AN INTEGRATIVE SYNTHESIS ABOUT THE BIODIVERSITY RESEARCH RELATED TO THE DECONTAMINATION PROCESSES OF THE NATURAL ECOSYSTEMS AFFECTED BY THE INDUSTRIAL POLLUTION FROM ROMANIA

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Abstract. Natural ecosystems have a complex structure, being, in most cases, made up of heterogeneous populations of organisms. These ecosystems are generally characterized by distinct spatial features, as a result of their geographical position and the specificity of layering processes, and temporal features, as a result of the successional patterns of the existing populations. All populations of organisms that occupy a specific habitat establish different types of interactions, both among themselves and with the abiotic environment. These types of interactions are highly influenced by the dynamics of natural phenomena, but, also, by the anthropogenic interventions. The present paper is an overview of the main research studies carried out in the Romanian sector of the Danube, which revealed the importance of the Danubian – Carpathian region in preserving natural biodiversity. The investigations were conducted in several areas from the Danube River, the Danube Delta, Tulcea County, and the rivers present in Oltenia Plain, at different periods of time. Different issues are addressed, especially related to the presence and distribution of gastropod species, the concentrations of heavy metals in soils and in the shells of some gastropods species, but, also, the dynamics of several physical-chemical and microbiological parameters, such as the total microbial biomass, numerical density of physiological groups of microorganisms and the intensity of extracellular enzymatic activity. Other issues presented in this paper are the results of microbiological research carried out in the contaminated industrial areas.

Keywords: biocoenoses, biosorbents, microbial biomass, microbial metabolism, extracellular enzymatic activity.

Rezumat. O sinteză integrativă asupra cercetărilor privind biodiversitatea care au legatură cu procesele de decontaminare a ecosistemelor naturale afectate de poluarea industrială din România. Ecosistemele naturale au o structură complexa fiind aproape întotdeauna heterogene din punct de vedere populațional. Acestea sunt caracterizate, în general, de particularități distincte, atât spațiale, determinate de poziția geografică și de specificul proceselor de stratificare, cât și temporale, un rezultat al succesiunilor populațiilor diferite de organisme existente în aceste ecosisteme. Toate populațiile de organisme care ocupă un anumit habitat stabilesc interacțiuni variate atât între ele cât şi cu mediul abiotic, aceste interacțiuni fiind influenţate de dinamica fenomenelor naturale dar şi de intervenţiile antropice. Lucrarea de faţă reprezintă o sinteză generală a cercetărilor efectuate în sectorul românesc al Dunării, care au evidenţiat importanţa spaţiului danubiano – carpatic în conservarea biodiversităţii naturale. Cercetările au fost efectuate în mai multe zone ale fluviului Dunăre, din Delta Dunării, din județul Tulcea, și din râurile prezente în Câmpia Olteniei, în perioade de timp diferite. Sunt abordate aspecte variate, în special privind prezenţa şi distribuţia speciilor de gastropode, concentrațiilor de metale grele din cochiliile unor specii de gastropode si din soluri, dar și rezultate despre dinamica mai multor parametrii fizici, chimici şi microbiologici, cum sunt biomasa microbiană totală, densitatea numerică a grupelor fiziologice de microorganisme și intensitatea activitatii enzimatice extracelulară. Alte aspecte prezentate în această lucrare sunt rezultatele obţinute în urma analizelor microbiologice desfăşurate în perimetrele contaminate industrial.

Cuvinte cheie: biocenoze, biosorbanţi, biomasa microbiană, metabolism microbian, activitate enzimatică extracelulară.

INTRODUCTION

Grigore Antipa studying the Danube and its area liable to flooding, the Danube Delta understood and explained the fundamental laws that govern supraindividual systems of organization of the living matter (populations, biocoenoses) embedded in their abiotic environment (ANTIPA, 1910; BREZEANU et al., 2011). In this context, by continuing the work of Antipa, Theodor Buşniţă initiated research programs aimed at hydrobiological study of the rivers tributary to the Danube, the floodplain and the Danube Delta (ARDELEAN et al., 1967; BUŞNIŢĂ & BREZEANU, 1970; BREZEANU et al., 2011). Nicolae Botnariuc and C. S. Antonescu made an important contribution to the knowledge of the functional structures of the aquatic ecosystems from the Danube Delta and the area liable to flooding (BOTNARIUC & BELDESCU, 1961; ANTONESCU, 1967).

