Poster presentations

Vegetated buffer strips on sandy soil to reduce nitrate leaching to surface water

Heinen, M.[1], Beek, C.L. van[1], Kleef, J. van[1] & Clevering, O.A.[2]

[1] *Alterra, P.O. Box 47, 6700 AA Wageningen, the Netherlands*
[2] *Applied Plant Research (PPO-AGV), P.O. Box 430, 8200 AK Lelystad, the Netherlands*

[*] *E-mail: marius.heinen@wur.nl*

Abstract

During two consecutive leaching seasons the nitrate (NO_3) concentrations in the upper groundwater of an arable field were measured as a function of distance to a ditch. A non-fertilised grass buffer strip of 3.5 m was located between the arable field and the ditch. The NO_3 concentrations decreased towards the ditch, and were significantly lower in the buffer strip than in the arable field. Clear evidence for denitrification was obtained from the Cl/NO_3 ratios (both seasons) and from delta ^{15}N data (second season only). Due to the phenomenological character of this research we were unable to establish the effectiveness of the buffer strip, since we could not elucidate non-buffer strip related effects. However, the observed decrease in NO_3 concentrations is promising and justifies the demand for additional research under Dutch conditions.

Keywords: ^{15}N, buffer strip, Cl/NO_3 ratio, leaching, nitrate

Background and objectives

Buffer strips are widely used to reduce nutrient leaching to surface water. However, the efficiency of buffer strips in reducing nutrient loads is highly variable as a result of differences in hydrological and soil conditions. On an arable farm on sandy soil the performance of an unfertilised grass buffer strip was assessed during two consecutive leaching seasons. This paper presents some highlights reported by van Beek *et al.* (2005).

Materials and methods

The arable farm 'Vredepeel' is situated in the southern part of the Netherlands on a sandy soil. A compacted peat layer is present at approximately 2.5 to 3 m soil depth. A field (100 x 70 m) with an initially three-year old buffer strip (3.5 m wide) adjacent to a ditch was selected for monitoring. The buffer strip mainly consisted of Red fescue, which was cut annually coinciding with a removal of about 50 kg N $ha^{-1}y^{-1}$. Hydraulic heads, groundwater levels, nitrate-N (NO_3-N) and chloride (Cl) concentrations in groundwater and (in the second season) delta ^{15}N values of groundwater were measured at about every 30 mm of precipitation surplus (which equalled eight to ten sampling rounds per leaching season). Altman and Parizek (1995) and Mengis *et al.* (1999) stated that the ratio of an inert tracer, here Cl, and NO_3 may increase under a buffer strip, if NO_3 removing processes, such as uptake and denitrification, occur. When delta ^{15}N increases under the buffer strip this is a qualitative indication that denitrification does occur (Mayer *et al.*, 2002). During the growing season measurements were interrupted because of farm activities.

Results and discussion

Although the hydrology at the farm 'Vredepeel' is complex, the water movement was mainly directed towards the ditch and was restricted to a shallow layer of soil of 2.5 to 3 m below soil surface. There was a small downwards leakage across the peat layer. Averaged over both seasons, the NO_3-N concentrations under the buffer strip were significantly lower than in the remainder of the field: 11 mg N L^{-1} versus 20 mg L^{-1}, respectively (Figures 1 and 2).

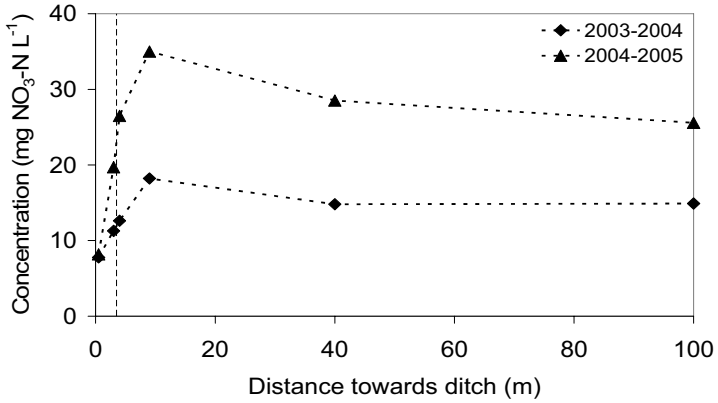

Figure 1. *Average NO_3-N concentrations in upper ground water as a function of distance from the ditch for both leaching seasons. The vertical broken line represents the boundary between buffer strip and arable field.*

