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Bioaccumulation of As, Cd, Cr, Cu, Pb, Zn in Ambrosia artemisiifolia L. in the polluted area by enterprise for the production and processing of batteries

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Bioaccumulation of As, Cd, Cr, Cu, Pb, Zn in *Ambrosia artemisiifolia* L. in the polluted area by enterprise for the production and processing of batteries

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Abstract

In this paper, the concentration of As, Cd, Cr, Cu, Pb, Zn was investigated in soil and Ambrosia artemisiifolia L. sampling from polluted cite near the enterprises for the production and processing of batteries in the city of Dnipro in Ukraine. The obtained results of the study provided to assess plants regarding bio-monitoring and phytoremediation. Although Ambrosia artemisiifolia L. is a weed that causes serious allergic reactions in humans, this species can also have a high bioaccumulative capacity regarding metals. The metals' concentration in roots was scientifically higher than in inflorescence part. Zn and Cu had the highest concentration in Ambrosia artemisiifolia L. although lead was characterized by the highest content of available to plants forms in the soil. The distribution of As, Cd, Cr, Cu, Pb, Zn was highlighted in different parts of the plant. According to plant-up taking indexes studied elements can be ranked in the following descending order: Cu>Zn>Cr>Cd>Pb. Ambrosia artemisiifolia L. could be proposed for phytoremediation in Zn, Cu, Cd, Cr contaminated soils although this species is resistant for lead soil pollution.

Key words: metals, bioaccumulation, polluted sites, soil, plant, Ambrosia artemisiifolia L.

Introduction

Toxic metals are famous pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature (Kabata-Pendias & Mukherjee, 2007; Alloway, 2010; Hazrat *et al*., 2019). Their acute or chronic poisonings may arise through water, air, and food for human as well as for biota. Although metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds (Kabata-Pendias & Mukherjee, 2007; Tangahu *et al*., 2011; Tchounwou *et al*., 2012; Jiang *et al*., 2014). The research of the potential bioaccumulation of plants as bioindicator is an important attempt that contributes to the findings of method in monitoring pollution as well as processing of phytoremediation in a polluted environment, especially in industrial sites. Such contaminated sites include the areas near the enterprises for the production and processing of batteries. The city of Dnipro in Ukraine is characterized by significant anthropogenic load and has enterprise for the production and processing of batteries (Bondar *et al*., 2022). In this regard, the areas near the enterprises for the production and processing of batteries has aroused interest in the study of plant bioaccumulation with revealing certain species of plants that are capable of high bioaccumulation on contaminated soils. The ability to bioaccumulate depends on the different factors, such as: physicochemical properties of metal and its quantity, soil type and its buffering properties, species of plants etc.. *Ambrosia artemisiifolia L.* is an annual herb native to Central and Northern America (*Ambrosia artemisiifolia*…2021*;* Smith *et al*., 2013). It has been accidentally introduced into Ukraine as well as others countries as a contaminant of seed and grains. *Ambrosia artemisiifolia* L. typically colonizes disturbed land where it produces a large number of seeds which can remain viable in the soil for 40 years or more. The pollen produced by species of Ambrosia is highly allergenic and can induce allergic rhinitis, fever, or dermatitis. However, this species is a powerful bioaccumulator (Kang *et al.*, 1998; Bae *et al.*, 2014; Cloutier-Hurteau *et al.*, 2014). The gained results of the study not only provided the environmental status in term of metal pollution and the bioaccumulation in Dnipro, but also allow to assess plants regarding bio-monitoring and phytoremediation.

Materials and methods

As, Cd, Cr, Cu, Pb, Zn content in soil and plants was studied in the area 716 m from the enterprise for the production and processing of batteries in Dnipro city in Ukraine. Soil and plants of *Ambrosia artemisiifolia* L. were sampling in July 2021 (Fig.1). The studied soil is ordinary low-humus black on heavy loess loam (pH salt 6.7; organic matter by Turin, Walkley-Black 4.4%).

