STUDIES AND RESEARCH ON *PHRAGMITES AUSTRALIS'* (COMMON REED) ABSORPTION CAPACITY OF HEAVY METALS FROM THE SOIL

Valentin Nedeff, Cristian Radu, Alexandra-Dana Chiţimuş, Emilian Moşneguţu, Narcis Bârsan

Abstract *Our research aimed at determining Phragmites Australis' (common reed) absorption capacity of heavy metals from the soil in the industrial area downstream of Bacau city, Romania. The plants' capacity to absorb metals from their environment is assessed by means of the relation between the concentration of the element in the plant and its concentration in the soil, named biological absorption coefficient, bioaccumulation index or transfer factor.*
Keywords: *heavy metals, absortion, common reed.*

Introduction

Heavy metals present in ecological systems are available to the absorption process only partially, depending on the type of pH of the environment in which they are found, on their chemical composition, as well as on the quantity of heavy metals in the soil, plants, sediments, water, or air [1÷10, 23, 24].

The absorption in the plant by means of the plant roots is the main transfer channel of heavy metals to the plant [3, 11, 16, 17].

Heavy metals, once reached into the environment undergoes an absorption processes between different living environments (soil, water, air), but also between those ecosystems organisms (Fig.1). Therefore heavy metals in the air can be inhaled directly, or reach the soil surface through precipitations [17, 18, 19, 23, 24, 26].

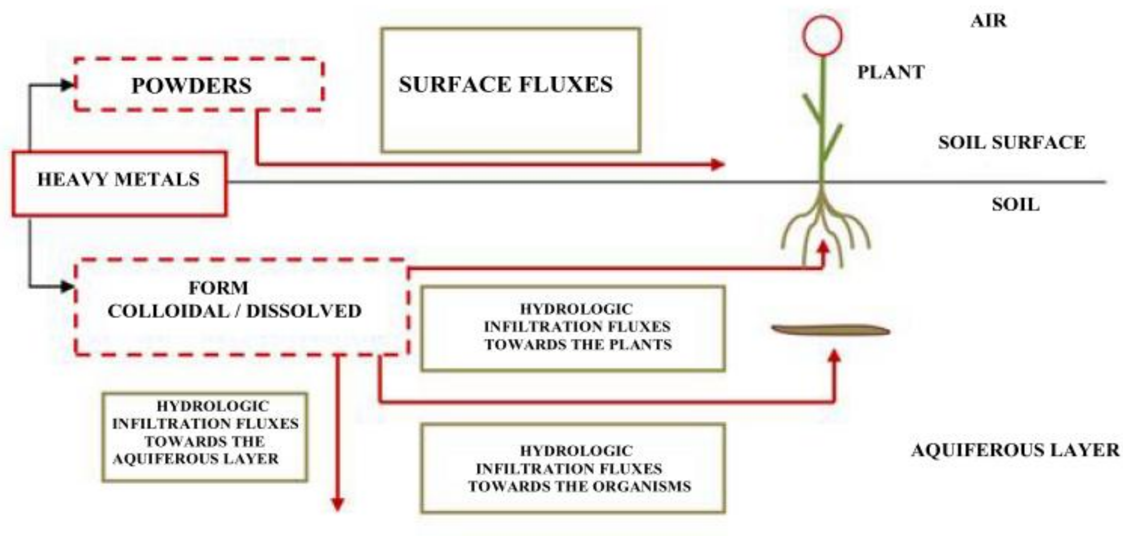

Fig. 1. The transport of heavy metals from pollution source to the air, soil surface, soil and aquiferous layer [17, 18, 19, 23, 24, 26].

Heavy metals, as opposed to the organic pollutants, and radionuclides are considered the most persistent contaminants in the soil tending to accumulate. Through the bioaccumulation heavy metals can have toxic effects on the flora, fauna and terrestrial vegetation on shore [20÷25].

The main industrial sources which generate heavy metals in the soil are [1, 4, 7, 8, 12, 16, 24]:

- mining and processing of metal ores;
- metallurgy;
- chemical industry;

- alloys industry;
- paint industry;
- glass industry;
- paper and pulpy idustry;
- dyeing and textile printing;
- chemical fertilizer industry;
- burning of coals etc.

