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The impact of liquid organic fertilization and associated application techniques on N_2, N_2O and CO_2 fluxes from agricultural soils

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Prediction of liquid manure effects on N transformations in soils and associated N_2O and N_2 fluxes is poor because previous investigations mostly excluded N_2, the end product of denitrification. We address the questions, (1) how liquid manure fertilization and its application technique impact N_2, N_2O and CO_2 fluxes from agricultural soil, and (2) how the water, mineral N and dissolved organic carbon (DOC) content of the manure amended soil change between the soil layers. A sandy arable soil was used in a 10 days laboratory incubation at constant 15°C, constant 40% and 60% water-filled pore space (WFPS) and amended with and without artificial slurry in three manure treatments (control, surface-applied, injected). N_2O and CO_2 fluxes were quantified by gas chromatography. N_2 and source-specific N_2O flux was quantified by isotope-ratio mass spectrometry. At 5th and 10th day, depth distribution of moisture, NH_4^+, NO_3^-, DOC, pH and ^{15}N enrichment of NO_3^- was determined with destructive sampling. The N_2+N_2O flux of the surface-applied and injected 40% WFPS treatments were 75% and 110% higher than the control and at 60% WFPS treatments were more than 610% and 1690% higher than the control. The product ratio of denitrification showed enhanced share of N_2 to the N_2+N_2O flux in the manure treatments, which we attribute to hot-spot dynamics of the manure layers. Our data demonstrate how the dynamics of moisture, labile C, NH_4^+-N, formation of NO_3^--N by nitrification and pH following manure surface application or injection interact and result in N_2O cycling by various pathways. The data-set can thus be used to evaluate and further develop models to predict denitrification and respiration processes of the manure-soil hot-spots. Further progress in unravelling and modeling manure induced hot-spot dynamics can be achieved if temporal and spatial resolution of our measurements is improved and additional techniques to determine O_2 distribution and distinguish gross N transformations and their gaseous N fluxes are included.