University of Belgrade, Technical Faculty in Bor

29th International Conference Ecological Truth & Environmental Research

EcoTER'22

Proceedings

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Prof. Dr Snežana Šerbula

21-24 June 2022, Hotel Sunce, Sokobanja, Serbia

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PREFACE

In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations. Therefore, environmental and many other scientists all over the world have been concerned about finding sustainable technology in resolving these issues. That is why environmental research and ecological truth are at the focus of the 29th International Conference Ecological Truth & Environmental Research 2022 (EcoTER'22), which will be held in Sokobanja, Serbia, 21–24 June 2022. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.

We hope to convey the message of the conference, which is that a transformation of attitudes and behavior would bring the necessary changes. This is also an opportunity for the participants who are experts in this field to exchange their experiences, expertise and ideas, and also to consider the possibilities for their collaborative research.

The 29th International Conference Ecological Truth & Environmental Research 2022 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology, the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica, the University of Zagreb, Faculty of Metallurgy – Sisak, the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Association of Young Researchers, Bor.

These proceedings include 85 papers from the authors coming from the universities, research institutes and industries in 6 countries: Bulgaria, Italia, Albania, Bosnia and Herzegovina, Montenegro and Serbia.

As a part of this year's conference, the 4th Student section – EcoTERS'22 is being held. We appreciate the contribution of the students and their mentors who have also participated in the Conference.

Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged by the Organizing Committee of the EcoTER'22 conference.

The support of the Platinum donor and their willingness and ability to cooperate have been of great importance for the success of EcoTER'22. The Organizing Committee would like to extend their appreciation and gratitude to the Platinum donor of the Conference for their donation and support.

We appreciate the effort of all the authors who have contributed to these Proceedings. We would also like to express our gratitude to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'22. Sincere thanks go to all the people who have contributed to the successful organization of EcoTER'22.

Prof. Snežana Šerbula,

President of the Organizing Committee

ANALYSIS OF As AND Pb ACCUMULATION IN GARDEN SOIL AND VEGETABLE CROPS IN THREE BELGRADE MUNICIPALITIES

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Abstract

This study evaluated concentrations of arsenic (As) and lead (Pb) in vegetable crops (carrots and cabbage) and garden soil in three municipalities in the City of Belgrade (Lazarevac, Obrenovac and Surčin) to assess soil contamination levels and the affinity of the crops to absorb these heavy metal(loid)s. Elevated levels of As and Pb were measured in garden soil in Lazarevac, which indicates a potential risk for growing vegetable crops in this municipality. Although bioconcentration factor values for both elements in both cultures indicated the low affinity of the examined species to accumulate these elements in those organs used in the human diet (BCF<1), As concentrations were found to be above the normal range for plants and higher than the permitted levels for dried vegetables in both vegetable cultures at all the sampling sites, while Pb content was higher in carrots than the permitted levels for dried vegetables as set out by national legislation, which requires further investigation.

Keywords: arsenic, lead, garden soil, vegetable crops, bioaccumulation

INTRODUCTION

Rapid industrial activity and the scale of exploitation in developing countries has led to many mining areas and industrial regions being contaminated to such an extent that the risk to human health is a matter of great concern [1,2]. A large number of heavy metal(loid)s from mining waste, tailings, thermal power plant emissions, fly ash, etc., are transferred to soil and affect plant performance [3,4]. In addition, mining and coal combustion residues are subjected to erosion and weathering processes, which release these contaminants into surrounding agricultural areas [5]. Heavy metal(loid)s are the most hazardous contaminants due to their build-up in crops and the consumption of contaminated crops can pose a serious risk to human health [6]. Potential risks from metal(loid)s can be assessed using the bioconcentration factor (BCF) to estimate the ability of crops to accumulate elements from soil. Bearing in mind the fact that vegetable crops are one of the essential foodstuffs in the human diet, understanding their ability to accumulate toxic concentrations of hazardous elements can help to reduce potential human health risks [7].

In this regard, this study focusses on an evaluation of concentrations of arsenic (As) and lead (Pb) in vegetable crops (carrots and cabbage) and garden soil in the vicinity of an open pit mine, thermal power plants, and fly ash disposal sites in three Belgrade municipalities (Lazarevac, Obrenovac and Surčin) and an assessment of the affinity of the examined plant cultures to absorb these chemical elements.