The Danube Delta is a unique macro-regional complex at European level, consisting of numerous natural ecosystems of different types and sizes: aquatic, lentic and lotic ecosystems, terrestrial ecosystems and wetlands. It presents a higher and well-preserved biodiversity and has a very important role in the development of biogeochemical processes at regional level, as well as an important impact on socio-economic development of local and regional communities (SIMON-GRUIȚA, 2000; POSTOLACHE, 2006). As it is the case with many other complex natural ecosystems of large size worldwide, The Danube Delta is subject to an increasing anthropogenic pressure, concretized by uncontrolled development of projects in the field of agriculture, industry and navigation (FLORESCU et al., 2013). This phenomen has, certainly, a significant impact on the conservation of the natural biodiversity.

Over the years, it has been carried out a number of the quantitative and qualitative research about planktonic and benthic communities in the Danube River, the Danube Delta and the Romanian rivers, especially within Oltenia Plain (Fig. 1) (CIOBOIU, 2014). These include studies on the ecology and population dynamics of Cladocera and the aquatic gastropods, made particularly in the floodplain of the Danube River by Alexandrina and Stefan Negrea between the years 1962 and 1996 (NEGREA & NEGREA, 1975; NEGREA & MARINESCU, 1992; NEGREA, 1994). Moreover, in the monographic studies

Limnology of the Romanian sector of the Danube (1967) and The hydro-biological studies of the Danube River and its tributaries from the Iron Gates area (1970), Gheorghe Brezeanu and collaborators presented data concerning the gastropods of the aquatic ecosystems from the river, the area liable to flooding of the Danube and numerous tributaries from the boundaries of Dolj County, respectively of Oltenia Plain (BREZEANU, 1967; BUŞNIŢĂ & BREZEANU, 1970; BREZEANU & CIOBOIU, 2008; BREZEANU et al., 2011; CIOBOIU, 2011).

All the investigations mentioned above were held in the complex interdisciplinary research programs and are based on the principles of the systemic analysis in which gastropods have been integrated and analysed in the context of the relations with abiotic and biotic factors of the specific ecosystems from the Oltenian sector of the Danube River. Over time, it was also assessed the role of microorganism, planktonic and benthic communities, in the decomposition processes of detritus organic matter from several types of aquatic, lotic and lentic ecosystems of the Danube Delta. Among the most important studies we mention those achieved in investigating the phylogenetic diversity of microorganisms isolated from contaminated industrial perimeters from Romania (CISMAȘIU, 2003; 2004). The research studies have been focused on assessing the dynamics of the parameters such as overall microbial biomass, the numerical density of the main groups of the physiological microorganisms involved in the biogeochemical cycles of carbon, nitrogen and sulphur, and the dynamics of the extracellular enzymatic activity (KARAVAIKO et al., 1998; CISMAȘIU et al., 2005; PĂCEŞILĂ, 2014).

At present, the main fields of biohydrometallurgy are concentrated and continue to focus on the environmental control, with special reference to pollution with cyanide, the extraction of metals by reducing active sulphate and the system for the passive treatment of water. In this situation, there are two types of treatments (a) active by optimizing the activity of the involved microorganisms; (b) passive by aerobic precipitation and anaerobic precipitation of sulphide and carbonate, filtration, removal of metals, neutralization generated by ammonia and precipitation, processes of adsorption and ion exchange (PETRIŞOR et al., 2002, 2003; CISMAȘIU et al., 2003, 2004; AL-AZKI, 2007, 2010-2011). This work represents a synthetic selection of the most relevant data regarding the biodiversity of the communities of planktonic and benthonic microorganisms, as well as invertebrates, derived from the above mentioned studies.