Research method

The selection of sampling points with the aim of determining the concentration of heavy metals from the soil and plants took place in the areas where pollution sources are located.

Soil and plant samples were taken, which had the following characteristics:

- in case of soil:
  - clayey soils;
  - granulometry lower than 63µm.

- in case of plants:
  - *Phragmites australis* plant species (the popular common reed);
  - root, stem, leaf.

Phragmites australis (common reed, Fig. 2) is a perennial herbaceous plant from the Gramineae family (Poaceae), having a rigid stalk of about 1-4 m, green-bluish lanceolate leaves and flowers laid out in tassels and is a good accumulator of heavy metals and hydrocarbons.

Fig. 2. Phragmites australis.

Soil and plant samples were taken downstream of the industrial area of Bacau city (Fig. 3).

Table 1 presents the location of sampling points for soil and plant samples.

Table 1.
Location of sampling points on the banks of Bistrita River.

Location of sampling	Emissary
downstream Bacau	Bistrita

Fig. 3. The location of sampling points on the banks of Bistrita River, downstream of the industrial area of Bacau city.

Experiments were conducted in order to determine the concentration of eight heavy metals in the soil and plants, respectively for As, Cd, Cr, Cu, Hg, Ni, Pb and Zn.

Table 2 presents the punctiform pollution sources with heavy metals on Bistrita River, in the surrounding area of Bacau city.

Table 2.
The punctiform pollution sources with heavy metals on Bistrita River, in the surrounding area of Bacau city.

The punctiform pollution sources (commercial companies)	Natural water course
C.J. Apa Serv. Neamt	Bistrita
S.C. Mecanica Ceahlău Piatra Neamt	
Pergodur International S.A. (joint stock company closed)	
S.C. Petrocart S.A.	
C.J. APA SERV. Neamt	
C.J. .APA SERV. Roznov	
S.C. FIBREX NYLON S.A. Savinesti	
S.C. Stofe Buhusi S.A	
S.C. C.R.A.B. – section Buhusi	
S.C. LETEA S.A. Bacau (joint stock company closed)	
S.C. C.R.A.B. - zone central BACAU	
S.C. AMURCO S.A. Bacau	

S.C. – trading company; C.J. – County council.

Soil samples were taken at 10 cm deep in the soil, for three levels (Fig. 4):
- minimum level: soil-water interface level of 0 cm;
- medium level: soil-water interface level of 50 cm, on the river bank;
- maximum level: soil-water interface level of 100 cm, on the river bank.

In Governmental Order no. 161 as of February 16 2006, entitled *Elements and standards concerning the chemical quality of the alluvia – section 63 μm*, Table 3 presents the established maximum concentration levels for heavy metals in the soil [27].

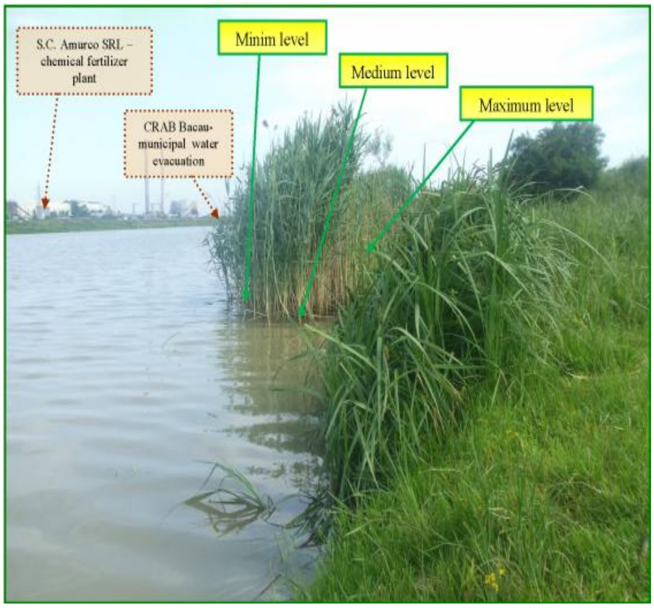

Fig. 4. Sampling points soil and plants.

