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Quantifying denitrification losses from a sub-tropical pasture in Queensland/Australia – use of the ^{15}N gas flux method

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The microbial mediated production of nitrous oxide (N_2O) and its reduction to dinitrogen (N_2) via denitrification represents a loss of nitrogen (N) from fertilised agro ecosystems to the atmosphere. Although denitrification remains a major uncertainty in estimating N losses from soils, the magnitude of N_2 losses and related N_2:N_2O ratios from soils are largely unknown due to difficulties measuring N_2 against a high atmospheric background. In order to address this lack of data, this study investigated the influence of different soil moisture contents on N_2 and N_2O emissions from a sub-tropical pasture in Queensland/Australia using the ^{15}N gas flux method.

Intact soil cores were incubated over 14 days at 80% and 100% water filled pore space (WFPS). Gas samples were taken up to six times per day after application of ^{15}N labelled nitrate, equivalent to 50 kg N ha^{-1} and analysed for N_2 and N_2O by isotope ratio mass spectrometry. Fluxes were calculated assuming non-random ^{15}N distribution in the headspace according to Mulvaney and Kurtz (1984) using the labelled pool of nitrate estimated from N_2O measurements (Stevens and Laughlin 2001).

The main product of denitrification in both treatments was N_2. N_2 emissions exceeded N_2O emissions by a factor of 1.3 ± 0.3 at 80% WFPS and a factor of 3 ± 0.8 at 100% WFPS. The total amount of N-N_2 lost over the incubation period was 13.5 ± 1.0 kg N ha^{-1} at 80% WFPS and 21.8 ± 1.8 kg ha^{-1} at 100% WFPS respectively. Over the entire incubation period, N_2 emissions remained elevated at 100% WFPS, showing high variation between soil cores, while related N_2O emissions decreased. At 80% WFPS, N_2 emissions increased constantly over time showing significantly higher values after day five. At the same time, N_2O fluxes declined. Consequently, N_2:N_2O ratios rose over the incubation period in both treatments.

Overall denitrification rates and related N_2:N_2O ratios were higher at 100% WFPS compared to 80% WFPS, confirming WFPS as a major driver of denitrification. This study highlights denitrification as a major pathway of N loss for sub-tropical pasture systems with a substantial amount of applied fertiliser lost as N_2 at high WFPS. The ^{15}N gas flux method proved an effective tool in assessing N losses from fertilised soils. However, its suitability to determine N_2 fluxes from soils with lower denitrification rates needs to be confirmed in future studies. The high variation between soil cores emphasises the need for field measurements with a high spatial and temporal resolution in order to capture the dynamics of N_2 emissions.

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