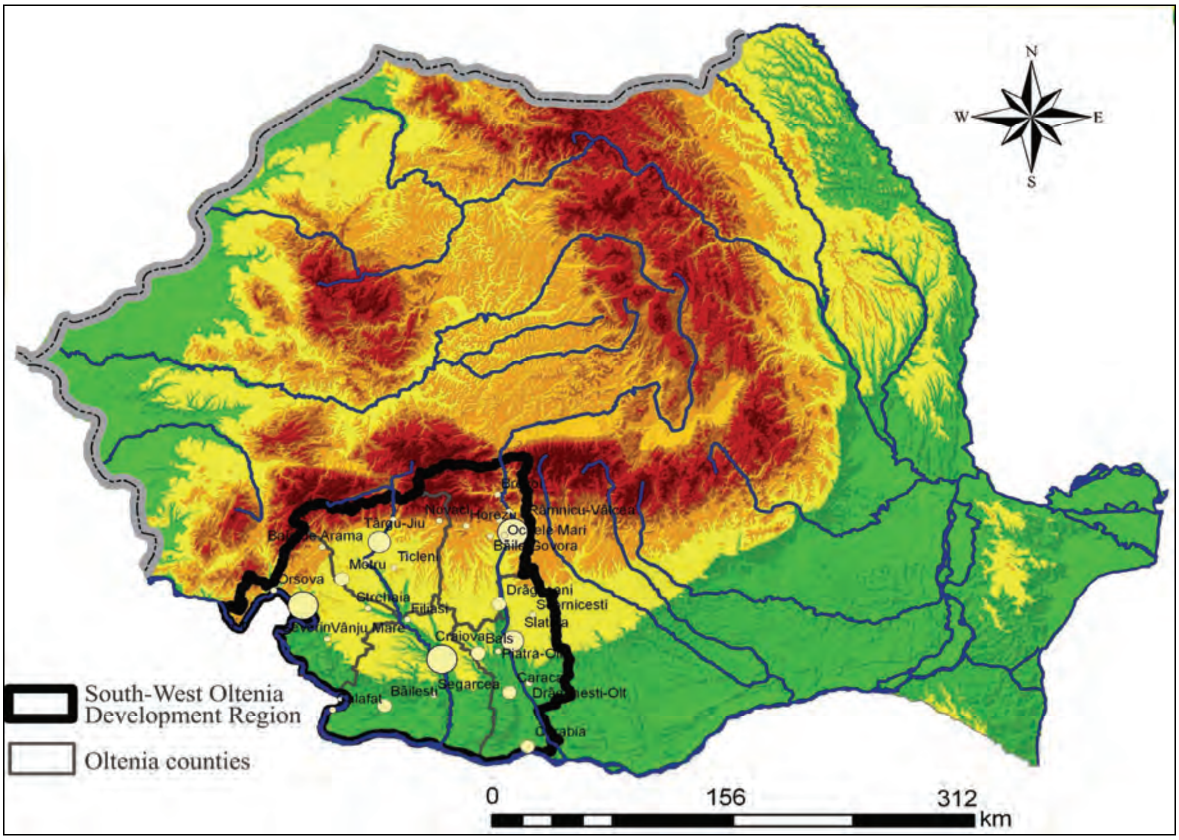

Figure 1. The Romania map with the delimitation of Oltenia (after POPESCU et al., 2015).

MATERIALS AND METHODS

On the basis of the data from the specialized literature and our own research, it was achieved a synthesis that allowed the global evaluation of gastropod populations in the Romanian Danube sector (GROSSU, 1993; CIOBOIU & BREZEANU, 2000; BREZEANU, 2002; CIOBOIU, 2006a, b; 2010a, b; BREZEANU & CIOBOIU, 2011; CUTTELOD et al., 2011; Fauna Europaea, 2014).

The studies regarding the dynamics of the microbial communities were conducted in the three distinct regions present along Sfântu Gheorghe branch, a result of human intervention from the ’80s, which aimed to improve navigation: the free-flowing sector (FS), the meander section (MS) and the newly built channel (NBC) (FLORESCU et al., 2013). The samples were taken from the water column and sediment from seven stations that correspond to the three sectors (Figs. 2; 3), in spring (April), in summer (July) and in autumn (October) in 2011-2013 period. The assessment of the intensity of the enzymatic activity was performed by substrate consumption measurement method (OBST, 1985) while the evaluation of the numerical density of physiological groups of microorganisms was performed using the method of the cultivation in vitro on specific media (PĂCEȘILĂ, 2012; 2014; PĂCEȘILĂ et al., 2013). In case of sediment, it has been reported the enzymatic activity per gram of dry substance (dry silt).

