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Can alternating groundwater level affect uncontrolled nitrogen losses from rewetted histosols under urea and CAN fertilization? Evidence from mesocosm lysimetric study on nitrogen atmospheric fluxes

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Background

Managing groundwater table in agricultural areas is one of the key-practices for counteracting climate change's impact on soil-water conditions. Shifting groundwater shapes soil aerobic conditions, affecting soil microbial activity and inducing redox potential changes in soil solution, which altogether may influence soil respiration. Still, the direct effect of alternating groundwater level on ammonia (NH_3) volatilization and nitrous oxide emission (N_2O) from fertilized histosols has not yet been fully understood.

Introduction

Here, we conducted a small scale lysimeter study in strictly controlled laboratory conditions aiming to investigate the direct effect of shifting groundwater table level on NH_3 and N_2O gaseous outflux derived from urea and calcium ammonium nitrate (CAN) fertilization, respectively. We hypothesized that changes in aerobic conditions in the soil saturation zone and moisture content in the capillary zone can increase N_2O emissions and lower NH_3 volatilization from fertilized histosols under rewetting conditions.

Methods

Soil lysimeters filled with 0,25m³ homogenised histosols sampled from peatland area located near Tyśmienica river, Lublin district. (N 51° 27′ 24.955″, E 22° 51′ 59.732″)

Alternated groundwater table treatments were designed as P 10, P 20, P 30, P 40 and P 50 meaning permanent groundwater level on 10, 20, 30, 40 and 50 centimetres below surface, respectively. Additionally FWT (fluctuating water table) treatment was established characterized by constantly fluctuating water level (depths 10-50cm, 1 full cycle lasted 24 hours).

Each treatment consisted of 3 lysimeters for urea and 3 lysimeters for CAN fertilization alongside with 3 lysimeters for unfertilized controls.

100 kg N/ha fertilization dose was applied with urea and CAN separately.

Each lysimeter was fitted with gas chamber closed for 30 minutes per day while the gaseous emissions were registered with Gasmet DX4000 FTIR spectrometer.

The measurements were carried out on days 1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 15, 17, 19, 21, 23 and 25 after fertilization.

Gaseous fluxes, emissions of N-N_2O from CAN, and volatilization of N-NH_3 from urea, were calculated as the gas concentration increase within the closure time and standardized for molecular outflux on the basis of mass composition.

Cumulative flows were determined as the sum of the flux rates of each day of the trail subtracting control readings. Linear interpolation was used to quantify the fluxes of the days in between of the two measuring days where needed.

Two way analysis of variance (ANOVA) followed by Tukey's post hoc tests was used to indicate the statistical significance of obtained results differences. Shapiro-Wilk test was done to check the normal distribution of residuals requirement to use parametric tests.

Fig. 1. Flowchart of applied methods.

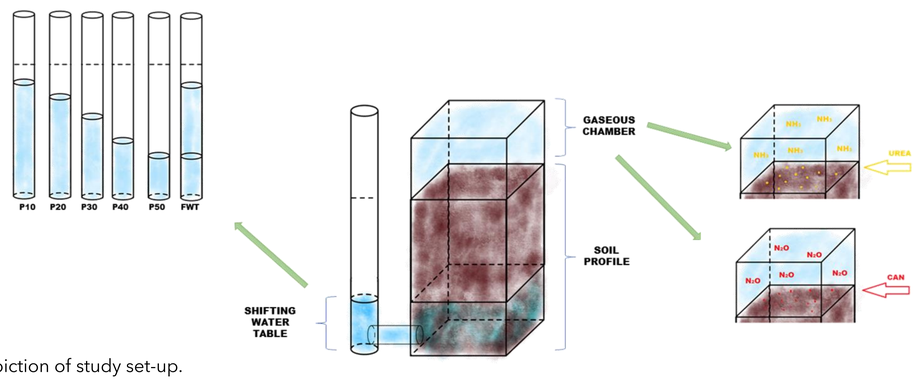

Fig. 2 Depiction of study set-up.

Results

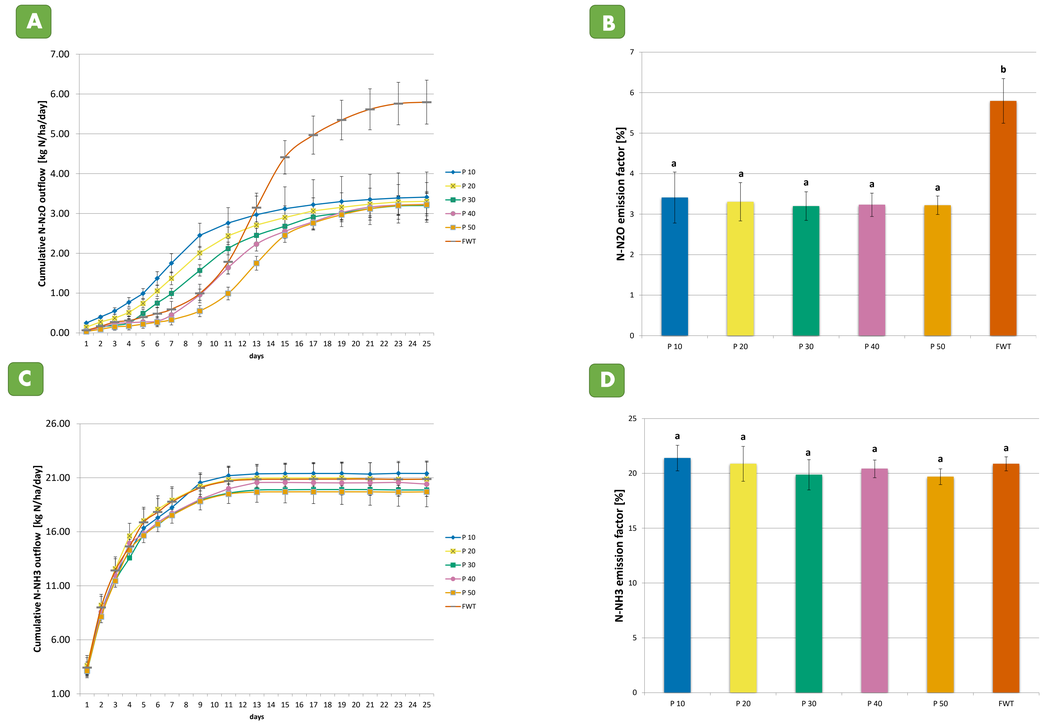

Fig. 2. A - Cumulative N_2O emissions over study time; B - Total N_2O outflux recalculated to N emission factor (% applied N); C - Cumulative NH_3 over study time; D - Total NH_3 outflux recalculated to N emission factor (% applied N). All results are expressed as means where corresponding vertical bars are its standard error. Values in each column which have different letters are significantly different ($p<0.05$).

- Stable rise of groundwater table on CAN fertilized soil shorten the time after which high N_2O emissions were registered but did not affect the total cumulative N_2O outflux.
- Fluctuation of groundwater table significantly increased N_2O emission following CAN application.
- Tested water table alternation strategies did not affect NH_3 volatilization rates.

Conclusions

I. Alternating groundwater table with stable levels did not increase environmental risks of uncontrolled gaseous nitrogen fluxes in aspects of NH_3 and N_2O emission factors despite affecting nitrogen turnover pace.
II. Special attention is needed when implementing fluctuating groundwater levels strategies due to not yet fully understood effect on N_2O emission rates following fertilization.
III. Further examination is still needed to validate the results in different environmental conditions.