ECOLOGICAL IMPLICATIONS OF BIODIVERSITY SPECIFIC TO INDUSTRIALLY CONTAMINATED ECOSYSTEMS IN NORTHWESTERN OLTENIA

CISMAȘIU Carmen-Mădălina, CIOBOIU Olivia, GAVRILESCU Elena, TOMUȘ Nicolae

Abstract. Both chemical and biological analyses, which aim at rendering water quality have advantages and disadvantages. If the chemical analysis provides information on the chemical characteristics valid only for sampling, the biological analysis provides information that reflects the situation for a long, retrospective period. This advantage is due to the fact that organisms, do not generally have an immediate response to the change in environmental factors but in a longer time, depending on the ecological valence of the species. Therefore, the biological and ecological analysis of water is based on the total response of organisms to environmental conditions. This is reflected in the qualitative and quantitative composition of biocoenosis in the ecosystem. Our research carried out within a national program of knowledge of industrially contaminated ecosystems in northwestern Oltenia has highlighted the presence of certain physiological groups of organisms (plants, invertebrates) adapted to different living environments, which have acquired perfect tolerance for ecological characteristics of substrates. In this respect, Mehedinți County is a reference area in determining the influence of physico-chemical conditions on the dynamics of the biodiversity evolution of industrially contaminated ecosystems in southwestern Romania.

Keywords: Oltenia, microorganisms, gastropods, ecological valence.

Rezumat. Implicații ecologice ale biodiversității specifice ecosistemelor contaminate industrial din nord-vestul Olteniei. Analiza chimică, cât și cea biologică, care au în vedere stabilirea calităţii apei, au avantaje și dezavantaje. Dacă analiza chimică dă informaţii asupra unor caracteristici chimice valabile numai pentru momentul prelevării probei, analiza biologică furnizează informaţii ce oglindesc situaţia pe o perioadă îndelungată, având un caracter retrospectiv. Acest avantaj este consecința faptului că organismele, în general, nu au un răspuns imediat la schimbarea factorilor de mediu, ci într-un timp mai îndelungat, în funcţie de valenţa ecologică a speciei. Așadar, analiza biologic-ecologică a apelor se bazează pe totalitatea reacţiilor de răspuns ale organismelor față de condițiile de mediu. Acest fapt se reflectă în componența calitativă şi cantitativă a biocenozei din ecosistemul respectiv. Cercetările noastre efectuate în cadrul unui program național de cunoaștere a unor ecosisteme contaminate industrial din nord-vestul Olteniei au evidențiat prezența cu pregnanță a anumitor grupe fiziologice de organisme (plante, nevertebrate) adaptate la diferite medii de viață, care au dobândit o perfectă toleranță la caracteristicile ecologice ale substratelor. În acest sens, județul Mehedinți reprezintă un areal de referință în stabilirea influenței condițiilor fizico-chimice asupra dinamicii evoluției biodiversității ecosistemelor contaminate industrial din sud-vestul României.

Cuvinte cheie: Oltenia, microorganisme, gasteropode, valența ecologică.

INTRODUCTION

Among the pollution factors pollution generated by chemical mineral substances and organic matter are particularly common. In case of organic substances, water is characterized by low levels of oxygen, the occurrence of toxic hydrogen sulfide, methanol, changes in pH and in organoleptic properties, increased turbidity. By virtue of their ability to adapt, some species live in waters polluted with organic matter and feed on these resources. Such organisms are called indicators of the organic load or water saprobity. At the same time, it is known that another category of organisms lives in clean waters with a very low load of organic substances. These species are biological indicators of the degree of water cleaning.

Considering that organisms in general have a certain plasticity to environmental conditions, in water quality assessment it is taken into account that only if the number of indicator species is very high and this happens in very polluted areas or, on the contrary, in very clean areas, a safe diagnosis on the water quality can be made. The main role in the process of self-purification of water is played by bacteria, the rest of the organisms continuing the transformations started by the bacteria. Some bacteria in the water develop in the presence of oxygen (the aerobic bacteria) and others in the absence of oxygen (the anaerobic bacteria). The aerobic bacteria play a major role in the process of self-purification, but the process involves both categories, as the activity of a category is conditioned by the activity of the others; they succeed, depending on the quantity and quality of organic substances, hydrological conditions and temperature.

