A STUDY REGARDING CORRELATION BETWEEN CONTENTS IN SOIL AND CONTENTS IN PARSLEY ROOTS OF CADMIUM, LEAD, ZINC AND COPPER IN SAMPLES COLLECTED FROM PRIVATE GARDENS IN COPSA MICA

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Abstract
Food security is a high-priority issue for sustainable global development both quantitatively and qualitatively. The increasing contamination of heavy metals in vegetables is attributed to multiple pathways, such as industrial emissions, sewage sludge discharge, agrochemicals and fertilizers abuse, and it has become a serious issue worldwide, especially in developing countries. Copşa Mică had the reputation of being the most polluted city in Europe until the Chernobyl nuclear accident. This was due to emissions from two factories Carbosin, which produced carbon black and Sometra, the other source of pollution, less visible, but much more serious from the point of view of the impact on the human health. For this study, were collected soil and parsley (Petroselinum crispum) samples from 36 households located in Copşa Mică area. The obtained data were used to estimate the accumulation of cadmium, lead, zinc and copper in parsley roots. by correlation factor between contents in soil and contents in parsley roots. For cadmium and lead, the value of linear correlation coefficient is r = 0.571 for cadmium and r = 0.381 for lead and it is indicating a good correlation between the cadmium and lead content in parsley roots and the cadmium and lead content in soil. For zinc and copper, the value of the linear correlation coefficient is r = 0.139 for zinc and r = 0.035 for copper is not significantly different from zero, indicating that the estimation of zinc and copper accumulation in parsley roots cannot be described by simple power-type regressions.

***Key words**: correlation, soil, parsley roots, heavy metals, Copsa Mica*

INTRODUCTION

The contamination of heavy metals in vegetable-growing soils is of increasing concern due to food safety and potential health risks via the consumption of contaminated vegetables (Cui et al., 2004, Huang et al., 2011). There is a general consensus that total concentration of heavy metals in soil is inadequate to assess their behaviour and potential risk to the environment (Krishnamurti and Naidu, 2003; Meers et al., 2007; Dziubanek et al., 2015).

The environmental pollution due to anthropogenic activities was reported to increase the metal content of soils which results in contamination of vegetables with metals (food chain) and ultimately increases the potential health risks in humans. Therefore, assessment of heavy metal contents in vegetable crops grown near industrial areas has been carried out but still published data is very limited (Ahmad and Goni, 2010; Mahfuza et al., 2017, Mandal and Kaur, 2019).

The health effects of dietary exposure to cadmium are kidney and bones disorders, prostate and breast cancer, disturbances of male fertility as well as disorders of pregnancy (Godt et al., 2006; Kippler et al., 2012).

MATERIALS AND METHODS

The present study was carried out during 2019- 2021 in one of the critical areas in terms of heavy metal contamination, Copșa Mică. The studied area includes seven localities: Avente Sever, Agârbiciu, Soala, Micăsasa, Târnava, Copșa Mica and Bazna. This area presents the highest risk of interception of heavy metals through locally produced local food, due to the large abundance of agrosystems in the structure of local socioecological systems. During this study were collected 36 soil samples, 36 parsley roots (*Petroselinum crispum*), samples from individual gardens located in contaminated area. Each soil sample was a mixture of 6 sub-samples that were collected from the surface soil (0-20 cm).

The soil samples were air-dried at room temperature and then crushed and sieved through 2 and 0.2 mm meshes, before storage and analysis. The heavy metals concentration of Pb, Cd, Zn and Cu was determined in the soil samples by atomic absorption spectrometry.

The vegetable samples were digested with nitric acid in a microwave digestion system. The metal content was measured using atomic absorption spectrometry (Flame GBC 932AA or Graphite furnace GBC SavanatAAZ). Microsoft Excel 2002 was used for the statistical processing and graphical representation of data.

