Geophysical Research Abstracts
Vol. 19, EGU2017-18134, 2017
EGU General Assembly 2017

Emissions of N_2O from organic soils managed by agriculture in North Western Denmark (Possible production and reduction spots)

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In North Western Denmark, organic soils are extensively under agricultural management for cereal and high-value cash crop production or as grazing land. The area (overlying raised seabed) has been classified as potentially acid sulfate soil. Drainage and tillage of organic soil is known to promote emissions of nitrous oxide (N_2O), but a previous monitoring program found annual N_2O emissions from adjacent fields with rotational grass and potato that were, respectively, 3 and 5 times higher than default values proposed by The Intergovernmental Panel on Climate Change (IPCC, 2014). In order to study underlying mechanisms, the same two sites and two new reference sites along an East-West transect were investigated during 2015.

The four sites (i.e. two with rotational grass and two sites with a potato crop) were equipped for weekly monitoring of soil surface N_2O emissions and sub-soil N_2O concentrations to 1 m depth during spring and autumn 2015. Also, various environmental variables (precipitation, air and soil temperature, soil moisture, groundwater level, and soil mineral N) were monitored. In April and August 2015, intact cores to 1 m depth were collected at the paired grassland and potato sites and analysed for pH, EC, nitrite, reactive Fe, acid volatile S (AVS) and chromium-reducible S (CRS).

Nitrous oxide concentrations in the soil profile showed strong temporal dynamics reflecting water table changes, as well as precipitation and in some cases fertilization. At the paired site concentrations in the potato field (reaching 2000 μL N_2O L^{-1}) were much higher than in the adjacent grassland (up to 20 μL N_2O L^{-1}). Soil pH averaged 4.9 at the two paired sites. The difference was confirmed at reference sites. Accumulated emissions of N_2O during monitoring periods (in total 151-174 d) corresponded to 18 and 48 kg N ha^{-1} at potato sites, but only 3 and 4 kg N ha^{-1} at the grassland sites. Nitrous oxide accumulated at depth in the soil during phases of declining water table in spring, but also when the water table raised to near the surface due to precipitation. On several occasions N_2O also accumulated at shallow depth, and with elevated emissions, in connection with rainfall. Total reactive iron and sulfur content, including AVS and CRS, showed great heterogeneity in the profiles of both grassland and potato fields, and no clear relationships have been found between reactive iron or sulfur compounds and N_2O concentrations in soil profile. However, controlled incubation experiments are on-going to identify possible mechanisms behind the accumulation and extremely high emissions of N_2O from potato fields, especially whether acidifying processes can be linked to soil nitrate or nitrite reduction (e.g., through oxidation of ferrous iron to ferric iron, and sulfide to sulfate).

Key words: Acid sulfate soils, organic soils, agricultural management, nitrous oxide emissions, environmental variables