Along with bacteria, which they always accompany, protozoa have a major role in the self-purification of contaminated water with organic substances. Among them, the most important are ciliates. Protozoa alone (without bacteria) cannot perform the cleaning, but as they are debris consumers, they contribute to the clarification of water and influence the development of microbial communities, which are ingested by them. Macro vertebrates are of multiple importance. Sponges, braziers, bivalves fulfill the role of water filtration, retaining the organic suspension they feed on. The swan mussel (*Anodonta cygnea* Linnaeus, 1758) can filter 40 liters of water in 24 hours.

Our research carried out within a national program of knowledge of industrially contaminated ecosystems in north-west Oltenia has revealed the presence of certain physiological groups of organisms (plants, invertebrates) adapted to different living environments that have acquired a perfect tolerance to the ecological characteristics of the substrates. In this respect, Mehedinti County located in the Western Plain of Oltenia, interfering with Banat, belonging to the Moesica province (Banat-Oltenia) represents a point of reference in determining the influence of physic-chemical influences on the dynamics of biodiversity evolution of industrially contaminated ecosystems from the south-west of Romania (Fig. 1).

Figure 1. The map with the delimitation of Mehedinți County in southwestern Romania (Google Earth, accessed: March 5, 2018).

The analysed territory is covered with sedimentary formations originating in the Lower and Upper Holocene, consisting of alluvial deposits, wind-shaped, such as sand dunes, and sedimentary formations made up of clay, clays and loess, belonging to the upper terrace of the Danube and the plain area, constituting the parental material for chernozems, on which Quercus vegetation has installed: Turkey oak (*Quercus cerris*), Hungarian oak (*Q. frainetto*), pedunculate oak (*Q. robur*), with intercalated plots of acacia plantations (*Robinia pseudoacacia*) (BERCEA, 2009; ADAM et al., 2012). The climate is temperate continental with Mediterranean influences (VLADUȚ et al., 2017). In the area, there are specific terrestrial ecosystems: dunes, meadows, forests, meadows integrated aquatic ecosystems represented by lakes, ponds, swamps. According to this ecosystem diversity, structures are characteristic floristic and faunistic (FIERA & OROMULU-VASILIU, 2009; BREZEANU et al., 2011; VICOL, 2015; CIOBOIU & BREZEANU, 2017).

MATERIALS AND METHOD

The case study refers to Halânga Thermal Power Plant, located 9 km from Drobeta Turnu Severin, in the northern region of Mehedinţi County, on the territory of Puţinei village, on the left slope of the Topolniţa at the confluence with its tributary, the Pleşuva. It produces electricity based on lignite excavated in the Husnicioara quarry (Fig. 2).

