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The impacts of climate-driven sea level rise on soil iron speciation

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Climate-driven sea level rise is causing saltwater intrusion on coastal soils at an increasing rate around the world. Saltwater intrusion causes changes in both salinity and redox environments, which can impact soil iron (Fe) speciation and concomitant cycling of nutrients and trace elements. Such impacts can affect water quality. However, how soil Fe speciation changes with saltwater intrusion remains poorly understood. In this study, five soils from a salinity gradient at the Rehoboth, Delaware Inlet Bay were collected and analyzed for Fe speciation using chemical extractions, Fe K-edge extended X-Ray absorption fine structure (EXAFS) spectroscopy, and ^{57}Fe Mossbauer spectroscopy. Soil salinity decreased from 29.3 mmhos cm^{-1} to 0.07 mmhos cm^{-1} with increasing distance away from the Bay. With increasing salinity, soil pH and Fe content decreased from 6.3 to 4.6 and from 3671 to 846 mg kg^{-1}, respectively. Iron contents were positively correlated with C, N, and P, suggesting the importance of Fe in nutrient cycling in coastal soils impacted by saltwater intrusion. Iron EXAFS showed that at the site with the highest salinity, soil Fe consisted of hornblende, illite IMt-1, and biotite with some ferrihydrite and pyrite. When salinity decreased to 9.01 mmhos cm^{-1}, pyrite and biotite were absent, and goethite occurred with increased proportions of ferrihydrite. When salinity further decreased, hornblende abundance was unchanged, but illite IMt-1 decreased. Goethite and ferrihydrite are the dominant Fe oxides in the soils. With decreasing salinity, goethite abundance kept increasing, while ferrihydrite initially increased before again decreasing. These results were consistent with the increasing contribution of Fe(III) to total Fe (69.5 – 94.3%) and the decreasing ratio of the oxalate extractable Fe to the dithionite-citrate-carbonate extractable Fe (85.6 – 22.5%) with decreasing salinity. The changes in Fe contents and speciation could be due to the deposits of suspended particles from the saltwater and the transitions in redox conditions from the more reducing to more oxidizing environments. Iron Mossbauer spectroscopic analysis will provide additional evidence to complement the EXAFS results. The results will enhance our understanding of the impact of sea level rise on Fe cycling in coastal soils.