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Arbuscular Mycorrhizal symbiosis enhances aggregate formation and organic matter sequestration in alkaline Fe ore tailings

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Alkaline Fe ore tailings are by far one of the most challenging environmental issue facing the global mining industry, which is ranked 4th globally in terms of their discharge volumes in storage dams. These tailings possess poor physical structures and adverse chemical properties (e.g., alkaline pH and deficiencies of organic carbon and nutrients) and it is hard for sustainable colonization of plants and microbial communities. Eco-engineering tailings into soil-like substrate in situ is a promising technology to achieve sustainable rehabilitation of tailing landscape. The formation of water stable aggregates (WSA) in tailings primed with eco-engineering inpiuts (e.g., plant biomass organic matter and fertilisers) is indicative of the first milestone of soil formaiton, resulting from bio-geochemically driven mineral weathering and cementation. WSAs are basic physical units underpinning soil structure and functions, such as the porosity and hydraulic conductivity, gas exchange and water retention, biological activities of microbes and roots. The further development and evolution may be enhanced by Arbuscular mycorrhizal (AM) fungi associated with plants colonising infertile soil (such as tailing-soil), because of their role in generating organic cements and organo-mineral interactions. Our previous study found that AM fungi were present in the Fe ore mine tailing site, associated with colonising native plants. In the present study, we have investigated the role of AM symbiosis (Glomus spp. in association with Sorghum spp.) in aggregate formation and organic matter sequestration in Fe ore tailings eco-engineered with organic matter amendment and pioneer plant colonization. The results showed that AM fungi formed symbiotic association with Sorghum spp. plant roots (with mycorrhizal colonization intensity above 80%) in the eco-engineered tailings. Quantitatively, AM symbiosis enhanced the formation of micro-aggregates (53~250 um) rather than macro-aggregate aggregates (250 um~2000 um) formation, which may be partially due to the direct role of extra-radical mycelium as revealed by FE-SEM analysis. Qualitatively, AM symbiosis increased the amount of organic carbon and nitrogen associated with mineral particles in the macro-aggregates. Those organic carbon associated with minerals was found to be rich in carboxyl C and alkyl C, as revealed by synchrotron based C 1s X-ray absorption near edge structure (NEXAFS, conducted in Australia Synchrotron) and the Attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectra. Overall, the study revealed the role of AM fungi in advancing the formation of microaggregates and increasing the sequestration of organic C and N in macroaggregates in the eco-engineered Fe ore tailings. These suggest that AM fungi inoculum be added to pioneer plants

to not only enhance plant growth via improved nutrient and water acquisition, but also to advance aggregate formation and quality via increased organic C and N sequestration with impacted mineral particles.