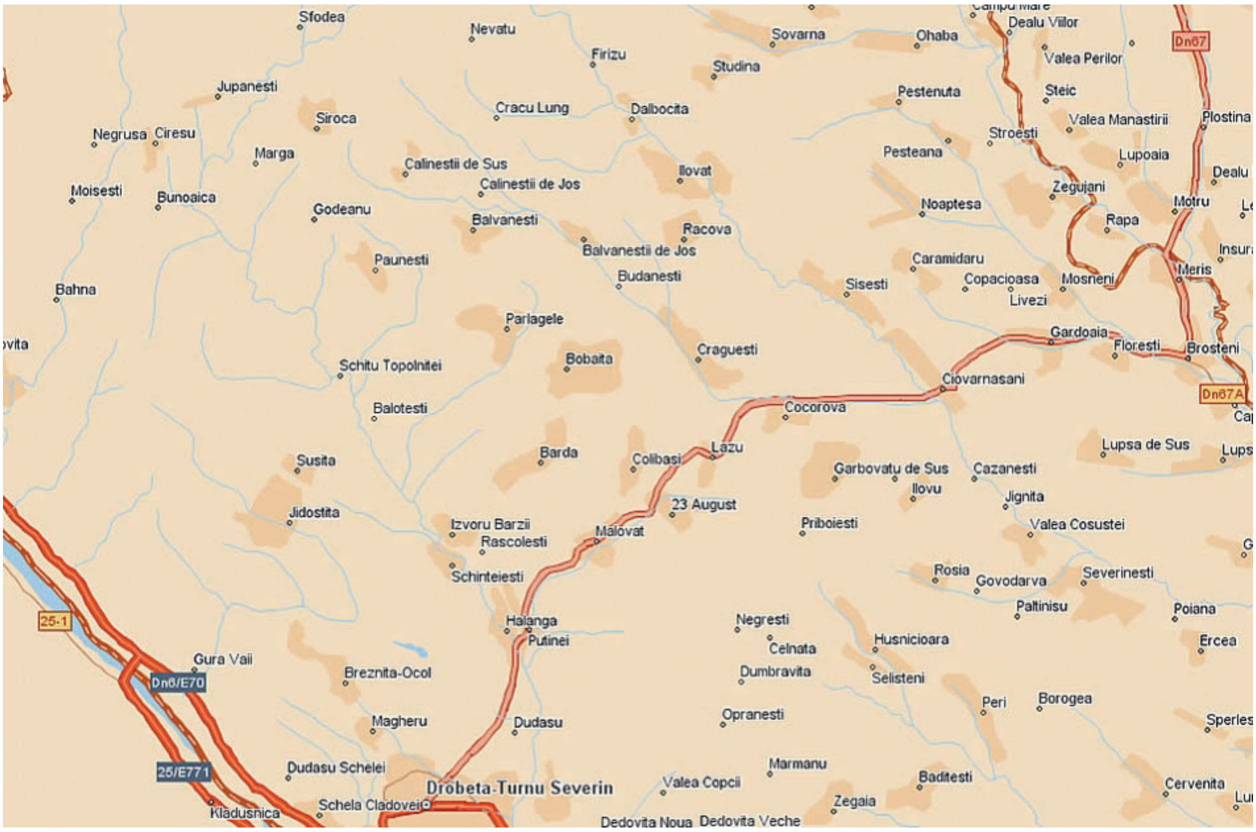

Figure 2. Map rendering the position of Halânga power plant to Drobeta Turnu Severin (Google Earth, accessed: March 5, 2018).

In this context, knowing the ecological mechanisms of adaptation and change in the structure of populations and biocoenoses, biological-ecological analysis can give information on the degree of the ecosystem intoxication chemical analysis can highlight it only if measurements are repeated frequently and over a long period of time. The limits of biological analysis are that it cannot provide information on the quantitative and qualitative values of the pollutants. Therefore, the two methods complement one another without giving partial information (GAVRILESCU & OLTEANU, 2003; GAVRILESCU, 2007; CISMAȘIU, 2009; CISMAȘIU et al., 2010; VICOL, 2011).

RESULTS AND DISCUSSIONS

In general, the acute pollution of the water with mineral substances is highlighted by the total absence of organisms. There are species that have a certain resistance to heavy metal ions, which does not mean they can achieve large numerical densities under such conditions. Because of this, they are not considered as indicator species. In this respect, there are known signaling organisms for the pollution with iron, calcium, sodium chloride, hydrogen sulphide and sulfur compounds, and oil pollution. Coal waste deposited in various places has a high content of pyrite. The most important issue related to environmental pollution is the oxidation of the pyrite and the generation of acidity. The waste is deposited and constitutes an active source of acid (H_2SO_4), which generates soil contamination at the surface, and groundwater, endangering ecosystems. Pyrite oxidation results in Fe^{2+}, SO_4^{2-} and H^{+}. Drainages of coal mines are characterized by low pH, a highly varied composition that prevails in high concentrations of sulphate, iron, manganese, aluminum and other toxic and radioactive ions, as well as solid particles in excess. This drainage is one of the oldest problems arising from coal mining (Fig. 3).

Figure 3. Map rendering the localization of Halânga Thermal Power Plant in northern Oltenia (Source: http://www.nationsonline.org/oneworld/map/google_map_romania.htm; Google Earth Software, accessed March 3, 2018).

