HEAVY METALS ACCUMULATION IN BELL PEPPER (CAPSICUM L.) FROM PRIVATE GARDENS IN COPȘA MICĂ AREA

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Abstract

There are many studies that reported high levels of metals (Cd, Pb, Zn) content in soils and vegetation from area affected by historical contamination in Copșa Mică area. In the period 2019-2021, a study was carried out in order to assess the accumulation of heavy metals in bell pepper cultivated in private gardens from a contaminated area. During this study 62 individual households were visited and 124 samples (62 soil samples and 62 bell peppers samples) were collected from these gardens, located in the Copșa Mică contaminated area. The results reveal that the accumulation of metals in edible parts of belly pepper had the following hierarchical pattern: Zn > Cu > Cd > Pb. Zinc (Zn) was the metal with the highest content identified in the edible part of pepper samples, ranging between 1.4 mg / kg f.w. and 7.0 mg / kg f.w.., while for cadmium (Cd) the content values ranged between 0.005 mg / kg - 0.162 mg / kg. The metals contents in bell peppers were positively correlated to total contents of metals in soil. The highest values of correlation coefficients were obtained for the regression curves established for the estimation of Cu, Cd and Zn accumulation in bell pepper (r = 0.443 for Cu, r = 0.399 for Cd, and r = 0.376 for Zn). In the case of lead the linear correlation coefficient is relatively low (r = 0.299). The results of this study are important to estimate the metals accumulation in vegetables from individual gardens, while also improving the safety of foodstuff produced in contaminated areas.

Keywords: *accumulation, bell pepper, contamination, heavy metals*

INTRODUCTION

The term “heavy metal” has a wide range of meanings, and there is still no coherent definition given by an authority body. Over the last two decades, this term has been used by numerous publications and legislation to indicate a particular group of metals or semi-metals that produce toxic effects for humans, animals and plants (Ponnusamy, 2012, quoted by Iosub, 2020). Vegetables are edible plants, grown for their plant parts, which are used in food, providing an important source of nutrients such as vitamins, minerals, fiber and antioxidants, and are essential for maintaining a balanced and healthy diet. Vegetables include a wide range of plants such as green leaves, roots, stems, flowers and fruits. They can be consumed consumed in a variety of forms, including raw, cooked, baked, boiled or fried.

Vegetable plants grown in environments contaminated with heavy metals can accumulate high concentrations of these elements, posing a significant risk to the health of consumers. Regular monitoring of heavy metals in effluents, wastewater, vegetables and other foods is essential to prevent excessive accumulation in the food chain. Main sources of contamination include industries such as battery production, the metallurgical industry, as well as vehicle emissions and diesel generators. These sources contributed significantly to the observed contamination, especially in vegetables. Heavy metals, such as cadmium, copper, lead and zinc, are significant pollutants, especially in areas irrigated with wastewater. These metals can be toxic and pose risks to the environment. Cadmium concentrations have been found to vary in different parts of plants, and cadmium levels increase as culture and cadmium levels increase in the environment (Sobukola et al., 2007).

Pepper or green pepper is a set of varieties belonging to the species Capsicum annuum (also known as hot peppers). The production of this plant brings fruit to the fore in a variety of colors, including red, yellow and orange. These fruits are often consumed in their unripe stage, when they are green (Demirezen and Ahmet, 2006). The peppers originate in the region of Mexico, in Central America and northern South America. The seeds of these plants were later brought to Spain in 1493, from where they spread to various countries in Africa and Asia. Today, Mexico continues to be one of the world's leading pepper producers (Sawidis et al., 2001).

The absorption of metals from the soil depends on different factors, such as their soluble content, soil pH; stages of plant growth, types of species, fertilizers and soil types (Rajamani 1999). Most laboratory research on heavy metal biosorption indicates there are some mechanisms responsible for metal absorption. In general, it is known that two mechanisms occur, by „ adsorption", which refer to the binding of materials on the surface and „ absorption ", which involves the penetration of metals into the inner matrix (Rejamani et al., 1999).

MATERIALS AND METHODS

In the period 2019-2021, a study was carried out in which soil and plant samples were taken from 62 individual households located in the villages of Axente Sever, Micăsasa, Șoala, Agârbiciu, Bazna and Copșa Mică. The purpose of this study was to determine the heavy metal content of the soil and plant. After conditioning (washed and chopped) plant samples (peppers) were treated with nitric acid and will be subsequently mineralized in the microwave using the digestion method.

Atomic absorption spectrometry was used to determine the heavy metal content of plant samples using equipment such as Flame GBC 932AA or GBC SavanatAAZ GBC Furnace Graphite. In this study, 62 soil samples were also collected from a depth of 0-20 cm. To determine the heavy metal content of the soil, the same method of determining (atomic absorption spectrometry) was used, after extraction in aqua regia (HNO_3:HCl – 1:3 v/v).

For the analysis of the data obtained, a comparison was made using the least significant difference test at a significance level of $p < 0.05$. A linear regression analysis was also performed using the statistical package STATISTICA CSS (Complete Statistical System developed by StatSoft, Tulsa, OK, USA).

