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Research Paper

The Influence of Abiotic Factors on the Reconstruction of the Biocoenosis areas Polluted with Organic and Inorganic Compounds from the Lower Sector of the Jiu River[#]

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Abstract: It is well-known that an environmental condition allows us to understand the distribution of microorganisms in nature and establish methods to fight against and eliminate undesirable microorganisms. Our studies illustrate the toxic effects of metals on living organisms and above all effective technologies for reducing concentrations of metals in the waste water by classical and modern systems. The concentrations of Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{2+} from the water of the lakes in the lower sector of the Jiu were found below the limit of detection admissible by international standards. Pb^{2+} and Cd^{2+} are not considered to be essential for life, but these metals are concentrated in the populations of *Viviparus acerosus* and *Radix balthica* from the aquatic environment. The process of accumulation of metallic ions in populations of microorganisms and gastropods strongly depends on their concentration in water and sediments as a living environment. Patterns of accumulation and HM transfer in biocoenosis are used for the characterization of the risks of environmental pollution in the aquatic ecosystems from Romania. The presented data are the result of the convention between the Institute of Biology Bucharest and the Oltenia Museum of Craiova.

Keywords*: Biocoenosis, metallic ions, bioaccumulation, Romania.*

Introduction

Uncontrolled discharge of wastewater containing metal ions into rivers causes profound changes in the quality of water pick-up, consisting of disrupting the ecosystem due to the disturbance of the processes in the food chains, the inhibition of mineralization, the accumulation of metals in high concentrations in some aquatic organisms, and toxic action of these metals for communities of aquatic organisms and ultimately to humans (Bacelar-Nicolau & Johnson, 1999; Deak *et al*., 2005; Brezeanu *et al*., 2007; Cismașiu, 2010).

Water pollution is one of the most serious problems faced by human communities everywhere, being the consequence of socio-economic development, in which consumption and unrealistic exploitation prevail against conservation and protection. It was considered that water resources are inexhaustible and to this it was added the neglect of abiotic factors (Brezeanu & Gâștescu, 1996; Brezeanu *et al*., 2011; Cioboiu & Brezeanu, 2014).

The influence of physical, chemical and thermal factors is variable, depending on the intensity and duration of their action on the distribution and activity of aquatic organisms. In this respect, our studies, carried out within an extensive national interdisciplinary research program, on the influence of abiotic factors on the biodiversity specific to the aquatic ecosystems in Southern Romania contribute to the knowledge of the action of metallic ions on the distribution of aquatic organisms in the lower sector of Jiu River (Cioboiu, 2014; Cioboiu & Cismașiu, 2016; Stancu, 2018).

Materials and Methods

In order to determine the chemistry, water samples were taken in containers of inert material (glass, plastic) from the habitat of reservoirs located on the Preajba River in the Jiu lower sector. Samples were analyzed using atomic absorption spectrophotometer type flame DR 2000 and GBC Avanta, SN 5378 to determine the concentration of metal ions, such as chromium, nickel, zinc, lead, cadmium, copper, manganese, and iron. Moreover, by the same method, there were emphasized the

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concentrations of metal ions in the shells and meat of different species, such as *Radix balthica* and *Viviparus acerosus*, species that are dominant in the aquatic ecosystems of the studied area (Figure 1).

In order to establish the chemical composition of the organic material, which is matured in the mortar, the samples were dried at about 70°C. The experimental mineralization processes were performed to determine the concentrations of the metallic ions from these solutions and were conducted in four steps: (1) in the Teflon tube, there is introduced 1 g of dried and ground organic material; (2) 65% nitric acid, 37% HCl and hydrogen peroxide are added to the tube; (3) 5 ml of the standard solution of 5 ppm is added to each sample and made up to the mark with distilled water in a 25 ml volumetric flask; (4) the calibration solutions in the ascending order of concentration and the blank sample (zero) are analyzed to determine the calibration curve at different wavelengths of the DR 2000 and Avanta (GBC) atomic absorption spectrophotometer.

