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Environmental Response Mechanisms of Saline-Alkali Ecosystems under Carbon Sequestration Processes

The goals of carbon peaking and carbon neutrality have brought increasing attention to the role of ecosystems in carbon sequestration. Saline-alkali lands, as a typical type of degraded land in northern China and other arid or semi-arid regions, have long been regarded as having low carbon storage potential due to harsh soil conditions, sparse vegetation, and limited biodiversity. However, with advancements in soil improvement, vegetation restoration, and ecological engineering, these landscapes are now showing potential as emerging carbon sinks. In particular, the introduction of salt-tolerant plant species, organic amendments, and microbial regulation techniques is gradually altering the carbon cycling dynamics within these ecosystems.

Carbon sequestration in saline-alkali land is not merely a physical process of CO_2 fixation; it is a complex ecological interaction involving soil–plant–microbe feedbacks under stress conditions such as salinity, alkalinity, and water imbalance. The efficiency and stability of carbon sequestration in these systems are influenced by multiple interrelated factors: soil organic matter content, microbial community composition, vegetation structure, salt stress intensity, and hydrological-salinity dynamics. However, the mechanisms through which these factors interact remain poorly understood, limiting our ability to accurately assess and enhance the carbon sink function of saline-alkali ecosystems.

This study focuses on the environmental response mechanisms of saline-alkali ecosystems during active carbon sequestration interventions. Using a combination of in situ monitoring, soil property analysis, greenhouse gas flux measurement, and high-throughput microbial sequencing, the research aims to quantify changes in carbon input, carbon emissions, and soil carbon stability. Particular emphasis is placed on understanding the synergetic responses among soil properties, vegetation dynamics, and microbial processes. By identifying the ecological feedback loops and dominant drivers, the study will construct a response model to describe the mechanisms of carbon transformation and stabilization in saline-alkali lands.

The outcomes of this research will not only enhance our understanding of carbon cycling processes in degraded lands but also provide theoretical guidance and technical pathways for ecological restoration and carbon sink enhancement in marginal landscapes. Ultimately, this will contribute to regional carbon neutrality strategies and sustainable land management under global climate goals.