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SAFETY OF POTATOES FROM ASPECT RESIDUAL SOIL CONTAMINATION BY RISK METALS

JAKOŚĆ ZIEMNIAKÓW Z PUNKTU WIDZENIA ZANIECZYSZCZENIA GLEBY METALAMI CIĘŻKIMI

Słowa kluczowe: ziemniaki, metale ciężkie, zanieczyszczenia.
Key words: potatoes, heavy metals, contamination.

Metale ciężkie należą do grupy podstawowych zanieczyszczeń monitorowanych w poszczególnych komponentach środowiska. Ryzyko, jakie powodują z punktu widzenia ekotoksykologii metale ciężkie i ich kumulacja w ożywionym i nieożywionym środowisku. Mikroelementy, które z biologicznego punktu widzenia są niezbędne, mogą być toksyczne, jeżeli przekroczą pewien próg stężeń. Łańcuch pokarmowy – od swego pierwszego ogniwa do produktu końcowego, jakim są środki żywienia zwierząt – narażony jest na wiele czynników. Kumulacja kadmu, miedzi, ołowiu i cynku w bulwach ziemniaka była analizowana w 4 lokalizacjach w Środkowej Słowacji, które charakteryzowała podwyższona zawartość w glebie wymienionych pierwiastków. Glebę charakteryzował odczyn kwaśny lub lekko kwaśny (pH/KCl 5,45–6,40), wysoka zawartość związków fosforu (236,38–598,85 mg·kg^{-1} gleby), potasu (474,5–6874,5 mg·kg^{-1} gleby), magnezu (384,5–591,0 mg·kg^{-1}) oraz wapnia (2615–3520 mg·kg^{-1} gleby). Badane metale z gleby były ekstrahowane w wodzie królewskiej, a ich zawartość wynosiła: kadm (Cd) od 1,22 do 11,72, miedź (Cu) od 36,0 do 155,8, ołów (Pb) od 87,2 do 1475,0 i cynk (Zn) od 184,0 do 1555,0. Oznaczono je w 1-molowym roztworze węglanu amonowego i ich zawartość wynosiła: Cd od 0,032 do 0,076, Cu od 0,09 do 0,5, Pb od 0,235 do 0,255, Zn od 0,125 do 3,735.

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Zawartość Cd, Cu, Pb i Zn w mg·kg^{-1} świeżej masy była analizowana w obranych ziemniakach po ich mineralizacji i wynosiła: Cd od 0,039 do 0,357, Cu od 1,20 do 1,40, Pb od wartości śladowych do 0,48, Zn od 4,94 do 6,87. Pierwiastki oznaczono techniką płomieniowej adsorpcji atomowej (AAS Varian AA Spectr DUO 240 FS/240Z/UltrAA).

1. INTRODUCTION

Toxic metals, mainly Zn, Pb and Cd get into soil in higher amounts by sedimentation of dust from industrial processes, from exhaust gas, from polluted waste waters and fertilizers [Vollmannová et al. 2006].

Ions of these metals are very easily absorbed by roots as their selectivity of transported proteins is probably insufficient for its severance from those elements which are for plants essential [Zrůst 2003]. Foreign substances could be stress factor and through food chain can present threat for plants and human organism. Their affecting on plants is considerably variable. Besides their accumulation in plant their high content in soil can be manifested by depressive effect on its growth [Hlušek et al. 2001]. They can also affect the nutritive composition of plant foods [Musilová et al. 2009]. From the hygienic standpoint it is determining if heavy metals have been accumulating in parts used for consumption.

