 12: 127-132.

VOICU ANCA, ȘTEFĂNESCU M. C., CORNEA CĂLINA-PETRUȚA, GHEIRGHE AMALIA. 2009. Microorganisms with biotechnological potential isolated from natural environments. *Biotechnology & Biotechnological Equipment*. Diagnosis Press. Bucharest. **23**(1): 747-750.

Cioboiu Olivia
The Oltenia Museum Craiova, Str. Popa Şapcă No. 8, 200422, Craiova, Romania.
E-mails: oliviacioboiu@gmail.com; cioboiu.olivia@yahoo.com

Cismaşiu Carmen-Mădălina
Institute of Biology Bucharest, Romanian Academy, Independence Spl. no. 296, sect. 6, 060031, Bucharest, Romania
E-mails: carmen.cismasiu@ibiol.ro; madalinabio@yahoo.com

Gavrilescu Elena
University of Craiova, Faculty of Horticulture,
Biology and Environmental Engineering Department, A. I. Cuza Street 13, Craiova, 200585, Romania.
E-mail: gavrilescu_elena@yahoo.com

Brezeanu Gheorghe
Institute of Biology Bucharest, Romanian Academy, Spl. Independentei No. 296, sect. 6, 060031, Bucharest, Romania.
E-mail: aurelia.brezeanu@ibiol.ro

Received: April 14, 2020
Accepted: June 26, 2020