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BIOACCUMULATION OF HEAVY METALS IN CARROT AND PARSLEY ROOTS SAMPLED FROM HOUSEHOLDS IN COPSA MICA

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Abstract

Naturally heavy metals like cadmium, zinc, lead and copper are found in Earth's crust and due to weathering, they are dispersed in the environment. All soils contain a full range of heavy metals, but their concentrations usually are very low. Although, heavy metals concentrations differ from soil to soil, toxicity level is seldom reached, because geochemical cycles are very slow. The study present bioaccumulation of heavy metals in carrot and parsley roots from households in one of the critical areas of heavy metal contamination, Copșa Mică. The bioaccumulation factor was used to investigate the translocation of heavy metals in the soil-crop system. Bioaccumulation factors for cadmium varied between 0.001 and 0.185 in parsley roots, and between 0.004 and 0.300 in carrot roots. Bioaccumulation factors for lead varied between 0.000 and 0.003 in parsley roots, and between 0.000 and 0.002 in carrot roots. Bioaccumulation factors for zinc varied between 0.004 and 0.056 in parsley roots, and between 0.003 and 0.028 in carrot roots. Bioaccumulation factors for copper varied between 0.015 and 0.065 in parsley roots, and between 0.004 and 0.024 in carrot roots. The bioaccumulation factors of parsley roots followed the order Cd (0.185) > Cu (0.065) > Zn (0.056) > Pb (0.003) and in case of carrot roots Cd (0.300) > Zn (0.028) > Cu (0.024) > Pb (0.002). As it can be observed, cadmium was most easily uptaken by crops while lead was identified as having the lowest accumulation in crops.

Key words: bioaccumulation factor, parsley roots, carrot roots, heavy metals, Copsa Mica

INTRODUCTION

Heavy metals contamination and accumulation in plants is a serious problem around the world due to the toxicity, abundant sources, non-biodegradable properties, and accumulative behaviour of heavy metals (Hu et al, 2017).

Many researchers have found that heavy metals are easily accumulated in various edible vegetables and fruits through contaminated soil (Wang et al., 2013; Atafar et al., 2010; Xiong et al., 2013; Sun et al., 2017).

Heavy metal concentration in plant is highly associated with the physico-chemical composition and properties of the growth media. However, some general trends, based on soil-plant accumulation factors can be explained clearly (Kasiuliene, 2018).

MATERIALS AND METHODS

The present study was carried out in one of the critical areas of heavy metal contamination, Copșa Mică. The pollution degree of soil with heavy metals in Copșa Mică is remarkably high. The studied area includes seven localities: Axente 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 29 soil samples, 29 parsley roots (*Petroselinum crispum*) and 29 carrot roots (*Daucus carota*), 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).

RESULTS AND DISCUSSIONS

The studied area includes seven localities and 29 samples have been collected. From Axente Sever (AS) were collected 6 samples, from Agârbiciu (AG) 4 samples, from Soala (SO) 3 samples, from Micăsasa (MS) 10 samples, from Târnava (TV) 3 samples, from Copșa Mica (CM) 2 samples and from Bazna (BZ) 1 sample.

Bioaccumulation (bioconcentration) factor (BAF) is defined as the ratio of the total concentration of element in the roots to its concentration in the soil in which the plant was growing. The bioaccumulation factor of each crop was used to assess the transfer of heavy metals from soil to plant. It can be calculated as:

$$BAF = C_C/C_S$$

where C_C and C_S are the total heavy metals concentrations in some kind of crops and corresponding soils samples, respectively, when calculating the BAF of some kind of crops (food, vegetables, fruits, beans, and tubers). When calculating the overall BAF, C_C indicates the mean content of heavy metals in all crops samples while C_S represents the mean content of corresponding heavy metals in all soil samples (Hang et al., 2016).

In table 1 are presented the bioaccumulation factors of cadmium in parsley and carrot roots. According with Order 756/1997, the normal values of the total cadmium contents in soil do not exceed 1 mg/kg, the alert threshold is 3 mg/kg and the intervention threshold is 5 mg/kg for sensitive use of land. Maximum concentration of cadmium in soil was registered in Copșa Mică and has a value by 18.98 mg/kg. 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}. Bioaccumulation factors for cadmium varied between 0.001 and 0.185 in parsley roots, and between 0.004 and 0.300 in carrot roots.

