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Copper removal from contaminated soils by soil washing process using camellian-derived saponin

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Antofagasta Region in North of Chile has been the main copper producer district in the world. As a consequence of a lack of mining closure regulation, a large number of abandon small-to-medium size metal-contaminated sites have been identified in the last survey performed by the Chilean Government. Therefore, more research development on sustainable reclamation technologies must be made in this extreme arid-dry zone. The objective of this study is to test the effectiveness of soil remediation by washing contaminated soil using camellian-derived saponin for the mobilization of copper.

Soil samples were taken from an abandoned copper mine site located at 30 km North Antofagasta city. They were dried and sieved at 75 μm for physico-chemical characterization. A commercial saponin extracted from camellias seed was used as biosurfactant.

The soil used contains 67.4 % sand, 26.3 % silt and 6.3 % clay. The soil is highly saline (electric conductivity, 61 mScm-1), with low organic matter content (0.41%), with pH 7.30, and a high copper concentration (2200 mg Kg-1 soil). According to the sequential extraction procedure of the whole soil, copper species are mainly as exchangeable fraction (608.2 mg Kg-1 soil) and reducible fraction (787.3 mg Kg-1 soil), whereas the oxidizable and residual fractions are around 205.7 and 598.8 mg Kg-1 soil, respectively. Soil particles under 75 μm contain higher copper concentrations (1242 mg Kg-1 soil) than the particle fraction over 75 μm (912 mg Kg-1 soil).

All washing assays were conducted in triplicate using a standard batch technique with and without pH adjustment. The testing protocols includes evaluation of four solid to liquid ratio (0.5:50; 1.0:50; 2.0:50, and 5.0:50) and three saponin concentrations (0, 1, and 4 mg L-1). After shaking (24 h, 20$\pm$1 °C) and subsequently filtration (0.45 μm), the supernatants were analyzed for copper and pH. The removal efficiencies of copper by saponin solutions were calculated in according to the concentrations of copper in aqueous solution and its initial concentration on contaminated soil.

It was found along this study that the washing of soils reaches a maximum performance when a 0.5:50 ratio soil:water, and 4 mg L-1 of saponin solution were used, in comparison with any other ratios and saponin dosage evaluated. Moreover, when saponin solution (4 mg L-1) was adjusted at pH 4.0, the efficiency of copper removal increased more than three times (98.3 mg Kg-1 soil) in comparison with the washing without pH adjustment (27.7 mg Kg-1 soil soil).

Copper removal was found to be dependent on saponin concentration. The carboxyl group of the saponin hydrophilic head molecule could form copper-aquo complexes, which contribute to the mobilization of copper. However, a low pH is also necessary to solubilize and release copper from soil allowing interaction with saponin.

It can be concluded that the use of saponin for washing soils containing copper is a cost-effective and environmental friendly alternative for cleaning and remediation of contaminated soils in the Antofagasta Region.