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HEAVY METAL CONTAMINATION OF SOIL IN BAIA MARE MINING AREA

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ABSTRACT. In the Baia Mare area, located in North-Western Romania, around an industrial complex involved in mining, metallurgical and chemical activities, the environment and particularly the soils are polluted due to the acid rains and heavy metals. The soils in this area are affected by the emissions from these industrial activities. From environmental point of view, all heavy metals are very important because they cannot be biodegraded in soils, so they tend to accumulate and persist in urban soils for decades. Lead, cadmium, copper, zinc and nickel are metals frequently reported to have a high impact on organisms. Heavy metal pollution of soil enhances plant uptake causing accumulation in plant tissues and eventual phytotoxicity. In Baia Mare, 35 soil samples were collected covering the whole area (industrial and residential). The concentrations of heavy metals were determined by inductively coupled plasma atomic emission spectrometry after *aqua regia* digestion. The obtained results showed that the concentrations of Pb exceeded the intervention level for all samples; for Cu and Zn concentrations, the half of samples exceeded the intervention level; for Cd concentrations, one third of samples exceeded intervention level; for As concentrations, the majority of samples exceeded alert level; Cr concentrations exceeded alert level for two samples; and the alert level for Ni has not been exceeded.

Keywords: *heavy metals, pollution, Baia Mare, ICP-AES*

INTRODUCTION

Heavy metals in soils continue to receive increasing attention due to the growing scientific and public awareness of environmental issues and the development of analytical techniques to measure their concentrations accurately [1].

The soils are both a source of metals and also a sink for metal contaminants. The factors controlling the total and bioavailable concentrations of heavy metals in soils are of great importance with regard to human toxicology and agricultural productivity [2].

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Some heavy metals such as Cu, Mn, Co, Cr, Mo and Zn are essential in small but critical concentrations for the normal healthy growth of plants, animal or both, although they are toxic at high concentrations [3, 4].

The heavy metals of greatest concern with regard to the human health, agriculture and ecotoxicology are: Cd, Pb, Ni, As. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. Heavy metals are dangerous because they tend to bioaccumulate [5].

Studies of heavy metals in ecosystems have indicated that many areas near urban complexes, metalliferous mines or major road systems contain anomalously high concentrations of these elements. In particular, the soils in such regions have been polluted from a wide range of sources with Pb, Cd, As [6].

The mining, manufacture and disposal of metals and metal-containing materials inevitably cause environmental pollution [7].

EXPERIMENTAL SECTION

The ecological role of soil in urban ecosystems is very important. The state of the urban environment is affected by different sources of contamination, being a complex problem, especially when pollution is considered [8].

Mining and nonferrous ore processing activities are the leading cause of metal emissions, often associated with elevated soil concentrations in adjacent regions.

The industrial activities in this area have lead to contamination of air, soil and vegetation for decades. The winds and residual water infiltration have a serious contribution to the pollutant dispersion in soil and ground waters, reaching also the food chain since the residents from rural adjacent areas cultivate the vegetables and the animals feed in their own gardens. Considering all these aspects, it is important to monitor the heavy metal pollution in soils from this area [9].

This paper reports the determination of heavy metals in soil samples for the pollution assessment of the Baia Mare area. Lead, copper, cadmium, zinc, chromium, nickel and arsenic contents have been chosen as indicators of the pollution degree for the studied area.

In our study, the soil samples were collected to cover the whole area (industrial and residential) and to reflect both industrial and traffic pollution. The sampling sites of soils are represented in figure 1.

A number of 35 soil samples were collected in Baia Mare, in March 2007. Soil samples were collected at 0-20 cm depth and were stored in polyethylene bags for transport to laboratory. The soil samples were air-dried,

mechanically ground and sieved to obtain the fraction below 2 mm. To determine the total content of heavy metals, the soil samples were digested in *aqua regia* (HCl 37.5% and HNO_3 65%), during 16 hours at room temperature and then, 2 hours, at reflux conditions.

