Characterization of soil Heavy Metal Contamination in the Abandoned mine of Zaida (High Moulouya, Morocco)

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Abstract

The abandoned mine of Zaida, located at about 30 km NW of Midelt in the Upper Moulouya (Morocco), was one of the main lead deposits operated between 1972 and 1985. The mining activities in this site generated large amounts of waste stored as tailings pits. The purpose of this study is to assess the total content of heavy metals in soils located around the tailings area and their spatial variation. Forty-two samples were taken from a depth of 20 cm and analysed for Cu, Zn, Cr, Co, Cd, Ni and Pb Using ACP-AES. Results showed that soils in the studied area have medium to low levels compared to normal levels of non-contaminated soil, except near the tailings and the mining center where the recorded levels are relatively high compared to the values of non-contaminated soil taken from the literature and are highly enriched in metallic elements.

Keywords: Soils, tailings, heavy metals, contamination, Zaida.

Introduction

Contamination of natural resources by heavy metals, especially soil contamination due to the disposal of industrial and urban wastes is one of the most pressing environmental issues[1, 2], because they cannot be biodegraded and they persist in the environment for a long time[3-5]. They also might enter the food chain and threat human health and animal health[6]. The mining activities are among the main sources of soil contamination by heavy metals. This risk may arise during operation and after mine closure du to tailings which are often stored in the absence of any environmental management plan. In the abandoned mine of Zaida, Many authors have shown the presence of high content of heavy metals in the different components of environment around the site including soils[7,8]. This study aims to determine soil contamination levels by heavy metals around the tailings and the spatial variation of this contamination.

Material and Methods

To assess heavy metals soil contamination levels in the mining center of Zaida, geochemical analyzes were conducted to determine concentrations of Pb, Cu, Zn, Cd, Co, Cr, and Ni. Table 1 presents a brief description of the studied area.

Forty two soil samples were collected from a depth of about 0-20 cm. The soils were sampled using a plastic shovel and placed in clean plastic bags and stored at room temperature. The location of the sampled points is shown in figure 1.

Analysis of physico-chemical parameters (pH, electrical conductivity, total calcium, phosphorus, potassium and organic matter) were conducted at the National Institute for Agricultural Research in Rabat.

Total heavy metal concentration (Pb, Co, Zn, Cu, Cd, Cr and Ni) was determined by ICP-AES (Inductive Coupled Plasma - Atomic Emission Spectroscopy). Samples were analyzed at the National Centre for scientific and technical studies of nuclear energy (CNESTEN) and the National Centre for Scientific and Technical Research in Rabat, Morocco.

Table-1
Brief description of the study area

Name	Zaida
Situation	High Moulouya, 30 Km North East of Midelt
Climate	Aride (annual rainful: 300 mm)
Soil types	Mineral soil regosoil and calcisoil
Period of mining	1972-1985
Mining method	Open pit methods

Results and Discussion

Physico-chemical parameters: Table-2 presents some physico-chemical properties of studied soil samples located around the abandoned mine of Zaida. The pH value ranged between 7 and 8.6. Based on previous studies[9,10], this alkalinity can be attributed to the presence of carbonates.

Soils have low salinity because. The electrical conductivity values ranged from 0.10 to 1.43 µS/cm. All the soil samples presented a low organic matter content ranging from 0.3 to 2.66%, The obtained results showed that soils in the mining area of Zaida are calcareous, with values ranging from 0.55 to 77.95%. These calcium concentrations are attributed to the formation lithology of the studied area[2].

Heavy metal contents in soil: Levels of heavy metals in soil are shown in table 3. The analysis of obtained results showed that the investigated soils contain high levels of heavy metals. The mean levels were 0.99 for Cd, 5.42 for Co, 47.35 for Cr, Cu for 15.31, 13.12 for Ni, 48.50 for Zn and 94.49 for Pb. These contents are relatively high compared to uncontaminated soil standards carried by other authors[11-14]. Two main factors seem to influence the level of soil contamination. The first factor is the distance from the tailings dam. Analysis of obtained results revealed that soils in the vicinity of tailings are more affected by metal pollution. Heavy metal contents decrease with increasing distance between the sampled points of mining wastes.

The second factor that seems to have a direct effect on the degree of soil contamination is the wind dispersion of sand particles. High contents of heavy metals were founded in the North East and South West direction, which correspond to the two prevailing wind directions in this area. Many authors reported that the contamination of land surrounding the mining sites is favoured by the wind [15, 16].

