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Role of organic amendment for the implementation of phytoremediation strategies of ion-adsorption rare earth element mine tailings in South China

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The exploitation of ion-adsorption rare earth element (REE) deposits in South China has generated large areas of mine tailings subjected to strong erosion. Main challenges for the revegetation of these tailings are the lack of organic matter and nutrients, unfavorable physical properties, acidity and Al toxicity and potentially high residual REE contents. The implementation of strategies of phytoremediation requires the use of amendments to improve the plant growth conditions. Within this aim, the effects of the addition of an organic amendment with different dosages and at different times on the plant development and changes in soil properties was assessed in a field trial.

Experimental plots (2x2 m) were set up on abandoned REE mine tailings in the Jiangxi province, China to test different remediation strategies: i) phytostabilization using grasses, ii) production of fiber plants and iii) phytoextraction using hyperaccumulating plants. An organic amendment (pig manure and sawdust) was mixed with the first 10 cm of the tailings with different rates (low: 0.65 kg/m², medium: 1.3 kg/m², high: 2.6 kg/m²). Plant growth was monitored over time. After two growing seasons (16 months), the surface bulk soil was sampled and analyzed for physical, chemical and biological properties. Soil profiles were described and sampled to study the microstructure.

Immediate changes induced by the organic amendment included the enrichment in organic C and in macronutrients (*e.g.* N, Ca and P) proportionally to the amendment rate. The pH was also slightly increased but remained acidic (pH <5). It did not change the low CEC of the tailings (< 5 $cmol^+/kg$) but increased the nonacid saturation and tended to decrease the Al saturation as well as the extractibility of REEs. The coverage by grasses increased over time and with the rate of amendment. However, fiber plant biomass decreased the second year. Only one species of hyperaccumulating succeeded to develop on the tailings. After 16 months, the profiles showed the development of a surface layer (0-10 cm) resulting from the mixing with amendment where roots developed preferentially. It was characterized by a lower bulk density and proportion of capillary porosity compared with unreclaimed tailings. The amended layers also showed higher bacterial diversity and enzyme activities.

Addition of amendment induced persistent changes in chemical, physical and biological soil properties, which are conducive to the phytostabilization of the tailings with grasses. However, fiber plants require higher nutrient inputs and amendment practices should be further optimized to conduct phytoextraction strategy.