Desulphurization techniques are physical, chemical, thermal or biological. These techniques are applicable to the desulphurization of coal before it is subjected to combustion. Many studies undertaken in the last decades on the desulphurization of coal have focused on the removal of pyritic sulfur (inorganic), which is half of the total sulfur content in coal. Organic sulphide is more difficult to remove by conventional processes as there are to strong organic bonds.

The physical treatment of inorganic sulfur removal involves magnetic separation or hydrocyclone use, while the elimination of organic sulfur is carried out in most cases by chemical and/or microbiological treatment. Chemical treatment involves the use of strong acids, bases or salts. This treatment is commonly performed at elevated temperatures (200-300 ºC) and is characterized by high selectivity. Leaching with nitric acid at high pressure and temperature (up to 90 °C) is an effective treatment, almost completely removing sulfur. Leaching with sodium carbonate, sodium hydroxide or potassium hydroxide is effective, removing 90% of organic and inorganic sulfur. Although these techniques can be considered feasible, they have high cost and negative environmental impact. The heat treatment involves the use of hydrolysis or steam-air mixture. These two processes operate at high temperatures: 350-500 °C, considered being quite complicated, and the degree of desulfurization depends on a number of parameters, such as temperature, particle size, composition of the air-steam-gas mixture, type of coal, heating and type of reactor used.

The biological desulfurization has been established as a laboratory technique by the use of bacteria with high capacity to oxidize pyrite, thus implicitly removing sulfur from coal. Recent studies on coal desulphurization have highlighted the successful application of biological techniques. The removal of sulfur from coal is a feasible process. The elimination of the pyrite in higher percentage leads to a reduction in the acidity of the waste. Physical, chemical or biological techniques can be applied with a double effect: removing sulfur on the one hand and decreasing the degree of susceptibility of the waste to oxidation.

Choosing the most feasible techniques requires extensive experimental studies, while their application requires the use of advanced techniques whose primary objective is environmental protection. In this context, the species of plants, invertebrates and microorganisms in contaminated areas are biomarkers for pollution with metal ions, sodium and calcium chloride, and sulfur compounds.

From the observations made in our country, *Helix pomatia* grows mainly in anthropogenic ecosystems, being an indicator of industrially contaminated areas (GROSSU, 1983; NEACŞU & CIOBOIU, 1999; 2000). In natural ecosystems, the species is mainly found in the bright forests, located in the plain, hilly or mountain areas. The best lands for the development of this snail are limestone, mobile and preferably dry soils. In general, acidic, sandy, clayey and marshy soil are avoided.

In these ecosystems, it occupies abiotic microhabits (vegetal remains, old wood or cement fences, soil, stones, cartons, metal vessels, concrete slabs, etc.) and biotic microhabits represented by various plant organs: leaves, stems and branches.

Helix pomatia Linnaeus 1758 is an euribiont species (widespread in a wide range of biotopes: gardens, forests and generally shady and humid places). The shell is globular, grayish-brown, with darker longitudinal stripes and a size of 38-40 mm. In cross section, the shell is made up of three parts: periostracum, ostracum and hypostracum. The body consists of head, foot and trunk. It is ovipar, deposits a few tens of eggs in June and July, in a pit with a foot and a shell.

The development is direct, without metaphorphosis, due to adaptation to terrestrial life and as a consequence of the constitution of relatively rich vitelus eggs. All stages of embryonic development occur in the egg shell from which the individual stands ready to provide. *Helix pomatia* buries to 25-35 cm in soil and closes its aperture with a limestone lid, isolating itself from the external environment and leading a latent life. It is a phytopathic species that feeds on mushroom hay and the green parts of the superior plants. It lives through bushes, orchards, lush and humid forests, under 500 m altitude, and up to 1800 m is a ubiquist species.