RESULTS AND DISCUSSIONS

The analysis of all plant and soil samples taken from selected households in the Copșa Mică industrial area in this study allowed the identification of four heavy metals: cadmium, copper, lead and zinc with high values content that exceed the normal content in soil and vegetables.

The elaboration and validation of the stochastic models obtained for peppers was performed using data collected from the 62 selected pilot households.

The total metal content of the soil (table 1) had the following model: Zn > Pb > Cu > Cd, and varied as follows: for the cadmium content of the soil values were obtained between: 0.07 – 27.11 mg/kg; values between: 25 - 138 mg/kg were recorded for copper content the soil; lead content recorded values between: 15 – 1074 mg/kg, while the soil zinc values content varied between 117 – 1472 mg/kg. The geometric mean of the total heavy metals in the soil varied between 2.21 for cadmium and 336.49 mg/kg for zinc. In terms of standard deviation, zinc obtained the highest value (330.78 mg/kg) and cadmium the lowest value (5.80 mg/kg). The coefficient of variation obtained the lowest percentage, 0.4%, in terms of copper, and the lead obtained the highest percentage of 1.65%.

Table 1. Values of statistical parameters that characterize the central tendency and the variability of the total cadmium, lead, zinc and copper contents in soil

Variable	Minimum	Maximum	Median	Geometric mean	Arithmetic mean	Standard deviation	Coefficient of variation
	- -			mg/kg DW	- -		
Cd_{soil}	0,7	27,11	4,22	2,21	5,41	5,80	1,37 %
Cu_{soil}	25	138	61	59,91	64	24,7	0,4%
Pb_{soil}	15	1074	112	105,99	168,09	185,89	1,65%
Zn_{soil}	117	1472	307,5	336,49	428,08	330,78	1,07%

DW – Dry Weight

Table 2. The values of the statistical parameters that characterize the central trend and the variability from the content of cadmium, lead, zinc and copper in pepper fruit

Variable	Minimum	Maximum	Median	Geometric mean	Arithmetic mean	Standard deviation	Coefficient of variation
	- -			mg/kg FW	- -		
Cd_{pepper}	0,005	0,16	0,023	0,023	0,03	0,33	1,42 %
Cu_{pepper}	0,2	2,1	0,7	0,733	0,826	0,39	0,56 %
Pb_{pepper}	0,015	0,351	0,054	0,056	0,075	0,07	1,29 %
Zn_{pepper}	1,4	7	2,70	2,67	2,84	1,06	0,39 %

FW – Fresh Weight

The concentration of heavy metals in peppers (table 2) had a slightly different pattern than in the soil, Zn > Cu > Pb > Cd. Zinc (Zn) was heavy metal with the highest content identified in the edible part of pepper samples, ranging from 1.4 mg/kg to 7.0 mg/kg, with an average of 2.70 mg/kg, a standard deviation of 1.06 and a coefficient of variation of 0.39%. The copper content (Cu) was the second largest metal with values between 0.2 mg/kg and 2.1 mg/kg and averaged 0.7 mg/kg. In terms of concentration, cadmium content (Cd) and lead (Pb) were between 0.005 mg/kg and 0.162 mg/kg and from 0.015 mg/kg to 0.351 mg / kg, while the standard deviations of the two elements recorded values between 0.07 – 0.33 mg/kg. the coefficient of variation for the three elements (Cu, Pb and Cd) ranged from 0.56 – 1.42 %.

According to European Commission Regulation 2021/1323, the cadmium content (Cd) in peppers exceeds the maximum permitted limit of 0.020 mg/kg, which can pose a risk to the health of the inhabitants of the studied area. The European Commission has also issued a similar warning regarding the maximum allowable lead level (Pb) in pepper fruit, which is 0.050 mg/kg. This suggests that lead, like cadmium, poses a potential danger to the health of locals.

To estimate the accumulation of heavy metals (Cd, Cu, Pb and Zn) in the edible part of pepper plants, stochastic models based on power regression curves can be used using as a variable the total heavy metal content of the soil, these being represented by logarithmic diagrams (Figure 1).

The stronger correlation between the total metal content of the soil and that of the plant was obtained for copper. There is a sharp tendency to accumulate copper in pepper fruits compared to other metals (r = 0.443) being very significantly different from zero (fig. 1d). And in the case of cadmium and zinc, the correlation established between the two variables is also strong for cadmium r=0.399 while for zinc r = 0.376 (fig 1 a, c). Reduced lead mobility, its non-essential role for living organisms but also the fact that in most gardens phosphorus-based fertilization treatments (complex fertilizer, poultry manure, etc. were applied.) affected the transfer of this metal to the pepper fruit and the correlation established for this metal was not very strong, r=0.299, being still significantly different from zero. Data from the literature indicate the ability of this vegetable (peppers) to limit the transfer of heavy metals to the fruit, in its edible part.