Figure 1. Sampling site:

**yellow point -sample cite; **red point – enterprise location; ***the line is drawn at a distance of 716 meters from the source of pollution (enterprise for the production and processing of batteries in Dnipro city in Ukraine) to the sample cite*

Mean standard deviations, variance, and minimum, maximum, and standard errors were calculated in four replicates. The experimental results were interpreted using standard statistical methods. Soil and plants were sampled in the phase of plants flowering. Analysis of soil samples (extraction with acetate-ammonium buffer pH 4.8) and plants (extraction with a mixture of concentrated acids $HN0_3$ and H_2SO_4) was carried out by atomic absorption spectrometry.

The plant up-taking index (PUI) for metals was calculated as follows:

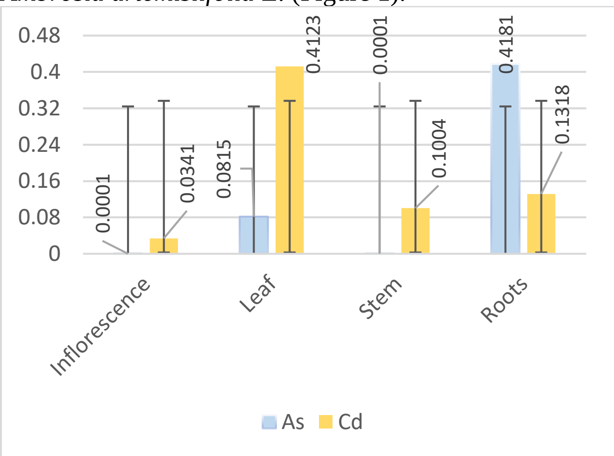
$$PUI = \frac{C_p}{C_s}, \qquad (1.)$$

Where C_p – concentration in plant, mg·kg^{-1} (dry weight);

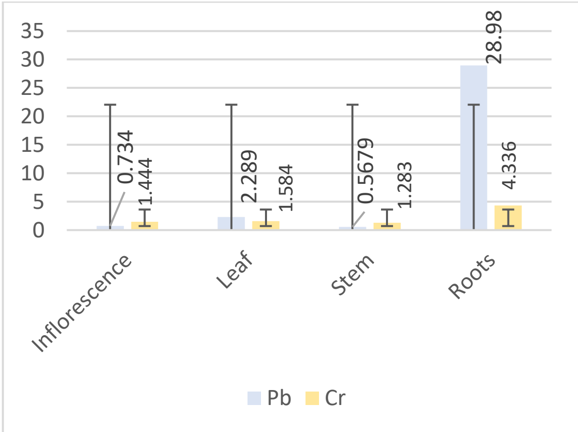
C_s – concentration in soil, mg·kg^{-1}.

Results and discussion

Among all studied metals, copper and zinc were characterized by the highest concentrations in plants of *Ambrosia artemisiifolia* L. (Figure 1).



a)



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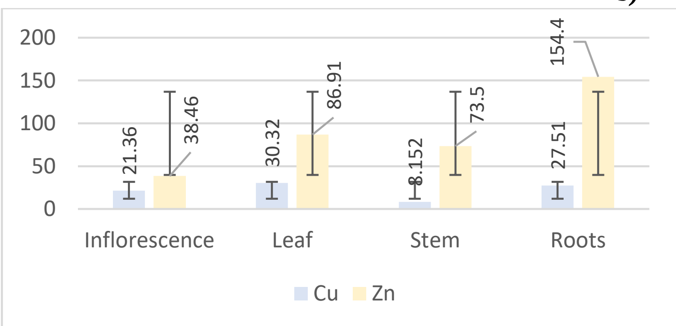

c)

