ACCUMULATION OF HEAVY METALS IN NATIVE PLANTS GROWING ON A CONTAMINATED OCNA DE FIER SITE (ROMANIA)

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ABSTRACT

In this paper, we evaluated the distribution of heavy metals (Pb, Cu, Zn and Fe) in the topsoil and plants collected from an area contaminated by mine tailings from SW Romania (Ocna de Fier). Soils and plants samples collected were analyzed using a Varian Spectra AAS. The results indicated that the soils affected by mining activities contain the high concentrations of phytotoxic metals. At the same time, our study showed that spontaneous plant species growing on contaminated sites may have the potential for phytoremediation.

INTRODUCTION

The exploitation activities in mining regions has serious consequences for the environmental by the rests of mining dumps, which represent dumping grounds of disintegrated rocks, fine-milled ores and chemical matters used during the dressing activities [1]. Contamination of heavy metals represents one of the most severe threats to water, plants and soil resources as well as human health from Ocna de Fier site. Metals are non-biodegradable and therefore persist in soils for long periods [2]. They may be transported through soils to reach ground waters or may be taken up by plants [3]. Therefore, phytoremediation can be potentially used to remediate metal-contaminated sites [4]. The purpose of this study was to investigate the heavy metal pollution in topsoil as well as the potential for bioaccumulation and phytoremediation of six species of plants growing on a contaminated Ocna de Fier site.

MATERIALS and METHODS

Plants and the associated soil samples were collected in October 2010 and analyzed for total metal concentrations. Soils and plants were sampled in vicinity of Danila Lake, in vicinity of Moravita river and from the refuse dump of Ursoanea mine from Ocna de Fier. The refuse dump is emplaced on the stream of Ursoanea creek which is flowing into Moravita. The six species of native plants (*Dactylis glomerata* L., *Dryopteris* filix-mas (L.) Schott., *Crepis sp., Equisetum arvense* L., *Tussilago farfara* L. *Cynodon dactylon* L..) 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 Cu, Pb Zn and Fe followed the ISO 11047/99 method. The plants sampling was done in accordance with the methodology described in STAS 9597/1-74. 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 $kg^{-1}$of D.M.) in soils, according to the MAPPM Order 756/1997. Concentration of metals in soil was correlated with their concentration in plant. One parameter named the Bioconcentration Factor (BCF) was calculated: BCF=metal concentration ratio of plant (Leaves + steam) to soil. This parameter is very important to estimate a plant's potential for phytoremediation purpose [4].

RESULTS

The study of the distribution of the metals (Me), in soil samples all around the Ursoanea Mare Stream (UMS), where is situated Waste Mining Dump, has shown high concentration in Pb, Cu, Zn and Fe, by comparison with the control soil samples (DL, MR) (Tables 1, 2, 3 and 4). This area is the most contaminated by metals in mining activity [5].
The analysis of plants has shown that the species collected in the vicinity of Waste Mining Dump are highly contaminated with Pb, Cu, Zn and Fe. This contamination illustrates the high amounts of these metals in the soil where they should be present as chemical forms that are mobile enough to be bio-available at the soil/root interface [6].
The concentration of metal in the soils and plants of the mining area is significantly different from the concentrations of the same elements in the soils and plants of the control ones.
The soil was mainly contaminated with Pb though both elevated Cu and Zn were found. Total lead concentrations in the soil samples collected from the site were variable, ranging from 198.9 at point 1DL to 887.5 mg kg^{-1} at point 3 UMS (Table 1). Though the site was predominantly contaminated with Pb, it also contained elevated concentrations of Cu, Zn, and Fe ranging from 33 to 867 mg kg^{-1} for Cu, from 204.7 to 557.4 mg kg^{-1} for Zn and from 2,503.0 to 3,214.1 mg kg^{-1} for Fe (Table 2, 3 and 4). Among the 5 locations sampled, points 3 and 4 were the most contaminated with all four metals (Table 1, 2, 3 and 4).
According with Alloway et al., [7] the metal concentrations in plants vary with plant species.
The lead concentrations in the plants ranged from 45.45 mg kg^{-1} (*Cynodon dactylon*) to 345.28 mg kg^{-1} (*Equisetum arvense*) (Table 1). None of the plant species accumulated Pb above 1000mg kg^{-1} in the aerial part, the criteria for a hyperaccumulator [8]. Copper concentrations in the plants varied from 58.8 (*Crepis sp*) to 222.7 mg kg^{-1} (*Cynodon dactylon*) and no plant species accumulated Cu above 1000 mg kg^{-1} (Table 2). The Zn contents in the plants ranged from 51.47 (*Crepis sp.*) to 176.67 mg kg^{-1} (*Cynodon dactylon*) (Table 3).
In this study, none of the plant species showed metal concentrations >1000mg kg^{-1} in the aerial part (Leaves and steam) (Tables 1, 2, 3 and 4). However, the ability of these plants to tolerate and accumulate heavy metals may be useful for phytostabilization. The bioconcentration factor (BCF) can be used to estimate a plant's potential for phytoremediation purpose [4]. Though none of the plants sampled were metal hyperaccumulators, some interesting observations were noted. Based on the average BCFs of all plant samples, aerial parts were most efficient in taking up Cu (BCF=1.23) and Zn (BCF=1.06). Among the four metals tested, only *Tussilago farfara* (site UMS) were most efficient in taking up Cu and *Dactylis glomerata* (site DL) in taking up Zn. These results may indicate that plant species growing on the site contaminated with heavy metals were tolerant of these metals.[4].

