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Hillslope Biogeochemistry Controls on Anaerobic Soil Organic Matter Decomposition in a Tundra Watershed

Michael Philben[1*], Baohua Gu[1], Stan Wullschleger[1], Alexander Kholodov[2], and David Graham[3]

[1] Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN;
[2] Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK;
[3] Biosciences Division, Oak Ridge National Laboratory, Oak Ridge, TN

Contact: philbenmj@ornl.gov

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We investigated rates and controls on greenhouse gas production in two contrasting water- saturated tundra soils within the Teller Road mile 27 watershed near Nome, Alaska. Three years of field sampling have shown that soil from a fen-like area at the base of the hillslope had higher pH and higher porewater ion concentrations than soil collected from a bog-like peat plateau at the top of the hillslope. The influence of these contrasting geochemical environments on CO_2 and CH_4 production was tested by incubating soil microcosms anaerobically at -2°C and 8°C for 55 days. NH_4Cl was added to half of the microcosms to test the effects of N limitation on microbial greenhouse gas production. We found that total CO_2 and CH_4 production were higher in the soils from the bottom of the hillslope. Water-extractable organic C (WEOC) was also higher in these soils, and fermentation of this C pool resulted in an increasing supply of low- molecular weight organic acids (e.g., acetate and propionate) throughout the incubations. Higher availability of labile DOC, in addition to higher pH, likely contributed to the more rapid greenhouse gas production at the bottom of the hillslope. Our results also indicate that inorganic N concentrations were lower and soil C decomposition was more N-limited in the peat plateau soils than the soils from the bottom of the hillslope, which exhibited net N mineralization while the peat plateau soils had net N immobilization. Nitrogen addition increased CO_2 production in the peat plateau soils but not the lowland soils, consistent with greater N limitation. Our results suggest that the movement of water, ions, and nutrients down the tundra hillslope can increase the rate of anaerobic soil organic matter decomposition by (1) increasing the pH of soil porewater; (2) providing bioavailable DOC and fermentation products such as acetate; and (3) relieving microbial N limitation through nutrient runoff.