



INSTITUTIONEN FÖR GEOVETENSKAPER

**Nitrous Oxide Production in Agricultural Soil
Linking Biogeochemical Pathways and Drivers**

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Abstract

Nitrous oxide (N_2O) is a long-lasting and potent greenhouse gas responsible for depletion of stratospheric ozone. As the atmospheric N_2O concentration reaches all-time highs, emission variability in space and time still leaves unresolved questions. The aim of this thesis is to improve our understanding of the origin of N_2O and its main drivers from the largest anthropogenic source: agricultural soil. Therefore, we investigated agricultural soil from long-term trial field sites in the laboratory and used ^{15}N -enriched tracers in two main approaches: partitioning of the sources of N_2O production and quantification of the gross rates of microbial processes competing for ammonium (NH_4^+) and nitrate (NO_3^-).

The varying relative contribution of NH_4^+ , NO_3^- and organic nitrogen (N_{org}) to N_2O emission highlights the influence of site-specific factors apart from the field management. Without fertilizer, N_{org} was the dominant N_2O source related to high carbon (C) contents and C:N ratios. High N_2O emissions were caused by increasing contributions of nitrification and denitrification, which was drastically stimulated by mineral nitrogen (N) fertilizer. In addition, N fertilizer application more than doubled N_2O production from native non-fertilizer N compounds, which provides evidence for primed N_2O production. By using the *Ntrace* model, we quantified gross rates of N cycle processes that compete for substrates and regulate N_2O production. In the long term, cropping systems can shift the balance between denitrification and dissimilatory nitrate reduction to ammonium (DNRA), which determines the fate of NO_3^- in soil. A perennial cropping system that maintains high SOM contents and C/ NO_3^- ratios has shaped the microbial community of dissimilatory nitrate reducers leading to higher N retention by DNRA and lower N_2O emissions. By applying selective inhibitors, we were able to quantify the specific activity of archaeal and bacterial nitrifiers competing for NH_4^+ . While both can coexist and be equally active in agricultural soil with low N supply, bacteria outcompeted archaea with increasing NH_4^+ concentration, which can be responsible for higher N_2O emissions as well.

This thesis illustrates how human action drives N_2O emission from agricultural soil in a variety of ways since field management affects N cycle processes in the short- and long-term. While N fertilizer application strongly stimulates N_2O production from added- and native N sources, long-term field management can change the soil properties, which shifts the abundance of microbial communities and thereby alters the N cycle processes responsible for N_2O production.

Keywords

Nitrogen, field management, fertilizer, ^{15}N -tracing, ammonium, nitrate, soil organic matter, priming, denitrification, nitrate ammonification, DNRA, ammonia oxidation, bacteria, archaea