Assessment of Heavy Metals Levels in Water, Sediments and Fish from Plumbuita Lake, Romania

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The contamination of aquatic ecosystems with a wide range of pollutants, especially with heavy metals cause direct toxic effects and has become a matter of general concern throughout the last decades. The aim of this study was to determine the concentrations of heavy metals (Pb, Cd, Cr, Cu, and Ni) in the water, sediments, and fish (Alburnus alburnus) of Plumbuita Lake (Bucharest, Romania), this species of fish being frequently part of the local people's diet. The results from this study provides useful information regarding concentration levels of heavy metals in the water, sediments and fish in the Plumbuita Lake, essential for the assessment of environmental quality and health of living organisms from this lake ecosystem.

Keywords: heavy metals, water pollution, fish, sediments

The most important global environmental issue is the quality of water as it represents an important part of the composition of all living organisms [1, 2]. As a result of various activities of human society's evolution, one of the highest environmental risk with adverse consequences for water quality and hence for entire lifetime, is the ubiquitous presence of heavy metals due to their toxicity, persistence and lack of biodegradation [3-7]. In the recent decades, the assessment of aquatic health of ecosystems in terms of heavy metals content is a priority in many developed and emerging countries [8]. The main sources of their penetration into the aquatic environment are the waste water, industrial effluents and agricultural activities [9]. After entering the aquatic environment, heavy metals tend to accumulate in sediments and suspended matter and can be taken up by living aquatic organisms leading to a reduction in biodiversity and therefore to contamination of the food chain with direct implications for human health [10-12].

Because in the aquatic environment the upper class of the food chain is represented by the fish, they can bioaccumulate metals in concentrations higher than in their environment (water, sediment and food), and sometimes the toxic effect of accumulated metals counteracts the beneficial effect of fish meat consumption on the human body [13-14].

The presence of certain elements in the living organisms is vital to conduct physiological processes, but for so called *heavy metals,* such as lead, cadmium and mercury, their beneficial role on the body has not been established yet, although recent research in the field has indicated that their presence is not beneficiary, but on contrary, it can lead to development of various serious affections [15]. To assess the health of an ecosystem and the toxic effects of heavy metals on the human body, their determination in the environment and biota (fish) is a necessary activity [16, 17]. Quantifying the concentrations of metals in fish muscle tissue, important information can be obtained regarding their bioavailability, involving the potential risk to the health of the entire food chain, including humans [18].

In Romania, at level of Bucharest city, an essential part of the urban ecosystem is represented by the 10 lakes located along the Colentina River, including Plumbuita Lake. The development and constructions in recent times just in the vicinity of the lake, the lack of connection to the sewerage network and the industrial unit's activities in the area pose a potential hazard to the water quality of the lake.

The aim of this study was to assess the health of the Plumbuita Lake in terms of concentrations of heavy metals: copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb) and nickel (Ni) in water, sediment and fish muscle tissue *(Alburnus alburnus)*.

Experimental part

Plumbuita Lake is part of the lakes of the Colentina River and has a total area of 44 ha, currently being used for fishing, irrigation and recreation activities [19]. To assess the heavy metals content of the aquatic ecosystem, a sampling campaign was organized in May 2015 for collecting samples of water, sediment and fish. Water and sediment samples were taken from three locations (L1, L2, and L3) represented in figure 1.

