Pathways for Nitrous Oxide Evasion from Ecosystems at Land-Water Boundaries

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Denitrification in environments at terrestrial-aquatic interfaces is an important control on nitrogen export to surface waters, but can lead to emissions of the greenhouse gas nitrous oxide (N_2O). N_2O evasion from soils depends on the relative contribution of gas transfer from mobile water to soil gas phases versus microbial N_2O reduction to dinitrogen gas. The objective of this study was to characterize pathways and quantify rates of water-air N_2O transport and thereby advance knowledge of how transport processes regulate N_2O emissions at land-water boundaries.

We employed dissolved gas tracer techniques to probe N_2O transport and gas exchange in laboratory model systems representing denitrifying porous media barriers and riparian wetlands. Trapping of immobile bubbles following water table fluctuations caused retarded N_2O transport due to water-bubble partitioning and a significant enhancement of N_2O emissions when water tables fell and released trapped bubbles. The inert tracers helium and sulfur hexafluoride were used to parameterize a nonequilibrium advection-dispersion-partitioning model to predict N_2O bubble partitioning and bubble-mediated fluxes in biologically active media under a range of hydrological conditions. In wetland mesocosms, push-pull tests with dissolved gas and non-volatile tracers were used to quantify rates of N_2O transfer through the root aerenchyma system. Soils with mature root systems were found to have greater rates of root-mediated N_2O transport and lower rates of microbial N_2O reduction, which we attribute to the role of oxygen diffusion from roots in inhibiting microbial N_2O reduction.