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Dynamics of Organic Carbon Stabilization by Minerals During Pedogenesis of Mine Tailings: A Conceptual Model

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Sustainable rehabilitation of metal mine tailings are urgent environmental challenges facing the mining industry worldwide. Eco-engineering of mine tailings to soil-like technosols has shown great potential in sustainable mine site rehabilitation (Huang et al., 2012). Soil organic carbon (OC) formation and stabilization are important processes in the eco-engineered pedogenesis from tailings as engineered parent materials, which is critical to the development of soil structure and biogeochemical functions (Wu et al., 2021). Much knowledge has been accumulated in literature on mineral stabilization of OC in natural soils and sediments, in which minerals have already been extensively weathered and stable. However, our knowledge is rather limited in the early pedogenesis phase of the tailings, which would exhibit different OC dynamics in mine tailings undergoing extensive mineral transformation. Particulay, the knowledge is lacking about how the rapid mineral weathering in tailings drive OC dynamics, early mineral protection and stabilization when the tailings undergo soil formation and ecological rehabilitation.

In the present study, we have initiated a conceptual model about OC dynamics and stabilization in tailings undergoing critical stages of eco-engineered pedogenesis (Figure 1). In the conceptual model, the dynamic weathering of minerals changes the mineralogical composition of the tailings, which drive chemical transformation, biological processing, and stabilization of OC in eco-engineered tailings, ultimately leading to OC molecular changes and stabilization. It is proposed that as pedogenesis progresses in eco-engineered tailings, mineral associated OC and its chemodiversity increase, driven by the transformation of primary minerals into secondary minerals of much elevated surface area (Figure 1). Thus, this model aims to lay down the framework to enrich our knowledge on the OC dynamics and stabilization in tailings undergoing soil formation and ecological rehabilitation. The enhanced OC stabilization and storage in tailings-soil would also contribute to the global C stock in the earth system, for sequestering CO_2 emitted into the atmosphere.

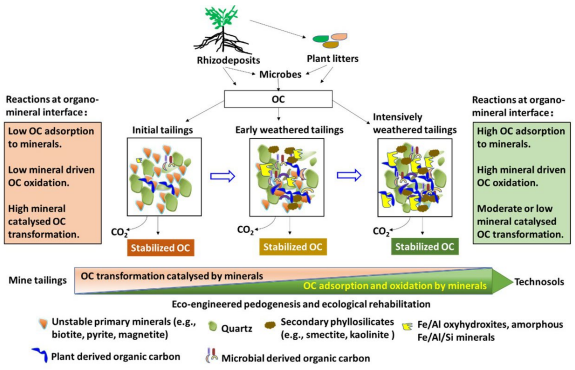

Figure 1. A conceptual model for dynamics of organic carbon stabilization driven by mineral weathering in tailings undergoing eco-engineered pedogenesis.

References:

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