STRUCTURAL AND FUNCTIONAL CHARACTERISTICS OF BIOCOENOSES IN THE FLOODED AREA OF THE DANUBE FOR THE BIOTOPE RECONSTRUCTION FROM INDUSTRIAL CONTAMINATED HABITATS

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Abstract. The floodplain of the Danube (811 – 661 km), commonly known as the Oltenian sector, is the benchmark that conserves the biocoenotic structures specific to wet areas. Even though the damming work of the river caused fundamental changes in the structure and functioning of the floodplain, the mentioned sector is characterized both by the new structural elements that are the result of the river embankment and especially by the existence of old specific ecosystem formations. In this regard, it is relevant to mention the specific terrestrial ecosystems: dunes, interdunes, meadows, forests, hayfields and the aquatic ecosystems represented by lakes, ponds, streams, swamps. Corresponding to this ecosystem diversity there are characteristic structures of flora and fauna communities. Research carried out on the extreme habitats has revealed the presence of some physiological groups of organisms that acquired a perfect adaptation to the physico-chemical characteristics of the substrates. The growth and multiplication of bacteria in the extreme biotopes, as well as the intensity of their activity depend to a fullest extent on the ecological conditions of the environment. The wealth of the species of microorganisms, invertebrates and plants represents a natural patrimony that must be protected taking into account its importance in ecogenetic and social development.

Keywords: microorganisms**,** invertebrates, plants, terrestrial ecosystems**,** the Danube, Romania.

Rezumat. Caracteristicile structurale şi funcţionale ale biocenozelor din zona inundabilă a Dunării pentru reconstrucţia biotopului din habitate contaminate industrial. Zona inundabilă a Dunării (Km 811 – 661), cunoscută sub denumirea de sectorul oltean, reprezintă un etalon care conservă structurile biocenotice specifice zonelor umede. Cu toate că lucrările de îndiguire a fluviului au determinat modificări fundamentale în structura şi funcţionarea zonei inundabile, sectorul menționat se caracterizează atât prin noile elemente structurale apărute în urma îndiguirii fluviului cât mai ales prin existența vechilor formațiuni ecosistemice specifice. În acest sens sunt relevante ecosistemele terestre specifice: dune, interdune, pajişti, păduri, fâneţe şi ecosistemele acvatice reprezentate prin lacuri, bălți, gârle, mlaștini. Corespunzător acestei diversități ecosistemice îi sunt caracteristice structuri floristice şi faunistice. Cercetările efectuate asupra biotopurilor extreme au evidenţiat prezenţa cu pregnanţă a anumitor grupe fiziologice de organisme, care au dobândit o perfectă adaptare la caracteristicile fizico-chimice ale substratelor. Creșterea și multiplicarea bacteriilor în biotopurile extreme, cât și intensitatea activității lor, depind în cea mai mare măsură de condițiile ecologice ale mediului. Bogăția de specii de microorganisme, nevertebrate şi plante reprezintă un patrimoniu natural ce trebuie protejat având în vedere importanţa sa in dezvoltarea ecologică şi socială.

Cuvinte cheie: microorganisme, nevertebrate, plante, ecosisteme terestre, Dunăre, România.

INTRODUCTION

The floodplain of the Danube (811 – 661 Km) known as the Oltenian sector sums up an area of 104,543 ha and includes a great diversity of physico-geographical, hydrological and hydrobiological elements present along the lower sector of the Danube (Fig. 1) (BREZEANU, 1967; TOMESCU, 1998; CIOBOIU & BREZEANU, 2008).

In the context of works carried out during 1965 – 1971, on 90 % of the total area of the floodplain of the Oltenian sector, there were performed complex works for land improvement that led to the disappearance of lacustrine ecosystems, deforestation and setting up fishing ponds. In this circumstance, due to these changes, the old morphology of the floodplain transformed so as to correspond with the needs of agricultural development. In this regard, there appeared anthropogenic forms of relief. Million m^3 of excavated lands used to build the longitudinal dyke and transversal dykes delimited the dammed areas of the agricultural lands. The negative forms of relief represented by the network of drainage channels or depression cuvettes of the former lacustrine basins: Potelu, Rast, Nedeia – Nasta – Sclavogul Complex became real fields of lacustrine origin transformed into agricultural lands (BREZEANU & MARINESCU, 1965).

