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Subsurface variation of soil physicochemical properties and redox-sensitive elements under different land covers in Gulf Coastal Plains

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November 23, 2022

Abstract

The redox potential of soils is critical in understanding the structure and function of ecosystems. Soil redox state strongly governs the speciation, bioavailability, and solubility of limiting nutrients like nitrogen and phosphorous in soil. It also drives the reactivity, mobility, and toxicity of redox-sensitive elements such as anthropogenic contaminants, affecting soil and groundwater quality by altering or retaining undesirable metals. Although these factors are highly variable among different landcovers and soil depths, limited studies try to link the redox-sensitive elements with soil physical and chemical properties in various depths and with different landcovers. With designed experiments in Brazos River corridor in Texas, we (1) evaluate the effect of different land use and land covers on the concentrations of electron acceptors (O_2, NO_3, and SO_4), reduced products (Mn(II), Fe(II)), and C, N, and P pools in the surface and deep soils, (2) determine effects of climatic gradient on redox biogeochemistry in deep soils, and (3) investigate the effects of soil physical and hydraulic properties on redox biogeochemistry. Soil physical and chemical properties were determined from varying soil depths (land surface up to 15 m) in different landcovers (grassland, forest, and salt marsh). Higher carbon and nitrogen content were observed in the surface soils due to carbon mineralization in all land covers. However, the phosphorous content was higher at 15-30 cm soil depth, because of the co-existing high iron and aluminum oxides concentrations that provide high surface area for phosphorous adsorption. C, N, P, and other redox-sensitive elements were positively correlated to clay content at various depths. The biogeochemical properties, including ammonium, ferric iron and sulfate, were disproportionally higher at the interface of soil layers where soil texture and hydraulic properties change. This finding reflects the role of soil layers as hot spots of biogeochemical processes in the subsurface. With the climate gradient across the study river basin, our data indicates C, N, P, and other redox-sensitive elements are more profound in the salt marsh and forest covers with higher annual mean temperature and precipitation as these factors stimulate microbial activity and thus influence redox processes.

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Subsurface variation of soil physicochemical properties and redox-sensitive elements under different land covers in Gulf Coastal Plains

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The reduction and oxidation (redox) potential of soils is critical in understanding the structure and function of ecosystems. Soil redox state strongly governs the speciation, bioavailability, and solubility of limiting nutrients like nitrogen (N) and phosphorous (P) in soil. It also drives the reactivity, mobility, and toxicity of redox-sensitive elements such as anthropogenic contaminants, affecting soil and groundwater quality by altering or retaining undesirable metals. Although these factors are highly variable among different landcovers and soil depths, limited studies try to link the redox-sensitive elements with soil physical and chemical properties in various depths and with different landcovers. With designed experiments in Brazos River corridor in Texas, we (1) evaluate the effect of different land use and land covers on the concentrations of electron acceptors (O_2, NO_3, and SO_4), reduced products (Mn(II), Fe(II)), and carbon, nitrogen, and phosphorous pools in the surface and deep soils, (2) determine effects of climatic gradient on redox biogeochemistry in deep soils, and (3) investigate the effects of soil physical and hydraulic properties on redox biogeochemistry. Soil physical and chemical properties were determined from varying soil depths (land surface up to 15 m) in different landcovers (grassland, forest, and salt marsh). Higher carbon and nitrogen content were observed in the surface soils (0-15 cm) due to carbon mineralization in all land covers. However, the phosphorous content was higher at 15-30 cm soil depth, because of the co-existing high iron and aluminum oxides concentrations that provide high surface area for phosphorous adsorption. Carbon, nitrogen, phosphorus, and other redox-sensitive elements were positively correlated to clay content at various depths. The biogeochemical properties, including ammonium, ferric iron and sulfate, were disproportionally higher at the interface of soil layers where soil texture and hydraulic properties change. This finding reflects the role of soil layers as hot spots of biogeochemical processes in the subsurface. With the climate gradient across the study river basin, our data indicates carbon, nitrogen, phosphorous, and other redox-sensitive elements are more profound in the salt marsh and forest covers with higher annual mean temperature and precipitation as these factors stimulate microbial activity and thus influence redox processes. Additionally, C and N concentrations are higher in forest sites (across all depths) relative to remnant grasslands as a consequence of the higher above- and below-ground productivity.