Soil Carbon Dynamics During Drying vs. Rewetting: Importance of Antecedent Moisture Conditions

Kaizad F. Patel,[1*] Allison Myers-Pigg,[1,2] Ben Bond-Lamberty,[3] Sarah J. Fansler,[1] Cooper G. Norris,[4] Sophia A. McKever,[1,5] Jianqiu Zheng,[1] Kenton A. Rod,[6] Vanessa L. Bailey[1]

[1] Biological Sciences Division, Pacific Northwest National Laboratory, Richland, WA
[2] Marine and Coastal Research Laboratory, Pacific Northwest National Laboratory, Sequim, WA
[3] Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park, MD
[4] Rochester Institute of Technology, Laboratory Science Technology, Rochester, NY
[5] Washington State University, School of the Environment, Richland, WA
[6] Washington State Department of Ecology, Richland, WA

(kaizad.patel@pnnl.gov, vanessa.bailey@pnnl.gov)

Project Lead Principal Investigator (PI): Vanessa L. Bailey

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Project Abstract:
Soil moisture influences soil carbon dynamics, including microbial growth and respiration. The response of such soil respiration to moisture changes is generally assumed to be linear and reversible, i.e., to depend only on the current moisture state. Current models thus do not account for antecedent soil moisture conditions when determining soil respiration or the available substrate pool. We conducted a laboratory incubation to determine how the antecedent conditions of drought and flood influenced soil organic matter (SOM) chemistry, bioavailability, and respiration. We sampled soils from an upland coastal forest, Beaver Creek, WA USA, and subjected them to drought (7 days) or flood (saturation) and then rewet or dried, respectively, to 5, 35, 50, 75, and 100 % saturation. We measured respiration and water extractable organic carbon (WEOC) concentrations and used ^{1}H-NMR and FT-ICR-MS to characterize the WEOC pool across the treatments. The drying vs. rewetting treatment strongly influenced SOM bioavailability, as rewet soils (with antecedent drought) had greater WEOC concentrations and respiration fluxes compared to the drying soils (with antecedent flood). In addition, air-dry soils had the highest WEOC concentrations, and the NMR-resolved peaks showed a strong contribution of protein groups in these soils. Both NMR and FT-ICR-MS analyses indicated increased contribution of complex aromatic groups/molecules in the rewet soils, compared to the drying soils. We suggest that drying introduced organic matter into the WEOC pool via desorption of aromatic molecules and/or by microbial cell lysis, and this stimulated microbial mineralization rates. Our work indicates that even short-term shifts in antecedent moisture conditions can strongly influence soil C dynamics at the core scale. The predictive uncertainties in current soil models may be reduced by a more accurate representation of soil water and C persistence that includes a mechanistic and quantitative understanding of the impact of antecedent moisture conditions.