The current situation demonstrates that, due to the special physical and geographical conditions of the area, the dam and transformation works of the floodplain in the agricultural area, at least in the sector between 811 – 661 km, did not give the expected results. In other words, the agricultural function of the floodplain, which excluded all other uses, proved to be inefficient from the economic viewpoint.

It is known that the areas liable to flooding represent depositories of a large biodiversity. The areas liable to flooding of the Danube are ones of the most important wetlands in Europe.

The studied sector includes all characteristics that make this part of the floodplain be considered a benchmark for the reconstruction of the ecosystems in the southern part of Romania (Fig. 2). This fact is reflected by the structures and functions of specific ecosystems in the area liable to flooding. There are integrated specific terrestrial ecosystems: dunes, interdunes, meadows, forests, hayfields and aquatic ecosystems represented by lakes, ponds, streams, swamps. Floristic and faunistic structures are characteristic to this ecosystemic diversity.

Figure 1. The Oltenian Sector of the Danube Floodplain from the Territory of Dolj County (Google Earth, accessed: March 21, 2016).

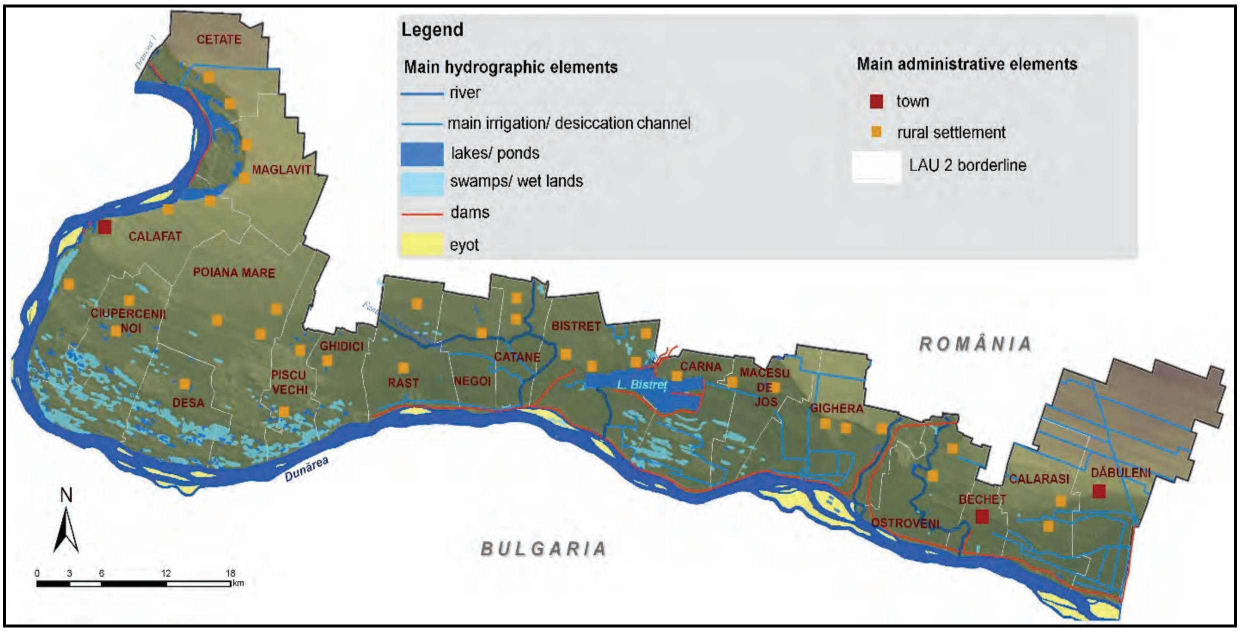

Figure 2. Main hydrographical characteristics of the Danube Floodplain in the Oltenian Sector (after POPESCU et al., 2015).

Microorganisms were isolated from all natural environments where water is present regardless of its temperature and pH values. The isolation and characterization of mesophilic, thermophilic and hyperthermophilic microorganisms generated several studies, mainly focused on highlighting the ways of their adaptation to high temperatures. The natural communities of microorganisms formed by a large variety of species that live together, frequently as dense populations, are relatively stable and hard to disturb. The indigenous microorganisms oppose to the disequilibrium produced by temporary ecological changes (for example, discharge of waste waters through soil or into natural waters). On the basis of knowledge regarding the nature of the interactions between acidophilic microorganisms, it is likely to design the microbial consortia for the biotope reconstruction of contaminated industrial areas.

