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Dynamics of nitrate limitation on gaseous nitrogen exchanges from pristine peatlands

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The cycling of gaseous nitrogen species in peatland ecosystems and the functioning of driving forces on microbial denitrification rates are poorly accounted. Physico-chemical soil conditions and biotic interactions[1] control the availability of nitrate for respiratory denitrification resulting in high spatial variability of gaseous nitrogen exchange rates in nutrient poor peat soils and complicating impact assessment of eutrophication. The responses of nitrous oxide (N_2O) and dinitrogen (N_2) fluxes to nitrate addition were compared between distinct contrasts in plant growth at a pristine, hummocky peatland. Allowing to determine the dynamics of nitrate limitation on gaseous nitrogen exchanges in accordance to covariance in soil anaerobiosis and resource competition.

Two quantification techniques were applied parallel to soil core incubations in order to determine N_2O and N_2 fluxes. Helium atmosphere incubation was used for direct quantification of net N_2O and N_2 fluxes. Reducing the background N_2 concentration in the soil atmosphere to approx. 20 ppm enabled highly sensitive measurement of N_2 fluxes. On the other hand a ^{15}N-N_2O tracer technique was explored as a tool to demonstrate and quantify gross consumption rates of atmospheric N_2O to N_2 and recycling of gaseous N-losses by microbial fixation. The headspace N_2O pool was increased with 0.03 ppm $^{15/15}$N-N_2O rendering an enrichment of ± 9.8 atom% $^{15/15}$N-N_2O. Triplicate soil core samples were taken from two contrasting soil habitat in a hummocky, Carex dominated fen located in the Biebrza National Park, NE Poland (53°07′N; 23°10′E). The hummocks had a gravimetric soil water content of 76.6 ± 2.2% and high root abundance, dissimilar to 83.4 ± 1.0% and little root prevalence in the hollows. Singular nitrate addition, comparable to the atmospheric NO^Y-deposition, was applied two days in advance of flux measurement.

Actual net gaseous nitrogen fluxes and responses to nitrate addition were apparently different for both soil habitat. Hummock soil cores showed to be net sources of N_2O sinks (-3.04 ± 0.12 μg N_2O-N h^{-1} m^{-2}). Net N_2 fluxes measured consistently higher from the hollows than the hummocks (resp. 2622.3 ± 106.3 and 1065.3 ± 139.2 μg N_2-N h^{-1} m^{-2}). Nitrate addition to the hummock habitat resulted in a small, non-significant increase of the net N_2O flux, while the hollow soil cores showed a drastic shift towards a net N_2O source upon nitrate addition (16.27 ± 2.87 μg N_2O-N h^{-1} m^{-2}). The N_2:N_2O ratios and net N_2O fluxes clearly illustrated that relatively more bio-available nitrogen is converted to N_2O by respiratory denitrification at higher soil nitrate availability. The $^{15/15}$N-N_2O tracer technique demonstrated consumptive reduction of atmospheric N_2O to N_2. With NO_3–addition the atom percent excess of ^{15}N in N_2 decreased for both soil habitat indicating that less atmospheric N_2O is reduced to inert N_2 when more nitrate is available for microbial denitrification. N_2O consumption rates will be discussed on the presentation. Indirect fumigation of soil samples proved that $CHCl_3$-labile nitrogen was significantly enriched in ^{15}N when ^{15}N-N_2O was applied in the headspace. Demonstrating that nitrogen lost during respiratory denitrification is recycled to microbial biomass, most likely a result of N_2-fixation by soil micro-organisms in this mineral N-depleted ecosystem.

Higher root abundance associated with lower soil anaerobiosis and higher resource competition caused net N_2O fluxes to be positive, but mitigated the effect of nitrate addition. Lower root abundance associated with higher soil anaerobiosis, caused natural peat soil to be net N_2O sinks, but lower resource competition however attributed to higher eutrophication susceptibility. Variance in physico-chemical soil conditions and biotic interactions showed to interfere with the effect of nitrate availability on consumptive reduction of atmospheric N_2O to N_2. Inverse covariance of soil anaerobiosis and resource competition as a result of variance in plant growth indicated to be a major regulatory dynamic of gaseous nitrogen exchanges from natural peatland, by which the susceptibility to

nitrate eutrophication is determined.

References

1 Silvan, N., Tuittila, E., Kitunnen, V., Vasander, H., Laine, J., 2005. Nitrate uptake by Eriophorum vaginatum controls N2O production in a restored peatland, Soil Biology & Biochemistry, 37:1519-1526.