Iranian Journal of Mining Engineering (IJME)
Vol 17, No 54, 2022, pp 21-23

DOI: 10.22034/IJME.2021.522564.1846
DOR: 20.1001.1.17357616.1401.17.54.6.2

Iranian Society of Mining Engineering (IRSME)

Spatial Distribution of Lead And Zinc And Their Potential Risk Levels in The Soils Around the Ahangaran Mine, Malayer, Hamedan Province

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Recived:2021/01/06 - Accepted: 2021/07/31

Abstract

The bioavailability of potentially harmful elements such as heavy metals has been ignored in many researches, and most studies are conducted based on total concentration. Considering that the total concentration of metals, in most cases, shows limited information about the mobility and bioavailability of heavy metals, therefore, partial concentration or extraction is the best method in estimating the content of metals in soil. In this study, 40 samples were collected from surface soils around the mine, tailing and agricultural soils around the Ahangaran mine. Total concentrations of lead and zinc were determined by ICP-OES, and the bioavailable fraction was carried out by single-stage method extraction (0.1N HCl) using atomic absorption spectroscopy (AAS). The contamination factor (CF) results for Pb in tailing and around the mine areas indicate very high contamination and moderate contamination for agricultural soils. The amount of CF for Zn presents a very high contamination factor in tailings and moderate contamination factor in the other areas. Pollution load index (PLI) values show that the tailings and soils around the mine are extremely polluted, and agricultural soils are moderately polluted. The Risk Assessment Code (RAC), which was calculated based on zinc and lead bioavailability, presented moderate risk for zinc in all study areas and low risk and for Pb (except agricultural soils that show moderate risk). Low bioavailable values indicate the presence of Pb and Zn in the residual phase (in the form of minerals) that do not pose much risk to living organisms. Increasing the amount of bioavailability in agricultural soils located at farther distances from the mine indicates the presence of these metals in carbonate and exchangeable phases.

Keywords

Bioavailability, lead and zinc, Ahangaran mine, Malayer.

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1- Introduction

Pollution of soils with potentially toxic elements is one of the most important hazards threatening natural ecosystems' health. The bioavailability of heavy metals has been ignored in many researches, and most studies are conducted based on total concentration. Considering that the total concentration of metals, in most cases, shows limited information about the mobility and bioavailability of heavy metals, therefore, partial concentration or extraction is the best method in estimating the concentration of metals in soil. In recent decades, Mining activities have led to the disruption of the geochemical and biochemical circles of these elements. The mine tailings are the most important pollution source of surrounding soils and groundwater. The present study was conducted to determine the intensity of soil contamination by heavy metals (Pb, Zn), identify the locations with high contamination levels, and assess the health risk and bioavailability of lead and zinc metals in the surrounding soils of the Ahangaran mine.

2- Methods

After the preliminary field studies, 33 soil samples from surface soils around the mine, three agricultural soils, three tailing samples, and one control sample were collected. First, the soil samples were air-dried at room temperature. Then, the large fragments and plant residuals were removed from the samples, and the remaining portion was passed through a 2 mm sieve, then physicochemical properties were determined. Total concentrations of lead and zinc were determined by ICP-OES, and the bioavailable fraction was carried out by single-stage method extraction (0.1N HCl) using atomic absorption spectroscopy (AAS). In order to evaluate the relationship between heavy metals (Pb, Zn) and soil properties, methods of assessing metal contamination and Pearson correlation were used.

3- Findings and Argument

The texture of the samples is medium to fine-grained (sandy silt). The range of calcium carbonate in samples was 1.35-24.72%. The average amount of organic matter in mine tailings around the mine and agricultural land is 4.8, 5.58 and 6.27%, respectively. The distribution map of lead and zinc elements in the study area is shown in Figure 1. The highest concentrations of lead and zinc are found around the mine and mine tailing.

