Linking Water Table Dynamics to Soil Biogeochemistry in a Column Incubation Experiment

G.J. PRONK[1*], A. MELLAGE[1]. T. MILOJEVIC[1], C. SMEATON[1], F. REZANEZHAD[1], P. VAN CAPPELLEN[1]

[1]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, N2L 3G1, Canada (*correspondence: gpronk@uwaterloo.ca)

Water table fluctuations govern the flooding and drying of soils, creating transient redox conditions and local hotspots of activity in the transition zone that have been linked to enhanced degradation of soil organic carbon (SOC).

To improve our understanding of SOC degradation under changing moisture content and redox potential, we carried out an automated soil column experiment with integrated monitoring of hydro-bio-geophysical processes under both constant and oscillating water table conditions. An artificial soil mixture composed of quartz sand, montmorillonite, goethite and humus was used to provide a well-defined system. Micro-sensors installed at different depths recorded changes in redox potential and O_2 levels using high-resolution, luminescence-based Multi Fiber Optode (MuFO) microsensors. Effluxes of CO_2 and CH_4 were determined from headspace gas measurements. Pore waters, collected periodically with MicroRhizon samplers at different depths, were analyzed to determine pH, EC, dissolved inorganic and organic carbon and ion/cation compositions. These measurements allowed us to track major electron donor and acceptor availability in direct relation to carbon cycling within each column. The columns were sacrificially sampled after 329 days and analyzed for SOC, microbial biomass and ATP content.

Drying and wetting cycles clearly affected CO_2 release from the soils, with lower CO_2 fluxes during flooding periods and enhanced CO_2 fluxes after drainage compared to the CO_2 flux under a constant water table. Pore-water composition showed that iron and sulfate reduction took place in all columns. Sulfur distribution with deph showed a clear peak in the transition zone between saturated and unsaturated conditions, indicating the steep geochemical gradient present there. This coincided with enhanced depletion of organic carbon across the depth interval affected by water table oscillations in the fluctuating water table column, and higher concentrations of ATP per mass of microbial biomass over the same depth interval. Overall, this experiment provides valuable information about the effect of transient redox conditions on soil biogeochemistry, and the development of local hotspots caused by water table fluctuations.