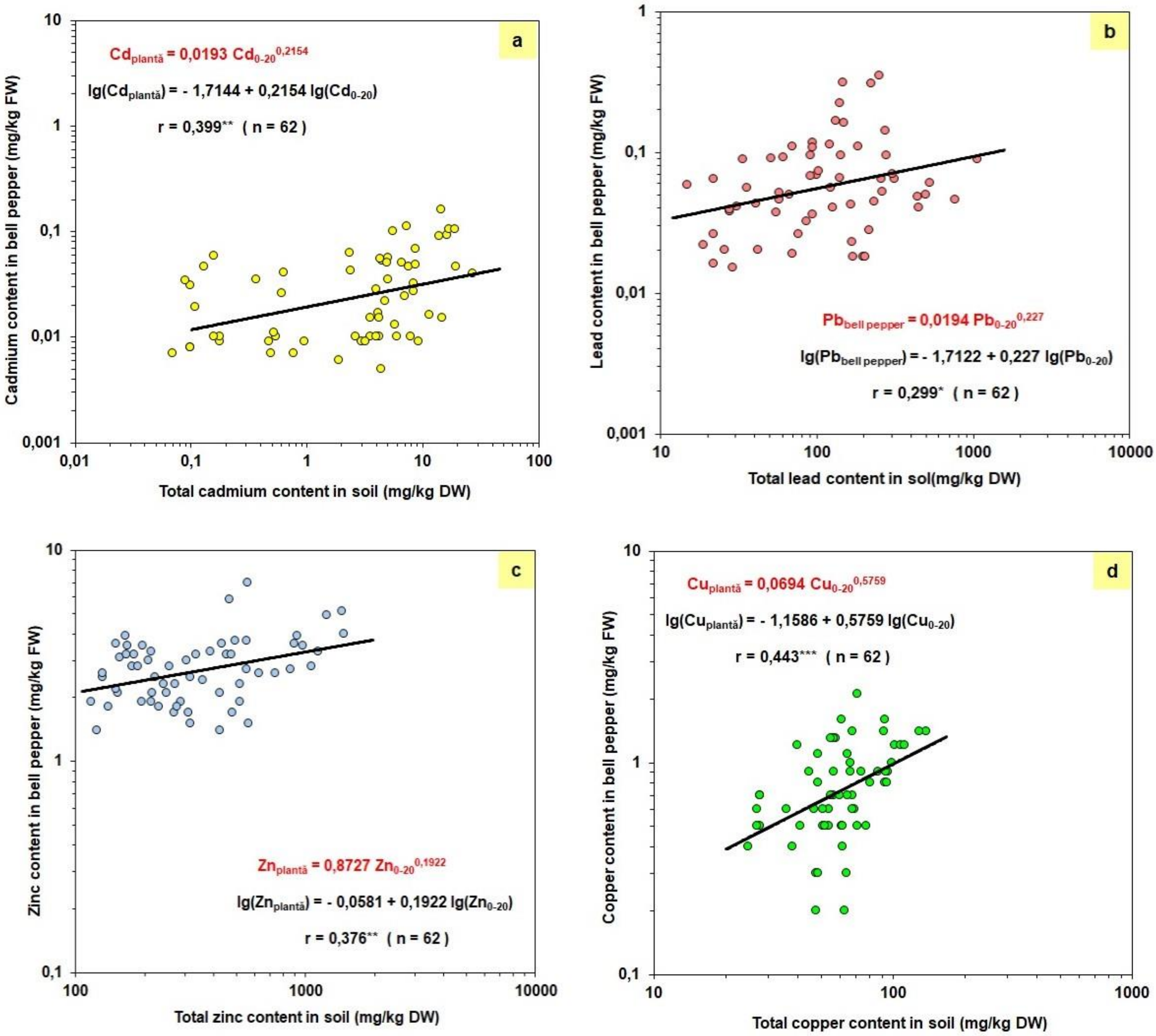

Figure 1. Log-log diagrams for power regression curves that estimate the stochastic dependency between the total cadmium, lead, zinc, copper contents in soil (layer 0-20 cm) and the cadmium, lead, zinc, copper contents in the bell pepper

CONCLUSIONS

The results of this study revealed that in the Copsa Mică industrial area, four heavy metals were identified in the plant and soil samples: cadmium, copper, lead and zinc. Data collected from 62 selected households were used to develop and validate the stochastic models for the content of these metals in peppers. According to these data, the total metal content in the soil followed the order Zn > Pb > With > Cd, with significant variations, while the concentration of metals in the pepper presented another model: Zn > Cu > Pb > Cd.

To estimate the accumulation of heavy metals in peppers, stochastic models based on power regression curves were used, using the total content of soil metals as a variable. A significant correlation was found between the total metal content of the soil and that of the plant, the strongest correlation being observed for copper (r=0.443). Significant correlations were also obtained for cadmium and zinc (r=0.399 and r=0.376). However, lead had a weaker correlation with the pepper content (r=0.299), due to the reduced mobility of this metal and the use of phosphorus-based fertilizers in gardens.

In conclusion, this study highlights the presence of significant levels of heavy metals in the soil and peppers in the Copsa Mică industrial area, with a potential impact on the health of the inhabitants. Continuous monitoring and implementation of appropriate measures to reduce these concentrations is important.

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