RESULTS AND DISCUSSIONS

The studied area includes seven localities and 36 samples have been collected. From Avente Sever were collected 7 samples, from Agârbiciu 5 samples, from Soala 5 samples, from Micăsasa 10 samples, from Târnava 4 samples, from Copșa Mica 2 samples and from Bazna 3 samples.

In table 1 are presented the values of statistical parameters that characterize the central tendency and the variability of the total cadmium, lead, zinc, copper contents in soil surface layer 0-20 cm.

The average contents for Cd, Cu and Pb, except Zn exceeds the alert thresholds for sensitive use of land according with Order 756/1997. In table 2 are presented the reference values of the total cadmium, lead, zinc, copper contents in soil for sensitive and less sensitive use of land.

In case of Cadmium were registered values that exceed the intervention thresholds in all the samples collected from Copsa Mica, 7 samples from 10 collected from Micăsasa, 4 samples from 7 collected from Avente Sever and 2 samples from 4 collected from Târnava. Also, were registered values that exceed the alert thresholds in 3 samples from 7 collected from Avente Sever, in 2 samples from 10 collected from Micăsasa and in 2 samples from 4 collected from Târnava. Normal values were registered in all samples collected from Agârbiciu, Bazna and Soala, also for one sample from 10 collected from Micăsasa.

Lead registered normal values in all the samples collected from Bazna, 3 samples from 5 collected from Soala and one sample from 5 collected from Agârbiciu. The alert threshold was exceeded in 4 samples from 5 collected from Agârbiciu, in 2 samples from 10 collected from Micăsasa, and in 2 samples from 5 collected from Soala. The intervention threshold was exceeded in all the samples collected from Copsa Mica, Avente Sever and Târnava and in 8 samples from 10 collected from Micăsasa.

Zinc values exceeded the intervention thresholds in all the samples collected from Copsa Mica, one sample from 10 collected from Micăsasa and one sample from 7 collected from Avente Sever. Also, were registered values that exceed the alert thresholds in 3 samples from 4 collected from Târnava, 5 samples from 7 collected from Avente Sever and 8 samples from 10 collected from Micăsasa. Normal values were registered in all samples collected from Agârbiciu, Bazna and Soala, also for one sample from 10 collected from Micăsasa and one sample from 7 collected from Avente Sever. Copper have registered normal values excepting one sample from 3 collected from Bazna.

Table 1 Values of statistical parameters that characterize the central tendency and the variability of the total cadmium, lead, zinc, copper contents in soil (n=36)

Variable	**Cd_{soil}**	**Pb_{soil}**	**Zn_{soil}**	**Cu_{soil}**
	- - - - - - - - - - - - - - - - - - mg/kg DW - - - - - - - - - - - - - - - -			
Minimum	0.10	22	117	25
Maximum	18.98	450	1069	108
Median	4.14	125.5	317	58.5
Geometric mean	1.99	103.4	320.2	57.0
Arithmetic mean	4.67	137.2	376	60.6
Standard deviation	4.51	100.7	223.1	20.7
Coefficient of variation	96.6%	73.4%	59.3%	34.2%

***DW** - **D**ry **W**eight

Table 2 The reference values of the total cadmium, lead, zinc, copper contents in soil for sensitive and less sensitive use of land according with Order 756/1997

Element	**Normal values**	**Alert thresholds**		**Intervention thresholds**	
		Sensitive use of land	**Less sensitive use of land**	**Sensitive use of land**	**Less sensitive use of land**
Cd_{soil}	1	3	5	5	10
Pb_{soil}	20	50	250	100	1000
Zn_{soil}	100	300	700	600	1500
Cu_{soil}	20	100	250	200	500

In table 3 are presented the values of statistical parameters that characterize the central tendency and the variability of the cadmium, lead, zinc, copper contents in the parsley roots. The cadmium content values in parsley roots collected during this study ranged between 0.005 mg kg^{-1} and 0.416 mg kg^{-1}. The lead content values in parsley roots collected during this study ranged between 0.025 mg kg^{-1} and 0.510 mg kg^{-1}. The zinc content values in parsley roots collected ranged between 1.6 mg kg^{-1} and 9.1 mg kg^{-1}. The copper content values in parsley roots collected during this study ranged between 0.96 mg kg^{-1} and 2.62 mg kg^{-1}. All the values registered for zinc and copper in parsley roots are normal values.