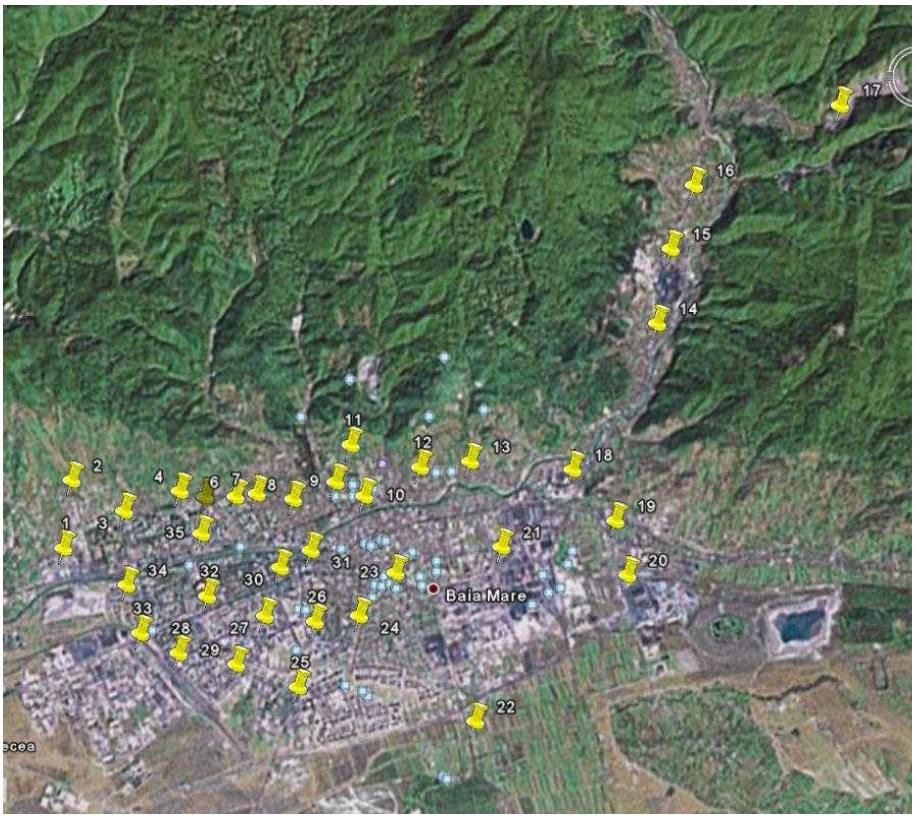

Figure 1. The sampling sites in Baia Mare.

The extract was analyzed by inductively coupled plasma atomic emission spectrometer (ICP-AES) using a SPECTRO FLAME (SPECTRO, Kleve, Germany). The quantification was performed using an external calibration with multielemental Merck standard solution.

The method detection limits and the uncertainties used in ICP-AES analyses for each metal are given in table 1.

In table 2 are shown the variation ranges, mean concentrations in soil and alert levels for sensitive soils, for Pb, Cu, Cd, Zn, Ni, Cr and Mn.

Table 1.

Detection limits and uncertainties of ICP-AES.

Element	Detection limit (DL), mg/kg	Uncertainty, %
Pb	2.2	8.9
Cu	0.25	7.9
Cd	0.25	9.2
Zn	0.5	7.8
Ni	0.7	8.2
Cr	2.1	9.0
Mn	0.1	7.6

Table 2.

Variation ranges, mean concentrations in soil, alert and intervention levels for sensitive soils.

Element	*Aqua regia*		Alert level (mg/kg)	Intervention level (mg/kg)
	Variation range (mg/kg)	Mean concentration (mg/kg)		
Cr	37,3-169	63,7	100	300
Ni	5,9-16,7	10,3	75	150
Cu	38,1-1770	314	100	200
Zn	109-11500	1830	300	600
Pb	87,8-23300	1792	50	100
Cd	1,9-29,9	7,9	3	5
As	22,6- 1910	166	15	25

RESULTS AND DISCUTIONS

The distribution of Cd, Ni, Cr contents, extracted in *aqua regia*, in Baia Mare area is represented in figure 2, and the distribution of Pb, Cu, Zn, As in figure 3, respectively.

The figures show that the obtained values are homogenous for Cd, Ni, Cu and As and varies in larger ranges for Pb, Cr and Zn.

The mean values of the determined concentrations are shown in figures 4 and 5, respectively.

