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Vertical distribution of soil microorganisms in a tailing dam of an abandoned mine

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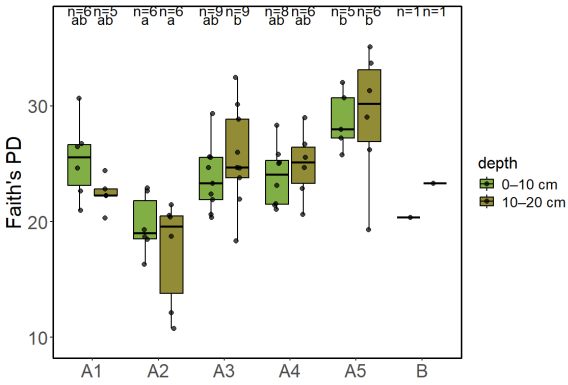

Revegetation of mine tailing dams remains a major ecological challenge due to severe soil degradation, extreme physicochemical conditions, and disruption of soil microbial communities that are essential for ecosystem recovery. Following the adoption of the Kunming–Montreal Biodiversity Framework in 2022, restoring biodiversity on degraded lands has become a global priority for achieving Nature Positive outcomes. However, the complex interactions among plant diversity, soil physicochemical properties, and soil microbial communities at such sites remain insufficiently understood. In this study, we investigated vegetation composition, soil physicochemical properties, and soil microbial communities at a tailing dam of an abandoned mine in Japan, where vegetation has gradually recovered without any revegetation efforts. Soil samples were collected from two depth intervals (0–10 cm and 10–20 cm) to assess vertical variation in soil physicochemical characteristics and microbial community structure. Our results indicate that a shift in soil pH from acidic toward neutral conditions, along with increased soil microbial phylogenetic diversity and biomass, was associated with greater plant species abundance. These findings suggest that shallow soil layers may have a critical role in regulating plant establishment. Moreover, areas with greater plant species abundance frequently harbored microorganisms closely related to plant growth-promoting rhizobacteria (PGPR), indicating the important role of microbial communities in facilitating vegetation recovery. In addition, depth-dependent patterns revealed variation in soil microbial alpha diversity. Shannon–Wiener diversity (reflecting evenness and richness) was generally higher in shallow soils, whereas Faith's phylogenetic diversity was greater in deeper soils in plots with higher plant species richness. Overall, our findings suggest that near-neutral soil pH with higher microbial phylogenetic diversity and biomass may enhance microbial functional capacity, including PGPR, thereby facilitating plant species establishment and increasing biodiversity in a tailing dam ecosystem of a degraded abandoned mine.