The evolution of the technology, deepening knowledge of the microbial diversity and the action of microorganisms on different natural substrates allowed the implementation of economic biotechnological processes with low polluting effects. The populations of microorganisms from a particular habitat establish a series of interpopulation relationships leading to the formation of a definite structure of a stable community at a certain level of diversity, which ensures the optimum use of energy flow from the ecosystems and a certain homeostasis, namely a degree of invariance and resistance to the environmental disturbing factors. In this way, the diversity of a community reflects the state of the population interactions from the community in dynamic terms (AXINI, 2012; CISMAŞIU et al., 2002; CISMAŞIU, 2003, 2004, 2009).

MATERIALS AND METHODS

1. Technology selection

In view of assessing the hydrobiological characteristics, there has been performed an extensive research program. Based on the existing data in the specialized literature and on our own research, it was made a summary which allowed the monitoring of the lacustrine ecosystem biodiversity from the studied sector (ANTIPA, 1910; BREZEANU & MARINESCU P., 1965; BREZEANU, 1967; NEGREA & NEGREA, 1975; GROSSU, 1993; TIŢĂ & NĂSTASE, 1997; TOMESCU, 1998; NICOLESCU et al., 1999; RÂŞNOVEANU & VĂDINEANU, 2000; PARPALĂ et al., 2002; PLENICEANU, 2003; BREZEANU et al., 2011; CIOBOIU, 2002, 2003, 2004, 2008, 2015; IONICĂ, 2007; GAVRILESCU, 2008; CIOBOIU & BREZEANU, 2008, 2014).

2. Mechanisms for metal removal

The cooperating interactions between microorganisms, invertebrates and plants in extreme conditions (acidic pH and higher concentrations of metallic ions) have a great ecological importance, particularly in achieving the circulation of biogeochemical elements in the biotope reconstruction from the Oltenian sector of the Danube. The formation of microorganism colonies is probably an adaptation based on cooperative interactions in the population. The production of extracellular enzymes by some members of colonies makes substrates available to all members of the population. The formation of colonies ensures not only aggregating individual organisms, but also to the efficient use of available resources. Thus, the positive interactions are especially important in nature, where the recalcitrant substances or the production of metabolites solubilizes the various compounds of the habitat, by making them available for other microorganisms (JOHNSON & RANG, 1993; ZARNEA, 1994; LAZĂR et al., 1997; JOHNSON, 1999; OBASOHAN et al., 2010; JUNG et al., 2014).

RESULTS AND DISCUSSION

1. Site and technology description

The previous researches and those carried at present emphasize the structural and functional characteristics of the area between 811 and 661 km, which is the premises of the ecological reconstruction (TOMESCU, 1998; PLENICEANU, 2003; BREZEANU et al., 2011).

According to the evaluation of the biodiversity of this area, it may be determined which are the plant and animal species specific to each type of ecosystem. In regard to terrestrial ecosystems (dunes, interdunes, meadows, forests, grassland) the characteristic species are: plants *Salix* sp., *Populus* sp., *Ulmus minor* Mill., *Fraxinus excelsior* L., *Acer campestre* L., *Rosa canina* L. *Chrysopogon gryllus* (L.) Trin., *Salsoa kali* L., *Plantago scabra* Moench., *Centaurea arenaria* Bieb., *Secale sylvestre* Host., *Festuca vaginata* Waldst et Kit., *Euphorbia cyparissias* L., *Silene conica* L., *S. trinervia* L., *Trifolium arvense* L., *Dianthus kladovanus* Degen., *Bassia laniflora* (S. G. Gmelin) A. J. Scott., *Corispermum nitidum* Kit., *Polygonum arenarium* Waldst et Kit., *Puccinelia distans* (Jacq.) Parl., *Salicornia europaea* L., *Juncus gerrardi* Lois. (TIŢĂ & NĂSTASE, 1997), animals *Helicella candicans* L. Pfeiffer, *Cepaea vindobonensis* (Fer.), *Helix pomatia* L., *Cerambyx cerdo* L., *Lucanus cervus* L., *Nimphalis vaualbum* L., *Bombina variega* (L.), *Bufo bufo* (L.), *Natrix natrix* L., *Testudo hermani* Gmelin, *Accipiter nisus* (L.), *Buteo buteo* (L.), *Coturnix coturnix* (L.), *Phasianus colchicus* (L.), *Cuculus canorus* (L.), *Asio flammeus* (Pontopp.), *Upupa epops* (L.), *Picus viridis* (L.), *Galerida cristata* (L.), *Anthus campestris* (L.), *Lanius excubitor* (L.), *Garrulus glandarius* (L.), *Pica pica* (L.), *Corvus monedula* (L.), *Citellus citellus* Pal., *Cricetus cricetus* L., *Vulpes vulpes* L., *Canis aureus* L. (TOMESCU, 1998; CIOBOIU, 2004).

