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# Dynamics of Soil Water and Salt in Saline Farmlands: Implications for Brackish Water Irrigation and Climate Resilience

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The dynamic changes of soil water and salt are crucial for crop growth and agricultural productivity. Understanding soil water and salt movement mechanisms, influenced by natural and human factors like climate change, groundwater, and brackish water irrigation, remains challenging. This study focused on the Yellow River Irrigation District, a critical grain-producing area with limited freshwater resources and saline soils. Using Yucheng Station as a case study, field experiments (2004–2020) and model simulations (2023–2053) were conducted to investigate the dynamics and influencing factors of soil water and salt under winter wheat-summer maize rotation.

Field experiments revealed that crop yields decreased with groundwater depth, significantly impacting soil water and salt dynamics. HYDRUS-1D simulations, calibrated with monitoring data (2020–2023), effectively captured these dynamics, achieving high accuracy in soil moisture and salt concentration predictions. Climate change scenarios showed soil water and salt fluctuations aligned with crop growth cycles, with rainfall intensity and crop evapotranspiration being key factors. Higher rainfall in SSP585 scenarios enhanced salt leaching compared to SSP245, while salt accumulation in the cultivation layer was prominent during dry years.

Groundwater depth significantly influenced farmland-water interactions. At shallower depths (2 m), groundwater contributed substantially to crop water use but posed risks of soil salt stress. Conversely, deeper depths (4 m) reduced these contributions, highlighting the balance needed for optimal groundwater management. Long-term brackish water irrigation showed increasing soil salt trends, with salt migration influenced by rainfall and groundwater depth. To mitigate risks and enhance brackish water use, irrigation with ≤3 g/L salt concentration and groundwater depth control at 3 m is recommended for sustainable soil water and salt management, ensuring crop productivity and food security under future climate conditions.