Fig.1 Metals concentration (mg kg^{-1}, dry mass) in different part of Ambrosia artemisiifolia L. phytomass:

a) As and Cd; b) Pb and Cr; c) Cu and Zn

Arsenic had the lowest content in total phytomass as well as in the inflorescence part of *Ambrosia artemisiifolia* L. There are several reasons of it. Cu and Zn are obligatory elements for plant growing and usually they are presence in significant concentration both in the soil and in the plant. However, in the same time Zn also could be as a pollutant because of possible emission by the enterprise for the production and processing of batteries. Lead was characterized also the rather high concentration in plants, mostly in roots. Lead is one of the main pollutants in production and processing of batteries. Similarly to lead, arsenic, chromium and zinc also had the main concentration in their roots. It may be explained by the soil pollution of these elements. Cadmium was characterized the high concentration in steam. In general, for all studied metals the concentration in roots was scientifically higher than in inflorescence part ($F_{theor} < F_{exper}$, P_{05}).

According to the coefficient variation of metals concentration in different part of plants, Pb and As were characterized by the greatest variability (Table 1). It means, that the distribution of these metal in different parts of the plant was very uneven (*V*>100%). Zinc and copper were most evenly distributed in different parts of the plant. This may be due to the low underground phytomass bioavailability of these elements for the *Ambrosia artemisiifolia* L.. In obedience to coefficient of variation of metals concentration in different parts of plant (V, %), studied metals can be ranked in the following descending order: Pb>As>Cd>Cr>Zn>Cu.

Cooper and zinc had highest PUI for different parts of plants. Pb had lowest PUI. Among numerous trace metals, lead is famous for its poor bioavailability even in polluted soils, in particular, in aboveground part of plants. This probably explains the main concentration of lead in the roots.

Table 1 Coefficient of variation of metals concentration in different parts of plant (*V, %*) and plant-up taking indexes (*PUI*) for different part of *Ambrosia artemisiifolia* L.

Metals	*V*, %	PUI			
		Inflorescence	Leaf	Steam	Roots
As	*138,04*	-	-	-	-
Cd	*85,15*	0,09	1,03	0,23	0,33
Cr	*58,28*	0,88	0,96	0,78	2,63
Cu	*39,11*	11,89	16,88	4,54	15,3
Pb	*147,97*	0,015	0,05	0,01	0,59
Zn	*47,62*	1,86	4,2	3,56	7,47

Lead was distinguished by the highest values of the content in soil, and cadmium was the lowest (Table 2). However, Zn and Cu had the highest concentration in phytomass which is probably related to their obligatory functions in the plant. According to plant-up taking indexes studied elements can be ranked in the following descending order: Cu>Zn>Cr>Cd>Pb. The variability between bioaccumulation coefficients for different metals is significant, meaning that each metal has its own range of bioavailability. *Ambrosia artemisiifolia* L. could be proposed for phytoremediation in Zn, Cu, Cd, Cr polluted soils. In the same time, this species is resistant for lead pollution in soil. The behavior of arsenic in soil and *Ambrosia artemisiifolia* L. plants arouses interest. The content of this element in the soil is below the detection limit, but its amount in the phytomass is quite significant. This can be explained by the foliar absorption of this element by the studied species or other sources of their content in plant.

Table 2 As, Cd, Cr, Cu, Pb, Zn concentrations in soil and *Ambrosia artemisiifolia* L. phytomass and bioaccumulation

Metals	Soil (acetate-ammonium buffer pH 4.8), mg kg^{-1}	Plant mg kg^{-1}, dry matter, total phytomas	PUI
As	-*	0,499±0,125	-
Cd	0,402±0,010	0,679±0,136	1,69
Cr	1,647±0,241	8,647±0,956	5,25
Cu	1,796±0,189	87,342±5,320	48,63
Pb	48,96±4,123	32,571±3,874	0,67
Zn	20,67±1,875	353,270±11,123	17,09
s^2	*437,68*	*18936,37*	*403,09*
(v), %			*122,44*