The floristic and faunistic structure of the lacustrine ecosystems is particularly diverse. The biggest diversity belongs to algae represented by the groups Cyanophyceae, Euglenophyceae, Pyrrophyceae, Heterokontae, Bacillaryophyceae and Chlorophyceae; the largest number of species is registered by Cyanophyceae, Bacillariophyceae and Chlorophyceae (NICOLESCU et al., 1999; MOLDOVEANU & FLORESCU, 2013).

Marsh and aquatic macrophytes occupy an important place in the bioeconomy of ecosystems, the dominant species being *Phragmites communis*, *Typha angustifolia*, *Nuphar luteum*, *Nymphaea alba*, *Rorippa amphibia*, *Poygonium 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) (Table 1, Fig. 3).

The fauna includes 24 groups of invertebrates, the dominating ones being protozoa (*Vorticella* sp.), rotifers (*Filinia longiseta* Ehrbg., *Brachionus angularis* Gosse, *Keratella quadrata* Muller), copepods (*Acanthocyclops vernalis* L., *Cyclops leuckarti* Claus), cladocerans (*Bosmina longirostris* Fish., *Ceriodaphnia pulchella* Muller, *Moina brachiata* Jurine), polychaeta (*Hypania invalida* Grube, *Hypaniola kowalewskii* Grimm.), oligochaete (*Eiseniella tetraedra* Sav., *Nais simplex* Pig., *Stylaria lacustris* Mull.), gastropods, bivalves (*Unio tumidus* Philip., *U. pictorum* L., *Anodonta cygnaea* L., *A. c. piscinalis* Nils., *Sphaerium riviculum* Lam., *S. corneum* L., *Dreissena polymorpha* Pall.), isopoda (*Jaera sarsi sarsi* Valk.), amphipods (*Corophium curvispinum* Sars, *Chaetogammarus tunellus* Mart., *Dikerogammarus* *haemobaphes fluviatilis* Mart., *Pontogammarus obesus* Mart.), dragonflies (*Ghamphus flavipes* Charp.), chironomida (*Pelopia punctipennis* Mg., *Cricotopus silvestris* F., *Diamesa campestris* Edw., *Prodiamesa olivacea* Mg., *Cryptochironomus demeijeri* Krus., *Tanytarsus exiguus* Joh.) (BREZEANU & MARINESCU P., 1965; NEGREA & NEGREA, 1975; RÂŞNOVEANU & VĂDINEANU, 2000; PARPALĂ et al., 2002; CIOBOIU, 2004, 2015).

Table 1. The species of marsh and aquatic macrophytes.

SPECIES	
MARSH	**AQUATIC**
Phragmites communis Trin.	*Lemna minor* L.
Typha angustifolia L.	*Nimphaea alba* L.
Typha latifolia L.	*Nuphar luteum* L.
Scirpus lacustris L.	*Polygonium amphibium* L.
Heleocharis palustris L.	*Potamogeton natans* L.
Juncus effusus L.	*Potamogeton crispus* L.
Mentha aquatica L.	*Potamogeton perfoliatus* L.
Mentha longifolia L.	*Potamogeton pectinatus* L.
Iris pseudacorus L.	*Salvinia natans* L.
Carex riparia L.	*Stratiodes aloides* L.
Carex hirta L.	*Schoenoplectus mucronatus* L.
Ranunculus aquatilis L.	*Myriophyllum spicatum* L.
Ranunculus repens L.	*Ceratophyllum submersum* L.
Polygonium hydropiper L.	*Hydrocharis morsus-ranae* L.
Pastinaca sativa L.	*Glyceria maxima* L.
Vicia peregrina L.	*Rorippa amphibia* (L.) Besser
Equisetum arvense L.	
Euphorbia palustris L.	

Figure 3. The area of the island invaded by macrophytes (original).

In the scientific literature it is well known that one of the fundamental factors of floodplain life is the Danube, the interdependence of which contributes to the structuring and functioning of planktonic and benthic populations. The river water entering periodically into the lakes is the engine of the productivity and the organic production in the aquatic ecosystems, leading to the development of primary producers and further through these to the consumers.