In case of terrestrial gastropods, hibernation is generally done in a sheltered place or in the ground. The nature of the soil is of great importance for terrestrial gastropods. They prefer limestone substrates because they provide material for building the shell, retaining water, having some moisture, allowing the development of a rich vegetation. Other terrestrial species belonging to the family Helicidae, common in natural (orchards, forests, bushes in hilly and flat) and anthropogenic ecosystems or cultivated (kitchen gardens, orchards, fields wine) and ruderal areas are *Helicella obvia* (Menke 1821), *Cepaea vindobonensis* (Ferussac 1821), *Helix lutescens* (Rossmassler 1837), *H. lucorum* (Rossmassler 1837).

In natural ecosystems (especially in orchards and forests), the species *Succinea putris* Linnaeus 1758 and *S. oblonga* (Draparnaud 1801), belonging to the Succineidae family, have a low frequency; they live near water, in wet orchards (GROSSU, 1993). *Arion hortensis* (Ferussac 1819) belonging to the Arionidae family is a European species present in all the provinces of Romania, the preferred habitat being represented by forests, meadows, orchards in both mountain and plains.

Originally from Spain, *Lehmania valentiana* (Ferussac 1823) belonging to the Limacidae family, is a cosmopolitan species, frequent in anthropogenic ecosystems (greenhouses, botanical gardens), where it produces significant damage. A harmful species belonging to the same family is *Deroceras reticulatum* (O. F. Muller 1774), frequent in large-scale vegetable gardens, but also in forests and orchards (GROSSU, 1993; CIOBOIU, 2005).

The ability of natural or artificial aquatic ecosystems to self-propel depends on a complex of environmental factors (physical, chemical, and biological) that interact in this process simultaneously or in a certain succession. It is understood, however, that if pollution is strong and occurs suddenly (in case of spills of large quantities of pollutants) the death of organisms can be instantaneous. Following the gradual change in the physicochemical characteristics of water as a result of pollution, a change in the ecological balance occurs: some species gradually disappear, changing the ratio of the populations constituting the biocoenosis; those adapted to the new conditions will multiply. There is a selection, depending on their ecological valence, forming another type of biocoenosis characteristic of polluted water (CIOBOIU, 2005; MANU & ONETE, 2014; TEODORESCU & MAICAN, 2014; MANU et al., 2017).

Water and soil contamination by both inorganic (e.g., metals) and organic (e.g., petroleum) pollutants is a major issue in several European countries. Petroleum and petroleum products (complex mixture of hydrocarbons) are the major source of energy for industry and daily life. Accordingly, petroleum hydrocarbons are one of the most important pollutants of the water and soil in Romania. Furthermore, there several approaches were performed for the isolation and characterization of new bacterial strains able to survive in the presence of different toxic hydrocarbons. These bacteria belong to several genera, such as *Vibrio*, *Rhodococcus*, *Lysinibacillus*, *Shewanella*, *Serratia* and *Pseudomonas* (VOICU et al., 2005; ŞTEFĂNESCU & CÎRSTEA, 2010; STANCU, 2014; 2015; 2016).

CONCLUSIONS

Increasing the efficiency of bacteriochemical solubilization techniques of industrial wastes is interconnected with the direct interaction between microorganisms and solid coal surfaces subjected to the action of the microbiological method of removal of inorganic sulfur. In addition, the obtained results have highlighted the ecological characteristics of the Helicidae family, which have an important role in the biogeochemical circuit, being indicators of Oltenia's contaminated industrial environments, as well as metal ion bioaccumulators from natural and anthropogenic ecosystems.

The studies conducted showed the increased tolerance of plant and invertebrate species to the presence in the environment of bivalent metallic ions from the industrial activities of solid coal waste processing. Biological methods are not particularly precise and they cannot be included in absolute mathematical formulas or specify the quantity and quality of the pollutant, but only their effect and not when sampling, but as a result of a long period of pollution, on the contrary, the decrease or elimination of this pressure. Therefore, in order to have a more accurate picture of the quality of ecosystems (and therefore the type and quantity of pollutants), biological methods must be accompanied by chemical determinations.

