Nitrogen losses to surface water on a heavy clay soil in the Netherlands

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Abstract

Losses of nitrogen to surface water were measured from autumn 2002 to spring 2005 at a grassland plot on a heavy clay soil in the Netherlands. The water balance showed that ditches were the dominant pathway for water and nutrients in this system. Annual nitrogen losses ranged form 13 kg/ha/year in the dry winter of 2002/2003 to 19 kg/ha/yr in the other two winters. Incidental losses of nitrogen after manure application strongly influenced the annual nitrogen losses. In wet years the loss of nutrients in autumn by drains and ditches contributes substantially to the yearly losses.

Keywords: ditches, drain water, leaching, losses, nitrogen

Background and objectives

Diffuse pollution of groundwater and surface water with nitrogen is a serious problem in the Netherlands. As a result of the EU-Nitrates Directive, the pollution of groundwater with nitrogen has been extensively studied (Fraters *et al.*, 2004). Relatively little attention has been paid to the pollution of surface waters disregarding the fact that the relative contribution of agriculture to the pollution of the surface water with nitrogen has increased from 43% in 1985 to 57% in 2002. To obtain more information on the pollution of surface waters by dairy farms, a number of measurement projects has been set up at the end of the nineties on a sandy soil, a peat soils and a clay soil. This study focuses on the losses of nitrogen from a dairy farm on a clay soil.

Materials and methods

The losses of nitrogen to surface waters were measured from autumn 2002 to spring 2005 on a grassland plot at a dairy farm. The plot had a size of 3.2 ha and the grass was alternately mowed and grazed. The total N application by fertilizer and manure was 463 kg/ha/yr. The average N surplus was 107 kg N/ha/yr and declined from 220 kg/ha/yr in 2003 to 49 kg/ha/yr in 2004.

The plot was located on a heavy clay soil (57% < 2μm; 40% 2-50 μm) The site was level and the soil was drained by subsurface drains and drainage ditches. The subsurface drains were located at a depth of 80 cm below the surface. The ditches were shallow (50 cm depth) and located at intervals of 46 m. Both the subsurface drains and the ditches fed a small channel that surrounded the plot.

To construct a water and nitrogen balance for the plot the amount and composition of the discharge from the drains, ditches and channel were continuously monitored. Water samples were collected automatically depending on discharge. Bulked samples were analysed every week for NO_3, NH_4, Kjeldahl-N, PO_4 and total-P.

Results

Discharge of water and nutrients from the plots was generally limited to the winter period (October to April). The average precipitation surplus in winter over the three year measurement period was 290 mm. The average discharge of the channel (296 mm) was almost equal to the precipitation surplus in winter (Table 1). The discharge from the drains and ditches to the channel was slightly (10%) lower. This difference may be due to overland flow from the plot or from a small road adjacent to the channel. Most of the water (60%) was carried to the channel by

means of the drainage ditches (Table 1). The drains contributed to the drainage by 30%. Discharge to groundwater was negligible due to the extremely low conductivity of the heavy clay (sub)soil.
The relative contribution of drains and ditches to the discharge changed considerably during the season. In autumn, when cracks are present in the heavy clay soil, drains contributed significantly to the monthly discharge (30-50 mm/month). During the winter, when cracks are closed due to swelling of the clay soil, the drainage reduces to values of 10-15 mm/month. In this period the ditches play a dominant role in the discharge. The importance of cracks for the functioning of the drains is also clearly shown when the results for 2003 and 2004 are compared. The summer of 2003 was dry and the discharge of the ditches remained relatively high until February leading to a total discharge of 90 mm. In the wet year 2004, the discharge by the drains was already strongly reduced in December and the total discharge was only 70 mm.

Table 1. *Average water and nitrogen fluxes and concentrations in drains, drainage ditches and channel over the years 2002/2003, 2003/2004 and 2004/2005.*

	Water fluxes (mm)	Flux (kg/ha)		Concentrations (mg/l)	
		Total N	Organic N	Total N	Organic N
Drains	85	5	4	5.6	4.2
Drainage ditches	183	12	9	6.3	4.6
Drains +ditches	268	17	12	6.1	4.5
Channel	296	13	10	4.1	3.1

The nitrogen discharge by the channel was on average 13 kg N/ha/yr (Table 1). Most of the nitrogen was in an organic form or present as colloids. Inorganic nitrogen consisted for approximately 50% of NO_3 and 50% of NH_4. De discharge of the drains and ditches was higher (17 kg N/ha/yr) than the discharge of the channel, due to a higher content of NO_3 (1.3 kg/ha/yr) and organic/colloidal N (2.8 kg N/ha/yr).

