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ASSESSMENT OF *AQUA REGIA* EXTRACTABLE AND PLANT-AVAILABLE Pb CONTENT IN POLLUTED SOIL

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ABSTRACT. In this study for monitoring the soil contamination with Pb in the industrially polluted area of Baia Mare, the *aqua regia* extractable Pb content as well as the plant-available fraction were determined by inductively coupled plasma atomic emission spectrometry, after extraction in HCl-NHO_3 mixture and in buffered DTPA, respectively. The *aqua regia* extractable Pb content was in the range of 88-2200 mg/kg, exceeding in all cases the alert level (50 mg/kg) and in most cases the intervention level (100 mg/kg) for sensitive soils. The plant-available Pb ranged between 10-292 mg/kg, exceeding in most soil samples the concentration limit of 20 mg/kg DTPA-extractable Pb considered to be the maximum level to avoid human risk. The average percentage of plant-available Pb was 21% showing that considerable amounts of Pb could be absorbed from soil by plants and propagated through the food chain in human organism.

Keywords*: soil contamination, aqua regia extractable Pb content, plant-available Pb*

INTRODUCTION

Lead is naturally found in the Earth's crust at about 15–20 mg/kg rarely occurring in its elemental state, but rather in its +2 oxidation state in various ores. However, the highest levels found in the environment come from human activities [1].

Pollution with lead is of major concern due to its high toxicity and potential to accumulate. The Environmental Protection Agency (EPA) has determined that lead is a probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic lead compounds are probably carcinogenic to humans, but the organics are not classifiable as to their carcinogenicity in humans based on inadequate evidence from studies in humans and in animals [2].

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Data obtained following the *aqua regia* extraction can be regarded as an approximation of the total contents, which is of concern especially for soils affected by anthropogenic contamination, but does not provide information regarding availability [3].

To assess the plant-available fraction, a great variety of single or sequential extraction schemes have been developed [4, 5]. The extraction with diethylenetriaminepentaacetic acid (DTPA) was initially designed to predict micronutrient deficiencies in soil, but it has also been employed for the estimation of metal availability for plants [6, 7].

This paper presents the *aqua regia* extractable Pb content as well as the plant-available Pb fraction determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) after extraction in *aqua regia* and in buffered DTPA, respectively, in Baia Mare.

EXPERIMENTAL SECTION

Situated in North West Romania, Baia Mare is one of the pollution hot spots of the region [8]. There is a long mining history in the surrounding area but the pollution becomes severe in the recent decades as a result of industrial development.

In a study for monitoring the soil contamination with Pb in the industrially polluted area of Baia Mare, 30 soil samples were collected in the summer of 2007 [9-11].

In each case the soil samples were collected from 0-20 cm depth using a stainless steel shovel, air dried to constant weight, sieved through a 2 mm diameter sieve. The fraction below 2 mm was split in two parts. One part was stored in polyethylene bags for the determination of plant-available Pb content. The other part was ground to a fine powder in a tungsten-carbide swing mill for 3 min and sieved through a 250 μm sieve. The fraction below 250 μm was homogenized and stored in polyethylene bags until the *aqua regia* extraction.

In order to determine the *aqua regia* extractable Pb contents, samples were processed according to ISO 11466:1995. An amount of 1 g soil sample (<250 μm) was weighed, introduced into the reaction flask and maintained at room temperature for 16 h with 21 ml of 12 M HCl and 7 ml of 15.8 M HNO_3. The mixture was then heated under reflux conditions for 2 h. The solution was filtered and diluted to 100 ml with 0.5 M HNO_3.

The plant-available Pb contents of soils were extracted in DTPA according to ISO 14870:2001. An amount of 10 g of soil sample (<2 mm) was weighed into a 125 mL Erlenmeyer flask, then 20 mL of DTPA extracting solution was added. Each flask was covered with a stretchable parafilm and shaken for 2 h at room temperature using a magnetic shaker.

Aqua regia extractable and plant-available Pb concentrations were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) using the scanning spectrometer SPECTROFLAME (Spectro Analytical Instruments, Kleve, Germany).

RESULTS AND DISSCUSION

The range, lower and upper quartile and median of *aqua regia* extractable and plant-available Pb are presented in figure 1.

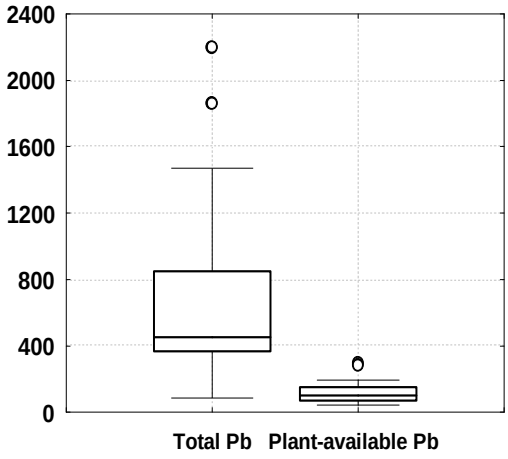

Figure 1. The range, lower and upper quartile and median of *aqua regia* extractable (total) and plant-available Pb.

The *aqua regia* extractable Pb content was in the range of 88-2200 mg/kg with an average of 680 mg/kg, exceeding in all cases the alert level (50 mg/kg) and in most cases the intervention level (100 mg/kg) for sensitive soils.

The averages of *aqua regia* extractable and plant-available Pb contents are presented in figure 2.

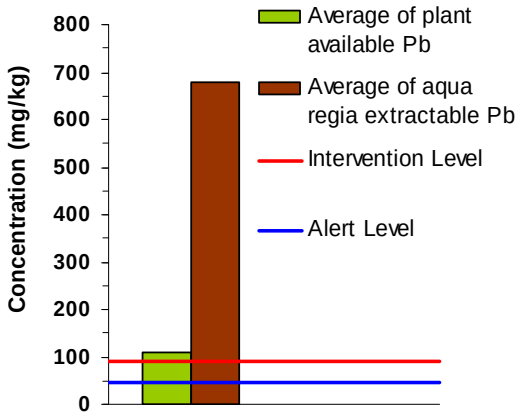

Figure 2. The average of *aqua regia* extractable and plant-available Pb contents.

The plant-available Pb ranged between 10-292 mg/kg with an average of 110 mg/kg, exceeding in most soil samples the concentration limit of 20 mg/kg DTPA-extractable Pb [12] considered to be the maximum level to avoid human risk.

The average percentage of plant-available Pb was 21% showing that considerable amounts of Pb could be absorbed from soil by plants and propagated through the food chain in human organism.

CONCLUSIONS

The high contents of *aqua regia* extractable and plant available Pb found in soil show a severe pollution in the studied area. Considering the environmental mobility and the toxicity of lead a global initiative aimed to monitor and minimize human and environmental consequences of the ongoing lead emissions is mandatory.

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