Figure 2. The sectors formed on Sfântu Gheorghe branch following the anthropogenic intervention:
SN (A), MS (B), SNC (C) **(**photos by C. BÎRSAN**).**

Figure 3. The sampling stations and their corresponding sectors:
SN – blue colour, MS – yellow colour, SNC – black colour (after PĂCEȘILĂ, 2014).

In Romania, there are mining areas where million tonnes of mining waste have been deposited in waste dumps, on surfaces of hundreds and thousands hectares. These contain significant quantities of ores containing heavy, rare and radioactive metals that, under the influence of the physical, chemical and biological mechanisms, are solubilised. These solutes, after the migration under the influence of dump erosion (wind and precipitation) are released into the environment where they act as pollutants. The diversity of species is a parameter correlated with the degree of stability by the microorganism communities in the ecosystem. This shall be amended under the influence of physical and chemical factors from the environment. Therefore, the biodiversity measurements are useful for monitoring the changes in the pollution degree and other disruptive factors of the ecosystem contaminated with metallic ions (ZARNEA, 1994; CISMAŞIU, 2004; POPEA et al., 2004).

RESULTS AND DISCUSSION

1. Chemical and biological characterization of lacustrine ecosystems

In the Romanian sector of the Danube, through the relations of the river with its area liable to flooding and the influence of several tributaries, the diversity of species of gastropods is high, being found 67 species (CIOBOIU, 2006a; 2011). In the river, there are found both the species characteristic to the eutrophic lacustrine ecosystems: *Theodoxus (Th.) danubialis stragulatus*, *Theodoxus (Th.) pallasi*, *Viviparus acerosus*, *Valvata (C.) piscinalis*, *Lymnaea stagnalis*, *Stagnicola corvus*, *Radix auricularia*, *Planorbis planorbis*, *Gyraulus (G.) acronicus*, as well as those that prefer the conditions of reophilous ecosystems: *Lithoglyphus naticoides*, *L. pygmaeus*, *Esperiana (M.) daudebardii acicularis*, *Radix ampla*, *Segmentina nitida* (Table 1). On the other hand, a number of species prefer sand facies *Theodoxus (Th.) prevostianus*, *Turricaspia (Oxypyrgula) ismailensis*, *Radix balthica,* other the argillaceous facies – *Lithoglyphus apertus, Galba truncatula* or areas with a rocky shore, such as the species *Bithynia tentaculata*, *Amphimelania holandri*.

Therefore, it appears that the variable environmental factors of the Danube River (flow rate, nature of the substrate, trophic status) determine the distribution of the gastropod populations (BUŞNIŢĂ & BREZEANU, 1970; NEGREA & MARINESCU, 1992; NEGREA, 1994; CIOBOIU & BREZEANU, 2000; CIOBOIU, 2008).

The Danube Delta, with a surface of about 434,000 ha, is the final segment of the Danube; 70% of its area is occupied by a great diversity of aquatic ecosystems, canals, lakes, swamps (Fig. 4). So far, there have been identified 45 species, among which the most common (with the highest frequency) are: *Theodoxus (Th.) danubialis*, *Th. fluviatilis*, *Viviparus acerosus*, *Pseudamnicola (P.) dobrogica*, *P. leontina*, *P. razelmiana*, *Potamopyrgus antipodarum*, *Turricaspia (Laevicaspia) lincta*, *T. dimidiata*, *Physella (Costatella) acuta*, *Anisus (A.) spirorbis*, *Gyraulus (Torquis) laevis*, *Planorbarius corneus* (GROSSU 1993; CIOBOIU, 2010a).