Hontiansky and Banskoštiavnický region are situated in the south-west of middle Slovakia. This area is characteristic by two types of contamination. The first one is anthropic and is caused by ore mining and by their processing. The second type is natural and is caused by weathering of rocks containing selected heavy metals. The river Štiavnica is significant transport medium of heavy metals which originates in the area of Štiavnické Hills. Percolations from mining shafts and waste heaps get into soil together with great amounts of risky metals that could contaminate alluvial soils by floods [Bajčan et al. 2007]. Contents of some selected elements significantly enhance legislatively given limit values, what ranks these soils among risky ones from this point of view, and their contamination was analytically proved [Tóth et al. 2005]. Thus it is very important to monitor transfer of heavy metals from contaminated soils into agricultural crops in mentioned area [Vollmannová et al. 2002].

2. MATERIAL AND METHODS

Soil and plant samples were taken from the vicinity of Štiavnica River which originates in the area of Štiavnické Hills and drain off large part of this area.

Soil. Soil taken from individual sites can be characterized as middle heavy, sandy-loam, with weakly acid and acid soil reaction (Tab. 1), content of available nutrients (P, K, Ca, Mg) in soil was assessed by method Mehlich II (Tab. 2).

Table 1. Characteristics of soil

Tabela 1. Charakterystyka gleby

Locality	pH/H_2O	pH/KCl
Terany	8.55	6.40
Hontianske Nemce	7.51	6.15
Prenčov (1)	7.45	5.45
Prenčov (2)	7.51	5.74

Pseudototal content of Zn, Cu, Cd and Pb including all of the forms besides residual fraction of metals was assessed in solution of *aqua regia* and content of mobile forms of selected heavy metals in soil extract of NH_4NO_3 (c = 1 mol.dm^{-3}). Gained results were evaluated according to Law 220/2004.

Analytical ending was flame AAS (AAS Varian AA Spectr DUO 240 FS/240Z/UltrAA).

Plant. Potato tuber (*Solanum tuberosum* L.) was the tested crop. It was early variety harvested in consumption maturity. Content of heavy metals was assessed in peeled potatoes after mineralization of samples by wet way method. Gained results were evaluated according to Foodstuffs Codex SR. AAS was analytical ending for all assessments (AAS Varian AA Spectr Duo 240 FS/240Z/UltrAA).

3. RESULTS AND DISCUSSION

Analyzed soil was characterised by high and very high contents of nutrients (Tab. 2).

Table 2. Contents of nutrients in soil (mg·kg^{-1})

Tabela 2. Zawartość substancji odżywczych w glebie (mg·kg^{-1})

Locality	P	K	Ca	Mg
Terany	338.32	474.5	2675	459.5
Hontianske Nemce	460.19	6874.5	3520	591.0
Prenčov (1)	236.38	794.5	2615	384.5
Prenčov (2)	598.85	1032.5	3190	497.5

Contents of Zn, Cu, Cd and Pb were higher in comparison with limit values given by Law 220/2004, significant enhancement was measured in soil samples taken from locality Prenčov, where the zinc content was 10.4-times higher than limit value for this element, the copper content was 2.6, cadmium 16.7 and lead content even 21.1-higher in comparison with limit values. Limit values for copper were not exceeded in locality of Terany and Hontianske Nemce. Critical values assessed for zinc were enhanced 1.6–1.87-times in soil taken from locality Prenčov (1), Prenčov (2) and content of lead was 2.4–2.55-times higher in all localities (Tab. 3).

Content of heavy metals in plants depends on their concentration and mobility in soil. Antanaitis A. i Antanaitis D. [2004] have referred that mobility of some heavy metals is in fol-

lowing order: Zn > Cd > Pb; resp. Zn ≥ Cu, while it depends mainly on physical and chemical soil traits [Otabbong et al. 2001].

Table 3. Content of heavy metals in soil ($mg \cdot kg^{-1}$)

Tabela 3. Zawartość metali ciężkich w glebie ($mg \cdot kg^{-1}$)

Locality		Zn	Cu	Cd	Pb
Terany	*Aqua regia*	212	36.4	1.64	97.6
Hontianske Nemce		184	36.0	1.22	87.2
Prenčov (1)		1555	140.6	11.72	1290.0
Prenčov (2)		1385	155.8	10.26	1475.0
	*Limit value**	*150*	*60*	*0.7*	*70*
Terany	NH_4NO_3 ($c=1\ mol.dm^{-1}$)	0.125	0.090	0.032	0.235
Hontianske Nemce		0.155	0.105	0.035	0.240
Prenčov (1)		3.735	0.160	0.076	0.255
Prenčov (2)		3.200	0.250	0.068	0.250
	Critical value*	2.0	*1.0*	*0.1*	*0.1*

* Law 220/2004.

