New Technology for Sustainable Rehabilitation of Metal Mine Tailings with Native Plant Communities

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ABSTRACT

Successful rehabilitation of 100s-1000s ha of tailings landforms at metal mines (e.g., magnetite-Fe, base metals, and precious metals) is critical to mining companies' "social licence to operate". Rehabilitation technology used is closely related to both economic sustainability of the mining companies and ecological of the mined environment.

The present paper introduces an emerging technology aiming to substantially reduce economic costs of rehabilitation and improve the sustainability of reconstructed soil-plant systems covering the tailings landscape, which are the building blocks of target ecosystem to be rehabilitated. Critical factors and processes have been explained in successful rehabilitation from substrate levels to the whole landform performance. The new technology involves two key aspects: (1) in-situ engineering tailing-soil for offset/reduction of materials required (addressing economic factors) and (2) in-situ engineering hydro-geochemical stability in tailings profile (addressing ecological sustainability). The choice of the soil formation methodology is dependent on the mineralogy and geochemistry of tailings concerned, ecophysiological requirements of target plant communities and local climatic conditions. Engineering tailing-soils involves purposed initiation and stimulation of mineralogical alterations, autotrophic oriented geomicrobiological activities and associated mineral weathering, towards the goals of functional technosols and/or hydro-geochemically stable hardpans. The weathered tailings undergo aggregation/ cementation, and evolution of heterotrophic microbial communities, towards the final goal of functional technosols in the tailings landscape. The roles of tolerant microbes in the initial phase of mineral weathering and geochemical stabilization are emphasized by using examples involving bauxite residues and sulfidic Pb-Zn tailings. Under high rainfall conditions, the substantially stimulated weathering of sulfidic minerals in the amended tailings under frequent and cyclic wetting-drying cycles shifts pollutant (e.g. sulfates, metals and metalloids) loading into wastewater within a short-term (e.g. years) which can be cost-effectively managed/treated on site, preventing longer-term unexpected geochemical reactivity in tailings sitting below the engineered capillary break layer and perpetual wastewater management after decommissioning.

From the above, a functional soil system is expected to be developed covering the tailings. With the colonization of native soil microbial communities, biogeochemical structure and functions are rehabilitated to form ecological linkages with target plant communities, in order to ensure the long-term sustainability of the whole ecosystem development.