MARTIN-LUTHER-UNIVERSITÄT HALLE-WITTENBERG

HELMHOLTZ Zentrum für Umweltforschung UFZ

Soil Science Colloquium - Halle

Prof. Dr. Andrey Guber

Michigan State University

27. June 2024 - 5pm
Julius-Kühn-Hörsaal, Theodor-Lieser-Straße 9, Halle

Manganese transformation in proximity to air-filled soil pores

Andrey K. Guber, James O'Sullivan, Jocelyn Richardson, Poulamee Chakraborty, and Alexandra N. Kravchenko

Abstract:
Soil manganese (Mn) plays a critical role in regulating litter decomposition, C protection, and nutrient cycling. Due to both abiotic and biotic reactions, Mn is constantly undergoing oxidation and reduction in the soil, which are controlled by a wide range of factors including availability of oxygen, pH, and biological activity. Higher oxygen levels promote the oxidation of Mn, whereas prolonged waterlogging triggers Mn reduction. The oxygen level and water content in soils vary greatly temporally and spatially due to high heterogeneity of soil pore structure. Moreover, soil pore characteristics directly affect plant root growth and microbial habitats, suggesting their indirect impacts on the Mn transformations by organisms. We investigate the microscale distribution and oxidation state of Mn and its associations with soil pore structure in soils under: (i) chisel ploughed corn-soybean-wheat rotation; (ii) native early successional plant community at the Kellogg Biological Station Long-Term Ecological Research experiment in Central Michigan long-term (34 years); (iii) monoculture switchgrass; and (iv) restored prairie including 18 species of forbs, grasses and legumes. Manganese distribution and speciation within intact soil cores were determined using a combination of synchrotron X-ray fluorescence microscopy (XRF) and X-ray absorption near-edge structure (XANES) spectroscopy. The locations and characteristics of soil pores were identified using X-ray micro-computed tomography (μCT). We observed a greater abundance of Mn(II) and Mn(III) hotspots in the soil of natural succession plots, with these hotspots occurring within the immediate vicinity of soil pores. This contrasts with soils from conventional agriculture, where Mn(II) and Mn(III) hotspots occurred 200 μm from the soil pores. Mn(IV) was enriched immediately adjacent to the soil pores in both systems. These results indicate that a native successional plant community drives the reduction of Mn within the vicinity of soil pores. Possible reasons for this might be the release of root exudates, which have a strong capacity to reduce Mn, and the high activity of Mn-transforming microorganisms. In switchgrass the abundance of oxidized and reduced Mn oxidation states varied with distance from pores consistently with anticipated O2 diffusion, while in the soil from restored prairie the spatial patterns suggested that biological activity played a greater role in influencing Mn distributions. Our study demonstrated that pore structure may have a multiplicative effect on the microscale distribution and oxidation state of soil Mn, which may have implications for the cycling of soil organic matter.