Table 3 Values of statistical parameters that characterize the central tendency and the variability of the cadmium, lead, zinc, copper contents in the parsley roots (n=36)

Variable	**$Cd_{parsley}$**	**$Pb_{parsley}$**	**$Zn_{parsley}$**	**$Cu_{parsley}$**
	- - - - - - - - - - - - - - - - - - mg/kg FW - - - - - - - - - - - - - - - -			
Minimum	0.005	0.025	1.6	0.96
Maximum	0.416	0.510	9.1	2.62
Median	0.026	0.102	5.45	1.47
Geometric mean	0.032	0.094	4.58	1.55
Arithmetic mean	0.059	0.126	5.00	1.60
Standard deviation	0.079	0.109	1.99	0.44
Coefficient of variation	133.9%	86.5%	39.8%	27.5%

***FW** - **F**resh **W**eight

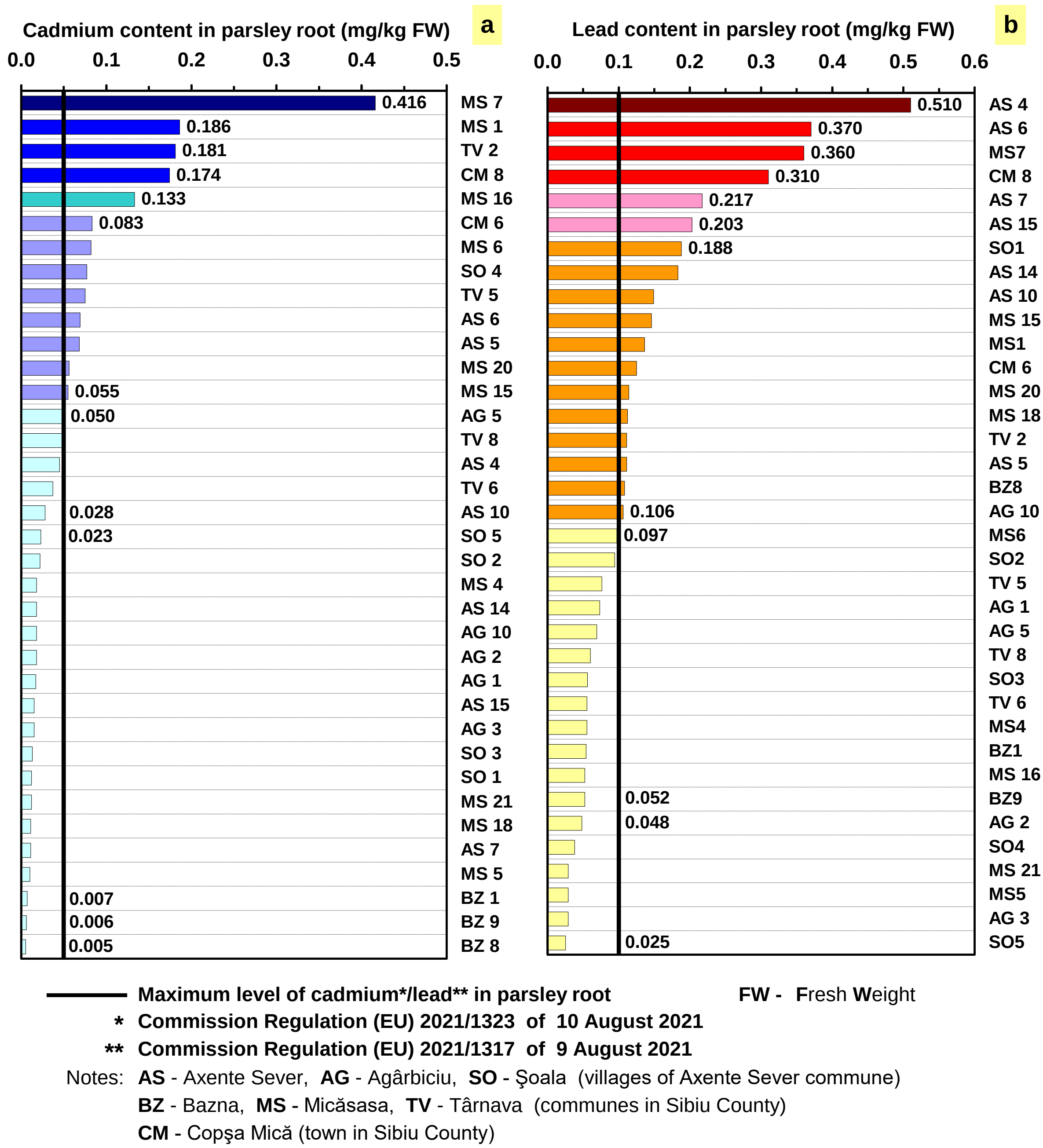

Figure 1 Cadmium and lead contents in the parsley roots harvested from the Copşa Mică area

In figure 1 is presented cadmium and lead contents in the parsley roots harvested from the Copşa Mică area. The average contents for Cd have a value by 0.026 mg kg^{-1} and do not exceed the alert thresholds contents in plant. According with EU Regulation 2021/1323, the maximum allowable value for cadmium for tropical roots and tubers, parsley roots, turnips is 0.05 mg kg^{-1}. The values obtained exceed the maximum allowable in all samples collected from Copsa Mica, in 2 samples from 7 collected from Avente Sever, in 2 samples from 4 collected from Târnava, in 6 samples from 10 collected from Micăsasa and in one sample from 5 collected from Soala.

The average contents for Pb in parsley roots have a value by 0.102 mg kg^{-1} and exceed the alert thresholds contents in plant. According with CE Regulation 2021/1317, the maximum allowable value for lead in root and tuber vegetables (excluding salsifies, fresh ginger and fresh turmeric), bulb vegetables, flowering brassica, head brassica, kohlrabies, legume vegetables and stem vegetables is 0.10 mg kg^{-1} wet weight. In all the samples collected from Copsa Mica and Avente Sever, in one from 3 collected from Bazna, in 5 samples from 10 collected from Micăsasa, in one sample from 5 collected from Agârbiciu and in one sample from 4 collected from Târnava the values obtained exceed the maximum allowable value for lead.

