Sources of nitrous oxide from intensively managed pasture soils

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Abstract

High N-inputs render pasture soils prone for N_2O emissions produced via multiple microbial pathways. Their contribution to N_2O production remains however unknown at various scales leading to uncertainty within models simulating the N-cycle. This soil microcosms study investigated sources of N_2O in response to wetting using ^{15}N tracing and the ^{15}N gas flux method. Emissions of N_2O via denitrification and nitrification mediated pathways showed an exponential response to soil water content across soils. Our results highlight the contribution of heterotrophic nitrification to N_2O production and demonstrate the proportion of nitrified N emitted as N_2O is an exponential function of soil water content.

Keywords: Nitrous oxide, nitrification, pasture soils, subtropical

1. Material and methods

Soil samples were collected from three dairy pastures in subtropical Australia, including a clay, a loam and a sandy clay loam. Soil microcosms were established with partially air dried soil and fertilised with NH_4NO_3 (35 µg N g^{-1} soil) either single ($NH_4{}^{15}NO_3$) or double ($^{15}NH_4{}^{15}NO_3$) labelled. Soil microcosms were then wetted to four different water-filled pore space (WFPS) levels and incubated over two days, with gas samples taken over the incubation period. The ^{15}N analysis of N_2O and the soil mineral N pools enabled to split N_2O production into N_2O derived from denitrification, autotrophic nitrification and heterotrophic nitrification. Following the hole in the pipe model, N_2O emissions were expressed as a fraction of the respective N gross transformation rate, obtained by a ^{15}N tracing model. For denitrification, the direct quantification of N_2 and N_2O via the ^{15}N gas flux method was used to quantify the fraction of denitrification emitted as N_2O.

2. Results and Discussion

The wetting induced emissions of N_2O across soils with peak losses > 8.5 µg N_2O-N g^{-1} soil from the clay. Denitrification was the main proces of N_2O production, accounting for 30-75% of overall N_2O emissions. The contribution of autotrophic nitrification and heterotrophic nitrification of organic N to N_2O emissions ranged from 20-30% and 5-50%, respectively. All N_2O production pathways increased exponentially with WFPS levels. The response of the fraction of denitrification emitted as N_2O differed between soils, reflecting the overlapping effects of N_2O

production and consumption. The fraction of nitrified N emitted as N_2O however showed an exponential increase with soil WFPS.

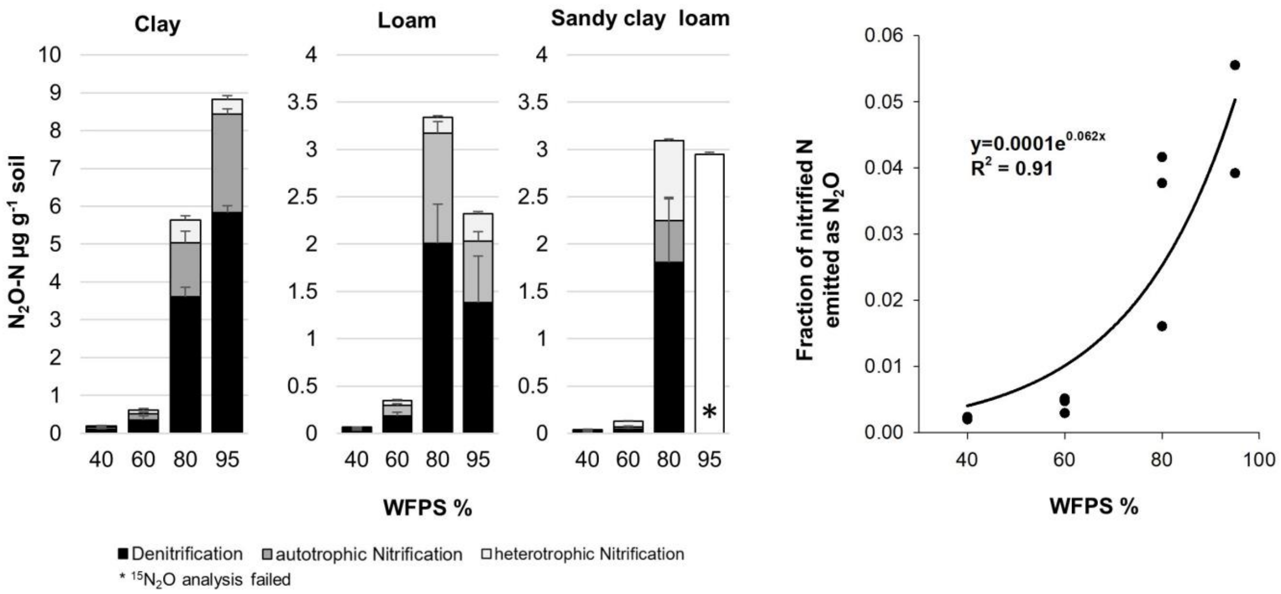

Fig. 1: Cumulative N_2O emissions derived from denitrification, autotrophic nitrification and heterotrophic nitrification from three pasture soils after wetting to four different water filled pore space levels and the fractions of nitrified N emitted as N_2O.

2. Conclusions

The exponential increase of N_2O emissions with soil WFPS demonstrates the rapid response of N turnover in C rich pasture soils, highlighting wetting events after dry conditions as critical for N_2O loss from these soils. Denitrification was the main process of N_2O production, but the significant contribution of heterotrophic nitrification shows organic N oxidation as an important source of N_2O. The exponential increase of nitrified N emitted as N_2O with WFPS provides experimental evidence to inform biogechemichal models simulating N_2O emissions and will help to constrain uncertainties when simulating N cycling from intensively managed pastures.

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