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RESEARCH ON CADMIUM SOIL POLLUTION IN THE FORMER ALMASU MARE MINING AREA

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Abstract

The gold mining activity performed in the past in Romania has led to the pollution of the environment, the degradation of large areas of land and currently represents a significant risk to human health. As a result of the gold mining activities performed in Almasu Mare area, there were large sterile dumps and gold mine galleries that continue to give their mark on the quality of the environment and human health through the amount of heavy metals in the soil and the sterile material improperly deposited, the water that comes out of the underground to the contaminated surface and which flows into the rivers in an uncontrolled way. This paper brings details of cadmium soil pollution in the studied area. The results obtained in the analysis of cadmium concentrations through the AAS spectrometry show that the analysed soil exceeds the admissible limits provided by the legislation in force, and the sterile material collected from the sterile dumps reflects values of the Cd concentration in the interval 10.7 – 22.6 mg/kg. Due to the high concentrations present in the soil and sterile material analysed, soil remediation interventions are required in the area.

Key words*: mining activities, sterile dump, gold mine galleries, soil pollution, cadmium concentrations.*

INTRODUCTION

Pollution has become an issue that currently concerns the entire world, its effects can lead to ecological imbalances, poisoning, etc. In the last decades, the assessment, environmental pollution and the threat they pose to the whole ecosystem have been vital challenges in the environmental engineering sciences (Pindaru, 2013; Sur and Micle, 2012).

One of the most serious soil pollution is the one caused by the presence of heavy metals, which have a particularly serious effect on the physiology of the terrestrial ecosystem vegetation as well as on humans and animals which comes in direct or indirect contact with the polluted sites.

For many regions around the world, heavy metal pollution from mining activities is considered to be a serious environmental problem. First, the fertile soil layer is lost, and then it can no longer be used agriculturally (Plugaru et al., 2017).

Pollution from the extractive industry also raises major problems along with pollution from tailing ponds and sterile dumps.

Their unsuitable management in the past has resulted in the accumulation of heavy metals in the environment, contributing to the contamination of soil substrates, the destruction of its texture, ecological landscapes, groundwater pollution and the decline in biological diversity (Liu et al., 2008).

The mining is an activity that has been taking place in Romania for more than 2000 years. The mining waste disposal has been done in many cases without preventive measures due to the lack of the legislative framework, the effect being on the quality of the environmental factors.

Consequently, many mining sites have a negative impact on human health and the environment. Many metals are essential components of the soil at low concentrations, but they exert toxic effects at high concentrations, such as those found in polluted environments (Romero et al., 1999).

Cadmium is one of the most dangerous heavy metals and is very toxic to humans and animals. It naturally occurs in soil at a concentration below 1 ppm (Karaca et al., 2010).

The aim of this paper is to determining the cadmium concentration from soil and sterile material samples collected from Almasu Mare mining area in order to apply the most suitable technology of remediation.

MATERIALS AND METHODS

The study area is located in the commune of Almasu Mare, which is situated on the southern periphery of the Apuseni Mountains, in the subunit of the Metaliferi Mountains, bordering the town of Zlatna from the county of Alba. The total area of Almasu Mare is 9330 ha. The mining activities performed in the past in Almasu Mare area have generated considerable amounts of mining waste (sterile dumps and acidic waters) in the environment that have put their mark on the quality of environmental factors (water, air and soil). Until the present no effective greening measures have been taken in the study area, which is still under the „Mining Strategy for 2008-2020" aiming at restoring the environment affected by mining operations (Keri et al., 2010; Hulpoi, 2008; Stancu, 2013).

In order to analyze the current situation of soil quality in terms of concentrations of cadmium, from the Almasu Mare area samples of soil and sterile material were collected from four different points and from three distinct depths (0-10 cm, 10-30 cm and 30-100 cm).

The first sampling point, shown in figure 1, belongs to the sterile dump „Hanes".

Figure 1. The sampling of sterile material on the „Hanes" dump

It is located approximately 150 m from the "Hanes" mine. On the surface of this heap, the vegetation is totally missing, and the acidic waters coming out of the Hanes mine pass over this wasteland and then reach the Ardeu brook and further on the Ampoi River and the Mures River.

The second sampling point is located near the „Hanes" mine, about 100 m away from it and 50 m from the sterile dump (between „Hanes" mine and the „Hanes" dump). At this point the vegetation is present very little, as can be seen in figure 2, and the soil is slightly wet, reddish-rusty due to the mine spills that have crossed this area of land.

Figure 2. The soil sampling near the „Hanes" mine

The sampling point 3 is located on the „Rades" dump (Figure 3), and the sampling point 4 along the „Rades" gallery.

Figure 3. The sampling of waste material on the „Rades" dump

The sampling point 4 is located in front of the Rades heap, the sampling point 5 is upstream of the dumps and mine galleries, and point 6 downstream of them.