Enhanced limit/critical value. Despite of that the content of Zn in soil of Prenčov locality Prenčov enhanced critical value, but it did not manifest by enhancing of its content in potato tubers because the content of zinc in tubers depends on its content in available form in soil, what is in consistency with the results of Hlušek et al. [1998]. The highest content of Zn (6.87 $mg \cdot kg^{-1}$ FM) was assessed in potato tubers from the site Prenčov (2) – Table 4.

Copper belongs among the elements, those content is monitored not only in soil, but also in foodstuffs, while the potatoes are mentioned as the least sensitive filed crops [Hlušek et al. 1998]. Enhanced content of copper in soil taken from two localities Prenčov (1) and Prenčov (2) did not manifest by enhancing of content of this element in potato tubers and was in range from 1.20 to 1.40 $mg \cdot kg^{-1}$ FM (Tab. 4). Besides low sensitivity of potatoes to copper, its content in potatoes depends, as well as for Zn, on its content in suitable form in soil and mobile contents of Cu that have the greatest importance from the standpoint of biotoxicity, did not enhance critical values.

Lead is the most strongly bounded by specific adsorption processes among all heavy metals and after Hg has the smallest mobility in soil horizon [Alloway 1990]. Despite the potatoes are less sensitive to enhanced content of lead in soil, than to content of cadmium [Hlušek et al. 1996], its enhancement in tubers was assessed, what is probably influenced by synergic effect of cadmium [Hronec et al. 2002]. Lead content was slightly enhanced (maximum by 0.18 mg/kg FM) in samples from locality Prenčov (2) in comparison with Foodstuffs Codex.

Cadmium is accumulated in soil in layer 0–50 mm from the surface and with the continuing depth its concentration decreases. With regard on the fact that it can not be degraded such as some organic pollutants, it presents long-period lasting risk for environment. The most significant

soil contamination manifested on accumulation of Cd in tubers, where besides samples from locality Terany the hygienic limit 1.1-times was enhanced in locality Hontianske Nemce, 2.6-times in locality Prenčov (2) and 3.6-times in locality Prenčov (1) – Table 4. Results of many works confirm that the under-limit content of foreign elements in soil does not guarantee that plants grown on this soil will always contain tolerable level [Hlušek et al. 1997].

Table 4. Content of heavy metals in potato tubers (mg/kg FM)
Tabela 4. Zawartość metali ciężkich w bulwach ziemniaków (mg/kg FM)

Locality	Dry mater (%)	Zn	Cu	Cd	Pb
Terany	19.45	5.29	1.39	0.039	ND
Hontianske Nemce	21.10	6.10	1.20	0.106	0.32
Prenčov (1)	18.35	4.94	1.38	0.357	0.36
Prenčov (2)	18.90	6.87	1.40	0.256	0.48
	Limit value (FC SR)	*10.0*	*3.0*	*0.1*	*0.1*

Objaśnienie: FM – fresh matter.
FC SR – Foodstuff Codex of Slovak Republic.

4. CONCLUSION

Enhanced content of cadmium and lead in soil had manifested by their enhanced concentration in tubers of potatoes in such range, that it was few fold enhanced when compared to limit value given by valid legislative. Lowering of the content of heavy metals in potato tubers can be partly reached by potatoes processing. In the case of lead, peeling of potatoes is a way to eliminate its content, while maceration influences also content of other elements [Míča, Vokál 1996]. Utilization of potatoes for others than on food purposes (alcohol production) is another possibility.

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