Table 3.
Elements and standards concerning the chemical quality of the alluvia [27].

Quality indicator	Unit of measure	Quality standard
Cadmium	[mg/kg]	0.8
Nickel		35
Chromium		100
Cooper		40
Plumb		85
Arsenic		29
Zinc		150
Mercury		0.3

Obtained results

Table 4 presents the values determined by means of experiments for the witness sample of *Phragmites australis* plant species from unpolluted soils, respectively for eight heavy metals.

Table 4.
Experimental values for eight heavy metals in the soil, respectively for the witness sample of *Phragmites australis* plant species from unpolluted soils.

Location unpolluted	Cd	Ni	Cr	Cu	Pb	As	Zn	Hg
	[mg/kg dry matter]							
Soil	0.67	33	91	35	80	26	124	0.1
Phragmites australis Root + stem + leaf	0.1	1.31	0.74	1.14	2.88	3.17	2.55	ND

ND- undetectable ≈ 0,0001mg/kg ≈ 0.

Tables 5, 6 and 7 present the experimental values for eight heavy metals in the soil and plants at three levels: minimum, medium and maximum, respectively for sampling areas downstream of the industrial area of Bacau.

Table 5.

Experimental values for eight heavy metals in the soil and plants at a minimum soil-water interface level, respectively for the area downstream of the industrial area of Bacau.

Downstream Bacau minimum soil-water interface level (0 cm)	Cd	Ni	Cr	Cu	Pb	As	Zn	Hg
	[mg/kg dry matter]							
Soil	1.185	34.70	79.68	69.03	40.98	17.52	158.7	0.246
Plant *Phragmites australis*	0.18	6.44	11.25	11.2	5.55	4.62	111.25	ND

Table 6.

Experimental values for eight heavy metals in the soil and plants at a medium soil-water interface level, respectively for the area downstream of the industrial area of Bacau.

Downstream Bacau medium soil-water interface level (50 cm)	Cd	Ni	Cr	Cu	Pb	As	Zn	Hg
	[mg/kg dry matter]							
Soil	1.45	48.15	73.03	56.5	79.19	18.15	230.8	0.288
Plant *Phragmites australis*	0.72	13.55	15.54	18.55	13.33	5.44	128.55	ND

Table 7.

Experimental values for eight heavy metals in the soil and plants at a maximum soil-water interface level, respectively for the area downstream of the industrial area of Bacau.

Downstream Bacau maximum soil-water interface level (100 cm)	**Cd**	**Ni**	**Cr**	**Cu**	**Pb**	**As**	**Zn**	**Hg**
	[mg/kg dry matter]							
Soil	1.32	49.16	109.9	71.88	92.79	19.57	268.9	0.366
Plant *Phragmites australis*	1.54	26.28	19.37	26.28	14.26	7.554	176.29	ND

Fig. 5 presents the variation of heavy metals concentration in the soil for the sampling point downstream of the industrial area of Bacau city, minimum level soil-water interface (0 cm), respectively the values obtained for the witness sample.

The established maximum concentration limit for heavy metals in the soil for a minimum level (0 cm soil-water interface) downstream of the industrial area of Bacau city is exceeded in case of:

- cadmium with 48.12 %
- cooper with 75.57 %
- zinc with 5.8 %.