In table 2 are presented the bioaccumulation factors of lead in parsley and carrot roots. According with Order 756/1997, the normal values of the total lead contents in soil do not exceed 20 mg/kg, the alert threshold is 50 mg/kg and the intervention threshold is 100 mg/kg for sensitive use of land. 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. Bioaccumulation factors for lead varied between 0.000 and 0.003 in parsley roots, and between 0.000 and 0.002 in carrot roots.

Table 1 The bioaccumulation factors (BAFs) of cadmium (Cd) in parsley and carrot roots

	Households code	Cd in soil (mg/kg DW*)	Cd in parsley (mg/kg FW**)	BAF*** Cd in parsley	Cd in carrot (mg/kg FW**)	BAF*** Cd in carrots
1	AG 1	0,96	0,017	0,018	0,054	0,056
2	AG 2	0,16	0,018	0,113	0,025	0,156
3	AG 3	0,64	0,015	0,023	0,021	0,033
4	AG 5	0,27	0,050	0,185	0,047	0,174
5	AS 5	5,02	0,068	0,014	0,226	0,045
6	AS 6	8,80	0,069	0,008	0,129	0,015
7	AS 7	4,50	0,011	0,002	0,073	0,016
8	AS 10	3,23	0,028	0,009	0,102	0,032
9	AS 14	4,00	0,018	0,005	0,052	0,013
10	AS 15	6,08	0,015	0,002	0,068	0,011
11	BZ1	0,10	0,007	0,070	0,030	0,300
12	CM 6	14,8	0,083	0,006	0,273	0,018
13	CM 8	18,98	0,174	0,009	0,285	0,015
14	MS 1	7,32	0,186	0,025	0,162	0,022
15	MS 4	11,52	0,018	0,002	0,082	0,007
16	MS 5	7,98	0,010	0,001	0,091	0,011
17	MS 6	7,09	0,082	0,012	0,066	0,009
18	MS 7	8,48	0,416	0,049	0,393	0,046
19	MS 15	7,60	0,055	0,007	0,163	0,021
20	MS 16	8,77	0,133	0,015	0,417	0,048
21	MS 18	4,39	0,011	0,003	0,050	0,011
22	MS 20	2,68	0,056	0,021	0,061	0,023
23	MS 21	3,75	0,012	0,003	0,015	0,004
24	SO1	0,48	0,012	0,025	0,009	0,019
25	SO2	0,52	0,022	0,042	0,008	0,015
26	SO5	0,16	0,023	0,144	0,010	0,063
27	TV 5	5,78	0,075	0,013	0,239	0,041
28	TV 6	9,32	0,037	0,004	0,125	0,013
29	TV 8	4,26	0,048	0,011	0,198	0,046
Minimum		0,100	0,007	0,001	0,008	0,004
Maximum		18,980	0,416	0,185	0,417	0,300
Median		4,500	0,028	0,012	0,073	0,021
Geometric mean		2,830	0,035	0,012	0,073	0,026
Arithmetic mean		5,436	0,061	0,029	0,120	0,044
Standard deviation		4,615	0,083	0,045	0,113	0,063
Coefficient of variation		84,9%	136,1%	155,2%	94,2%	143,2%

*DW - Dry Weight; **FW - Fresh Weight; ***BAF – bioaccumulation factor

Table 2 The bioaccumulation factors (BAFs) of lead (Pb) in parsley and carrot roots

