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Combined rehabilitation of gossan and sufide wastes by Technosol application and Cistus ladanifer L. growth

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Phytostabilisation with Cistus ladanifer L. and Technosols, containing amendment mixtures and gossan wastes (GW), is a promising solution for rehabilitation of this type of mine wastes. Sulfide wastes (SW) generating acid leachates containing great concentrations of several elements did not support any vegetation, even with amendments application. This study aimed to evaluate, in microcosm assay, the efficiency of a combined rehabilitation of SW and GW, by amendments application and development of C. ladanifer.
Composite samples of GW and SW were collected in São Domingos mine. Pot experiments were conducted with four Technosols (n=4 replicates) containing GW and mixtures of organic/inorganic wastes, at 75 and 150 Mg/ha, applied over layers of biomass ashes and limestone gravels that separate GW from SW (bottom of the pot). In Technosols, C. ladanifer was sown and it development was monitored. Chemical characteristics of Technosols (pH, EC and multielementar concentration in the available fraction), before sowing (after one month of incubation) and after three years (end of experiment), and the concentrations of the same elements in roots and shoots were determined. Gossan wastes had acid pH (3.5) and great total concentrations of several elements (g/kg; Al: 20.9, As: 10.0, Cu: 0.3, Fe; 236 and Pb: 33.4). Technosols had higher available concentrations of Ca, Fe, Mg and Mn in both sampling periods and K and Zn at the beginning (between 2 and 32-fold higher, depending on element and sampling) than control (mg/kg; Ca: 22.6-362.4, Fe: 27.0-36.8, K: 8.2, Mg: 4.0-41.5, Mn: 0.9-2.2, Zn: 0.6). In contrast, available Cu and Pb were reduced in Technosols (<0.8 and <2.8 mg/kg, respectively) compared to control (mg/kg; Cu: 1.65-2.21, Pb: 9.55-15.61). This reduction is an advantage for GW rehabilitation. However, Al and As increased between 2.5 and 6-fold in available fractions in both sampling periods, compared to control (mg/kg; 18.9-49.2 and 0.3-0.6, respectively). Seeds germination occurred in all treatments, but was stimulated in Technosols (control: 1%; Technosols: 3-6%). One month after sowing, seedlings from control died while in Technosols plants grew without visible symptoms of nutritional deficiency or toxicity. No clear tendency was observed among plants height. At the end of the experiment, plants from Technosols containing high amendment dose had the highest fresh shoot biomass (g; 75 Mg/ha: 41.2-45.0, 150 Mg/ha: 67.9-76.4) however for roots this trend was not observed (23.0-30.9 g depending on treatment). Nutrients (except Cu and Fe) were translocated from roots to shoots while Al, As and Pb were stored in roots. In general, elements concentrations in shoots were considered sufficient or below the phytotoxic level. Concentrations of Cu in shoots were deficient (2.85-3.38 mg/kg), independently of Technosol, while As concentrations in shoots from Technosol containing residues from carob liquor distillation were above phytotoxic (5.58-9.55 mg/kg; other plants: ≈3.4 mg/kg). Isolation of sulfide tailings and development of C. ladanifer in Technosols applied over SW contributed to prevent sulfides oxidation. Consequently, the generation of acid mine drainage and elements dispersion by leachates was reduced. The combined rehabilitation of these two mine wastes was adequate and environmental sustainable.