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Coral island primary succession improves soil aggregate distributions, organic carbon sequestration and turnover

DR. XIANGLONG XI[1], YOUFEI FANG[1], HAIYANG ZHANG[1], LIBIN WU[2], LIQIANG XU[3] AND XIAODONG LIU[1]

[1]School of Earth and Space Sciences, University of Science and Technology of China
[2]Institute of Surface-Earth System Science, School of Earth System Science, Tianjin University
[3]School of Resources and Environmental Engineering, Hefei University of Technology

The study of soil aggregates in ecosystem succession has been comprehensively conducted, while little attention has been given to islands, especially coral island ecosystems. Here, soil samples were collected from nine coral islands, across different ecological succession stages in the Xisha Islands, South China Sea. The soil aggregate stability, soil organic carbon and nitrogen, stable carbon isotopes, and organic carbon sequestration and turnover processes were investigated. The results demonstrate that the coral island ecological succession has significantly improved soil physical and chemical properties, and the increase in vegetation coverage has accelerated the weathering of the parent material. The proportions of large aggregates (>2 mm) and silt-clay fractions (<0.053 mm) in the advanced ecological succession stage were significantly higher than those in the early stage. At the same time, the mean weight diameter and stability of soil aggregate were increased significantly with ecological succession. Soil total organic carbon (TOC) and total nitrogen (TN) contents rise with ecological succession, with TOC content exhibited significantly improvement from the early to the late stages. The variation trend of soil total phosphorus content was different, which mainly affected by the heterogeneity of guano deposition. Unlike terrestrial ecosystems, soil TOC and TN are mainly enriched in small aggregates during the unique pedogenesis of coral islands. Ecological stoichiometry reveals decreasing C: N and C: P ratios of soil aggregates with particle sizes as ecological succession, reflecting enhanced nutrient cycling. Stable carbon isotope analysis indicates that with ecological succession, the isotopic fractionation of organic carbon in aggregates weakens, with a significant increase in carbon exchange frequency. The dynamics of soil aggregate changed from the formation dominated in the early stage of primary succession to the fragmentation dominated in the later stage. Collectively, the study underscores the significant potential of coral islands as crucial contributors to soil carbon sequestration in the context of global warming. Meanwhile, these findings offer valuable insights into soil development, aggregate formation, and SOC sequestration during coral island succession.