CADMIUM AND LEAD SOIL POLLUTION IN COPSA MICA AREA IN RELATION WITH THE FOOD CHAIN

Edward MUNTEAN, Nicoleta MUNTEAN, Tania MIHĂIESCU

University of Agricultural Sciences and Veterinary Medicine
Cluj-Napoca, Romania 3-5 Calea Manastur Str., 400372 – Cluj Napoca, Romania;
Corresponding author: edimuntean@yahoo.com

Abstract: *High levels of heavy metals concentrations in soil can direct to plant contamination; thus, soil contaminated by heavy metals may pose a threat to human health if these enter the food chain. Copsa Mica is one of the sites with the highest degree of heavy metal pollution in Romania, the whole area being well known for the ecological lack of balance due to the a non-ferrous smelter plant: Sometra. The aim of this study was to establish the soil contamination with lead and cadmium in the target area; as the local population produces, sells and consumes agricultural products, food chain analysis was performed in order to establish the levels of contamination with lead and cadmium. Samples were processed through microwave-assisted mineralization; analyses were performed using atomic absorption technique with a Shimadzu AA-6300 double-beam instrument. The obtained results showed that lead and cadmium contamination of soil in Copşa Mică area and its surroundings is significant; the high heavy metal content in plants grown in the vicinity of the industrial site, as well as in different products for food purposes represents a severe risk for public health. For soil samples, the maximum lead concentrations were recorded in samples originating from Micasasa and Agarbiciu, while those for cadmium were recorded for a sampling point from Copsa Mica, near the pollution source, being higher than the maximum allowed limits. For the other samples, the highest concentrations of lead were recorded for snails originating in Copsa Mica, followed by grass (Seica Mare, Copsa Mica) and potatoes (Micasasa). The maximum cadmium concentrations were found in snails (Copsa Mica) and grass (Seica Mare, Copsa Mica).*

Key words**:** *cadmium, lead, heavy metals, soil, pollution, food*

INTRODUCTION

Industrial pollution has been and continues to be a major factor causing the degradation of the environment [ADRIANO – 1986; CONSTANTINESCU – 2002; MULLIGAN – 2001; STĂTESCU - 2003], being the cause that Copsa Mica (Sibiu county) is one of the most polluted areas from Romania. Pollution in this town area was almost entirely caused by two factories: CARBOSIN (which produced carbon black for dies and tires from 1936 until 1993) and SOMETRA (a non-ferrous smelter plant that used ecological hazardous technologies, being officially closed in 2009). Carbon black produced by CARBOSIN consistently left everything - plants, laundry, and people - covered in soot until it was finally closed in 1993. The other industrial plant from Copsa Mica, S.C. SOMETRA S.A, is the main responsible for the pollution; for thirty years it sprayed a cocktail of heavy metals over the surrounding area. SOMETRA is largely responsible for the most health problems of Copsa Mica's population due to its emissions of sulphur dioxide, the solid particles in suspension and heavy metals which are present in the atmosphere, in water, in soil and in vegetation.

High levels of heavy metals concentrations in soil can direct to plant contamination; thus, soil contaminated by heavy metals may pose a threat to human health if these enter the food chain [LĂCĂTUŞU – 1996; WANI – 2008], especially in cadmium's case [NOGOWA – 2004; OSKARSSON – 2004; SATOH – 2002].

The aim of this study was to establish the soil contamination with lead and cadmium in the target area. As the local population produces, sells and consumes a great number of agricultural products, food chain analysis was performed in order to establish the levels of contamination with lead, zinc and cadmium.

MATERIAL AND METHODS

Standard solutions of cadmium and lead, as well as hydrofluoric acid, nitric acid, perchloric acid were all purchased from Merck (Darmstadt, Germany). Ultrapure water with a specific resistance of 18.2 M□/ cm was utilized for preparation of mobile phases as well as for sample dilution, being obtained from a Direct Q 3UV Smart (Millipore).

Samples were collected during April 2009, shortly after the official closing of SOMETRA; sample processing was accomplished by wet digestion using a Berghoff Microwave Digestion System MWS-3+. The soil samples were treated with 3 ml of HNO_3 65% and 3 ml of HF 40%, while the food and plant samples were digested using a mixture of nitric and perchloric acid (3:1).