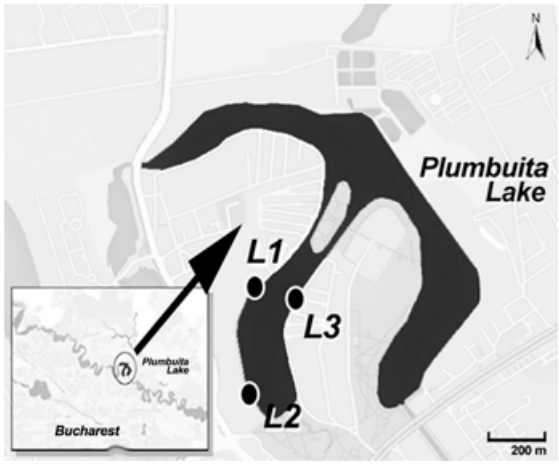

Fig. 1. Map of study area with sampling locations on Plumbuita Lake

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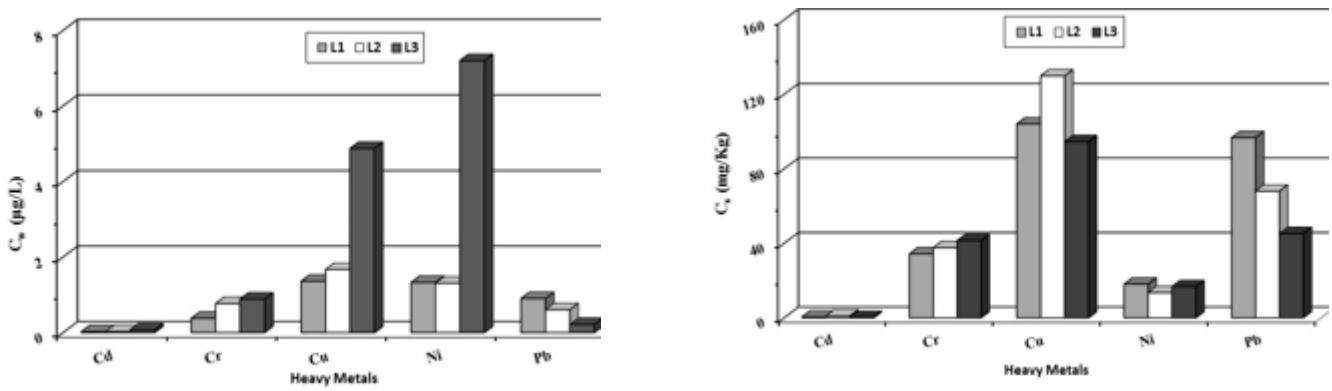

Fig. 2. The level of heavy metals in water samples (a) and in sediment samples (b) for the three sampling locations from Plumbuita Lake

Sampling

Samples for analysis were taken as follows:

- water samples were collected from approximately 50 cm below the water surface in clean polyethylene containers decontaminated by washing in advance with nitric acid solution and then rinsed twice with distilled water [20];

-sediment samples were collected in polyethylene bottles, washed with detergent and rinsed distilled water using core sampler;

- the samples of fish (*Alburnus alburnus*), purchased from local fishermen on the Plumbuita Lake, generally had a length of about 15 cm and an average weight of 0.030 Kg. They were transported to the laboratory, washed with double distilled water and stored at 4 ^{0}C until analysed.

Samples treatment

To determine the total concentration of metal, a volume of 250 mL taken from the test water was acidified to prevent hydrolysis of the metals, by adding 0.5 mL of nitric acid (65 %) in it [21]. Approximately 0.5 g of dried sample of sediment (fraction < 63 µm) was digested with 9 mL of hydrochloric acid (37 %) and 3 mL of nitric acid (65 %). Microwave digestion system (Ethos 1 Milestone) equipped with a temperature and pressure control was used to digest the sediment and fish samples. Fish muscle tissue was dried to about 80^{0}C in the laboratory oven, milled to homogeneity in a non-metallic mortar. Approximately 0.5 g of sample were weighed and digested using a mixture of 7 mL of 65% nitric acid (Suprapur) and 1 mL of 30 % hydrogen peroxide (Suprapur) using the mentioned microwave digestion system. All reagents were purchased from Merck, Germany.

Analysis procedure

After bringing all the samples in solution, for determining the heavy metals (Pb, Cd, Cr, Cu and Ni), a High-Resolution Continuum Source atomic absorption spectrometer - ContrAA 700 was used. All solutions for calibration, samples, and rinsing were prepared using ultrapure water and Suprapur nitric acid (65 %). The stock solutions were prepared using ultrapure water, obtained through a Micropure Ultrapure water system (TKA, Germany).

Partition coefficient

To characterize the process of distribution of heavy metals in the abiotic compartment, the sediment/water partition coefficient (Kp) was calculated according to equation (1.1).

$$K_p = \frac{C_s\,(mg/Kg)}{C_w\,(mg/L)} = (L/Kg) \qquad (1)$$

Bioaccumulation factor (BAF)

For the characterization of the heavy metals transfer process from the abiotic to the biotic compartment, it was calculated the bioaccumulation factor (BAF_w) in relation to heavy metals concentration in water and the bioaccumulation factor (BAF_s) versus the heavy metals concentration in sediments [4, 10].

$$BAF_w = \frac{M_{tissue}}{C_w} \qquad (2)$$

$$BAF_s = \frac{M_{tissue}}{C_s} \qquad (3)$$

M_{tissue} - the concentration of heavy metals in fish (mg/Kg, dry weight);

C_s - the concentration of heavy metals in sediment (mg/Kg, dry weight);

C_w - the concentration of heavy metals in water (mg/L).

Results and discussions

Figures 2 show the distribution of concentrations of metals analyzed in water samples (fig. 2.a) and in sediments (fig. 2.b) for the three selected sampling locations, and figure 3 presents the content of heavy metals in the muscle tissue of the analyzed fish species

Analysing the obtained values for heavy metal concentrations referred to the law of Romania M.O. 161/2006 [22], all recorded values for water samples fell in class I of water quality, while samples of sediment recorded exceed the chemical quality standards for copper of approximately three times.

Through a comparative analysis of the obtained values for heavy metals in fish fillets with permissible limits laid down in the EC Regulation No 1881/2006, amended by the EC Regulation No 629/2008 [23] it was observed that the values obtained for Cd do not exceed the maximum level allowed, while for Pb there were exceedances of approximately 10 times the maximum allowed level.

