University of Belgrade, Tecnical Faculty in Bor and
Mining and Metallurgy Institute Bor

43rd International October Conference On Mining and Metalurgy

The 43rd International October Conference on Mining and Metallurgy
12-15 October 2011, Kladovo (Serbia)
www.ioc.tf.bor.ac.rs

TRANSFER OF HEAVY METALS TO SPONTANEOUS FLORA FROM SOIL DEVELOPED ON A MINING AREA (SW ROMANIA)

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* Partially sustained by the project "Cross-border network for advanced training and research in environmental protection – RoS-Net" (code 464) within the Romania-Republic of Serbia IPA Cross-border Cooperation Programme

Abstract

The heavy metals derived from mining activity can contaminate aquatic and terrestrial ecosystems which represent a major environmental problem. In this study, we assess the heavy metals in soil and plants collected from an area contaminated by mine tailings from Ocna de Fier (SW Romania). Soils and plants samples collected were analyzed using a Varian Spectra AAS. Results show that the soils affected by mining activities contain Mn, Cr, Cu, Pb, Zn, Cd above toxic thresholds. Also, results show that spontaneous plants could phytoextract heavy metals that depend on the accumulation ability that differs with species, category and metal concentrations.

Keywords: *mining activity, heavy metal, soil, spontaneous plant, phytoremediation*

INTRODUCTION

To many people, heavy metal pollution is a problem of the surrounding environment associated in special with areas of intensive industry. Soil contamination by heavy metals as a result of human activities is a major environmental risk and a serious environmental issue all over the world [1]**.** Anthropogenic activities, such as mining activity, have a serious environmental impact on water streams, soils and plants. Mining activity in Ocna de Fier area has started ever since Roman epoch, and the location was intermittently exploited until 1997 [2]. In Ocna de Fier, remnants of mining activity since bronze and iron epochs are still preserved. Mining activity has a strong imprint on the entire area. The impact of this activity upon environment can be observed not only in natural exposures and quarries, but also by the deposition of the rocks extracted from the mine as waste dumps and implicitly by pollution of waters, soil and vegetation with heavy metals [3, 4]. The dumps, as relics of past explorative works are colonized by a spontaneous vegetation which contribute to the circulation of heavy metals in the food chain through their active and passive absorption, accumulation in tissues as well as subsequent grazing by animals or consumption by humans [5]. Species growing within polymetallic mineraliza-tion zones tend to exhibit elevated levels of heavy metals in their tissues [5]. The reclamation of metal contaminated sites by spontaneous plants to toxic areas aims to stabilize the soil, immobilizing trace elements in the rhizosphere and thereby reducing the risks of the dissemination of metalliferous dust by wind, water erosion or by downward water percolation from the root zone [6].

The objective of this paper was to determine the composition and the metals concentrations of mine topsoil in the vicinity of the Ursoanea mine (the waste dump) and the availability of these metals for the natural vegetation at this site. The accumulation of metallic elements and transfer to spontaneous plants were also studied, in order to evaluate the phytoremediation ability of these plant species.

EXPERIMENTAL

In October 2008, we sampled soils and vegetation in the Ursoanea mining waste dump at Ocna de Fier. The waste dump is emplaced on the stream of Ursoanea creek which is flowing into Moravița river and this in Barzava. For the study of heavy metal contamination of environment both plant and soil samples have been collected. Soil and plant samples have been collected from five points of the dump, starting from upstream to downstream. The five species of spontaneous plants (*Taraxacum officinale, Tussilago farfara, Euphorbia sp., Verbascum banaticum, Fragaria sp.)* were collected, as well as the soil below the plants (top 0-20 cm soil layer). All sampling points were georeferenced by GPS. Soil sample preparation was done in accordance with ISO 11464/98, whereas the determination of Cd, total Cr, Cu, Fe, Mn, Pb and Zn followed the ISO 11047/99 method. Dried soil samples were digested with *aqua regia*. The plants sampling was done in accordance with the methodology described in STAS 9597/1-74. The dried plant tissues were digested with concentrated hydrochloric acid. Plant and soil extracts analysis was done using a Varian Spectra AAS (atomic absorption spectrophotometer) at the National Institute of Research and Development for Industrial Ecology Timişoara laboratories. Data resulted from the analysis of soil samples have been compared with the reference values for metal contents (mg kg^{-1} d.m.) in soils, according to the MAPPM Order 756/1997. Concentration of metals in plant was correlated with their concentration in soil.

RESULTS AND DISCUSSIONS

Soil samples collected from Ursoanea mining waste dump showed very high metal concentrations.

Thus, the highest concentrations were observed for Cd (between 8.10-16.1 mg kg^{-1} d.m.), Mn (S3=2,980 mg kg^{-1} d.m.), Cu (between 198.8 - 980.2 mg kg^{-1} d.m.) and Pb (between 342.1- 790.6 mg kg^{-1} d.m.) in the soils studied in this area (Table 1). Also, the concentration of Zn (between 314.8-497.5 mg kg^{-1} d.m.) exceed of three or four times the normal limits (100 mg kg^{-1} d.m.). These soils affected by mining activities presented Cd, total Cr, Cu, Mn and Pb above toxic thresholds. In addition, the high content in Fe (S3 = 3,147 mg kg^{-1} d.m.) is explained through presence in waste dump of minerals that are rich in Fe (hedenbergite, hematite, goethite, pyrite, ludwigite, magnetite, epidote etc).

