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Dynamics of soil GHG emissions shaped by hydration state, aggregate size distribution and carbon placement: Column experiments using artificial soil aggregates

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Dynamics of soil hydration affect microbial community dynamics and various biogeochemical processes (soil respiration, denitrification, methane production). Evidence suggests that anoxic conditions may persist in soil aggregates (long after bulk soil is aerated) thereby providing niches for anaerobic microbial communities (hot spots). Despite their recognized role in mediating soil biogeochemical fluxes, systematic studies of the impact of different environmental conditions on CO_2, N2O and CH4 emissions from soil aggregates remain rare. We constructed artificial aggregates using a silt loam soil of different sizes and different carbon configurations (mixed, core, no addition) to study effects of hydration, aggregate size and carbon source configuration on GHG emissions. An assembly of aggregates of three sizes (18, 12, and 6 mm aggregates) was embedded in sand columns at four distinct layers (3 replicates for each aggregate-carbon source, 9 columns) and the water level was varied periodically to quantify effects of wetting/drying and submersion on GHG fluxes. Several gas samples were taken from the headspaces of each column (after closure) and analyzed using GC with the proper detectors to resolve fluxes. Results illustrate the critical role of hydration states on GHG emission, for example, lowering the water table (unsaturated conditions) decreases CH4 emissions while increasing N2O flux. We observe links between aerobic processes (e.g., nitrification) and anaerobic denitrification presumably by promoting alternative pathways (e.g., ammonia and nitrite oxidation). Methane production was activated under highly anoxic conditions (prolonged inundation). N2O production was highest form aggregates with carbon placed in the (anoxic) core whereas CO_2 production rates were comparable from mixed and centered carbon sources (at rates that fluctuated with hydration conditions). Experimental results of artificial soil aggregates are of interest for improvement of physically- and processes- based models for realistic representation of biogeochemical gas fluxes from soil profile.