ACKNOWLEDGEMENT

The study is the result of the collaboration between the Institute of Biology Bucharest, the Department of Microbiology and the Museum of Oltenia Craiova, respectively the collaboration convention numbers 1797 / 20.05.2015 and 1402 / 21.05.2015 on: *Biodiversity of microbiota in Oltenia industrial contamination areas and potential biotechnological applications in order to reduce it.*as well as the collaboration convention numbers 39 / 05.01.2018 respectively 18 / 08.01.2018 with the theme *The integrative study of the biodiversity specific to industrial polluted ecosystems in Oltenia, as well as neighboring areas.* The data presented are part of the project no. RO1567-IBB05 / 2018 developed at the Bucharest Institute of Biology of the Romanian Academy.

REFERENCES

ADAM I., IVANSCHI T., MERCE O., TURCU D., CADAR N., CÂNTAR I. 2012. Înfiinţarea perdelelor forestiere de protecţie în zona de câmpie a judeţului Mehedinţi, *Revista de Silvicultură şi Cinegetică*. Edit. Universitaria. Braşov **17**(30): 23-35.

BERCEA I. 2009. Caracterizarea stațiunilor forestiere cu gârniţă şi cer din Bazinul Jiului. *Analele Universităţii din Craiova, Seria Agricultură - Montanologie – Cadastru*. Edit. Universitaria. Craiova. **39**: 30-47.

BREZEANU GH., CIOBOIU OLIVIA, ARDELEAN A. 2011. *Ecologie acvatică*. Vasile Goldis University Press. Arad. 415 pp.

CIOBOIU C. OLIVIA. 2005. *Ecologia şi protecţia mediului*. Edit. Sitech Craiova. 195 pp.

CIOBOIU OLIVIA & BREZEANU GH. 2017. Iron Gate I reservoir – ecological evolution, Romania. *International Journal of Ecosystems and Ecology Sciences (IJEES)*. Universitaria Press. Tirana. **7**(2): 199-206.

CISMAȘIU CARMEN-MĂDĂLINA. 2009. The acidophilic microorganisms diversity present in lignite and pit coal from Paroseni, Halânga, Turceni mines. *International Conference of Science*. The Annals of Oradea University-Biology Fascicle. Oradea. **2**: 60-65.

CISMAȘIU CARMEN-MĂDĂLINA, POPESCU GABRIELA, VĂCĂROIU CORINA, MERCIU SIMONA, DUMITRU LUCIA, COJOC ROXANA, POPA ELENA. 2010. The bacterial desulphurization of different coal samples from Romanian mining sites. In: *Book of Abstracts, The Anniversary Conference of the Institute of Biology, 50 Years of Academic Research in Biology*. Edit. ARS DOCENDI. University of Bucharest: 146-147.

FIERA CRISTINA & OROMULU-VASILIU LILIANA. 2009. The impact of dump on springtails fauna (Collembola) of Râul Mare (Retezat Massif, Romania). In: *Proceeding of the XIII Balkan Mineral Processing Congress* (edited by Krausz S., Ciobanu L., Cristea C., Ciocan V., Cristea G.). Universitas Press. Petroșani. **2**: 689-695.

GAVRILESCU ELENA & OLTEANU I. 2003. *Calitatea mediului. Monitorizarea calității aerului.* Edit. Universitaria. Craiova. **3**. 200 pp.

GAVRILESCU ELENA. 2007. *Surse de poluare și agenți poluanți ai mediului*. Edit. Sitech. Craiova. 191 pp.

GROSSU Al. V. 1983. *Gastropoda Romaniae. Ord. Stylommatophora, Suprafam. Arionacea, Zonitacea, Ariophantacea şi Helicacea*. Edit. Litera Bucureşti. 563 pp.

GROSSU Al. V. 1993. *Gastropodele din România. Melci marini, de uscat şi apă dulce. Compendiu*. Edit. Litera Bucureşti. 413 pp.

MANU MINODORA & ONETE MARILENA. 2014. Taxonomical structure of the soil mites fauna from a cliff ecosystem and its adjacent area (Doftana Valley, Romania). *Romanian Jounal of Biology-Zoology*. Roumanian Academy Publisher. Bucharest. **59**(2): 113-121.

