

Measurements of the atmospheric emission of N₂O from biogenic sources in general and by grassland ecosystems in particular

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Abstract

The project is part of the 'Integrated N₂O grassland project'. The project carried out at TNO aims to determine the atmospheric emissions of N₂O from biogenic surface sources in the Netherlands. The following activities were part of the project :

- determination of N₂O emissions from grassland
- comparison of methods to measure N₂O emissions in the field
- determination of N₂O emissions from arable land
- determination of N₂O emissions from fresh water systems and coastal waters
- organisation of a round robin to compare measurements of N₂O concentrations in air

1. INTRODUCTION

The objective of this study was to measure the N₂O emission from relevant sources in the Netherlands with an emphasis on grassland. Other ecosystems studied include agricultural land, sea water and fresh water bodies. It was intended to measure these fluxes on an ecosystem scale ie. using the aerodynamic gradient method wherever possible. In other cases the dynamic enclosure technique was to be employed.

This project was part of the so called 'Integrated N₂O grassland project' in which several Dutch groups (including RIVM, NMI, LUW and AB-DLO) participated. In the framework of this project a round robin was organised in which a comparison was made between the methods that are used in the programme to measure N₂O concentrations in air [1].

2. THEORY AND METHODS

Dynamic enclosures designed by TNO [2] and NMI design static enclosures [3] and the aerodynamic gradient method were used. The dynamic enclosures cover a surface of 20 x 100 cm whereas the static enclosure cover a surface with a diameter of 20 cm.

In the gradient method the flux is derived from the concentration gradient of the trace gas in the air above the surface and measurements of the turbulence intensity. The method is described in detail in [4].

3. RESULTS

3.1 Comparison studies

In two comparison campaigns the enclosure methods and aerodynamic methods were applied simultaneously. The aim of this experiment was specifically to investigate the spatial distribution of N_2O sources on a field scale. To this purpose 42 static enclosures were operated continuously by the NMI [3]. The enclosures were placed along a transect between the two dikes bordering the site at distances of one meter. Close to the dikes the observed fluxes were smaller, often around $0.5 \text{ mg N/m}^2/\text{hr}$ whereas in other areas some chambers showed fluxes as high as $10 \text{ mg/m}^2/\text{hr}$. More than 80 % of the variation in N_2O fluxes could be attributed to variations in soil moisture and nitrate concentrations in the soil.

The equipment used for the gradient method was located in such a way that the flux determination was expected to be representative for the area studied using the enclosures. Figure 1 shows the results of the experiment. The flux estimated using this method varied with time between 0 and $2.5 \text{ mg N/m}^2/\text{hr}$. At night fluxes showed much less variation and varied between 0.5 and $1 \text{ mg N/m}^2/\text{hr}$. During the day fluxes as high as $2.5 \text{ mg N/m}^2/\text{hr}$ were observed but the variation was much stronger. The dynamic enclosures showed fluxes with a median value of around $1 \text{ mg/m}^2/\text{hr}$. During or after rain the direction of the flux indicated deposition, i.e. flux of N_2O towards the surface. These phenomena were also observed with the enclosures.

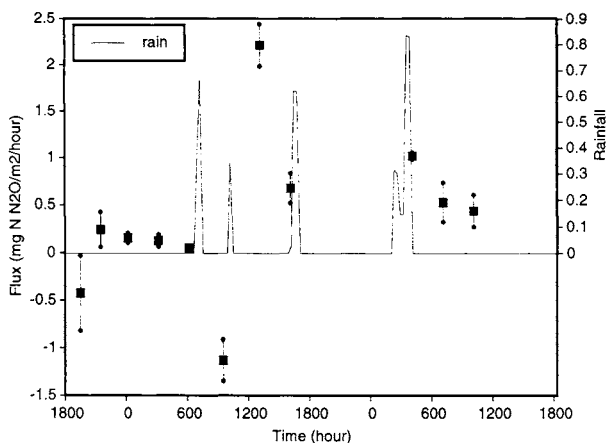


Figure 1 Fluxes of N_2O observed during the inter comparison experiment over peat grassland at Zegveld in June 1993

In a second experiment in November the static enclosures and the gradient method were used. With the 42 static enclosures, this time located in a 6X7 meter grid showed fluxes varying between zero and 1.3 with an average of 0.25 mg N/m²/hr. With the gradient method hourly averaged fluxes varying between 0.15 and 0.7 mg/m²/hr were observed. The results of these experiments are not easy to generalize. The results of the first phase study were confirmed showing that static chamber results can show large variation probably linked with the scale of variation of relevant soil parameters and processes.