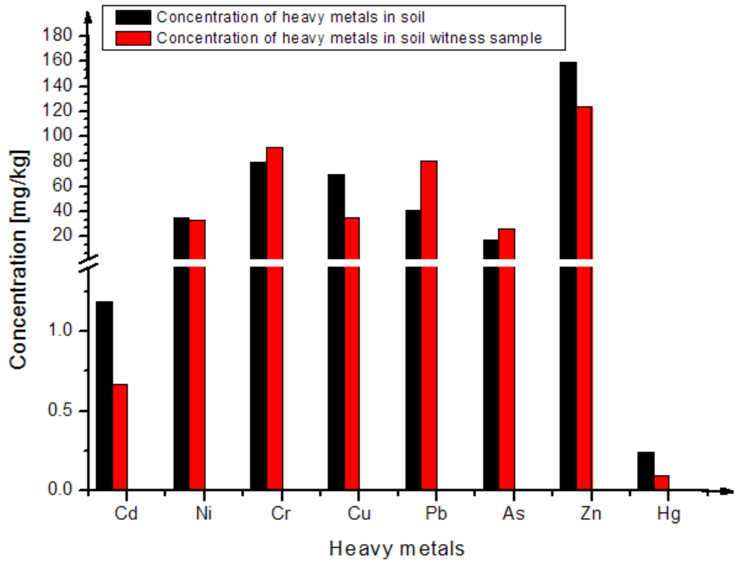

Fig. 5. The variation of heavy metals concentration in the soil and the witness sample for sampling point downstream of the industrial area of Bacau city at a minimum level (0 cm soil-water interface).

Fig. 6 presents the variation of heavy metals concentration in *Phragmites australis* plant species for the sampling point downstream of the industrial area of Bacau city, minimum level soil-water interface (0 cm), respectively the values obtained for the witness sample.

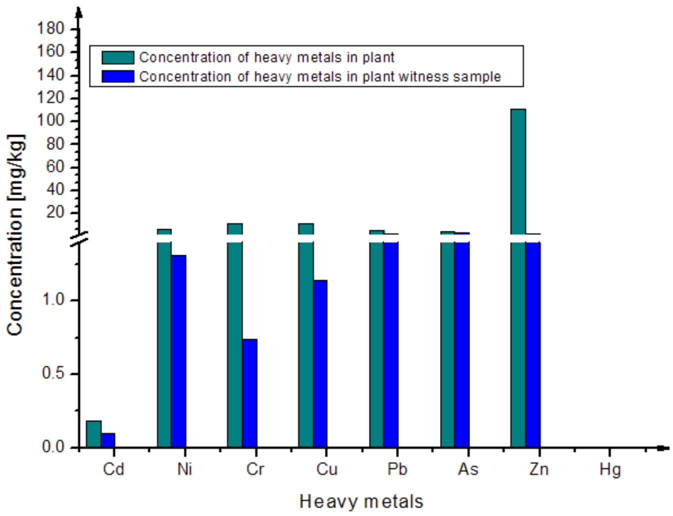

Fig. 6. The variation of heavy metals concentration in the plants and the witness sample for sampling point downstream of the industrial area of Bacau city at a minimum level (0 cm soil-water interface).

A lower absorption capacity of heavy metals from the soil was recorded, for a minimum level of soil-water interface, downstream of the industrial area of Bacau city, regarding *Phragmites australis* plant species, for cadmium, nickel, chrome, copper, plumb, arsenic and zinc.

The absorption capacity of heavy metals from the soil for a minimum level (0 cm soil-water interface) in case of *Phragmites australis* was much higher for zinc, the value determined in the plant was 29.89 % lower than in the soil.

Fig. 7 presents the variation of heavy metals concentration in the soil for the sampling point downstream of the industrial area of Bacau city, medium level soil-water interface (50 cm), respectively the values obtained for the witness sample.

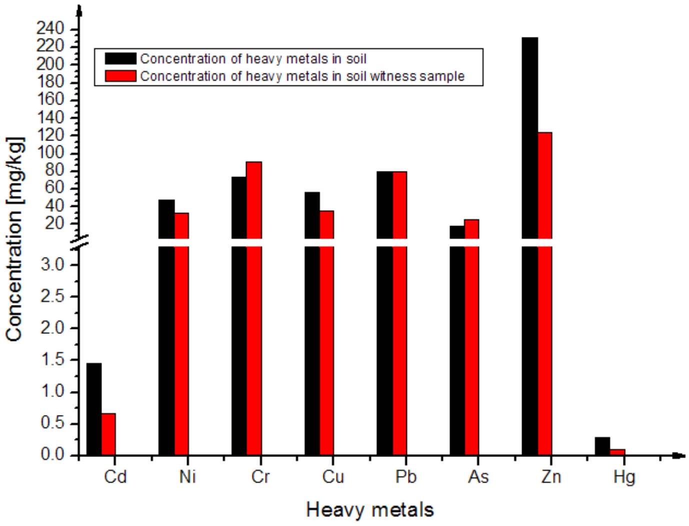

Fig. 7. The variation of heavy metals concentration in the soil and the witness sample for sampling point downstream of the industrial area of Bacau city at a medium level (50 cm soil-water interface).

