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Assessment of factors related to heavy metals distribution in abandoned mining soils in Madrid, central Spain

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Exploitation of metallic mineral deposits and its subsequent abandonment in last decades has lead to significant environmental hazard for natural systems. The present study concerns the distribution and mobility of heavy metals and trace elements mainly As, Cu, Cd, Co, Mn and V, in sulphide-rich soils. The site studied (Sierra de Guadarrama, Garganta de los Montes, Madrid) is at 1200 m asl. Soils are Humic and Dystric Cambisols (WRB) developed on gneisses; the main minerals consist of sulphides and include chalcopyrite, pyrite, marcasite, galena and arsenopyrite. Concentration data of the different species of heavy metals as dependent variables in addition to a series of independent variables mainly soil organic matter were subjected to multivariate chemometric treatments including multidimensional scaling (MDS), principal component analysis (PCA) and support vector machine (SVM) for a preliminary survey on the possible role of soil organic matter in the distribution and speciation of heavy metals in soils.

The soil heavy metals speciation was determined using the BCR (Community Bureau of Reference, European Commission) sequential extraction procedure and analysed by ICP-MS. The total contents of these elements were calculated as the sum of the four BCR fractions. The results showed element concentrations decreasing with the distance from the source of pollution. The highest amounts of As and Mn, and Cu, Cd, Co and V were found at 10 and 100 m respectively. These values exceed the allowed limits of the environmental regulation. The percentages of extractable elements (step one of BCR) in relation to total elements show that Cu and Cd were significantly more easily extractable than the other elements. Metal availability in soils was generally controlled by total metal concentration.

Data processing techniques coincided in pointing out the association of high levels of organic matter with the concentrations of elements extracted just in the most available forms: i.e. step III (mainly in the case of As and Cd), but this was also the case with elements extracted in step I, e.g., Mn and As, or in fraction II in the case of As. In general, concentrations of elements in fraction IV were unrelated to the concentration of OM.

As a whole, the amounts (mg•kg-1) of some trace elements associated with the bioavailable fraction of the soil are high (Cu 419±5; Cd 3.6±0.1), suggesting that further research is needed for a better evaluation of the potential risk of diffuse contamination and the consequences of this process on the entire ecosystem.