APPLICATION OF A RED MUD DERIVATE IN THE PHYTOSTABILISATION OF MINE TAILINGS: EFFECTS ON TRACE ELEMENTS SOLUBILITY, SPECIATION AND PLANT ACCUMULATION

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Introduction

Mine tailings are considered one of the most relevant sources of contamination associated to mining activities as they contain large amounts of trace elements (TEs), usually in highly available chemical forms (Bes et al., 2014). Phytostabilisation has proven to be an efficient remediation option for these sites, but the selection of the adequate combination of amendments is a critical issue for its success. Any modification of tailings physico-chemical and biological properties caused by the addition of amendments will have an influence on TEs mobility and bioavailability and, therefore, on their potential dispersion and transfer to living organisms (Pardo et al., 2016). In this sense, the evaluation of the effects of the amendments on parameters related to both the mobility and availability of TEs, like their solubility, speciation or accumulation in the plants will help to optimize the remediation technique and minimize any potential undesired environmental impact. The aim of the present study was to assess the use of a red mud derivate and its combination with compost in the phytoremediation of a highly acidic TEs-contaminated mine tailing, and compare with the use of hydrated lime. With that aim, TE solubility and plant accumulation were studied and their chemical speciation in soil solution modelled.

Methods

A greenhouse experiment was carried out using tailings from a mine pond situated in an area known as "El Descargador", within the mining district of La Unión-Cartagena (SE Spain),characterized by an extremely acidic pH (<3.3), high concentrations of TEs (≈1100; 4700-6900; 5000-20000 mg kg^{-1} of As, Pb and Zn, respectively), and elevated electrical conductivity (3-9 dS m^{-1}). A commercial product derived from red mud (R, mainly composed of Fe and Al oxides and Ca and Mg minerals), its combination with a mature compost (R-CM) and hydrated lime (HL) were used as amendments. The treatments were applied in field plots of 0.25 m^2, where a PVC cylinder of 20 cm of diameter and 7 cm height was inserted in the middle of each plot. After four months of field stabilization, the cylinders were extracted and transferred to a greenhouse, and seeds of *Atriplex halimus* and *Zygophyllum fabago* (halophyte species) were sown. After three months, physicochemical properties of soil and soil solution (extracted *in situ*), plant growth and shoot TEs accumulation were analysed. The speciation of TEs present in soil pore water and their saturation index (SI) were estimated using the software Visual MINTEQ 3.0.

Results

In untreated soils (CT), soluble and $CaCl_2$-extractable concentrations of some TEs were very high (especially Al, Pb and Zn) and the dominant species were free ions and SO_4^{2-}- complexes (>70% for all TEs, Figure 1). The application of the amendments increased soil pH (from 3.3 to 6.7-7), successfully reducing TEs solubility and extractability (>80-99%), but also changing the speciation of soluble Al, Cu, Pb and Zn and provoking the formation of hydroxides and/or organo-metallic forms (Figure 1). However, the treatments increased the concentrations of $NaHCO_3$- extractable As, and the addition of R (with and without compost) enlarged soluble (pore water) Tl concentrations (from 0.9 to 4.8 mg l^{-1}).

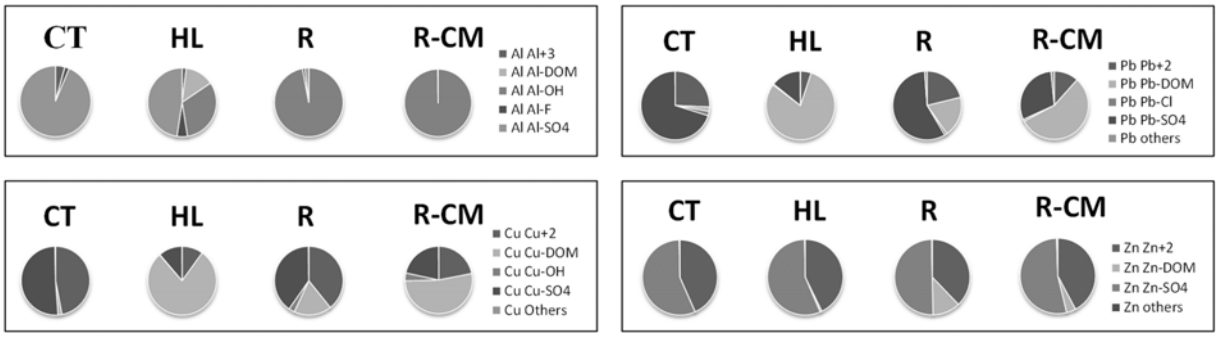

Figure 1. Distribution of the chemical species of Al, Cu, Pb and Zn present in pore water according to the model.

A. halimus and *Z. fabago* were not able to grow in untreated soils, but all treatments made it possible, and the addition of compost improved their nutritional status (higher values of K and P). Plants presented similar levels of Al, As, Cd and Zn. However, the addition of R increased Pb accumulation in *Z. fabago,* and Mn and Tl in both species, especially Tl when it was combined with compost (possibly related to the increase of K availability due to their chemical similarity; Madejón et al., 2007).

Conclusion

The red mud derivate in combination with compost can be a good phytostabilisation strategy to remediate highly acidic TEs-contaminated mine tailings. However, the dose applied must be carefully studied in order to avoid any possible solubilization of As and Tl.

References

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