The established maximum concentration limit for heavy metals in the soil for a medium level (50 cm soil-water interface) downstream of the industrial area of Bacau city is exceeded in case of:

- cadmium with 81.25 %;
- nickel with 37.57 %;
- cooper with 41.25 %
- zinc with 53.86 %.

Fig. 8 presents the variation of heavy metals concentration in *Phragmites australis* plant species for the sampling point downstream of the industrial area of Bacau city, medium level soil-water interface (50 cm), respectively the values obtained for the witness sample.

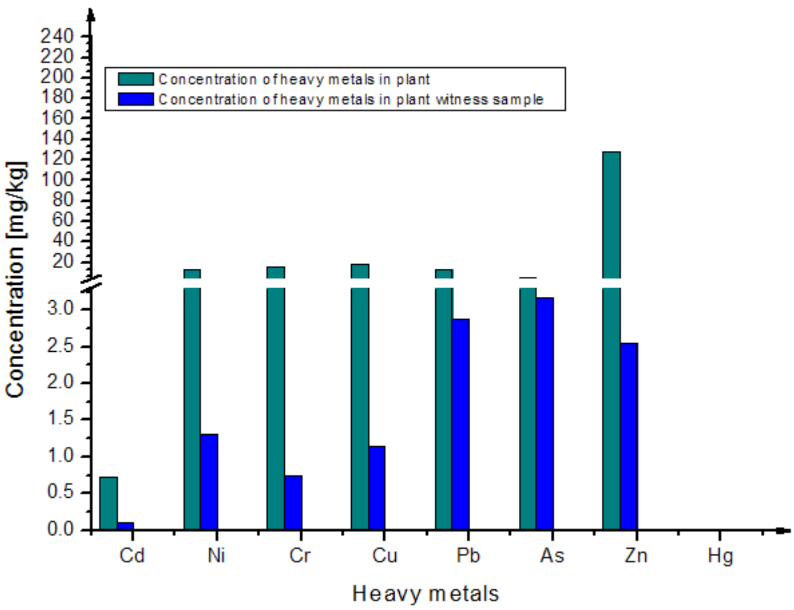

Fig. 8. The variation of heavy metals concentration in the plants and the witness sample for sampling point downstream of the industrial area of Bacau city at a medium level (50 cm soil-water interface).

The absorption capacity of heavy metals from the soil for a medium level of soil-water interface in case of *Phragmites australis* was much higher for the heavy metals below, as follows:

- for cadmium, the value determined in the plant was 50.34 % lower than in the soil;
- for zinc, the value determined in the plant was 44.3 % lower than in the soil.

Fig. 9 presents the variation of heavy metals concentration in the soil for the sampling point downstream of the industrial area of Bacau city, maximum level soil-water interface (100 cm), respectively the values obtained for the witness sample.

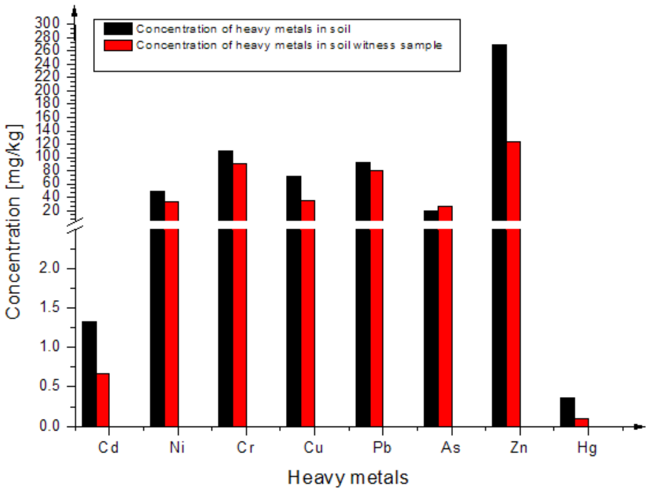

Fig. 9. The variation of heavy metals concentration in the soil and the witness sample for sampling point downstream of the industrial area of Bacau city at a maximum level (100 cm soil-water interface).