It seems justified to conclude that on a day scale the fluxes of N₂O measured using the static chambers lie within a factor of 2 to 3 from fluxes measured with the gradient method.

3.2 Continuous measurements of fluxes from grassland

On the peat grassland site at Zegveld N₂O fluxes were determined every day from April 1993 to June 1994. To this purpose samples were taken every afternoon. Figure 2 shows the monthly averaged emissions calculated from all observations from April 1993 to June 1994 expressed in kg N/ha/year. The average emission is roughly 10 kg N/ha over this period with peaks in the summer. In general two peaks are found midsummer and November 1993. The December period was quite wet. The annual fertilizer input on the site was roughly 100 kg N/ha.

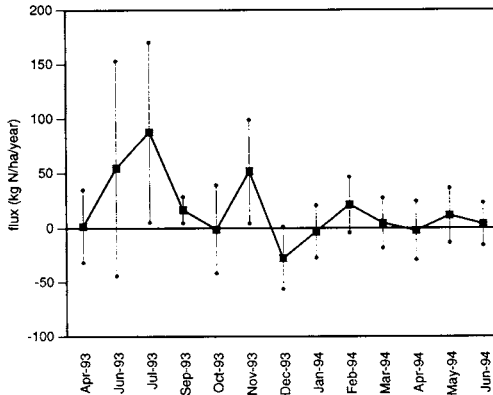


Figure 2 Median emission of N₂O observed over peat grassland at Zegveld.

3.4 Emissions of N₂O from coastal waters and freshwater systems.

A campaign was carried out along the Dutch Waddensea. To estimate the flux the concentration of N₂O was determined at two heights 0.3 and 4 m above the sea surface. The N₂O concentration in the sea was high compared to open sea values ie. around 1000 ng/l. The observed emission from the sea was equivalent to 2 kg N₂O N/ha/yr. If this emission rate would be observed all year the Dutch Waddensea would emit roughly 500 ton N₂O N per year.

In April and May several campaigns were carried out over the freshwater lake Ketelmeer. This lake was chosen because of its high nitrate concentrations. In one case significant gradients were detected with relatively high fluxes equivalent to 3 kg N/ha/yr. In those cases high N_2O concentrations of more than 2000 ng/l were observed in the water phase.

Further water samples were taken from sweet as well as salt water bodies in the Netherlands. The results indicate a quite strong relation between nitrate and ammonium content on one hand and N_2O concentration on the other. This result is shown in Figure 3 which shows the N_2O concentration observed as a function of the ammonium and nitrate content for several salt and fresh water systems in the Netherlands.

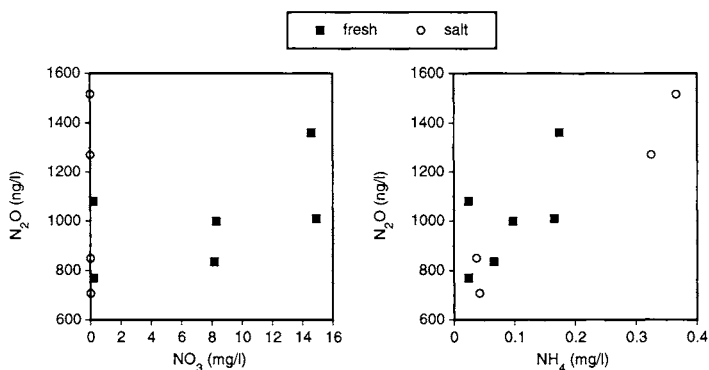


Figure 3 The concentration of N_2O as a function of Nitrate and ammonium content

3.5 Emissions from arable land

Measurements of the emission rates of N_2O from arable land were started in spring 1994. Two sites were chosen. One set of experiments was carried out at the agricultural experimental station at Nagele in the Noordoostpolder on a sea clay soil. The other experiments were carried out over a sandy soil in Vredepeel. Measurements were carried out over potatoes and onions over the clay soil and over peas, potatoes and grassland on a sandy soil. Measurements using two enclosures were carried out over bare soils and during crop growth. Around two weeks after fertilizer application a maximum in the emission rate is found. The emission from the onions upon which N fertilizer was applied was around a factor of three lower.

4. REFERENCES

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