The range of Zn bioavailability in the samples is 11-987 mg/kg. The highest bioavailability concentration of Zn was observed in samples belonging to mine tailing. Zinc can usually be absorbed onto the soil in various forms (Kabata-pendias & Pendias, 2000), that calcium carbonate in the soil acts as a strong adsorbent for the element Zn (Ramos et al., 1994). Hydrochloric acid treatment can easily separate the element Zn from calcium carbonate. Therefore, this element shows relatively high bioavailability in the samples. The range of changes in Pb bioavailability in the samples is from 1 to 223 mg/kg. The highest amount of Pb bioavailability was recorded in the samples around the mine. The Pb will not have an environmental problem as long as it is not in the form of ionic compounds. Since Soil colloids easily absorb Pb, its mobility is often reduced (Wu et al., 2004). The contamination factor (CF) results for Pb in tailing and around the mine areas indicate very high contamination and moderate contamination for agricultural soils. Pollution load index (PLI) values show that the mines' tailings and soils are extremely polluted, and agricultural soils are moderately polluted. The Risk Assessment Code (RAC), which was calculated based on the bioavailability of Zn and Pb, presented a moderate risk for Zn in all study areas and low risk for Pb (except agricultural soils that show moderate risk).

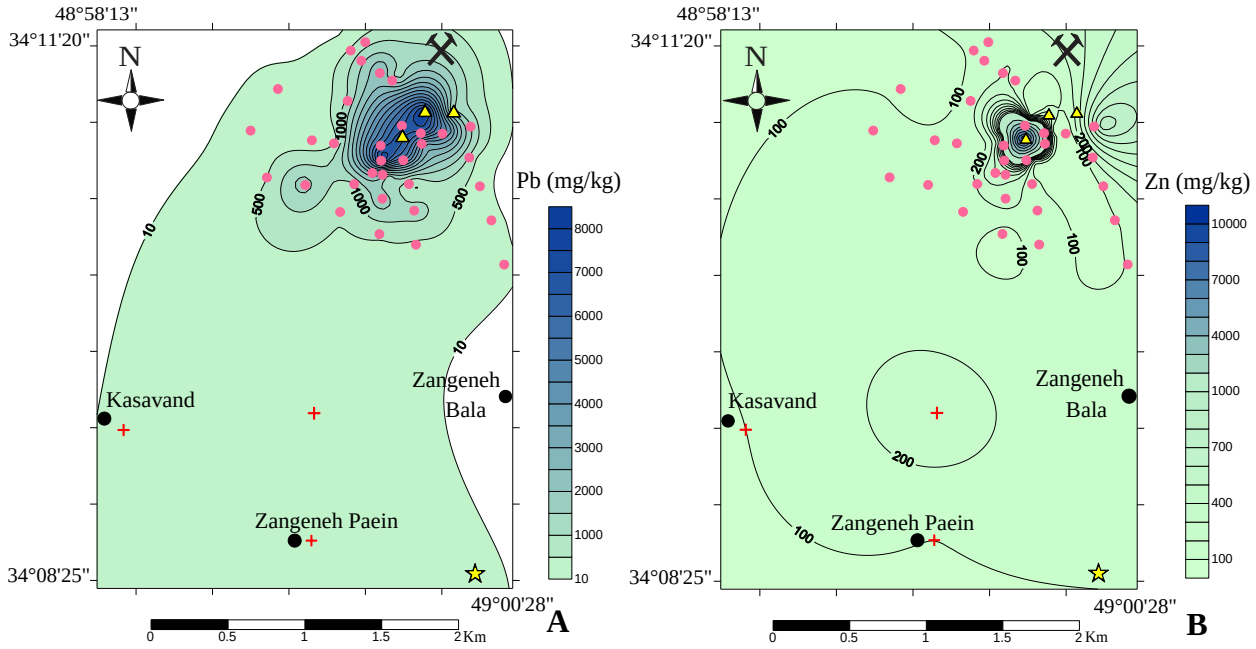

Fig 1. Distribution map of the total concentration of A) Pb and B) Zn in the Ahangaran mine area. (⚒: Location of the mine, ☆: Control sample, +: agricultural land sample, ●: Around the mine, △: mine tailing)

4- Conclusions

The results revealed that the concentration of Pb and Zn around the Ahangaran mine was increased due to the mining activities. The mine's most negative environmental and health effects resulted from higher Pb and Zn concentrations in the soil. The contamination factor (CF) for Zn presents very high CF in tailings and moderate contamination factor in the other areas. Low bioavailable values indicate the presence of Pb and Zn in the residual phase (in the form of minerals) that do not pose much risk to living organisms. Increasing the amount of bioavailability in agricultural soils located at farther distances from the mine indicates the presence of these metals in carbonate and exchangeable phases.

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