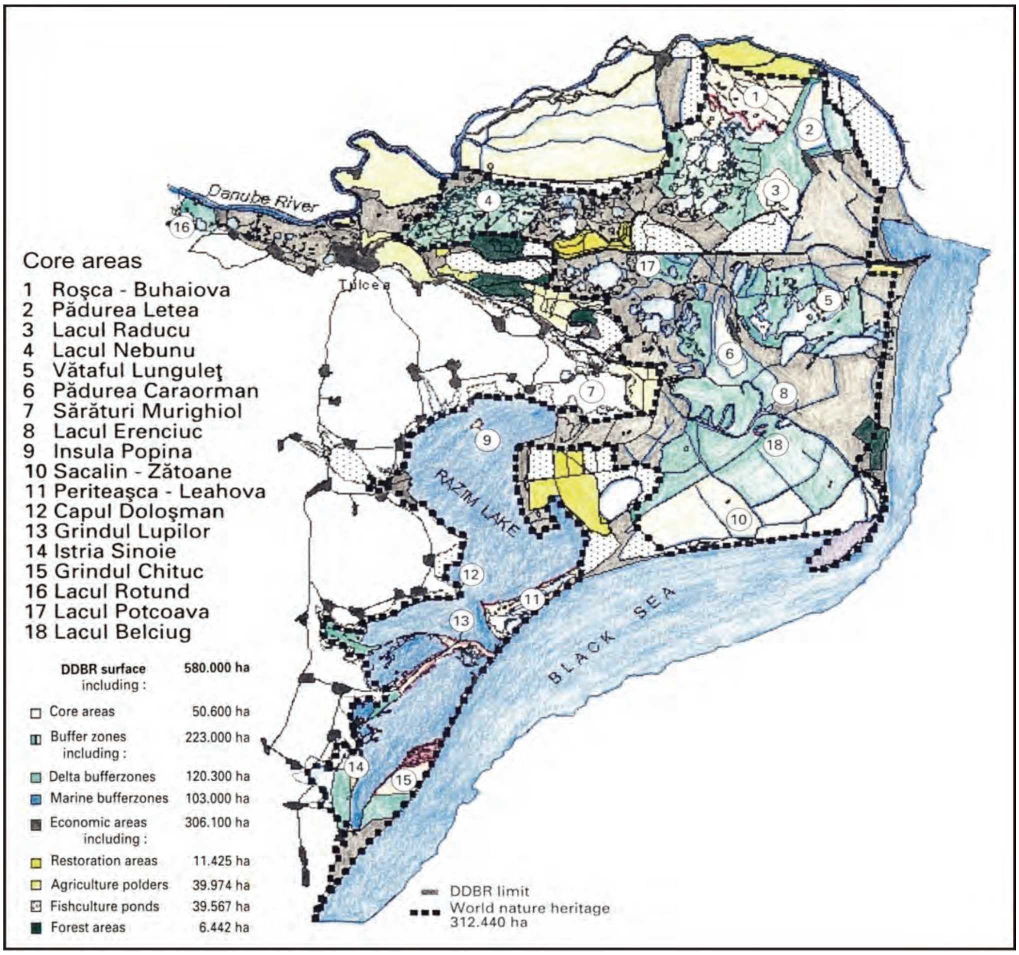

Figure 4. The Danube Delta (after BREZEANU et al., 2011).

Table 1. The taxonomic composition of gastropods from the Romanian sector of the Danube.

SPECIES	THE DANUBE	THE DANUBE DELTA	THE RIVERS IN ROMANIA
Theodoxus (Th.) danubialis	+	+	+
Theodoxus (Th.) d. stragulatus	+		+
Theodoxus (Th.) euxinus	+	+	
Theodoxus (Th.) fluviatilis	+	+	
Theodoxus (Th.) pallasi	+	+	
Theodoxus (Th.) prevostianus	+		
Theodoxus (Th.) transversalis	+		+
Viviparus acerosus	+	+	+
Viviparus contectus	+		+
Viviparus mamillatus	+		
Viviparus viviparus	+	+	+
Valvata (Cincinna) piscinalis	+	+	+
Valvata (Cincinna) studeri			+