Measurements were performed using an Shimadzu AA-6300 double beam atomic absorption spectrophotometer (Shimadzu, Japan), with both flame atomization and graphite furnace, equipped with deuterium lamp for background correction and hallow-cathode lamps for each of the studied elements, as well as an ASC-6100F autosampler, data acquisition and processing software. The operation conditions were those recommended for each metal in the instrument's method. Calibration curves were prepared using five concentrations, the linear correlation coefficients obtained being 0.9990 for cadmium and 0.9996 for lead. For samples with concentrations outside the established linear range, the samples were diluted with nitric acid 0.1 M and re-analyzed. All measurements were carried out in triplicate.

RESULTS AND DISCUSSIONS

On the Copsa Mică platform, the heavy metal pollution is due to the non-ferrous metallurgy. From a pedological point of view, the area is characterized by acid soils with B argic horizon which brings forward the humidity excess and the retention of the pollutants, having an increased potential of vulnerability to the action of the pollutant factors. The soils in the river meadow area are less acid and clayey, allowing a more intense vertical movement of water and pollutants. The area is characterized by periods of atmospheric calmness, in which air masses stops over the area, releasing the atmospheric pollutants in the Târnava river basin.

For lead, the reference value is 20 ppm, while the alert level in the sensitive area is 50 ppm. Three from the recorded values for lead in soils were over the alert level (figure 1), the maximum recorded values being from Micasasa and Agarbiciu, two small communities located near Copsa Mica. The sampling sites Micasasa, Seica, Agarbiciu and Copsa Mica were explored both from surface (s.index) and depth (d index), the lead behavior being different, depending of the soil type: higher values for 20 cm depth soil for Micasasa and Copsa Mica, comparing with surface soil, and lower lever for 20 cm depth soil for Seica and Agarbiciu.

For cadmium, the reference value is 1 ppm, while the alert level is 3 ppm. Most of the recorded values for soil concentrations were over the reference level, with more than half over the alerting level, the maximum one being obtained in a sampling point from Copsa Mica, near SOMETRA. Again, different concentrations were recorded in surface soils: smaller concentration for cadmium in surface samples due to levigation in Micasasa and Agarbiciu, and higher concentrations in Seica and Copsa Mica.

For assessing the impact of soil contamination on food chain, a large number of samples were processed, covering a quite large geographical area. The obtained results are presented in table 1, from which is obvious that the highest concentration of lead was recorded for snails originating in Copsa Mica, which accumulates also the highest level of cadmium (table 1), followed by grass (Seica Mare, Copsa Mica) and potatoes form Micasasa.

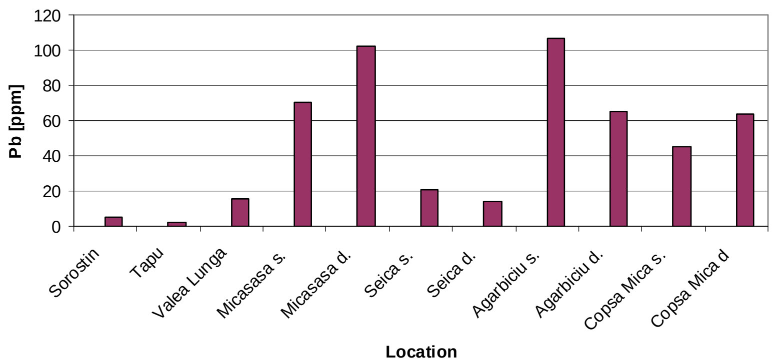

Figure 1. Mean levels of lead concentrations in soil samples originating from Copsa Mica and surrounding villages

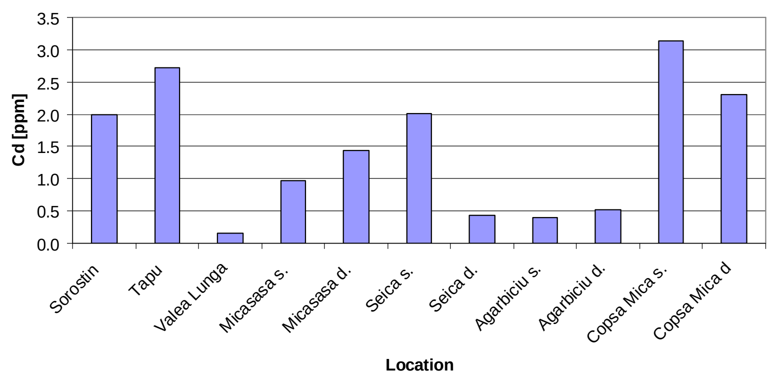

Figure 2. Mean levels of cadmium concentration in soil samples originating from Copsa Mica and surrounding villages

For cadmium, the maximum concentration was that found in snails grown in Copsa Mica, followed by grass (Seica Mare, Copsa Mica). The most contaminated plant product was grass, which can be used hence as an indicator of contamination with lead and cadmium.