A major component of the biological production from the lacustrine ecosystems in the area is represented by the populations of gastropods, preponderantly the benthic organisms that respond actively to the heterogeneity of the microhabitats they inhabit. There was identified a number of 25 species (Table 2), among which *Viviparus acerosus*, *Radix balthica*, *Physella* (*Costatella*) *acuta*, *Lymnaea stagnalis*, *Planorbarius coneus* are characteristic to the eutrophic lacustrine ecosystems from the area liable to flooding (GROSSU, 1993; CIOBOIU, 2002, 2008, 2015).

The gastropods spread in the lakes and marshes of the area liable to flooding taken in the study is determined by the nature of the benthal facies as rendered in table 3; thus, in the muddy facies, there were 18 species, 15 species in the detritus and 9 species in the sandy facies. It is noted that the largest number of species populates the muddy – detritus bottom near the shore in shallow areas (Fig. 4). These areas present the best possible conditions for food. Gastropods find abundant food on the coarse detritus, on the leaves fallen in the water but still unaffected by putrefaction on which a rich develops and on the silt rich in organic substances (NEGREA & NEGREA, 1975; CIOBOIU & BREZEANU, 2014).

The smallest diversity of species was determined in the areas where the substrate is predominantly sandy. Certainly, their distribution depending on the facies is relative, because the species from a certain category may be present (in low number) in other types of facies as well considering that there exists some degree of interference between the categories of the typical facies.

Table 2. The taxonomic diversity of gastropods.

CLASS GASTROPODA Cuvier 1798	
SUBCLASS PROSOBRANCHIA Milne Edward 1848	
ORDER ARCHAEOGASTROPODA (Thiele 1952)	
Family Neritidae Rafinesque 1815	*Theodoxus danubialis* C. Pfeiffer 1828 *Theodoxus fluviatilis* Linnaeus 1758
ORDER MESOGASTROPODA (Thiele 1925)	
Family Viviparidae Gray 1847	*Viviparus acerosus* Bourguignat 1870 *Viviparus viviparus* Linnaeus 1758
Family Valvatidae Thomson 1840	*Valvata (Cincina) piscinalis* O. F. Muller 1774
Family Lithoglyphidae Troschel 1857	*Lithoglyphus naticoides* C. Pfeiffer 1828
Family Bithyniidae Gray 1849	*Bithynia tentaculata* Linnaeus 1758
Family Thiaridae Troschel 1857	*Esperiana esperi* (Ferussac 1829) *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) spirorbis* (Linnaeus 1758) *Segmentina nitida* (O. F. Muller 1774) *Planorbarius corneus* (Linnaeus 1758)

Table 3. The taxonomic composition according to the benthal facies.

SPECIES	**BENTHAL FACIES**		
	SANDY	**MUDDY**	**DETRITUS**
Theodoxus danubialis	+	+	
Theodoxus fluviatilis	+		
Viviparus acerosus		+	+
Viviparus viviparus	+	+	
Valvata (Cincina) piscinalis		+	+
Lithoglyphus naticoides		+	+
Bithynia tentaculata		+	
Esperiana esperi	+	+	
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.) spirorbis		+	
Segmentina nitida			+
Planorbarius corneus		+	+

Figure 4. The preferred areas of gastropods (original).

The fish populations are characteristic to the lakes and ponds in this region: *Esox lucius* L., *Rutilus rutilus* Raf., *Scardinius erythrophthalmus* L., *Aspius aspius* L., *Chondrostoma nasus* L., *Leucaspius delineatus* Heckel, *Alburnus alburnus* Raf.., *Cobitis taenia* L., *Pelecus cultratus* L., *Lepomis gibbosus* L., *Carassius gibelio* Bloch, *Cyprinus carpio* L., *Silurus glanis* L., *Perca fluviatilis* L., *Stizostedion lucioperca* L. (BREZEANU et al., 2011).

2. Mechanisms for metal reduction potential

The exploitation of microorganism diversity in the biotechnology depends on the efficient way of detecting new microorganisms and their useful activities in natural environments. The industrial and agro-zootechnical development leads to the generation of impressive volumes of waste waters contaminated with metallic ions, sulphates, nitrates/nitrites and other pollutants that affect the environment. As a result of the extraction and advanced processing of ores there result significant quantities of solid, semisolid or liquids waste, which contains high concentrations of toxic elements. These, under the influence of physical, chemical and biological agents (solubilisation) are mobilized and migrate around horizontally, contaminating the soil, lakes and rivers from the vicinity or, vertically, contaminating the aquifers.