Valvata (Cincinna) piscinalis antiqua	+	+	
Valvata (Valvata) cristata	+		+
Borysthenia naticina	+	+	+
Pseudamnicola (P.) dobrogica	+	+	
Pseudamnicola (P.) leontina		+	
Pseudamnicola (P.) penchinati	+	+	
Pseudamnicola (P.) razelmiana		+	
Potamopyrgus antipodarum	+	+	+
Lithoglyphus apertus	+	+	+
Lithoglyphus naticoides	+	+	+
Lithoglyphus pygmaeus	+		
Bithynia (Bithynia) tentaculata	+	+	+
Bithynia (Codiella) troschelii	+		
Bithynia (Codiella) leachii	+	+	+
Turricaspia (Clessiniola) variabilis	+		
T. (Laevicaspia) lincta		+	
T. (Oxypyrgula) ismailensis	+	+	
T. (Turricaspia) dimidiata	+	+	
Esperiana esperi	+	+	+
E. (Microcolpia) daudebardii	+	+	+
E. (Microcolpia) daudebardii acicularis	+	+	+
Amphimelania holandri	+		+
Physa fontinalis	+		+
Physella (Costatella) acuta	+	+	+
Physella (Costatella) heterostropha	+		+
Aplexa hypnorum	+		+
Lymnaea stagnalis	+	+	+
Stagnicola corvus	+	+	+
Stagnicola palustris	+	+	+
Stagnicola turricula	+		+
Radix ampla	+		+
Radix auricularia	+	+	+
Radix balthica	+	+	+
Radix labiata	+		+
Galba truncatula	+		+
Ancylus fluviatilis	+		+
Ferrissia (Pettancylus) clessiniana	+	+	+
Acroloxus lacustris	+	+	+
Planorbis (Planorbis) carinatus	+	+	+
Planorbis (Planorbis) planorbis	+	+	+
Anisus (Anisus) calculiformis	+		+
Anisus (Disculifer) vortex	+		+
Anisus (Disculifer) vorticulus	+	+	+
Bathyomphalus contortus	+	+	+
Gyraulus (Armiger) crista	+	+	+
Gyraulus (Gyraulus) acronicus	+		+
Gyraulus (Gyraulus) albus	+	+	+
Gyraulus (Torquis) laevis	+	+	+
Hippeutis complanatus	+	+	+
Segmentina nitida	+	+	+
Planorbarius corneus	+	+	+
Oxyloma (Oxyloma) dunkeri	+	+	+
Oxyloma (Oxyloma) elegans	+	+	+
Oxyloma (Oxyloma) pinteri	+		+

Although the aquatic ecosystems in the Danube Delta have a unitary character through the biotope and biocoenosis structure, the areas close to the Black Sea present a particular character due to the influence of the brackish water of the sea in the Danube Delta. This is also reflected in the structure of gastropod populations, meaning that brackish water species develop here (*Pseudamnicola razelmiana*, *Potamopyrgus antipodarum*, *Turricaspia lincta*) (Table 1).

A small number of species present in all mountain, hill and lowland water courses from Romania belong to the category of the ubiquist species: *Theodoxus (Th.) transversalis, Viviparus acerosus, Esperiana esperi, Physa fontinalis, Physella (Costatella) acuta, Lymnaea stagnalis, Stagnicola palustris, S. corvus, S. turricula, Radix auricularia, R. balthica, R. lagotis, Galba truncatula, Acroloxus lacustris, Planorbis (P.) planorbis, Anisus (A.) spirorbis, A. leucostoma, A. (Disculifer) vortex, Gyraulus (G.) albus, G. (Armiger) crista, Hippeutis complanatus, Segmentina nitida, Planorbarius corneus*.

A more limited distribution is registered by the species *Viviparus contectus*, *Valvata (Cincinna) piscinalis*, *V. (Tropidina) macrostoma*, *Bithynia (B.) tentaculata*, *Amphimelania holandri*, *Gyraulus (G.) acronicus* (CIOBOIU, 2010a).

There was achieved a preliminary study regarding the content of heavy metals in sediments and freshwater snails in Maglavit lake, formed on place of certain former branches of the Danube from the Oltenian sector of the floodplain, which can accumulate higher levels of Mn^{2+}, Fe^{2+} and Cu^{2+} than the concentrations from the environment (Table 2).

Table 2. Concentrations of metals from soil and shells of pulmonic snails *Lymnaea stagnalis*.

NO.	THE ANALYZED INDICATOR (mg/Kg/SU)	MAGLAVIT (soil)	SNAILS (shells)	THE METHOD OF ANALYSIS	THE USED APPARATUS
1	Iron	0.27	180	The working method specified in the user manual of the spectrometer by the atomic absorption – Avanta GBS	The spectrometer of the atomic absorption with flame Avanta GBC, SN A 5378
2	Manganese	0.008	187		
3	Nickel	< SLD	0.475		
4	Chromium	< SLD	4.07		
5	Copper	< SLD	8.1		
6	Zinc	0.006	0.115		
7	Cadmium	0.0015	0.1		
8	Lead	< SLD	0		

Note: SLD – below the limit of detection

The performed analyses illustrate the ability of the pulmonic snail species *Lymnaea stagnalis* to accumulate the metal ions of the type Mn^{2+}, Fe^{2+} and Cu^{2+} in direct correlation with the concentration of those ions from the soil. Furthermore, the performed studies have shown increased tolerance of these snail species (e.g. species of branchial snails such as *Viviparus acerosus* and pulmonic snails such as *Radix balthica*) to the presence into the environment of the metal ions from the industrial processing of solid wastes (CISMAŞIU et al., 2015). These species are bio-indicators of contaminated industrial environments from Oltenia Plain because they signal earlier the emergence of negative changes in the lacustrine ecosystems.