Table 1- Concentration of heavy metals in devloped soil on the Ursoanea mining waste dump at Ocna de Fier, Roman

Sample	Metal content, mg kg^{-1} d.m.*						
	Cd	Total Cr	Cu	Fe	Mn	Pb	Zn
S1	12.80	13.40	506.80	2,993	1,445	645.7	362.9
S2	5.90	6.10	198.80	2,994	1,231	408.3	314.8
S3	8.10	69.90	476.60	3,147	2,980	342.1	497.5
S4	16.10	49.80	980.20	3,142	1,422	790.6	396.2
S5	15.20	49.90	963.11	3,135	1,456	775.8	384.3

*Dried material

The spontaneous plants were analyzed, in order to identify special characteristics that would be interesting for soil phytoremediation and reclamation [3]. Natural vegetation from the waste dump contains consistently higher levels of Fe, Mn, Cd, Cr, Cu, Zn and Pb; these concentrations of the metals in the plants were correlated with those of the soil [4]. The highest concentrations of Fe were found in *Taraxacum officinale* (P1 – Fe: 3,376.2 mg kg^{-1} d.m.), of Mn and Pb in *Euphorbia sp.* (P3 - Mn: 1,294 mg kg^{-1} d.m.; Pb: 1,761.6 mg kg^{-1} d.m.) and of Cu in *Fragaria sp.* (P5 - Cu: 196.4 mg kg^{-1} d.m.) (Table 2).

Table 2. Concentration of heavy metals in plants growing on the Ursoanea mining waste dump at Ocna de Fier, Romania

Sample	Species	Metal content, mg kg^{-1} d.m.*						
		Cd	Total Cr	Cu	Fe	Mn	Pb	Zn
P1	*Taraxacum officinale*	udl**	9.28	3.09	3,376.2	592.40	98.80	291.6
P2	*Tussilago farfara*	2.68	5.30	79.50	1,934.0	403.34	74.56	196.4
P3	*Euphorbia sp.*	1.63	38.20	62.01	1,033.6	1,294.0	1,761.6	158.9
P4	*Verbascum banaticum*	3.32	udl**	29.05	1,222.9	220.30	37.80	145.7
P5	*Fragaria sp.*	3.32	14.34	196.40	1,428.5	349.20	124.60	145.7

*Dried material **Under detection limit

Though, the ecological studies show that, in generally, lead is not accumulated in plant aerial parts [7], however, in our study, *Euphorbia sp.* (S3 - Pb:1,761.6 mg kg^{-1} d.m.) exceeded the threshold values for the hyperaccumulation of Pb, fixed at 1,000 mg kg^{-1}: [6]. All plants exam-ined (*Taraxacum officinale, Tussilago farfara, Euphorbia sp., Verbascum banaticum and Fragaria sp.*) accumulated high amounts of heavy metals. However, *Verbascum banaticum* showed lower concentrations of some heavy metals (Mn, Pb and Zn) in her tissue, in compari-son to the other four species. The lowest concentrations of Fe were observed in *Euphorbia sp.*,(P3- Fe: 1,033.6 mg kg^{-1} d.m.) of Mn and Pb in *Verbascum banaticum*, (P4 - Mn: 220.3 mg kg^{-1} d.m.); Pb: 37.80 mg kg^{-1} d.m.) and of Cu were found in *Taraxacum officinale* (P1 – Cu: 3.09 mg kg^{-1} d.m.).

Correlating the concentration of heavy metals in soil with their concentration in plants, our results show that these plants could phytoextract metals, while the ability of accumulation differs with species, concentrations and categories of heavy metals [8]. However, it is necessary to search plants that have spontaneously colonized mine tailings from ancient times and therefore are completely adapted to these polluted environments [9]. As well, vegetation can improve nutrient conditions in the soil [10] and prevent wind and rain erosion [11]. The potential use of studied species in monitoring metal concentration in the environment requires further investigation.

The metal levels observed in these soils and plants reflect the potential risk still remaining due to the past mining activities at this site [3]. Our results show that many of the plants growing in this area survivre in contact with relatively high levels of heavy metals in the soil.

•CONCLUSIONS

The soil developed on the Ursoanea mining waste dump is heavily polluted by various toxic heavy metals at different concentrations. The contamination extends out of the mining site, especially because of the transport of metalliferous particles by wind and water. All exam-ined plants (*Taraxacum officinale, Tussilago farfara, Euphorbia sp., Verbascum banaticum and Fragaria sp.*) accumulated high amounts of heavy metals. These tolerant species can be used as efficient tools for phytostabilisation and phytoremediation of toxic metal-polluted areas. These plants could phytoextract heavy metals, the ability of accumulation differed with species, concentrations and categories of heavy metals. The potential use of studied species in monitoring metal concentration in the environment requires further investigation.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Nicoleta Ianovici from Biology Department of West University of Timisoara for help in identification of plant species. This paper was prepared within Romania-Republic of Serbia IPA Cross-border Cooperation Programme, within project MIS-ETC Code 464 and Subsidy contract from IPA No 8518.

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October 12-15, 2011, Hotel "Aquastar Danube", Kladovo, Sebia