MANU MINODORA, LOTREAN N., CIOBOIU OLIVIA, POP O. GR. 2017. Diversity of soil mites (Acari: Mesostigmata) and gastropods (Gastropoda) fauna from Leaota mountains – Romania. *Oltenia. Studii şi comunicări. Stiinţcle Naturii*. Muzeul Olteniei Craiova. **33**(1): 193-201.

NEACŞU P. & CIOBOIU OLIVIA. 1999. Contribuţii asupra ecologiei speciei *Hclix pomatia* L. (Gastropoda Pulmonata) din Oltenia. *Oltenia. Studii şi comunicări. Stiinţcle Naturii*. Muzeul Olteniei Craiova. **14**: 62-66.

NEACŞU P. & CIOBOIU OLIVIA. 2000. Contribuţii la cunoaşterea microhabitalului melcului de livadă – *Helix pomatia* L. (Gastropoda Pulmonata). *Oltenia. Studii şi comunicări. Stiinţcle Naturii*. Muzeul Olteniei Craiova. **16**: 203-205.

STANCU MIHAELA MARILENA. 2014. Physiological cellular responses and adaptations of *Rhodococcus erythropolis* IBB_{Po1} to toxic organic solvents. *Journal Environmental Science*. Springer. Berlin. **26**: 2065-2075.

STANCU MIHAELA MARILENA. 2015. Solvent tolerance mechanisms in *Shewanella putrefaciens* IBB_{Po6}. *Water*, *Air*, & *Soil Pollution*. Springer. Berlin. **226**: 1-16.

STANCU MIHAELA MARILENA. 2016. Response mechanisms in *Serratia marcescens* IBB_{Po15} during organic solvents exposure. *Current Microbiology*. Springer. Berlin. **73**: 755-765.

ŞTEFĂNESCU M. C. & CÎRSTEA DOINA. 2010. Isolation of some bacterial strains with oil degradative potential from polluted environments in Romania. In: *Book of abstracts, The Anniversary Conference of the Institute of Biology, 50 Years of Academic Research in Biology*. Edit. ARS DOCENDI. University of Bucharest: 144.

VICOL IOANA. 2011. A study regarding the impact of forestry management on lichen flora within forests from Bucharest surroundings (Romania). *Oltenia. Studii și comunicări*. Muzeul Olteniei Craiova. **27**(1): 165-170.

VICOL IOANA. 2015. Effect of old-growth forest attributes on lichen species abundances: a study performed within Ceahlău National Park (Romania). *Cryptogamie Mycologie*. Adac. Tous droits reserves, Paris. **36**(4): 399-407.

VLĂDUŢ ALINA, NIKOLOVA NINA, LICURICI MIHAELA. 2017. Influence of climatic conditions on the territorial distribution of the main vegetation zones within Oltenia region, Romania. *Oltenia. Studii şi comunicări. Stiinţcle Naturii*. Muzeul Olteniei Craiova. **33**(1): 154-164.

VOICU A., LĂZĂROAIE M. M., ŞTEFĂNESCU M. C., DOBROTĂ S., TUNARU M. 2005. Consideration about involvement of some bacteria in corrosion of metallic surfaces. In: *Proceedings of the 4th International Conference URB-CORR "Study and Control of Corrosion in the Perspective of Sustainable Development of Urban Distribution Grids", 4th International Conference*. Edit. Printech. Sibiu: 96-101.

TEODORESCU IRINA & MAICAN SANDA. 2014. Diversity of entomofauna (Hymenoptera, Diptera, Coleoptera) in the Comana Natural Park (Romania). *Romanian Journal of Biology-Zoology*. Roumanian Academy Publisher. Bucharest. **59**(1): 17-34.

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

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

Gavrilescu Elena
University of Craiova, Faculty of Agriculture and Horticulture,
Biology and Environmental Engineering Department, Libertăţii Street 15, Craiova, 200585, Romania.
E-mail: gavrilescu_elena@yahoo.com

Tomuş Nicolae
Research and Development National Institute for Metals and Radioactive Resources (INCDMRR), Ilfov, Romania.
E-mail: icpmrr@icpmrr.ro

Received: March 30, 2018
Accepted: June 9, 2018