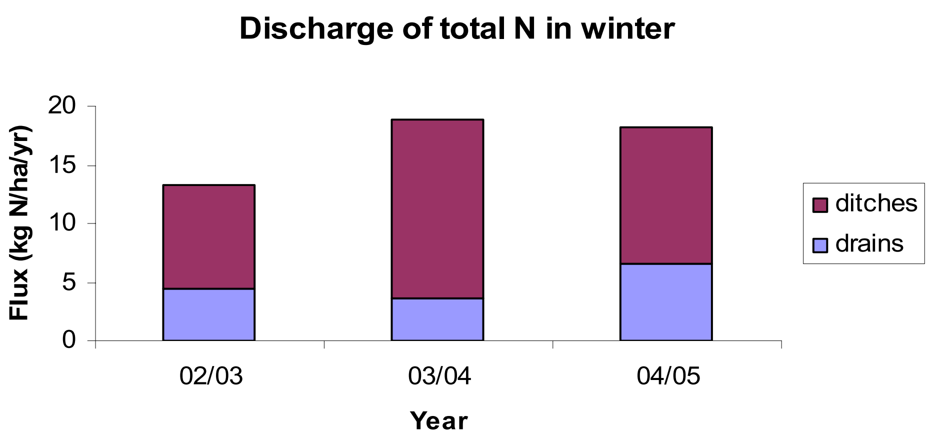

Figure 1. *Discharge of total N by drains and ditches in the winter period (October-April) of the years 2002/2003, 2003/2004 and 2004/2005.*

The discharge of nitrogen by drains and ditches varied considerably form year to year (Figure 1). The year 2002/2003 was rather dry (total discharge of 243 mm) and there was no discharge from February onwards. In 2003/2004 and 2004/2005 discharge of water and nutrients was considerably higher (approx. 280 mm, and 19 kg N/ha/yr). The higher nitrogen losses in 2003/2004 are partly caused by rainy weather (31 mm) in the week

following manure application in March. The rainfall led to a discharge of 19 mm of water and 9.4 kg N/ha by the ditches, accounting for 50% of the annual nitrogen loss in 2004. In 2004/2005 a similar incident took place. However, due to lower rainfall the nitrogen losses were only 3 kg N/ha/yr. Despite this the nitrogen losses in autumn 2004 were high compared to 2002, due to the higher water discharge in autumn.
During the three year period the N-surplus at the field decreased from 220 – 49 kg ha^{-1} yr^{-1}. This decline in N –surplus did not lead to a decline in N leaching during the observation period. Moreover the potential decline in N leaching upon a reduction in yearly N application rates will be limited as a substantial part of the N leaching is caused by incidental losses.

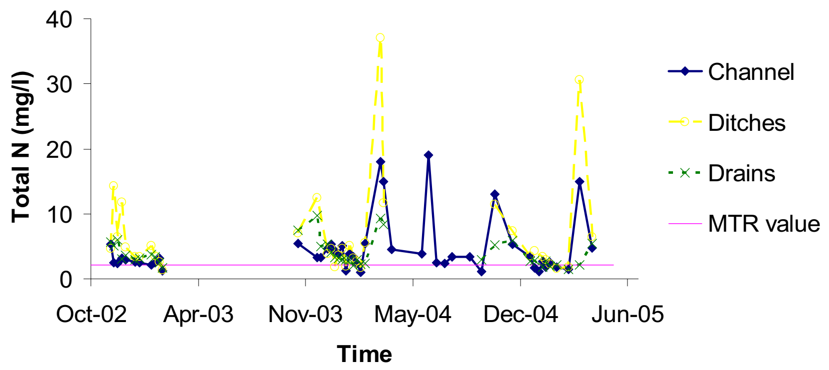

Figure 2. Total nitrogen concentrations in channels, ditches and drains during the monitoring period.

Average nitrogen concentrations in the channel were well above the Maximum Tolerable Risk (MTR- values) for stagnant surface waters in the Netherlands during the summer period (2.2 mg N/l). Nitrogen concentrations in the channel were generally quite close to the concentrations in the ditches. Concentrations in the drains are generally somewhat lower. Nitrogen concentrations in the discharge water were highest in autumn and spring and lowest during mid-winter (Figure 2). The high spring concentrations were closely linked to manure applications in spring. For example in spring 2004, concentrations of more than 40 mg/l were measured following manure application.

Conclusions

Discharge of water en nutrients on this heavy clay soil was limited to the winter period. The ditches played a dominant role in the drainage of water and the loss of nutrients from the plot. The contribution of the drains was strongly dependant on the presence of cracks in this heavy clay soil. The total annual loss of nitrogen is strongly influenced by incidental losses of nitrogen after manure application in spring. In wet years substantial losses of nutrients occur in autumn through both drains and channels.

References

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