Besides gastropods, bivalves constitute an important group in the bioeconomy of the ecosystems from the Danube, the floodplain and the Danube Delta being identified a number of 35 species, most frequently belonging to the families *Unionidae*, *Sphaeriidae* and *Dreissenidae* (GROSSU, 1963; CIOBOIU, 2006b). In the Danube, there are present especially reophilous species *Unio crassus cytherea*, *U. tumidus tumidus*, *Pisidium amnicum*, *P. casertanum*; in the floodplain and the Danube Delta stagnophilous species such as *Pseudanodanta complanata*, *Corbicula fluminalis*, *Pisidium moitessierianum*, *Musculium lacustre* are dominant. The other species present an ubiquist character. The variable environmental factors of the Danube: the flow rate, which determines the passive movement of the larvae by using the water current or veliger larvae that have active movements combined with the currents of the water, the nature of the substrate, the trophic status determine this distribution of bivalve populations.

With regard to the bivalves in freshwaters of our country is found that the nine genera inhabiting the continental waters namely *Unio*, *Anodonta*, *Pseudoanodonta*, *Dreissena*, *Corbicula*, *Pisidium*, *Sphaerium*, *Musculium* display a wide zoogeographical distribution. However, they have a lower zoogeographical value and variability compared to gastropods (CIOBOIU, 2010b).

2. **Biotechnological applications of microorganisms**

The microbiological research performed along Sfântu Gheorghe branch revealed a high dynamics of decomposition processes in the two analysed compartments (Tables 3; 4). In the upper layer of the sediment it was found that decomposition processes were conducted more actively, so the intensity of the extracellular enzymatic activity as well as the numerical density of the studied microorganisms generally registered higher values compared with the water column. In most of the cases, the summer season has been the most favourable to the development of heterotrophic microorganisms in the water column and sediment, elevated temperature representing, most probably, the main factor stimulating microbial metabolic activity. A similar result was observed in the case of the amylase activity, while phosphatase and glucosidase activities did not register a clear pattern of the seasonal dynamics. From the spatial viewpoint, decomposition processes are occurred more actively in the MS. The main physical-chemical factors that influenced significantly the dynamics of degradative processes were: temperature, pH, the oxygen concentration in the water column, the amount of available organic matter and the nutrient concentrations of nitrogen and phosphorus: NO_2^-, NO_3^-, PO_4^{3-} and organic phosphorus.

Table 3. The numerical density variation of the extracellular enzymatic activity of microorganisms in the water column and sediments of Sfântu Gheorghe branch (after PĂCEȘILĂ, 2014).

EXTRACELLULAR ENZYMATIC ACTIVITIES	THE WATER COLOMN (nmol substrate L^{-1} h^{-1})	SEDIMENT (nmol substrate g^{-1} h^{-1})
α - amylase	(2.7 ± 1.3) x 10^2	(8.1 ± 4.6) x 10^2
β -glucosidase	(5.6 ± 3.7) x 10^2	(3.5 ±2.6) x 10^3
alkaline phosphatase	(5.6 ± 3.7) x 10^2	(5.5 ± 3.8) x 10^3

Table 4. The numerical density variation of the physiological groups of microorganisms in the water column and sediments of Sfântu Gheorghe branch (after PĂCEȘILĂ, 2014).