	Households code	Pb in soil (mg/kg DW*)	Pb in parsley (mg/kg FW**)	BAF* Pb in parsley	Pb in carrot (mg/kg FW**)	BAF*** Pb in carrots
1	AG 1	67	0,073	0,001	0,155	0,002
2	AG 2	58	0,048	0,001	0,015	0,000
3	AG 3	55	0,029	0,001	0,040	0,001
4	AG 5	52	0,069	0,001	0,052	0,001
5	AS 5	140	0,111	0,001	0,071	0,001
6	AS 6	252	0,370	0,001	0,143	0,001
7	AS 7	141	0,217	0,002	0,107	0,001
8	AS 10	123	0,149	0,001	0,105	0,001
9	AS 14	143	0,183	0,001	0,143	0,001
10	AS 15	128	0,203	0,002	0,130	0,001
11	BZ1	22	0,054	0,002	0,034	0,002
12	CM 6	316	0,125	0,000	0,227	0,001
13	CM 8	450	0,310	0,001	0,245	0,001
14	MS 1	168	0,136	0,001	0,097	0,001
15	MS 4	306	0,055	0,000	0,116	0,000
16	MS 5	204	0,029	0,000	0,027	0,000
17	MS 6	216	0,097	0,000	0,030	0,000
18	MS 7	235	0,360	0,002	0,121	0,001
19	MS 15	166	0,146	0,001	0,115	0,001
20	MS 16	264	0,052	0,000	0,118	0,000
21	MS 18	86	0,112	0,001	0,058	0,001
22	MS 20	70	0,114	0,002	0,028	0,000
23	MS 21	109	0,029	0,000	0,023	0,000
24	SO1	61	0,188	0,003	0,090	0,001
25	SO2	34	0,094	0,003	0,016	0,000
26	SO5	51	0,025	0,000	0,077	0,002
27	TV 5	183	0,076	0,000	0,155	0,001
28	TV 6	274	0,055	0,000	0,037	0,000
29	TV 8	103	0,060	0,001	0,064	0,001
Minimum		22,000	0,025	0,000	0,015	0,000
Maximum		450,000	0,370	0,003	0,245	0,002
Median		140,000	0,097	0,001	0,090	0,001
Geometric mean		122,080	0,094	0,001	0,071	0,001
Arithmetic mean		154,379	0,123	0,001	0,091	0,001
Standard deviation		102,409	0,095	0,001	0,060	0,000
Coefficient of variation		66,3%	77,2%	100,0%	65,9%	0,0%

*DW - Dry Weight; **FW - Fresh Weight; ***BAF – bioaccumulation factor

In table 3 are presented the bioaccumulation factors of zinc in parsley and carrot roots. According with Order 756/1997, the normal values of the total zinc contents in soil do not exceed 100 mg/kg, the alert threshold is 300 mg/kg and the intervention threshold is 600 mg/kg for sensitive use of land. As it can be observed, bioaccumulation factors for zinc varied between 0.004 and 0.056 in parsley roots, and between 0.003 and 0.028 in carrot roots.

Table 3 The bioaccumulation factors (BAFs) of zinc (Zn) in parsley and carrot roots

	Households code	Zn in soil (mg/kg DW*)	Zn in parsley (mg/kg FW**)	BAF*** Zn in parsley	Zn in carrots (mg/kg FW**)	BAF*** Zn in carrots
1	AG 1	257	6,0	0,023	2,6	0,010
2	AG 2	181	2,2	0,012	2,1	0,012
3	AG 3	231	2,3	0,010	5,1	0,022
4	AG 5	180	5,4	0,030	3,0	0,017
5	AS 5	270	3,4	0,013	4,6	0,017
6	AS 6	555	4,0	0,007	4,0	0,007
7	AS 7	387	4,0	0,010	2,1	0,005
8	AS 10	311	2,7	0,009	2,7	0,009
9	AS 14	632	3,4	0,005	4,3	0,007
10	AS 15	457	8,0	0,018	4,3	0,009
11	BZ1	156	5,3	0,034	4,3	0,028
12	CM 6	902	7,7	0,009	4,6	0,005
13	CM 8	1069	5,7	0,005	3,5	0,003
14	MS 1	428	6,4	0,015	2,8	0,007
15	MS 4	742	2,6	0,004	2,2	0,003
16	MS 5	566	2,8	0,005	2,5	0,004
17	MS 6	520	3,3	0,006	3,5	0,007
18	MS 7	495	9,1	0,018	6,9	0,014
19	MS 15	470	5,6	0,012	5,1	0,011
20	MS 16	561	6,6	0,012	6,3	0,011
21	MS 18	317	1,6	0,005	2,3	0,007
22	MS 20	216	5,7	0,026	2,5	0,012
23	MS 21	317	5,5	0,017	3,1	0,010
24	SO1	195	4,7	0,024	2,0	0,010
25	SO2	150	2,6	0,017	1,9	0,013
26	SO5	117	6,5	0,056	2,8	0,024
27	TV 5	425	6,0	0,014	3,2	0,008
28	TV 6	559	6,5	0,012	2,7	0,005
29	TV 8	358	6,5	0,018	4,4	0,012
Minimum		117,000	1,600	0,004	1,900	0,003
Maximum		1069,000	9,100	0,056	6,900	0,028
Median		387,000	5,400	0,012	3,100	0,010
Geometric mean		358,138	4,485	0,013	3,286	0,009
Arithmetic mean		414,621	4,900	0,015	3,497	0,011
Standard deviation		228,647	1,949	0,011	1,300	0,006
Coefficient of variation		55,1%	39,8%	73,3%	37,2%	54,5%