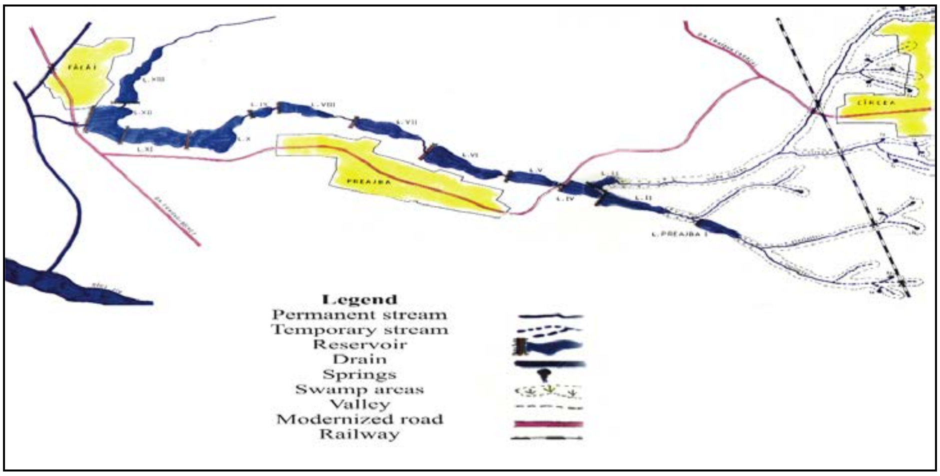

Figure 1. A Map of the reservoirs located along the Preajba River in the Jiu lower sector (after Cioboiu, 2014).

Results

The study of the physico-chemical peculiarities of the reservoirs on the Preajba River presents a great practical importance as it offers the possibility of qualitative assessment of the aquatic ecosystems in the lower Jiu sector, as well as a classification in the surface water quality categories (Marx *et al*., 1967; Bileţchi, 1998; Cioboiu, 2003; 2011).

The analysis of the main physico-chemical indicators reveals the conditions of water formation as well as the mineralization stage of these lakes. The chemical composition of water is characteristic of eutrophic ecosystems. Taking into account the particularities of biotopes and biocoenoses (sandy-muddy bottom rich in organic substances, development of macrophytes and phytoplankton in summer), as well as the fact that the reservoirs are supplied by springs located both on the shores and bottom, we have a picture of the conditions that determine the chemistry of water.

Based on the ionic balance and the anion and cation content the water of lakes is included in the bicarbonate-sulphato-calcic-magnesium category, characteristic to the mixed mineralization stage (Table 1). The average values of the pH range from 7.29 to 7.84 (weakly alkaline range) in accordance with the bicarbonate content (414-695 mg/l). Biogenic content is a particular feature of the reservoirs. The average concentrations of nutrients (NO^{3-} and PO_4^{3-}) are 10.5 mg/l or 7.9 mg/l and are the result of rainwater washing agricultural areas. High concentration of the phosphate ions to the maximum admissible value for the surface water, 0.35 mg/l may be due to the discharge of detergents.

Among cations, we first mention calcium (Ca^{2+}), the origin of which is linked to the sedimentary rocks found within the basins of the reservoirs, as well as the amendments applied in agricultural fields. Calcium and magnesium ions, together with carbonates, bicarbonates and sulphates present in the water of the reservoirs are the cause of the high values of the temporary and total hardness of the water (over 20 degrees) (Brezeanu *et al*., 1968; Cioboiu, 2011).

The concentrations of Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{2+} in the water of the reservoirs located within the Lower Basin of the Jiu were below the detection limit allowed by international standards (0.001 - 0.01 mg / l) (Table 2).

Table 1. A Physico-chemical composition of water in the reservoirs (average values).

