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Phytomanagement of mine tailings using Vetiver associated with vermicompost and microbial-enriched hydrogels

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Abstract

Mine tailings represent a major source of pollutants from mining activities. In addition, the poor nutritional content and adverse pH deprive tailings of a vegetation cover, which allows the dispersion of pollutants, namely metals and metalloids. However, by combining a sustainable site management system with phytotechnologies - phytomanagement - economically valuable metal-tolerant plants can be established in tailings, allowing the phytostabilization of contaminants, the decrease of acid drainage, and the control of erosion processes. Phytotechnologies also use, e.g., amendments and bioinocula to promote the plants' growth and their resilience to stress, as well as to improve the physical, chemical, and biological properties of the tailings.

Vetiver (*Chryzopogon zizanioides*) is a high-biomass crop that can withstand harsh tailings conditions and has the potential of serving as feedstock for several end-products such as fodder and building materials. Vetiver's growth may benefit from compost application and inoculation with beneficial microorganisms, such as plant-growth-promoting bacteria (PGPB) and arbuscular mycorrhizal fungi (AMF). In this work, we explored the use of vermicompost, a commercial biodegradable hydrogel (Polyter©), and bioinoculants to promote plants growth and metal stabilization in mine tailings of a wolfram former mine (Borralha mine, northern Portugal) contaminated with Cu. To assess treatments' effects, we set up a greenhouse experiment with one vetiver per 20 L-pot for 90 days. Bioinocula was comprised of a mixture of the metal tolerant PGPB *Cupriavidus metallidurans*, isolated from Borralha's tailings, and AMF spores of *Rhizoglomus irregulare*, F*unneliformis mossae,* and *F. caledonium* (INOQ Advantage©). These microorganisms were previously mixed with hydrogel in treatments where the combination of both was tested. After the three months, the development of vetiver as assessed, as well as the soil physico-chemical (e.g., pH, CEC, total and bioavailable Cu, organic matter) and biochemical properties (e.g., dehydrogenase and urease activities). The effect of the plant without any treatment on these parameters was also determined. Globally, the use of vermicompost, hydrogel, bioinoculants, and vetiver improved soil parameters, showing the feasibility of plant-based remediation strategies.

This study demonstrates the potential of the use of low-cost amendments and bioinoculants in the phytostabilization of Cu-contaminated tailings, decreasing pollutant linkages and promoting soil restoration. It also represents the valorization of wastes and the restoration of contaminated land, following the current European policies of sustainable management practices.