The information on soil and plant metal concentrations from this site is needed to assess the severity of the pollution and develop a strategy for soil reclamation such as phytoremediation and phytostabilization [9](**Escarré et al., 2010**)

Table 1. Lead concentrations in topsoil and plant samples (mg kg^{-1}) from the Ocna de Fier site, Romania

Site	**Sampling points**	**Species**	**Leaves + steam**	**Topsoil**	**Bioconcentration factor (BCF)**
Danila Lake (DL)	1 DL (control)	*Dactylis glomerata* L.	26.76	27.1	0.98
Moravita River (MR)	2 MR	*Dryopteris* filix-mas (L.) Schott.	32.42	198.9	0.16
Ursoanea Mare Stream (UMS) where is situate Waste Mining Dump	3 UMS	*Crepis sp.*	53.8	887.5	0.06
		Equisetum arvense L	58.85	550.0	0.10
		Tussilago farfara L.	80.26	115.6	0.69
	4 UMS	*Cynodon dactylon* (L.) Pers	45.45	722.1	0.06
		Equisetum arvense L.	16.74	713.0	0.02
		Tussilago farfara L.	78.37	733.3	0.10
	5 UMS	*Equisetum arvense* L.	345.28	769.8	0.44
		Tussilago farfara L.	27.78	786.0	0.03

Table 2. Copper concentrations in topsoil and plant samples (mg kg^{-1}) from the Ocna de Fier site, Romania

Site	**Sampling points**	**Species**	**Leaves + steam**	**Topsoil**	**Bioconcentration factor (BCF)**
Danila Lake (DL)	1 DL (control)	*Dactylis glomerata* L.	16.1	79,6	0.20
Moravita River (MR)	2 MR	*Dryopteris* filix-mas (L.) Schott.	15.0	33,0	0.45
Ursoanea Mare Stream (UMS) where is situate Waste Mining Dump	3 UMS	*Crepis sp.*	58.8	534.6	0.10
		Equisetum arvense L	82.29	741,1	0.11
		Tussilago farfara L.	82.89	66,5	**1.23**
	4 UMS	*Cynodon dactylon* (L.) Pers	222.7	385.5	0.57
		Equisetum arvense L.	12.62	375.1	0.03
		Tussilago farfara L.	50.67	388,5	0.13
	5 UMS	*Equisetum arvense* L.	87.41	867.3	0.10
		Tussilago farfara L.	27.78	845.4	0.03

Table 3. Zinc concentrations in topsoil and plant samples (mg kg^{-1}) from the Ocna de Fier site, Romania

Site	**Sampling points**	**Species**	**Leaves + steam**	**Topsoil**	**Bioconcentration factor (BCF)**
Danila Lake (DL)	1 DL (control)	*Dactylis glomerata* L.	65.62	61.6	**1.06**
Moravita River (MR)	2 MR	*Dryopteris* filix-mas (L.) Schott.	53.68	64.0	0.83
Ursoanea Mare Stream (UMS) where is situate Waste Mining Dump	3 UMS	*Crepis sp.*	51.47	382.6	0.13
		Equisetum arvense L	130.20	432.1	0.30
		Tussilago farfara L.	59.21	204.7	0.28
	4 UMS	*Cynodon dactylon* (L.) Pers	176.67	555.3	0.31
		Equisetum arvense L.	65.53	556.4	0.11
		Tussilago farfara L.	84.45	557.4	0.15
	5 UMS	*Equisetum arvense* L.	80.41	387.3	0.20
		Tussilago farfara L.	67.96	389.5	0.17

Table 4. Iron concentrations in topsoil and plant samples (mg kg^{-1}) from the Ocna de Fier site, Romania

Site	**Sampling points**	**Species**	**Leaves + steam**	**Topsoil**	**Bioconcentration factor (BCF)**
Danila Lake (DL)	1 DL (control)	*Dactylis glomerata* L.	799.0	2,705.6	0.20
Moravita River (MR)	2 MR	*Dryopteris* filix-mas (L.) Schott.	817.0	2,627.0	0.31
Ursoanea Mare Stream (UMS) where is situate Waste Mining Dump	3 UMS	*Crepis sp.*	385.3	2,976.0	0.12
		Equisetum arvense L	612.24	3,030.0	0.20
		Tussilago farfara L.	357.9	2,503.0	0.14
	4 UMS	*Cynodon dactylon* (L.) Pers	995.45	3,214.1	0.30
		Equisetum arvense L.	557.0	3,101.0	0.17
		Tussilago farfara L.	656.5	3,016.0	0.21
	5 UMS	*Equisetum arvense* L.	491.07	3,045.0	0.16
		Tussilago farfara L.	666.67	3,143.1	0.21

CONCLUSIONS

The geochemical investigation has shown that the soil, in slopes of Ursoanea Mare Stream is contaminated by Pb, Cu, Zn and Fe, due to the location of mining wastes in this area and of wind. The analysis of plants has shown that the species collected in the vicinity of Waste Mining Dump are contaminated with Pb, Cu, Zn and Fe. Among the 10 plant samples of 6 plant species, no plant species were identified as metal hyperaccumulators. However, 2 plants had BCF greater than one. *Tussilago farfara* (site UMS) were most efficient in taking up Cu and *Dactylis glomerata* (site DL) in taking up Zn. The phytoremediation potential of these plant species needs to be investigated.

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