PHYSIOLOGICAL GROUPS OF MICROORGANISMS	THE WATER COLOMN (cells mL^{-1})	SEDIMENT (cells/g^{-1})
Amylolytic microorganisms	(2.7 ± 1.8) x 10^2	(9.1 ± 7) x 10^4
Aerobic cellulolytic microorganisms	(1.12 ± 1.12) x 10^2	(6.3 ± 6.2) x 10^3
Anaerobic cellulolytic microorganisms	(4.15 ± 4.15) x 10^1	(6.71 ± 6.7) x 10^3
Proteolytic microorganisms	(1.251 ± 1.25) x 10^6	(2.25 x 2.25) x 10^8
Ammonifying microorganisms	(2.51 ± 2.48) x 10^5	(1.901 ± 1.9) x 10^8
Denitrifying microorganisms	(1.28 ± 1.27) x 10^4	(2.25 ± 2.24) x 10^5
Microorganisms that decompose the proteins with sulfur	(1.15 ± 0.85) x 10^2	(2.93 ± 2.05) x 10^4

In nature, acidity is common and appears in aerobic environments in which there occur oxidation reactions of inorganic compounds. H_2SO_4 appears through the oxidation of sulphide such as H_2S and pyrite (FeS_2). Sulphides are common in geothermal habitats, swamps and seas. In the absence of oxygen, sulphides are stable compounds, but if conditions are changed and they come into contact with air, through a rapid oxidation achieved either spontaneously or under the action of certain sulphur-oxidizing bacteria, H_2SO_4 is produced. Acidic drainage waters also appear in the areas of coal extraction, where rocks above deposits are rich in sulphides, especially pyrite. When the water from precipitations penetrates the soil, it extracts the acid from the rock and the springs and lakes that appear are strongly acidic. Frequently, they are also rich in iron, which is solubilized by acidic waters and precipitate forming residue, which extends for miles around the areas affected by acidic drainage waters.

The persistence and multiplication of the acidophilic microorganisms depends on their genetic structure, which is decisive for their adaptation to their environment and which limits strictly the potential for the phenotypic adaptation. As a result, the survival, growth and multiplication of microorganisms in an environment involve the mechanisms of evolutionary adaptation, and also the phenotypic adaptation: (1) the evolutionary adaptation is an adaptation to prolonged variations based on modification of the genotype and selection of strains better suited to the conditions of the concerned environment; (2) the phenotypic (physiological) adaptation is the result of the response of the organism or the population to temporary changes, within limits under genetic control. The indigenous microorganisms compete for substrates which contain electron donors, organic and inorganic acids. The different environmental factors such as temperature, pH and concentrations of dissolved metals have a great influence on the microorganisms that develop in extreme environmental conditions. In extreme environments, it is easy to establish the qualities which enable the resistant microorganisms of an ecosystem to get it colonized, to multiply and persist. These influence in their turn, sometimes significantly, the physic-chemical properties of the environment through their action in the ecosystem (CANTY, 1998; PETRIȘOR et al., 2002; DUMITRU et al., 2003; SANDU et al., 2004; STANCU, 2015).

CONCLUSIONS

The research conducted in the Romanian sector of the Danube River revealed that the largest diversity of species can be found in the lower sector of the Danube River, especially in the Romanian part of the river where the floodplain, the Danube Delta and the network of streams are factors that enrich the diversity of populations from the Danube River. In this framework, gastropods and bivalves play an important role in the functioning of habitats they inhabit. The species of *Viviparus acerosus*, *Radix balthica*, *Lymnaea stagnalis* represent bio-indicators of contaminated industrial environments from Oltenia Plain because they indicate early the emergence of negative amendments in the framework of the lacustrine ecosystems.

The decomposition processes of detrital organic matter present in the water column and sediments of Sfântu Gheorghe branch have shown complex spatial - temporal dynamics. In summer, these processes took place with full intensity, and the MS sector was the most favourable for the metabolic activity of heterotrophic microorganisms. Also, in the same period, there were identified more physico-chemical parameters that had a significant influence on the evaluated degradative processes.

The performed studies have shown the fact that the microorganisms in those environments have increased resistance to the present metallic ions, having a higher capacity of reduction and oxidation of the inorganic and organic compounds from the industrial habitats. This kind of extracellular metabolic adaptation may be used for the bioremediation processes of the industrial contaminated sites from Romania. As a result of the investigations in the areas mentioned above, from the sites contaminated by industrial wastes, there were isolated and identified the bacteria of the genera: *Bacillus*, *Pseudomonas*, *Acidiphilium* and *Acidithiobacillus* involved in the biotechnological processes of the industrial decontamination.

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