MATERIALS AND METHODS

Study areas

To determine As and Pb content in soil and plant material, as well as assess vegetable crop efficiency to accumulate these elements from the soil, soil and plant material sampling was conducted in three municipalities in the City of Belgrade - Lazarevac, Obrenovac and Surčin. Sampling was carried out in gardens located in the vicinity of the fly ash disposal site at the 'Nikola Tesla-A' thermal power plant in the municipality of Obrenovac (Krtinska village, lat. 44°30' N long. 19°58' E, average altitude 80 m), in the municipality of Lazarevac (Sokolovo village, lat. 20°19'7'' E, long. 44°28'32'' N, average altitude 93 m), and in the municipality of Surčin (Jakovo village, lat. 20°15'45'' E, long.44°44'35'' N, average altitude 75 m). The research area is characterized by a moderate continental climate with a mean annual temperature of 12.5 °C and mean annual precipitation of 690.1 mm.

At each of the three sampling sites, five sampling points (gardens) were randomly selected for plant and associated soil sampling. At each sampling point, one paired soil and plant sample was collected (soil samples from the surface layer at 0–10 cm, plant samples from individuals, 30 g).

Analysis of the content of the tested chemical elements in soil and vegetables from vegetable gardens

Pseudo-total heavy metal(loid) As and Pb concentrations in soil and total concentrations in the edible parts of carrots and cabbage were determined after wet digestion in a microwave oven (CEM, Mars 6 Microwave Acceleration Reaction System, Matthews, NC, USA) [8,9]. Certified reference materials were analysed to test the accuracy of the analytical procedures: soil (Clay ERM – CC141) and plant material (Beech leaves BCR – 100), provided by the Institute for Reference Materials and Measurements (Geel, Belgium), certified by the European Commission - Joint Research Centre. Concentrations of arsenic and lead (mg/kg) in the examined samples were determined using inductively coupled plasma optical emission spectrometry (ICP-OES, Spectro Genesis, Spectro-Analytical Instruments GmbH, Kleve, Germany). Detection limits for As and Pb were 0.005 mg/kg and 0.004 mg/kg, respectively. The average recovery values for the elements in the standard reference materials were in the range of 100 ± 20%. The efficiency of the investigated vegetables to absorb As and Pb from soil was compared by assessing the bioconcentration factor (BCF), which was calculated according to the formula: BCF = Element concentration in edible parts of vegetables/Element concentration in soil [10].

Statistical analysis

All values in Tables 1 and 2 are presented as the mean (M) with the standard deviation (SD) of 6 replicates (n=6). The data from this study was analysed using statistical analysis (ANOVA) and means were separated with a Bonferroni test at a level of significance of $p<0.05$, using the Statistica software package (StatSoft In., Tulsa, USA, 2007). Correlations between the levels of the tested elements in soil and the roots and edible parts of vegetables were obtained using the non-parametric Spearman rank-order correlation coefficient at a level of significance of $p<0.05$.

RESULTS AND DISCUSSION

The highest content of As and Pb in the soil was measured at the sampling site in Lazarevac (Table 1). Arsenic concentrations above the average range for world soils (4.4–8.4 mg/kg) [11] were measured in Lazarevac, while higher levels than average background concentrations in world soils (5 mg/kg) [12] were measured at all the sampling sites. At the same time, As concentrations at all the localities were lower than the maximum acceptable limits for agricultural soil recommended by the European Community (20.0 mg/kg) [13], and lower than the MAC as prescribed by the National Regulations on Permitted Quantities of Hazardous and Harmful Substances in Soil (25 mg/kg) [14]. Lead concentrations in all samples were also higher than the average concentration range for world soils (22–28 mg/kg) [11], but lower than the maximum permissible concentrations in soils for agricultural purposes (375 mg/kg) [15], and also lower than concentrations posing an ecological risk (200 mg/kg) [16] and the MAC (100 mg/kg) [14].

Table 1 *Content of As and Pb in soil from vegetable gardens at the study sites*

Study site	**As**	**Pb**
	M(SD) mg/kg	
Surčin	5.55±0.78 b	43.83±5.93 b
Lazarevac	19.83±0.04 a	63.50±0.84 a
Obrenovac	5.43±1.11 b	50.83±8.08 b

These non-essential and toxic elements are generally poorly mobile in soil and are most common in the surface layer thanks to their being adsorbed on fine soil particles, organic matter and amorphous oxides [11]. Additionally, their elevated levels in agricultural soils may be the result of the earlier use of lead-arsenate pesticides. In conditions of low organic matter, phosphates and low pH, plants easily absorb these elements from such soils [17].

A very low correlation was found between As and Pb concentrations in soil and concentrations in carrots and cabbage ($r=0.1952$, $p<0.05$; $r=0.1055$, $p<0.05$, respectively), which can be explained by the effect of the different physical and chemical soil characteristics on their bioavailability, as well as the impact of different types and sources of pollution at the study sites. In agricultural soils, these pesticide-derived elements are more available and phytotoxic than those originating from thermal power plant emissions and mining activities [18].