No.	Indicators	Measured values	Permissible values Order no.161/2006-the Cl. II quality	Method of analysis	The used equipment
1.	Hydrogen ions conc. (pH), unit. pH	7.5	6.5	SR.ISO 10523 - 97	ORION 420A, series 049576
2.	Oxidizable organic substances CCOCr (O_2) mgO_2/dm^3, max.	9.5	25	SR ISO 6060 - 96	-
3.	Fixed residue, mg/dm^3, min./max.	375	750	STAS 9187 - 84	Analytical balance PRECISA 205A,
4.	Electrical conductivity µS/cm, max.	750	-	STAS 7722 - 84	Cond WTW 340,
5.	Alkalinity HCl 0.1	7.8	-	-	-
6.	Ammonia (NH_3), mg/dm^3, max.	0.023	0.1	STAS 3048 - 90	Spectrophotometer DR 2000, no.
7.	Ammonium (NH_4), mg/dm^3, max.	10.5	13	Method 355	Spectrophotometer DR 2000, no.
8.	Phosphates mg/l	7.9	0.35	STAS 3265 - 66	Spectrophotometer DR 2000,
9.	Ion ammonium mg/l	0.35	1.0	STAS 3049 - 86	Spectrophotometer DR 2000,
10.	Total hardness, German degrees, max.	21.78	-	STAS 3026 -76	-
11.	Calcium (Ca^{2+}), mg/dm^3, max.	83	100	STAS 3662 - 62	-
12.	Magnesium (Mg), mg/dm^3, max.	45	50	STAS 66-74	-

An important role in the biological production of lake ecosystems in the area is played by the gastropod populations, predominantly benthic organisms that actively respond to the heterogeneity of the micro-habitats they populate. A number of 18 species have been identified, among which *Viviparus acerosus*, *Radix balthica*, *Physella* (*Costatella*) *acuta*, *Planorbis planorbis* are characteristic of the eutrophic lake ecosystems in the lower Jiu sector (Grossu, 1993; Cioboiu, 2014)

In industrially contaminated environments, indigenous organisms exist in the form of mixed populations, interacting with each other, both positively and negatively. Their presence is evidenced by the products of metabolism rather than by the accumulation of biomass. The accumulation of products with inhibitory activity and antagonism phenomena contribute-together with the quantitative changes of nutrients to the emergence of the new aquatic communities of microorganisms that underlie the succession of populations in an ecosystem.

Table 2. B Concentrations of heavy metals in the water of studied reservoirs compared with the maximum permissible levels stipulated in Order no. 161 / 2006.

No.	Indicators (mg/Kg/SU)	Preajba Valley reservoirs	MPL ac. Ord. 161/2006	Method of analysis	The used equipment
1	Iron	< 0.005	0.1	Working method specified in the user manual atomic absorption spectrometer GBS-Avanta	Avanta GBC atomic absorption spectrometer SN A 5378
2	Manganese	< 0.001	0.01		
3	Nickel	0.016	0.1		
4	Chromium	< 0.003	0.1		
5	Copper	< 0.01	0.01		
6	Zinc	< 0.005	0.05		
7	Cadmium	< 0.001	0.005		
8	Lead	< 0.01	0.01		

In this whole ecosystem gastropod populations have an important role among consumers, representing a factor of accumulation and transfer of mass and energy to the higher order consumers -

fish. Moreover, the populations of *Viviparus acerosus* and *Radix balthica* are one of the reference factors for the accumulation of heavy metals of Pb^{2+} and Cd^{2+} type.

Radix balthica inhabits especially the oozy-detritic substrate near the shores in shallow areas. These areas have the best food conditions. This species and pulmonate gastropods, in general, find abundant food on the rough debris, on the leaves fallen in water but not decomposed on which a rich periphyton is attached, as well as in the silt layer rich in organic substances.

Regarding the presence of bivalent heavy metals in sediments and freshwater snail shells, it has been found that they can accumulate levels of Pb^{2+}, $Cd^{2+,}$ Mn^{2+} and Fe^{2+} higher than the maximum admissible values (0.001-0.01 mg / l) according to order 161 / 2006. The performed analyses illustrate the capacity of the pulmonate species *Radix balthica* to accumulate metal ions of the types Pb^{2+}, Cd^{2+}, Mn^{2+}, Fe^{2+} and Ni^{2+} in direct correlation with the concentration of the respective ions in the soil Table 3, Figure 2. At the same time, studies have shown the increased tolerance of the branchiate snail *Viviparus acerosus* to the presence of bivalent metallic ions from the industrial solid waste processing activities (Cismaşiu *et al.*, 2015a; Cioboiu & Cismaşiu, 2016). These species are bioindicators of industrially contaminated environments in the studied sector as they signal the early appearance of negative changes in lacustrine ecosystems.