In the last decade, the discovery of the microorganism capacity to degrade a variety of synthetic organic compounds into inorganic products contributed to the development of bioremediation technologies. The plasticity of microbial metabolism represents a higher adaptive character, with ecological significance. The accumulated data demonstrate that acidophilic chemosynthetic bacteria underlie a food chain, which allows the abundant development of some populations by organisms specifically adapted for growth in the vicinity of industrial contamination sources from the Oltenia Plain. From the ecological point of view, it is an absolutely original phenomenon due to its total independence by energy from the sun. Although they are concentrated on limited area, these communities develop very efficiently benefiting from the position of primary producers of the bacteria, which ensures the transformation of the geothermal energy into chemical energy required to generate the organic carbon.

According to their behaviour to molecular oxygen, acidophilic microorganisms can be grouped into 4 respiratory types: (1) strictly aerobic microorganisms, which require for their development atmospheric molecular oxygen that they use as a final acceptor of electrons in the course of cellular respiration; (2) strictly anaerobic microorganisms which cannot grow in the presence of molecular oxygen; (3) anaerobic microorganisms, aerobic optionally, capable to orient their metabolism according to the availability of oxygen; (4) microaerophilic microorganisms that require a lower quantity of O_2 than the one of the atmospheric air. In this context, acidophilic heterotrophic bacteria performed incomplete oxidation of organic substances resulting from the fermentation of alcohols, aldehydes and ketones. In this process, there are produced organic acids such as: pyruvic acid, fumaric acid, citric acid, glycolic acid, oxalic acid.

Acidophilic chemolithotrophic bacteria have the capacity to produce energy through the oxidation of inorganic compounds, such as: hydrogen, iron, the reduced compounds of sulfur and nitrogen. Acidophilic microorganisms have the ability to metabolize organic compounds through the oxidation-reduction reaction with the formation of less complex organic substances. In these metabolic reactions, both the donors as well the acceptors of electrons are organic compounds.

Acidophilic heterotrophic and chemolithotrophic bacteria act as biochemical agents by two mechanisms which complement one another: (1) secretion of acids which dissociate-mineral elements (silicates of aluminium, potassium, iron, magnesium) that make up the rocks; (2) introduction of organic acids containing carboxyl group, hydroxyl group or amino group, resulting from the catabolism of organic residues or secreted by microorganisms into the environment (PETRIŞOR et al., 1997, 2000, 2002; ZLĂGNEAN et al., 2007; TOMUŞ & CISMAŞIU, 2014).

Certain global ecological processes can concentrate different toxic substances, through the complex biological processes. In these processes, microorganisms isolated from extreme environments due to their metabolic activity and the higher report of surface/volume can act as important vectors for the introduction of heavy metals in the trophic networking (AL-AZKI, 2014).

The discovery of biological detoxification mechanisms has suggested the possibility of using them to control the pollution with heavy metals. Thus, heavy metals may have important environmental effects on the growth of biological species, but in a certain concentration range. Nevertheless, there are several heavy metals with noxious effect on aquatic ecosystems (VOICU et al., 1999a, b; 2000; 2009; STANCU, 2015).

CONCLUSIONS

The area liable to flooding of the Danube between 811 and 661 Km is characterized by a diversity of ecosystem types specific to wet areas. Due to this diversity of ecosystems, there are characteristic flora and fauna structures. One of the fundamental factors of the floodplain life is the Danube, the interdependence of which contributes to the structuring and functioning of planktonic and benthic populations.

The fauna includes 24 groups of invertebrates, protozoa, rotifers, copepods, cladocerans, oligochaete, gastropods, bivalves, amphipods, dragonflies, chironomida being predominant. The populations of gastropods constitute an important part of the biological production of the eutrophic lacustrine ecosystems in the area. The ichtyofauna characterizes and particularizes the functionality of such ecosystems pre-existing the impoundment of the river.

The compounds of the heavy metals have an obvious influence on plants, especially near the metallurgical companies; the limits of the heavy metal toxicity are established according to their influence effects on plants. The toxicity of heavy metals depends on the component size of the soil, the soil acidity and soil moisture, the ratio between the metals and nutritional elements from the environment as well as on individual plant species. Thus, it has been found that their maximum tolerance to different metal ion concentrations is achieved only under certain conditions of temperature and pH.

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