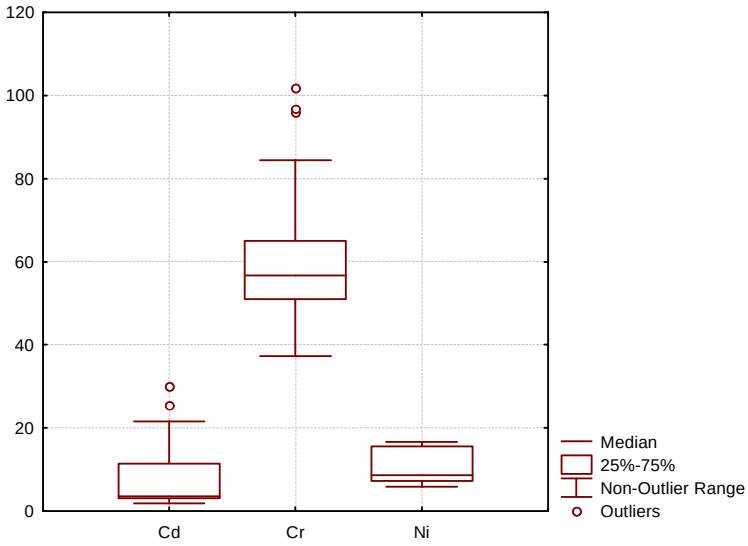

Figure 2. The distribution of Cd, Cr, Ni concentrations.

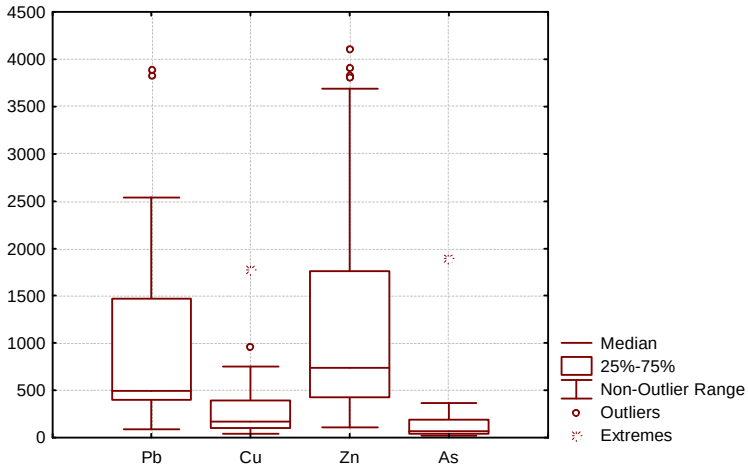

Figure 3. The distribution of Pb, Cu, Zn, As concentrations.

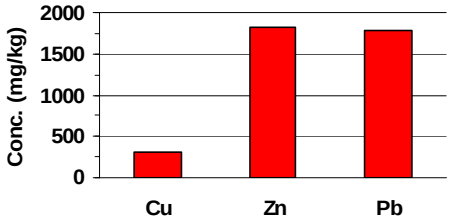

Figure 4. Mean concentrations of Cu, Zn, Pb in Baia Mare area.

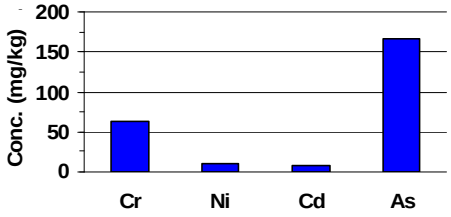

Figure 5. Mean concentrations of Cr, Ni, Cd, As in Baia Mare area.

The obtained results showed that the concentrations of Pb exceeded the intervention level for all samples; for Cu and Zn concentrations, the half of samples for Cd and third of samples for As exceeded the intervention level; and for booth metals the majority of samples exceeded alert level. The Cr concentrations exceeded alert level for two samples, and the alert level for Ni has not been exceeded.

CONCLUSIONS

The results showed that heavy metals contamination of soil in Baia Mare area is significant, indicating a severe situation, needing urgent measurements of pollution stopping and applying soil decontamination solutions, especially they cannot be degraded or destroyed.

Due to the high metal content from both areas the metal accumulation in vegetables grown in the vicinity of industrial sites represents a potential risk for public health.

The determined concentrations represent a tool for human health risk assessment and urban soil quality evaluation for planning and soil management practices [10].

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