*below the limit of definition

Conclusions

Among all studied metals, copper and zinc were characterized by the highest concentrations in plants of *Ambrosia artemisiifolia* L. although lead was characterized by the highest content of available to plants forms in the soil. The distribution of Pb and As in different parts of the plant was very uneven (*V*>100%) in contradistinction to Zn and Cu (*V*<50%). The metals' concentration in roots was scientifically higher than in inflorescence part ($F_{theor}<$

F_{exper}, P_{05}). The content of As in the soil was below the detection limit, but its amount in the phytomass is quite significant. This can be explained by the potential foliar absorption of this element by the *Ambrosia artemisiifolia* L.. According to plant-up taking indexes studied elements can be ranked in the following descending order: Cu>Zn>Cr>Cd>Pb. *Ambrosia artemisiifolia* L. could be proposed for phytoremediation in Zn, Cu, Cd, Cr polluted soils. In the same time, this species is resistant for lead pollution in soil.

References

1. Kabata-Pendias, A., Mukherjee, A., 2007. *Trace Elements from Soil to Human*, Springer-Verlag, Berlin-Heidelber, 550 pp.
2. Alloway, B., 2010. *Heavy metals in soils. Trace elements and Metalloids in Soils and their Bioavailability, Third edition*. Springer, UK, 235 p.
3. Hazrat, A., Ezzat, K., Ikram, I., 2019. *Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation*. Journal of Chemistry. 2019: 1-14. https://doi.org/10.1155/2019/6730305.
4. Tangahu B., Abdullah S., Basri H., 2011. *A Review on Heavy Metals (As, Pb, and Hg) Uptake by Plants through Phytoremediation.* International Journal of Chemical Engineering. 2011: 1-32. https://doi.org/10.1155/2011/939161.
5. Tchounwou, P., Yedjou, C., Patlolla, A., Sutton, D., 2012. *Heavy Metals Toxicity and the Environment.* Molecular, Clinical and Environmental Toxicology. 2012: 133-164. doi: 10.1007/978-3-7643-8340-4_6.
6. Jiang, X., Lu, W., Zhao, H., Yag, Q., Yang, Z., 2014. *Potential ecological risk assessment and prediction of soil heavy metal pollution around coal gangue dump*. Natural Hazards and Earth System Sciences.14:1599–1610. https://doi.org/10.5194/nhess-14-1599-2014.
7. Bondar O., Ryzhenko N., Laptiev V., Makhniuk V. 2022. *Bioaccumulation of Hg, Cr, Zn, As, Cd, Pb, Cu in the "soil-plant" system in the rea of influence of enterprises for the production and processing of batteries*. Ecological science. 1(40):11-16. doi https://doi.org/10.32846/2306-9716/2022.eco.1-40.2ю
8. *Ambrosia artemisiifolia (common ragweed)*. 2021. CABI. Available at: https://www.cabi.org/isc/datasheet/4691
9. Smith M., Cecchi L., Skjøth C.A., Karrer G., Šikoparija B. 2013. *Common ragweed: A threat to environmental health in Europe*. Environment International. 61: 115-126. doi: 10.1016/j.envint.2013.08.005.
10. Bae, J., Byun, C., Watson, A.K., et Benoît, D.-L. 2014. *Ground cover species selection to manage common ragweed (Ambrosia artemisiifolia L.) in roadside edge of highway*. Plant Ecology, 216(2): 263-271. doi : 10.1007/s11258-014-0433-9
11. Cloutier-Hurteau B., Gauthier S., Turmel M-C., Comtois P., Courchesne F. 2014. *Trace elements in the pollen of Ambrosia artemisiifolia: What is the effect of soil concentrations?* Chemosphere. 95: 541-549. doi: 10.1016/j.chemosphere.2013.09.113.
12. Kang Byeung Hoa, Shim Sang In, Lee Sang Gak, Kim Kwang Ho, Chung Ill Min. 1998. *Evaluation of Ambrosia artemisiifolia var. elatior, Ambrosia trifida, Rumex crispus for phytoremediation of Cu and Cd contaminated soil.* Korean Journal of Weed Science. 18(3): 262-267.