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Nitrous-oxide production partitioned between nitrification and denitrification over the soil-moisture range of the world's peatlands

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Emission of nitrous oxide (N_2O), a powerful greenhouse gas and the leading stratospheric-ozone depleter from nitrogen- (N) rich organic soil peaks at intermediate (50% volumetric) soil moisture. Nitrification (oxidation of ammonia (NH_4)) and denitrification (reduction of nitrate (NO_3)) are the dominant sources of N_2O production in soils and their contribution to net N_2O emission, in addition to other soil factors, is affected by the degree of saturation with water and subsequently oxygen. Therefore, knowing the effects of soil moisture on the relative contribution of denitrification and nitrification to N_2O emission from organic soils across the world could identify management action to reduce N_2O emissions.

We utilised our library of organic-soil samples collected from 21 peatland sites across the world, tropical to boreal climates. We source-partitioned N_2O production in the laboratory using the ^{15}N gas-flux method in a factorial design representing the full globally observed range of organic-soil moisture and N content. For the source partitioning, we added either $^{15}NH_4^+$ or $^{15}NO_3^-$(at $\sim$ 20 % of the ambient soil NH_4^+ and $^{15}NO_3^-$ concentration) in two separate 30g aliquots while retaining the ambient moisture content. We incubated them in the dark for 24h. We then quantified total N_2O flux and the relative contribution of denitrification and nitrification from the isotopic signatures of the ^{15}N in the N_2O gas as per the ^{15}N gas-flux method. Additionally, we estimated gross N mineralisation and nitrification according to the isotope dilution technique.

Most of the soils that produced a high N_2O flux were from ploughed tropical fens in Uganda and Myanmar that were low in $^{15}NO_3^-$but with above average in NH_4^+ concentration. The N_2O fluxes peaked at around 75% soil moisture. Across all the peatland types, this pattern pointed towards nitrification as the dominant source of N_2O production.

The N_2O evolved from $^{15}NH_4^+$ amended peat (the nitrification source) peaked between 65–75% soil moisture. The N_2O evolved from $^{15}NO_3^-$ amended peat (the denitrification source) was positively related to soil moisture all the way up the moisture scale. The nitrification/denitrification ratio (N_2O from $^{15}NH_4^+$ / N_2O from $^{15}NO_3^-$) showed a distinctive pattern along the soil-moisture scale. From 40–75% the ratio stayed flat around 1, indicating equal contribution of nitrification and denitrification; while at moisture content of >75% the ratio dropped to 0.01 indicating prevalence of denitrification.

N_2O-emission mitigation proposals that emerge from our results are: 1) even moderate drainage of fertile peatlands induces high N_2O production from nitrification; 2) if wet peat is used for agriculture, only ammonium-based fertiliser (manure) should be applied to avoid denitrification, and 3) on drained peat farmers should avoid N fertilisation to avoid both nitrification and denitrification. Instead the farmers should rely on the plentiful inorganic N released from mineralisation of the drained peat.