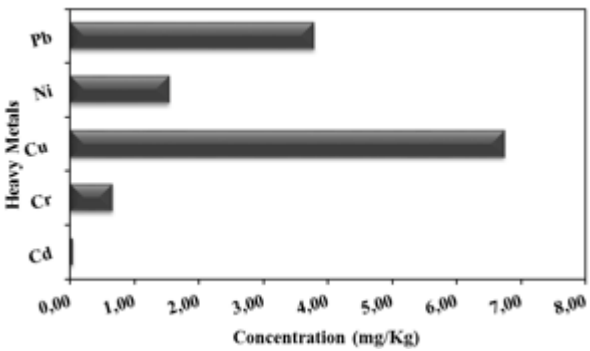

Fig. 3. Heavy metal content in analyzed fish species (*Alburnus alburnus*) from Plumbuita Lake

Figure 4 shows the distribution of heavy metals in the abiotic compartment where it can be observed that the value of the sediment/water partition coefficient in locations L1 and L3 presents a variation as follows: Ni <Cd <Cu <Cr <Pb and for location L2 the following variation was observed: Ni <Cd <Cr <Cu <Pb.

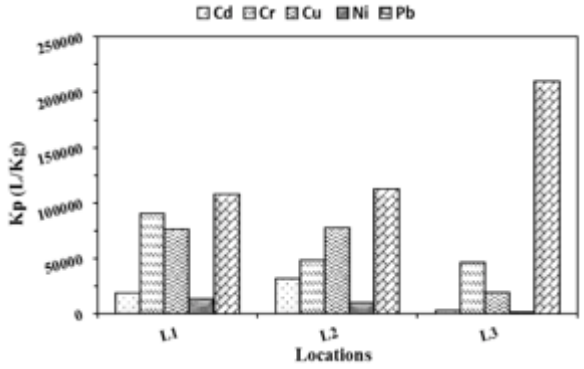

Fig. 4. Distribution of heavy metals in the abiotic compartment

The higher value of the partition coefficient for lead indicates its greater tendency to accumulate in the solid phase, while the lower value of the partition coefficient for nickel indicates the tendency to remain in the aqueous phase.

Figure 5 shows that the analyzed fish species (*Alburnus alburnus*) has a tendency to accumulate metals in muscle tissue in relation to its surrounding environment (water) in the following order: Pb> Cu> Cd> Cr> Ni, and in the following order: Cd> Ni > Cu> Pb> Cr in relation to sediments.

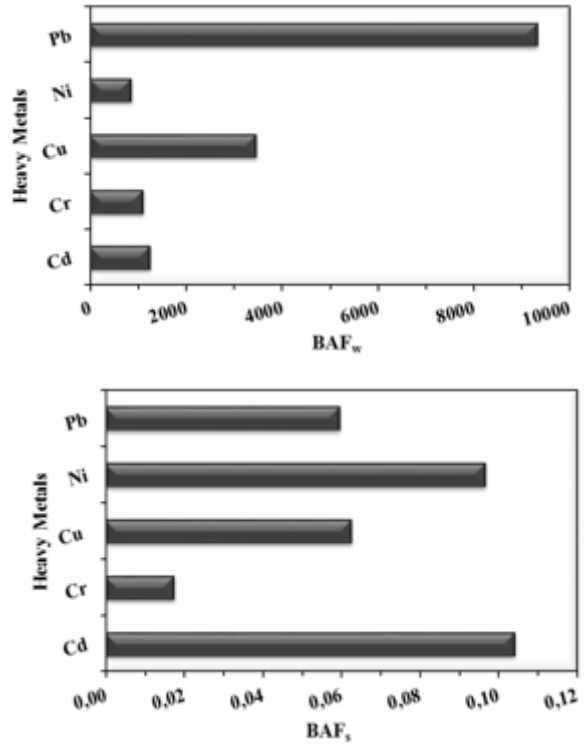

Fig. 5. Variation of bioaccumulation of heavy metals in fish muscle tissue in relation to their concentration in water (a) and sediments (b)

Conclusions

This study analyzed the level of heavy metals in water, sediment and fish muscle tissue of species *Alburnus alburnus* from Plumbuita Lake (Colentina River) located in Bucharest. According to the results, water samples were classified in class I of quality according to relevant national regulation (M.O. 161/2006), while for sediments, copper had higher values compared to chemical quality standard. The average concentrations for lead in fish muscle tissue recorded much higher values than the maximum level specified by the EC Regulation No 1881/2006, amended by the EC Regulation No 629/2008. Therefore, consumption of fish species *(Alburnus alburnus)* caught in this lake may represent a hazard for human health. The research on the trend of bioaccumulation of heavy metals in biota provided important information for assessing the effects of pollution on aquatic ecosystems.

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