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Does this redox boundary make me look red? How soil moisture impacts iron minerology and P availability through arctic soil profiles

ERIN VANDERJEUGDT[1], LAUREN E. KINSMAN-COSTELLO[1], ERIN ROONEY[2], KRISTEN BIDAS[2], IMTIAZ MIAH[3], ELIZABETH HERNDON[4] AND MICHAEL WEINTRAUB[5]

[1]Kent State University
[2]University of Tennessee Knoxville
[3]Sylhet Agricultural University
[4]Oak Ridge National Laboratory
[5]Pacific Northwest National Laboratory

Presenting Author: evanderj@kent.edu

Climate change in the Arctic is warming soils and increasing seasonal thaw depth. The net impact of warming on soil microbial activity will be modulated by changing moisture conditions and nutrient availability. Biotic demand often exceeds phosphorus (P) availability in the tundra due to the ability of phosphate to adsorb to iron(oxyhr)oxides. Patterns of soil moisture drive microbial oxidation and reduction of iron, creating and dissolving iron(oxyhydr)oxides. Oxygen availability, which rapidly decreases in saturated organic soils due to microbial consumption, shapes nutrient cycling and may shift with changing soil moisture regimes. Iron-associated P may accumulate with iron at soil profile redox interfaces, as determined by water table level. The relative location of water table-induced interfaces with respect to the organic and mineral horizons is highly dynamic during the relatively short growing and thaw season and in topographically variable soils in the tundra. We ask 1) How does P associate with iron through the vertical soil profile along a soil moisture gradient? 2) How does iron accumulate and behave through the soil profile in varying soil types? We sampled soils near Toolik Field Station, AK during the 2022 and 2023 growing seasons from organic, transition, and mineral horizons along a hillslope transect with well-drained, semi saturated, and inundated soils. For each soil core we measured the depth of the water table and presence and location of visible accumulated iron (iron bands). We measured sequentially extracted P and iron forms, along with a phosphate sorption index which provides a comparative measure of a soil's capacity to sorb phosphate. Drained organic soils at the tops of vertical soil profiles contained more phosphate associated with redox-sensitive iron than saturated organic soils (below the water table). Iron bands observed in well drained and inundated soils existed at contrasting depths in the soil profile and exhibited different mineral compositions, however these bands accumulated at the water table and were closely related to reactive P associated with redox-sensitive iron. As greater thaw increases well-drained soil conditions across the arctic landscape, we can expect reactive P to become associated with redox-sensitive iron, further limiting microbial access to P.