The established maximum concentration limit for heavy metals in the soil for a maximum level (100 cm soil-water interface) downstream of the industrial area of Bacau city is exceeded in case of:

- cadmium with 65 %;
- nickel with 40.45 %;
- chromium with 9.9 %;
- cooper with 79.26 %
- plumb with 9.16 %;
- zinc with 79.26 %;
- mercury with 22 %.

Fig. 10 presents the variation of heavy metals concentration in *Phragmites australis* plant species (cadmium, nickel, chromium, cooper, plumb, arsenic, zinc, mercury) for the sampling point downstream of the industrial area of Bacau city, maximum level soil-water interface (100 cm), respectively the values obtained for the witness sample.

The absorption capacity of heavy metals from the soil for a maximum level (100 cm soil-water interface) in case of *Phragmites australis* was much higher for the heavy metals below, as follows:

- for cadmium, the value determined in the plant was 16.66 % higher than in the soil;
- for nickel, the value determined in the plant was 46.54 % lower than in the soil;
- for zinc, the value determined in the plant was 34.44 % lower than in the soil.

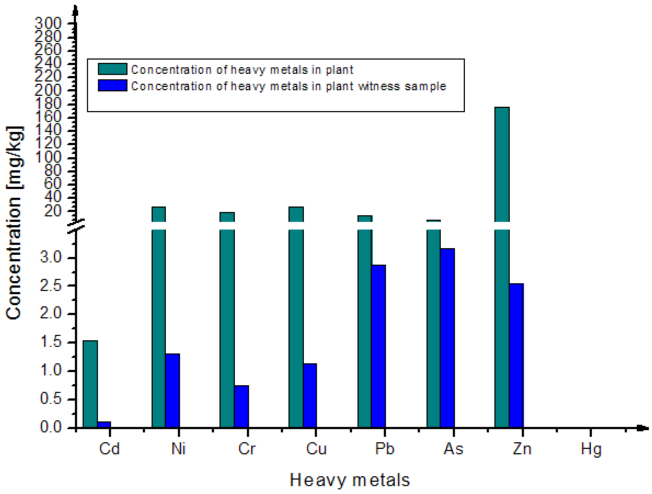

Fig. 10. The variation of heavy metals concentration in the plants and the witness sample for sampling point downstream of the industrial area of Bacau city at a maximum level (100 cm soil-water interface).

Conclusions

Exceeding values for the concentration of heavy metals in the soil and *Phragmites australis* are caused by activity of industry, agriculture and the improper storage of waste around Bistrita river bed.

A good absorption capacity for *Phragmites australis* was recorded in case of the following heavy metals: cadmium, nickel and zinc.

The highest absorption capacity of heavy metals from the soil for *Phragmites australis* was observed in case of zinc and copper, and the lowest absorption capacity of heavy metals from the soil was identified in case of lead.

Phragmites australis plant species can be used in soil phytoremediation processes, more precisely in the rhizodegradation process (a method for depolluting soils that are contaminated with heavy metals and hydrocarbons), its harvestable part being a very good accumulator of heavy metals, especially on banks of emissaries, taking into account the territory where these plants grow.

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ABOUT THE AUTHORS

Valentin Nedeff, “Vasile Alecsandri" University of Bacau, Faculty of Engineering, Calea Marasesti, 157 Bacau – 600115, Romania, e-mail: vnedeff@ub.ro

Cristian Radu, “Romanian Waters” National Administration of Siret Basin, Romania, e-mail: cristofor_radu@yahoo.com

Alexandra-Dana Chiţimuş, “Vasile Alecsandri" University of Bacau, Faculty of Engineering, Calea Marasesti, 157 Bacau – 600115, Romania, e-mail: dana.chitimus@ub.ro

Emilian Moşneguţu, “Vasile Alecsandri" University of Bacau, Faculty of Engineering, Calea Marasesti, 157 Bacau – 600115, Romania, e-mail: emos@ub.ro

Narcis Bârsan, “Vasile Alecsandri" University of Bacau, Faculty of Engineering, Calea Marasesti, 157 Bacau – 600115, Romania, e-mail: narcis.barsan@ub.ro