According to Baghdad[7], High Moulouya is submitted to intense wind erosion that allows the dispersion and transport of sand particles towards remote areas. Indeed, the ETM evacuation can be carried out under the very active action of winds in the region from mining residues that were abandoned without adequate stabilization.

Table-2
Physico-chemical characteristics of soils in Zaida mine

	pH	CE µS/cm.	CaCO3‾ total%	MO %	P mg/kg	K⁺ mg/kg
Minimum	7,00	0,10	0,55	0,30	2,14	146,00
Moyenne	8,16	0,31	39,04	1,26	19,37	299,62
Maximum	8,60	1,43	77,95	2,66	197,10	732,04

Table-3
Average, minimum and maximum contents (mg / kg) of heavy metals in soil samples

	Cd	Co	Cr	Cu	Ni	Zn	Pb
Minimum	0,03	0.38	0.01	0.11	0,03	0,13	0,36
Moyenne	0,99	5,42	47,35	15,31	13,12	48,50	94,49
Maximum	3,00	20,40	777,20	77,2	48,90	206	830,95
[1]	0,35	-	-	30	-	90	35
[2]	-	-		5-80	-	20-300	2-200
[3]	0,05 -0,45	2 à 23	10 à 90	2 à 20	2 à 60	10 à 100	9 à 50
[4]	0,2 - 1	10	70 - 100	20 - 30	50	50	10 - 30

i. Natural levels in the terrestrial crust.

Figure-1
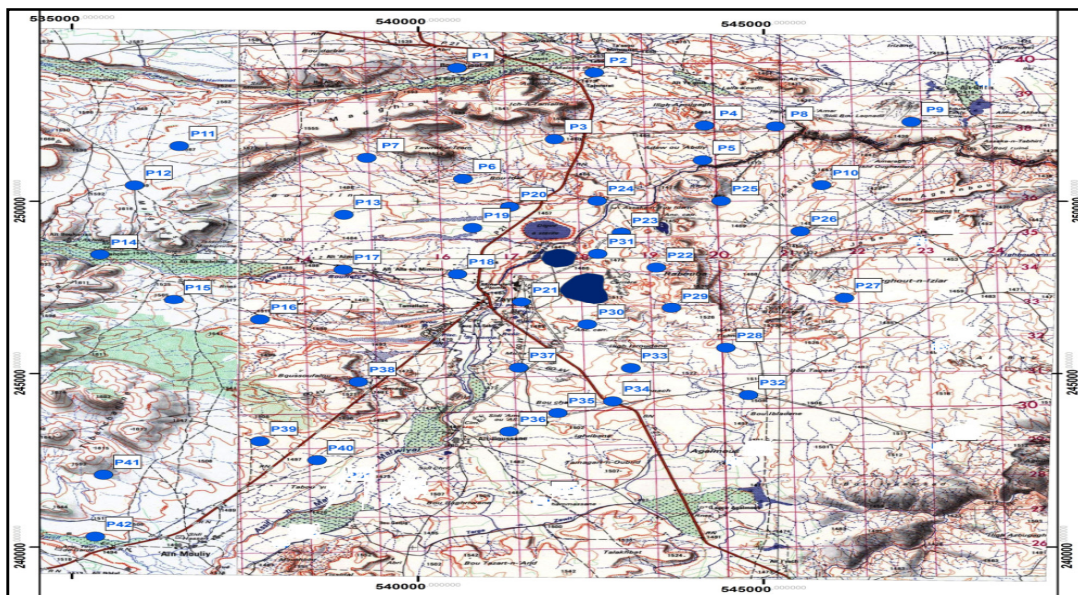**Distribution of sampled points**

Conclusion

The assessment of soil contamination by heavy metals (Cu, Zn, Cr, Co, Cd, Ni and Pb) in the district of Zaida shown that soils are affected by polymetallic pollution. Indeed, the soils located near the tailings dam and those in the two main prevailing wind directions in the studied area have relatively high levels compared to the values of uncontaminated soil from the literature. This enrichment by heavy metals can be mainly attributed to the action of the wind on the sand particles. Therefore, tailings of Zaida Mine, which were abandoned without any rehabilitation plan, constitute a major source of soil contamination by ETM.

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