In relation to the dynamics of precipitation and the use of water for fish farming, in some periods, the upstream reservoirs, as a result of the evaporation process, drastically reduce their surface. They get the character of marshlands and are favorite places for gastropods, the dominant species being *Radix balthica*.

Table 3. Concentrations of metals from the soil and shells of the pulmonate snail *Radix balthica*.

No.	Indicators (mg/Kg/SU)	Preajba Valley reservoirs (soil)	Snails (table meat)	Method of analysis	The used equipment
1	Lead	0.27	180	Working method specified in the user manual atomic absorption spectrometer GBS-Avanta	Avanta GBC atomic absorption spectrometer SN A 5378
2	Cadmium	0.008	187		
3	Nickel	0.0042	0.475		
4	Chromium	< SLD	4.07		
5	Copper	< SLD	8.1		
6	Zinc	0.0006	0.115		
7	Iron	0.0015	0.1		
8	Manganese	0.075	0.124		

Note: SLD – below detection limit

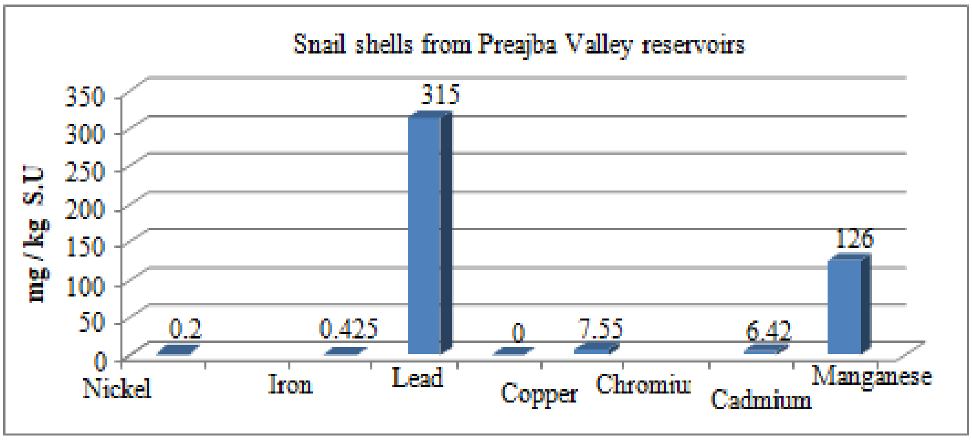

Figure 2. B Concentrations of heavy metallic ions from snail shells of *Radix balthica*.

Conclusions

The concentrations of Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{2+} in the water of the reservoirs located in the Lower Jiu basin were found below the detection limit allowed by international standards. Pb^{2+} and Cd^{2+} that reach the aquatic environment through leaching are not considered essential for life, yet they are concentrated in the populations of *Viviparus acerosus* and *Radix balthica*. The process of accumulation of metal ions by populations of microorganisms and gastropods is strongly influenced by their concentration in waters and sediments. HM accumulation and transfer models in biocoenosis are used to characterize the pollution risks of aquatic ecosystems in Romania.

Discussions

Knowledge of environmental conditions allows understanding the distribution of microorganisms and invertebrates in aquatic ecosystems and identifying methods to evaluate the accumulation of metal ions present in water bodies and sediments. In this context, our studies show toxic effects of heavy metals on living organisms and efficiency of technologies for reducing the concentrations of metal ions from wastewater by classical and modern systems meant to contribute to the biocoenotic reconstruction of the industrial polluted ecosystems in southern Romania. Moreover, the populations of *Viviparus acerosus* (branchiate species) and *Radix balthica* (pulmonate species) represent one of factors of reference with regard to the accumulation of heavy metals of the type Pb^{2+} and Cd^{2+} (Cismașiu, 2010; Brezeanu *et al*., 2011; Cioboiu, 2014; Cioboiu & Brezeanu, 2014; Cismaşiu *et al*., 2015a; b).

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