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Soil denitrification potential and its influence on the N_2O / N_2 product ratio and N_2O isotopomer ratios

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Nitrous oxide (N_2O), a potent greenhouse gas (GHG) and ozone depleting substance, is mainly emitted from soils where it is produced by biological denitrification and nitrification processes. It has been shown that N_2O production and consumption rates are largely affected by substrate availability, but also by soil properties and soil microbial community. Advancing N_2O mitigation strategies requires better understanding of microbial N_2O production and consumption processes, but also ways of N_2O source apportioning. The analysis of the intramolecular ^{15}N site preference (SP) within the asymmetric N_2O molecule has been shown to have potential to differentiate between denitrification and nitrification to a certain extent, but also to be affected by N_2O reduction. We conducted two soil incubation experiments with different soil types to assess the influence of the soil type on the denitrification rate and denitrification product ratio.

Three different soils, a clay soil, a loam soil, and a sandy soil, were collected from unfertilized field plots and repacked into incubation vessels. Soil was amended with potassium nitrate solution and incubated in two incubation experiments under He atmosphere in a laboratory setup for 9 (Experiment 1; loam vs. clay) or 28 days (Experiment 2; loam vs. sand), respectively. N_2O and N_2 release was measured by online GC. Additionally, gas samples were collected and ratios of the major N_2O isotopomer species were analyzed by IRMS.

Comparing the clay and the loam soil in Exp. 1, both, cumulative N_2O and N_2 release, were significantly higher from the clay soil. Nevertheless, the N_2O / (N_2O + N_2) product ratio was similar. The N_2O SP increased from both soils during the experiment, however, it was constantly c. 8 ‰ higher from the clay soil. In Exp. 2 cumulative N_2O release from the sandy soil was significantly higher while N_2 production was lower compared to the loam soil, resulting in a four times higher N_2O / (N_2O + N_2) product ratio with the sandy soil. Total N loss by denitrification was twice as high from the loam soil. N_2O SP values were clearly lower from the sandy soil compared to the loam.

These results confirm that the denitrification potential of different soils differs significantly and that the N_2O / (N_2O + N_2) product ratio or the N_2O reduction rate, respectively, is not necessarily correlated with the total denitrification rate. The observed N_2O isotope values indicate that initial SP values of produced N_2O are clearly different from all three soils, but it remains open if this is solely due to different production pathways.