***DW** - **D**ry **W**eight; ****FW** - Fresh **W**eight; ***BAF – bioaccumulation factor

In table 4 are presented the bioaccumulation factors of copper in parsley and carrot roots. According with Order 756/1997, the normal values of the total copper contents in soil do not exceed 20 mg/kg, the alert threshold is 100 mg/kg and the intervention threshold is 200 mg/kg for sensitive use of land. Bioaccumulation factors for copper varied between 0.015 and 0.065 in parsley roots, and between 0.004 and 0.024 in carrot roots.

Table 4 The bioaccumulation factors (BAFs) of copper (Cu) in parsley and carrot roots

	Households code	Cu in soil (mg/kg DW*)	Cu in parsley (mg/kg FW**)	BAF*** Cu in parsley	Cu in carrots (mg/kg FW**)	BAF*** Cu in carrots
1	AG 1	57	1,4	0,024	0,47	0,008
2	AG 2	45	1,0	0,022	0,59	0,013
3	AG 3	78	1,3	0,016	0,59	0,008
4	AG 5	43	2,3	0,053	0,42	0,010
5	AS 5	28	1,6	0,057	0,66	0,024
6	AS 6	65	1,4	0,021	0,72	0,011
7	AS 7	49	1,3	0,027	0,45	0,009
8	AS 10	48	1,0	0,020	0,40	0,008
9	AS 14	93	1,4	0,015	0,50	0,005
10	AS 15	94	1,7	0,018	0,51	0,005
11	BZ1	61	1,8	0,030	0,99	0,016
12	CM 6	52	2,0	0,039	0,88	0,017
13	CM 8	81	2,4	0,030	0,81	0,010
14	MS 1	61	2,6	0,043	0,63	0,010
15	MS 4	65	1,4	0,022	0,52	0,008
16	MS 5	48	1,1	0,024	0,49	0,010
17	MS 6	87	1,5	0,017	1,19	0,014
18	MS 7	92	2,1	0,022	0,94	0,010
19	MS 15	57	1,3	0,023	0,40	0,007
20	MS 16	71	1,4	0,020	0,80	0,011
21	MS 18	62	1,2	0,019	0,60	0,010
22	MS 20	41	1,4	0,034	0,44	0,011
23	MS 21	60	1,5	0,025	0,31	0,005
24	SO1	74	1,5	0,020	0,30	0,004
25	SO2	57	1,1	0,019	0,51	0,009
26	SO5	27	1,8	0,065	0,51	0,019
27	TV 5	55	1,3	0,023	0,59	0,011
28	TV 6	68	2,5	0,037	0,65	0,010
29	TV 8	55	1,1	0,02	0,68	0,012
Minimum		27,000	0,960	0,015	0,300	0,004
Maximum		94,000	2,620	0,065	1,190	0,024
Median		60,000	1,400	0,023	0,590	0,010
Geometric mean		58,561	1,500	0,026	0,574	0,010
Arithmetic mean		61,172	1,557	0,028	0,605	0,011
Standard deviation		17,625	0,454	0,013	0,208	0,004
Coefficient of variation		28,8%	29,2%	46,4%	34,4%	36,4%

***DW** - **D**ry **W**eight; ****FW** - Fresh **W**eight; ***BAF – bioaccumulation factor

CONCLUSIONS

The bioaccumulation factors are different for heavy metals in parsley and carrot roots. The bioaccumulation factors for parsley roots followed the order Cd (0.185) > Cu (0.065) > Zn (0.056) > Pb (0.003). in case of carrot roots Cd (0.300) > Zn (0.028) > Cu (0.024) > Pb (0.002). As it can be observed, Cd was most easily uptaken by crops while Pb was identified as having the lowest accumulation in crops.

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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.