Nitrous Oxide Emission from a Spray Field Fertilized with Liquid Lagoonal Swine Effluent in the Southeastern United States

Stephen C. Whalen[1], Rebecca L. Phillips[2], and Eric N. Fischer[3]

Contemporary agriculture is characterized by the intensive production of livestock in confined facilities and land application of stored waste as an organic fertilizer. Emission of nitrous oxide (N_2O) from receiving soils is an important, but poorly constrained term, in the atmospheric N_2O budget. In particular, there are few data for N_2O emissions from spray fields associated with industrial scale, swine-production facilities that have rapidly expanded in the southeastern United States. In an intensive, 24-day investigation over three spray cycles, we followed the time course for changes in N_2O emission and soil physicochemical variables in an agricultural field irrigated with liquid lagoonal swine effluent. The total-N [535 milligrams per liter (mg/L^{-1})] of the liquid waste was almost entirely NH_4^+-N (>90%) and thus had a low mineralization potential. Soil profiles for nitrification and denitrification indicated that >90% of potential activity was localized in the surface 20 centimeters (cm). Application of this liquid fertilizer to warm (19 to 28°C) soils in a form that is both readily volatilized and immediately utilizeable by the endogenous N-cycling microbial community resulted in a sharp decline in soil NH_4^+-N and supported a rapid and short-lived (days) burst of nitrification, dentrification, and N_2O emission. Fluxes of nitrous oxide as nitrogen (N_2O-N) as high as 9,200 micrograms per gram dry weight of soil per hour ($\mu g\ g_{dw}^{-1}\ h^{-1}$) were observed shortly after fertilization, but emissions decreased to prefertilization levels within a few days. Poor correlations between N_2O efflux and soil physicochemical variables (temperature, moisture, NO_3^--N, NH_4^+-N) and fertilizer-loading rate point to the complexity of interacting factors affecting N_2O production and emission. Total fertilizer N applied and N_2O-N emitted were 29.7 grams per square meter (g/m^{-2}), and 395 milligrams per square meter (mg/m^{-2}), respectively. The fractional loss of applied N to N_2O (corrected for background emission) was 1.4%, in agreement with the mean of 1.25% reported for synthetic fertilizers. The direct effects of fertilizer application appear to be more immediate and short-lived for liquid swine waste than for manures and slurries that have a slower release of nitrogenous nutrients.

---

[1]University of North Carolina, Department of Environmental Science and Engineering, Chapel Hill, NC 27599-7400 (steve_whalen@unc.edu)

[2]University of North Carolina, Department of Environmental Science and Engineering, Chapel Hill, NC 27599-7400 (rebecca.phillips@sph.unc.edu)

[3]University of North Carolina, Department of Environmental Science and Engineering, Chapel Hill, NC 27599-7400 (efischer@email.unc.edu)