In both vegetable crops at the study sites, no significant differences were found in As concentrations (Table 2).

Table 2 *Content of As and Pb in carrot and cabbage samples*

Study site	**As**	**Pb**
	Carrot M(SD) mg/kg	
Surčin	2.49±0.75 a	3.29±0.32 a
Lazarevac	3.35±1.06 a	4.90±0.23 a
Obrenovac	2.77±0.77 a	3.84±0.43 a
	Cabbage M(SD) mg/kg	
Surčin	3.64±0.79 a	<0.004
Lazarevac	3.32±0.52 a	<0.004
Obrenovac	3.10±0.64 a	<0.004

Although carrots and cabbage did not accumulate As (BCF<1; Figure 1), its concentrations were above the normal range for plants (1–1.7 mg/kg) [11] and higher than the permitted levels for dried vegetables under national legislation (1 mg/kg) [19]. Namely, the relatively high solubility of As in water contributes to the greater potential for its uptake in the tissues of the roots and leaves of vegetable crops, especially root vegetables [17,20]. Likewise, some *Brassicaceae* species showed high potential for the uptake and translocation of As [21].

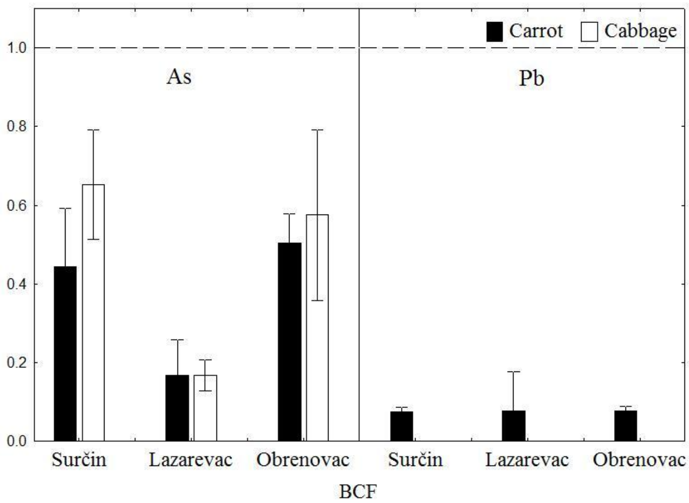

Figure 1 *Affinity of carrots and cabbage to accumulate the tested chemical elements in vegetable gardens at the study sites based on the bioconcentration factor (BCF)*

The studied cultures also did not accumulate Pb (BCF<1; Figure 1), but the content of this element in carrots from all localities was still higher than the permitted levels for dried vegetables (3 mg/kg) [19]. In previous research, in soils with elevated As and Pb content, similar concentration ranges were found in carrots for As (0.38–1.64 mg/kg) and for Pb (2.67–7.3 mg/kg) [22]. In general, the lower transfer of Pb compared to As previously determined in leafy vegetables [17] was also confirmed in this study with the example of cabbage, where the Pb content was below the detection level. The lower accumulation of Pb in leafy vegetables can also be the result of its predominantly airborne transportation and deposition on aboveground parts, from where it can easily be removed by atmospheric precipitation [23,24].

CONCLUSION

All the findings revealed elevated levels of As and Pb in garden soil in Lazarevac in comparison to the other two sampling sites, which indicates a potential risk for growing vegetable crops in this municipality. In regard to the reference values for concentrations of As and Pb in world soils, higher concentrations of these potentially toxic elements were measured at all the sampling sites. However, they are still lower than the maximum acceptable limits for agricultural soils as recommended by the European Community and the maximum concentrations allowed by Serbian legislation.

At the same time, As concentrations were found to be above the normal range for plants and higher than the permitted levels for dried vegetables in both vegetable cultures at all the sampling sites, while Pb content in carrots was higher than the permitted levels for dried vegetables as set out by national legislation. This was despite bioconcentration factor values for both elements in both crops (BCF<1) indicating the poor affinity of the investigated species to accumulate these elements in those plant organs used in the human diet.

Bearing in mind the fact that the bioavailability of these toxic elements is conditioned by different physical and chemical soil characteristics, the forms of the elements, and the influence of different types and sources of pollution at the study sites, it is necessary to investigate the fractions of these elements available to plants further, as well as different species-specific factors of plants related to the uptake, accumulation and transfer of heavy metal(loid)s. This will contribute to a better understanding of contamination risks for vegetable crop cultivation in the vicinity of urban and industrial zones.

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