CONCLUSIONS

The growing concern on the quality of the environment has stimulated a particular interest regarding heavy metals behavior in soil and their effects. While heavy metals remain closely linked to soil constituents, their accessibility is reduced; however, when conditions allows heavy metals to migrate from soil solution, they become the source of direct pollution of plants, contaminating further the animals who consume those plants and groundwater or surface water, by levigation.

The obtained results showed that lead and cadmium contamination of soil in Copşa Mică area its surroundings is significant, indicating a severe situation, needing measurements of pollution reduction and applying soil restoration solutions. The high heavy metal content in plants grown in the vicinity of the industrial site, as well as in different products for food purposes (especially in snails) represents a severe risk for public health.

Table 1

Lead and cadmium in monitored products

Sample	Location	Pb [ppm]	Cd [ppm]	Distance to Copsa Mică [Km]
Apples	Sorostin	0.000	0.000	18
	Micasasa	0.199	0.008	7
Aubergine	Tapu	0.000	0.000	13
Cabbage	Sorostin	0.000	0.020	7
	Tapu	0.000	0.002	13
Carrots	Tapu	0.000	0.357	13
	Seica Mare	0.006	0.000	12
	Sorostin	1.216	0.084	18
	Micasasa	0.500	0.023	7
Corn	Copsa Mică	0.000	0.167	0
	Sorostin	0.000	0.000	18
	Micasasa	0.141	0.015	7
Cow milk	Seica Mare	0.994	0.000	12
Cucumbers	Sorostin	0.000	0.009	18
Goat milk	Mihai Viteazu	0.000	0.000	60
	Seica Mare	0.027	0.000	12
Grass	**Copsa Mică**	**7.002**	**1.302**	0
	Mihai Viteazu	0.900	0.052	60
	Seica Mare	**8.991**	**1.741**	12
	Sorostin	0.000	0.072	18
	Valea Lunga	**5.078**	**0.311**	16
Ground water	Seica Mare	0.001	0.000	12
	Sorostin	0.002	0.000	18
	Micasasa	0.010	0.000	7
Mushrooms	Seica Mare	0.559	0.594	12
Onion	Seica Mare	0.000	0.001	12
	Micasasa	0.024	0.055	7
Parsley	Micasasa	0.109	0.010	7
	Seica Mare	0.010	0.000	12
Potatoes	Sorostin	0.000	0.085	18
	Tapu	0.000	0.054	13
	Seica Mare	0.024	0.069	12
	Micasasa	**5.272**	**0.055**	18
Pumpkins	Seica Mare	0.000	0.003	12
	Sorostin	0.000	0.000	18
Sheep milk	Seica Mare	0.000	0.000	12
	Sorostin	2.027	0.000	18
Snails	**Copsa Mica**	**25.001**	**2.578**	0
String bean	Seica Mare	0.016	0.056	12
	Sorostin	0.383	0.000	18

BIBLIOGRAPHY

1. ADRIANO D.C., 1986, Trace Element in the terrestrial Environment, Springer Verlag, New York, Berlin, Heidelberg, Tokio.
2. CONSTANTINESCU G.C., 2002, Environmental chemistry, Uni-Press Publ.House, Bucharest.
3. LĂCĂTUSU R., C.RĂUTĂ, S.CÂRSTEA, I.GHELASE, 1996, Soil-plant-man relationships in heavy metal polluted areas in Romania, Appl. Geochem.,11, 105-107.
4. MULLIGAN C.N., R.N.YOUNG, B.F.GIBBS, 2001, Remediation technologies for metal contaminated soils and groundwater: an evaluation., Eng.Geol., 60, 193-207.
5. NOGOWA J., 2004, Environmental cadmium exposure, adverse effects, and preventative measures,. Biometals, 17(5), 581-587
6. OSKARSSON A., ANNA W., ING-MARIE O., GRAWÉ K. P., 2004, Cadmium in food chain and health effects in sensitive population groups, Biometals, 17(5), 531-534
7. SATOH M., KOYAMA H., KAJI T., KITO H., TOHYAMA C., 2002, Perspectives on Cadmium Toxicity Research, Tohoku J. Exp. Med., 196(1), 23-32
8. STĂTESCU F., 2003, Monitoring of Soil Quality, Ed. "Gh. Asachi", Iasi.
9. WANI P.A., M.S KHAN., A. ZAIDI, 2008, Effects of Heavy Metal Toxicity on Growth, Symbiosis, Seed yield and Metal Uptake in Pea Grown in Metal Amended Soil, 81(2), 152-158.