TRACE HEAVY METAL UPTAKE BY CROP ROOTS

C. Oprea, M.V. Gustova, I.A. Oprea

Joint Institute for Nuclear Research (JINR), Dubna 141980, Russian Federation

Abstract

Cabbage, potato and celeriac, grown in industrially polluted region, were included in the present research. We investigated the level of pollution and the way heavy metals enter the crop root, by surveying soil and plant samples. The contents of heavy metals in chosen samples were determined by analytical measurements with photon neutron activation spectrometry method (IPNAA). In particular, cabbage is suitable for growing in industrially polluted regions as it removes considerable quantities of heavy metals from the soil by the own root system and can be used as potential crop for remediate soil from heavy metals.

Keywords: *crop root, IPNAA, heavy metals, bio-accumulation, uptake*

Introduction

The behavior of heavy metals released by industrial activities is reflected in agriculture lands and that has been the center of much attention during the last decades. Previous experiments established that a clearly distinguished species characteristic exists in the accumulation of heavy metals in the vegetative parts of several agricrops. As a developed continuation of the earlier researches of the paper's authors, *The Project: Trace Heavy Metal Uptake by Crop Roots (2011-2012)* was started.

Toxic heavy metals such as As, Co, Cr, Fe, Ni and Zn, are constantly released into the environment. In particular, heavy metal pollution of soil is a significant environmental problem with a negative potential impact on human health and agriculture. The crop root, as an important interface of soil and plants, plays a significant role in transmission of contaminated soil by heavy metals through the food chain. This project develops a

methodology to evaluate transport of the main contaminating trace heavy metals from root soil and its uptake by crop roots.

The aim of this study was the continuation of the previous researches of the heavy metal bioaccumulation in the several agricrops. Determination of heavy metals in agricultural crops is frequently required in health-related environmental studies, because of severe toxicity of trace amounts of such elements for human organism.

For the assay of essential and trace heavy metals content in the aimed samples the photon neutron activation spectrometry method was already been tested and it is employed during the present researches.

Materials and methods

Sampling

The environmental samples were collected from the agricultural area surrounding a ferrous work near Ploiesti. The experimental plots were situated at different distances (0.5 and 15 km) from the source of pollution—the Ferrous-Metal Work. The same types of samples were recorded from a rural area chosen as a clean spot, situated at 20 km remoteness.

Sample preparation

Prior to analysis the crop samples were rinsed with distilled water to remove the adhering particles from soil and/or atmospheric deposition. For each type of crop, an average sample was prepared by mixing the samples collected from a site (three pieces). Then the samples were air dried for about one month and later by 48 hours at 40^0C in the thermostat until constant weight. Aliquots of about 2 g of each sample were used for IPNAA. The fresh/dry mass ratio determined for crops were 7.62, 5.24 and 8.36 for cabbage root, potato root and celeriac root, respectively.

IPNAA

For the heavy metal assay, the photon neutron activation analysis at the Microtron MT-25 was used. The analytical methodology of IPNAA at MT-25 was largely described in our previous papers (see list of references).

The method provides detection limits of about 10 % for the elemental concentrations in investigated crops. On the crop samples were done four types of measurements, in order to account the elemental concentrations based on the activity of very short-, short-, medium- and long lived isotopes which exhibit times of disintegration of about few minutes, few hours, 1-3 days and, respectively, more than 4 days.

Results and discussion

Contents of toxic heavy metals such as As, Co, Cr, Fe, Ni and Zn, were determined by IPNAA in the studied crop roots, respectively cabbage, potato and celeriac (Table 1). As it is observed, the crop species showed remarkable difference in metal bio-accumulation and uptake from the root soil.

Table 1. Heavy metal concentrations (mg/kg) in crop root at 1 km from the ferrous complex as $x \pm SD$; x -average value (mg/kg) from five repetitions; SD: mean standard deviation

HM / Crop type	Cabbage root	Potato root	Celeriac root
Cr	17.5 ± 0.7	4.7 ± 0.3	7.2 ± 0.4
Fe	5370 ± 110	518 ± 26	632 ± 35
Co	5.08 ± 0.11	0.71 ± 0.04	0.95 ± 0.05
Ni	8.32 ± 0.25	1.30 ± 0.21	0.85 ± 0.17
Zn	61 ± 2.0	24 ± 1.5	28 ± 1.6
As	0.73 ± 0.09	0.22 ± 0.05	0.30 ± 0.07

The content of the same inorganic constituents for the concerned root soil are reported (Table 2). The distribution in the bio-accumulation of heavy metals from soil to plant for the studied crops seems to be selective, following the decreasing order: soil>root>pulp>leaf. Cabbage is the crop that most strongly absorbs and accumulates heavy metals from the soil. (as shown in Tables 1 and 2). With some exceptions, the levels of the heavy metals recorded in plants are in agreement with the normative allowable levels established in Romania.

A strongly exhibited tendency towards diminution of the contents of heavy metals in the soils and crop roots is observed with the increase of the distance from the ferrous smelter complex. The results concerning this aspect will constitute the subject of another report.

Table 2. Heavy metal concentrations (mg/kg) in host soil of the crop root at 1 km from the ferrous complex as x±SD; x -average value (mg/kg) from five repetitions;
SD: mean standard deviation

HM / Crop type	Soil of cabbage root	Soil of potato root	Soil of celeriac root
Cr	64.7 ± 3.0	75.3 ± 4.2	64.1 ± 3.0
Fe	31650 ± 450	38150 ± 650	30840 ± 450
Co	18.3 ± 0.5	21.6 ± 0.5	18.1 ± 0.5
Ni	41 ± 9	48 ± 12	40 ± 9
Zn	95 ± 15	115 ± 20	92 ± 13
As	14.1 ± 1.5	18.3 ± 2.5	13.8 ± 1.4

Conclusion

It was established from the present findings that cabbage root is a hyper-accumulator of most of the trace heavy metals such as Fe, Zn and As. This peculiarity could be used for selection of this vegetable crop for cultivation on metal contaminated soils.

The three vegetable crop species also showed notable differences in respect of heavy metal uptake and their bio-accumulation. Then our results may be useful for selecting suitable crop species for different metal contaminated soils.

References

[1] Allison DW, Dzialo C (1981). Plant Soil 62: 81

[2] Barman SC, LAL MM (1994). J Environ Biol 15:107

[3] Barman SC, Saku RK, Bhargava SK, Chaterjee C (2000).
Bull Environ. Contam. Toxicol. 64:489

[4] Khairiah J, Zalifah MK, Yin YK, Aminah A (2004). J Biol Sci 7:1438

[5] MCKenna IM, Chaney RL, Williams FM (1993). Environ Res 8(3-4):679

[6] Oprea C, Maslov OD, Gustova MV, Belov AG, Szalanski PJ, Oprea IA (2009).
Vacuum 83 1:S162

[7] Oprea CD, Mihul A (2003). Romanian Rep in Phys 55 32:91

[8] Oprea C, Gustova MV, Oprea IA, Maslov OD, Belov AG, Ciofu R (2011).
Proceedings of ISINN-18:322

[9] Oprea C, Maslov OD, Gustova, MV, Belov AG, Oprea IA, Ciofu R, Mihul A (2010).
Proceedings of ISINN-17:91

[10] Sanders JR, Mc Grath SP, Adams T (1987). Environ Pollut 44:193

[11] Tlustos P, Balik J, Pavlikova D, Szakova J (1997). Rostlinna Vyroba 43(10):487