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Driving Factors and Spatiotemporal Variations of Soil Organic Carbon in the Northeast China Plain

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Soil organic carbon (SOC) plays a critical role in ensuring food security and addressing climate change. This study, based on a regional-scale soil quality geochemical monitoring network established by the China Geological Survey (covering approximately 2.6×10^5 km^2), systematically analyzed the spatiotemporal evolution characteristics and driving mechanisms of SOC in the Northeast China Plain. A total of 1910 and 1920 topsoil samples were collected in 2005 and 2018, respectively, and analyzed using empirical Bayesian kriging interpolation and random forest methods. The results indicate that: (1) SOC density ranged from 0.83 to 8.79 $kg{\cdot}C{\cdot}m^{-2}$ (median: 3.25 $kg{\cdot}C{\cdot}m^{-2}$). The spatial distribution of SOC exhibited significant zonal characteristics, with concentrations gradually increasing from the southwest to the northeast. Soil SiO_2 content, Fe_2O_3 content, and mean annual precipitation were identified as the primary driving factors, explaining 38.2%, 18.8%, and 13.3% of the spatial variability, respectively, while other factors such as topography, NPP, and NDVI showed relatively weaker explanatory power. (2) From 2005 to 2018, SOC density and SOC stock increased by 0.16 $kg{\cdot}C{\cdot}m^{-2}$ and 49.79 Tg, respectively, representing growth rates of 5.18% and 5.84%. Spatially, 57.91% of the study area exhibited an increase in SOC, with 18.07% of the area showing a growth rate exceeding 20.00%. (3) Land use change had a limited contribution to SOC stock variation, as regions with unchanged land use types accounted for 73.03% of the total SOC stock increase. This study reveals the spatiotemporal evolution patterns of SOC in the Northeast China Plain, providing scientific insights for regional soil carbon management and offering important guidance for formulating effective soil conservation strategies.

