Poster presentations

Different methods for quantifying actual denitrification for a permanent and temporary grassland

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Abstract

Nitrogen emissions from agricultural soils to the surrounding environment are controlled by field management and physical conditions in the soil. Measuring denitrification under field conditions is difficult and expensive. This study compared several methods to quantify denitrification for a wet and a dry sandy soil with grass: a balance method, a (complex) deterministic model, a simplified process model and measurements. The first three methods were either used with generic data or with plot-specific data. Most methods show that denitrification is highest in the permanent grassland with shallow groundwater levels (wet field). Taking into account plot-specific circumstances (weather, N surpluses) results in different estimates for denitrification in comparison to the generic input data. For the dry field, temporary grassland with deep groundwater levels, the differences between the estimated denitrification were the largest. The best suitable method probably depends on the available data, but should be as plot-specific as possible.

Keywords: denitrification, grassland, leaching, modelling, nitrate

Background and objectives

Nitrogen (N) emissions from agricultural soils to the surrounding environment are controlled by N application rates, field management and physical conditions in the soil. Measuring denitrification under field conditions is difficult and expensive due to temporal and spatial variations and methodological difficulties. The objective of this study is to compare different methods to quantify total denitrification under field conditions. The difference between the total amount of N emission and the total denitrification is an estimate for nitrate leaching, as there is a general trade-off between N losses.

Material and methods

We present the results of a desk study focusing on different modelling approaches, supplemented with a variety of field and laboratory measurements as input to different models. The field measurements were carried out on two fields on the experimental farm 'De Marke' in the Netherlands. Field A, a permanent grassland, was situated on a sandy soil with shallow groundwater levels during winter (Mean Highest Groundwater level (MHG) between 25 and 40 cm below soil surface (-ss)). Field B, a temporary grassland (ley), was situated on a dry sandy soil (MHG below 140 cm -ss) and is considered to be vulnerable for nitrate leaching.

During the winter of 2004-2005 soil samples were taken from six layers of each field plot. The soil samples were used to determine potential denitrification (Van Beek *et al.*, 2004), actual denitrification using isotope pairing (Arah, 1992), mineral nitrogen content, bulk density and volumetric water content. During this period groundwater levels, precipitation, and air temperature were monitored. Nitrate concentrations in groundwater were measured once.

The used methods are described in Table 1. They were applied to calculate the total denitrification for each plot (period March 2004 - March 2005; soil layer 0 - 1 m -ss).

Table 1. Description of the seven methods used to compute denitrification.

Method	Description
1	The balance method: denitrification and nitrate leaching were calculated using representative values for nitrogen surpluses, leaching fractions and precipitation surpluses following Schröder *et al.* (2004).
2	The plot-specific counterpart of (1) uses the actual nitrogen and precipitation surpluses and measured nitrate concentrations (in spring).
3	Denitrification was taken from the Dutch national scale model STONE (Wolf *et al.,* 2003) for two STONE plots resembling the two fields of 'De Marke'.
4	With SWAP (Kroes and Van Dam, 2003) and ANIMO (Groenendijk and Kroes, 1999) (both incorporated in STONE) plot-specific denitrification was computed by adapting input of (3) to site-specific conditions of the two plots.
5	A widely used simplified denitrification process model (Heinen, 2005a,b) was used to calculate actual denitrification based on potential denitrification and three reduction functions for nitrate content, degree of water saturation and soil temperature. The required time series (per decade) for nitrate content, degree of saturation and temperature came from method (4).
6	Instead of using a standard parameter valueset (as in (5)), plot-specific parameter values were used in the simplified denitrification process model. The plot-specific parameter values were estimated from the measurements in the soil samples.
7	The last method calculates the total denitrification by integrating the measured actual denitrification over depth and time.

Results and discussion

The calculated denitrification per plot, using methods (1) - (7), is presented in Figure 1.

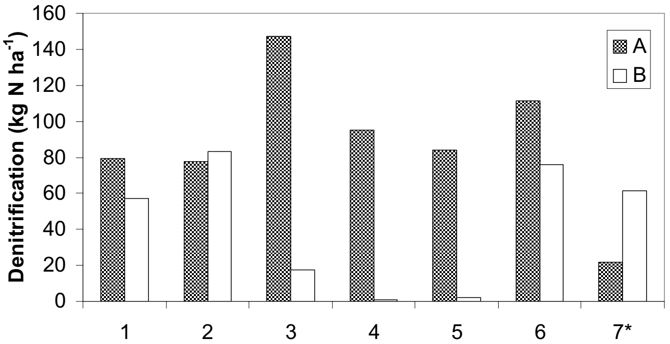

Figure 1. Total denitrification in kg N ha^{-1} for the permanent (A) and temporary (B) grassland using different methods. (1) balance method based on Schröder et al. (2004), (2) plot-specific balance method, (3) STONE model for representative plots, (4) STONE model with plot-specific input, (5) simplified denitrification process model with representative parameter values, (6) simplified denitrification process model with plot-specific parameter values, (7) integration of denitrification measurements over time and depth. (*) Method (7) is applied over a shorter period, i.e. 120 days instead of 365 days.

Results of the first balance method (1), both STONE methods (3,4), and both simplified process models (5,6) show that denitrification is highest in field A. Field A is the wettest field of both fields considered, which is advantageous for denitrification to occur. Furthermore, field A is a permanent grassland, which generally implies higher N applications and higher amounts of N stored in the soil. The plot-specific balance method (2) indicates that denitrification in field B is comparable or even higher than in field A. This can be explained by the difference in N surplus in the considered period. The N surplus of field B is almost 30 kg ha^{-1} higher than the N surplus of field A. Furthermore, March 2004 – March 2005 was a relatively dry period with 719 mm precipitation (the 30-year average precipitation for this region is 750 - 775 mm).

The differences between the calculated denitrification of the generic methods (1) and (3) and the plot-specific methods (2) and (4) are mainly caused by drier than average circumstances and by the differences in N surpluses. The used plot-specific parameter values in (6) are the result of a poor fit, so results of this method should be judged with care.

The measured denitrification of field A is the lowest. However, the measured period is a third of a year. We expect more denitrification to occur in field A than in field B during the remainder of the considered year. This expectation is confirmed by modelling results of method (3) and (4). We could not find a good explanation for the low measured denitrification of field A. The samples of field A were usually a bit warmer (except last sampling) and had a higher moisture content. The nitrate contents in the first two layers were highest in field B. In the other layers nitrate contents were highest in the samples of field A.

Conclusions

The average denitrification of methods (1) - (6) for field A and B is 99 (± 27) and 39 (± 37) kg N ha^{-1}, respectively. The variation between the different methods is high. Most methods show that denitrification is highest in the wet permanent grass field A despite the lower N surplus with respect to the dry temporary grass field B. Taking into account plot-specific circumstances (weather, N surpluses) results in different estimates of denitrification. The best suitable method probably depends on the available data, but should be as plot-specific as possible.

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