Soil sampling was performed in accordance with STAS 7184/1-75 „Soils - sampling for soil and agrochemical studies" and was processed in accordance with SR ISO 10381-6: 1997 and SR ISO 11464: 1998, in November, 2016.
Soil samples and sterile material from Almasu Mare area were analyzed through Atomic Absorption Spectrometry (AAS) using a SHIMADZU AA-6800 spectrometer. Prior to the AAS analysis, the moist soil and sterile material was crumbled, dried at 40°C, sieved and milled. Then 3 g of prepared samples were placed in a 100 ml beaker with 21 ml of concentrated HCl and 7 ml of concentrated HNO_3. The glasses were covered with a glass plate and left for mineralisation. After these, samples were filtered. Since for calibration of cadmium by atomic absorption spectrometry it is necessary to draw a calibration line, calibration solutions were prepared (Figure 4).

Figure 4. The samples preparation for determination of cadmium concentrations

After preparation each calibration solution was introduced into the flame and the absorption signal was measured at the analytical wavelengths of the metals to be determined. Finally, the samples were analyzed in flame in order to measure the cadmium absorption signals followed at the same wavelengths as those used for calibration.

RESULTS AND DISCUSSIONS

In order to assess the degree of soil pollution in the studied area, the values of cadmium concentrations in the soil samples were compared with the reference values: the alert threshold and the intervention threshold for less sensitive soils set by Order No. 756/1997 of the Ministry of Waters, Forests and Environmental Protection.
Based on the values obtained, the following graphs were drawn: graphs 1, 2 and 3 showing the cadmium concentrations present at the six sampling points.
Figure 5 shows the Cd concentrations present in the samples of sterile material collected from the sampling point 1 („Hanes" dump) and sampling point 3 („Rades" dump).

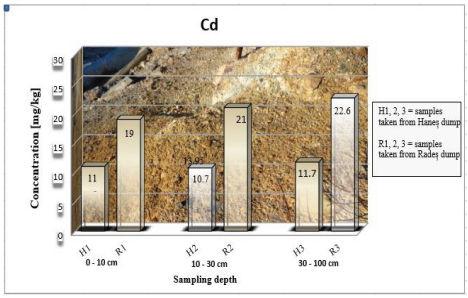

Figure 5. Cadmium concentrations present in sterile material collected from the „Hanes" and „Rades" dumps

The results obtained by analyzing the Cd concentrations in the samples collected from the sampling point 1 („Hanes" dump) showed that Cd concentration values were in the range of 10.7 – 11.7 mg/kg. The Cd concentrations determined from the samples collected from the „Rades" dump showed higher values than those in the „Hanes" dump, these being in the interval 19 - 22.6 mg/kg, a concentration increase with the depth being observed.
Figure 6 shows the Cd concentrations present in the soil samples collected from the sampling point 2 („Hanes" mine) and the sampling point 4 („Rades" mine).

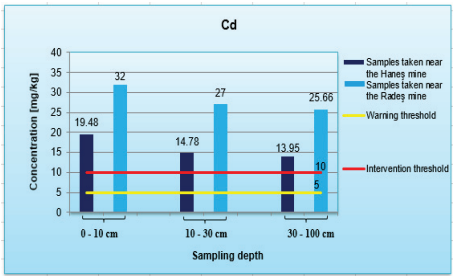

Figure 6. Cd concentrations present in the soil samples collected from near the „Hanes" and „Rades" mines

The cadmium concentrations determined from the samples taken near the „Hanes" and „Rades" mining galleries exceed the admissible values, both the alert threshold and the intervention threshold. Soil samples taken from the Hanes mine reflect a decrease in Cd concentration with depth, with values ranging from 19.48 to 13.95 mg/kg. In the case samples taken near the „Rades" mine, Cd concentrations are higher, but they also decrease with depth, ranging from 32 to 25.66 mg/kg.
In figure 7, Cd is highlighted in soil samples collected upstream and downstream of pollution sources.

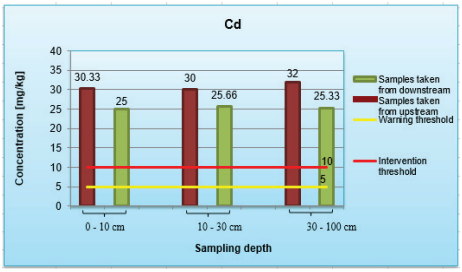

Figure 7. Cadmium concentrations in upstream and downstream of pollution sources

Upstream from the sources of pollution, the Cd concentrations are slightly higher than the downstream. Upstream were registered, values in the range 30 – 32 mg/kg, downstream concentrations were around 25 mg/kg.
All recorded values exceed both the alert threshold and the intervention threshold provided by the legislation in force.

CONCLUSIONS

The sterile dumps and mine galleries are considered to be widespread contamination of the environment. Cadmium concentration from the sterile material collected from the „Hanes" and „Rades" dumps is in the range 10.7 – 22.6 mg/kg. All of the soil samples collected from near the mine galleries exceeds the alert threshold and the intervention threshold. The samples collected near the „Rades" mine are higher than those near the „Hanes" mine.
Upstream and downstream of pollution sources, Cd concentrations are higher than downstream of these. Both sampling points exceeded the intervention thresholds at all sampling depths. In this area it is necessary to apply remediation methods.

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