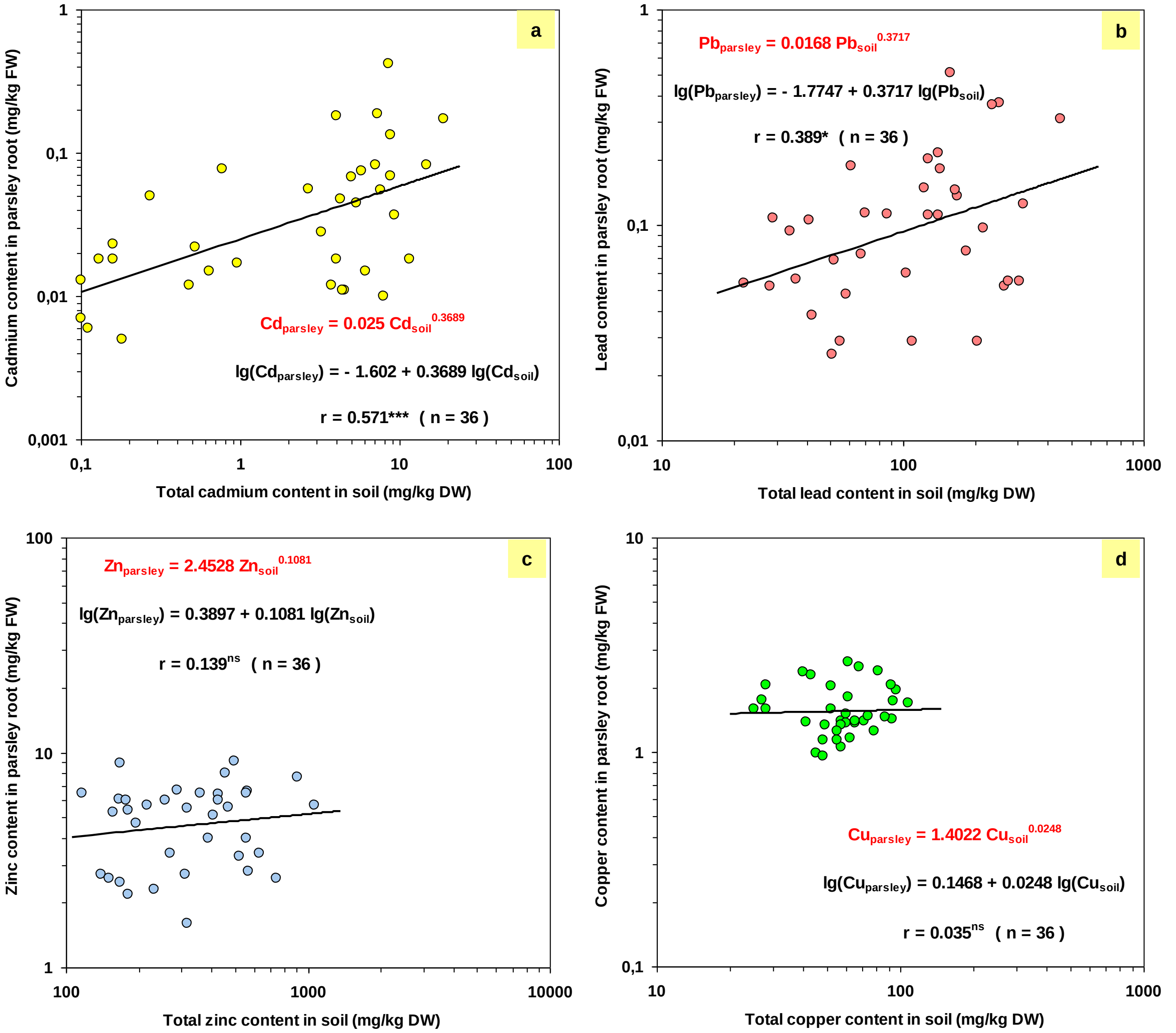

Figure 2 Log-log diagrams for power regression curves that estimate the stochastic dependency between the total cadmium, lead, zinc, copper contents in soil (layer 0-20 cm) and the cadmium, lead, zinc, copper contents in the parsley root.

According to log-log diagram (Figure 2), the parsley roots accumulated amounts of cadmium. The values of cadmium, lead, copper and zinc contents in parsley were correlated with total cadmium, lead, copper and zinc content in soil by means of a power regression equation. For cadmium and lead, the value of linear correlation coefficient r = 0.571*** for cadmium and r = 0.389* for lead, corresponding to linear form of the regression equation was highly significantly ($p < 0.05$) indicating a good correlation between the cadmium content in soil. The value of linear correlation coefficient for zinc is $r = 0.139^{ns}$ and for copper is $r = 0.035^{ns}$ has no significant correlation.

CONCLUSIONS

The contamination of arable layer of soil is the reason for contamination of locally cultivated vegetables with cadmium and lead much more above the maximum permissible concentration. The highest correlations between soil and plant total metal content were obtained for cadmium and lead. In the case of copper and zinc, the correlation established between the two variables is not very strong. The results can be used to estimate the health risk of consumption of vegetables cultivated.

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***COMMISSION REGULATION (EU) 2021/1323 of 10 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of cadmium in certain foodstuffs.

***COMMISSION REGULATION (EU) 2021/1317 of 9 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of lead in certain foodstuffs.