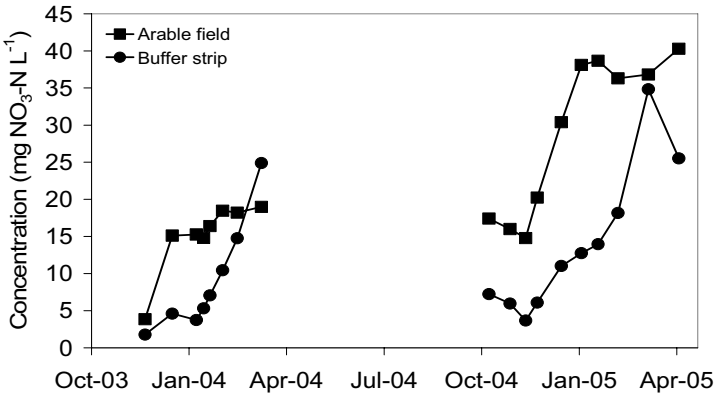

Figure 2. *Average NO_3-N concentrations in upper ground water in buffer strip and arable field as a function of time.*

However, the EU NO_3-N target level for ground water of 11.3 mg N L^{-1} was exceeded frequently in the buffer strip, especially during the second season. Within the buffer strip the concentrations decreased in the direction of the ditch.

Close to the boundary between buffer strip and arable field the concentrations were highest. This was most likely caused by soil compaction due to turning of agricultural machineries resulting in less growth and thus less N uptake, and presumably by spilling of fertilizer. At the end of the first leaching season the NO_3-N concentration in the buffer strip was higher than in the arable field. Apparently, a concentration peak originating from the arable field reached the buffer strip, while in the field itself the NO_3 concentrations decreased in time.
Since we have measured concentrations near the ditch, it seems worthwhile to estimate the NO_3-N load towards the ditch. The water flow towards the ditch was estimated from a classical drainage theory (Hooghoudt, 1937, 1940) based on measured ground water levels in the middle of the field and an assumed hydraulic conductivity at

saturation of 2 m d^{-1}. The estimated loads during both leaching seasons were 5 kg N ha^{-1} and 7 kg N ha^{-1}, respectively. For a whole year the loads will be somewhat higher, and then will be close to the Dutch Inventory of MINAS and the Environment of 25 kg ha^{-1} (RIVM, 2002).

Ratios of Cl/NO_3 increased towards the ditch, indicating that NO_3 consumption processes do occur under the buffer strip. Uptake by the crop at greater depths is unlikely, since the grass roots are mainly present in the top 10 to 20 cm. In the second season at a few occasions we found a clear increase in delta ^{15}N under the buffer strip. An increase in delta ^{15}N values is qualitative evidence of denitrification. At the end of the second season we determined TOC in the groundwater samples, with an average of about 40 mg L^{-1}, with no trend with distance to the ditch. So, even at greater depths, there is organic matter present, a prerequisite for denitrification to occur.

Conclusions

Due to the phenomenological character of this research we cannot exactly assess the effectiveness of this buffer strip. We have shown that NO_3-N concentrations decreased within the buffer strip and that denitrification occurred in the buffer strip. Because of the observed trend of decreasing NO_3 concentrations in the upper groundwater under the buffer strip, in a forthcoming project the efficiency of unfertilised buffer strips will be quantified in more detail by comparing N loads exported to the ditch for fields with and without a buffer strip.

Acknowledgements

This study was funded by the Dutch ministry of Agriculture, Nature and Food Quality within the research programme 398-II 'Mest en Mineralenprogramma'.

References

Altman, S.J. & Parizek R.R. (1995)
Dilution of nonpoint-source nitrate in ground water. *Journal of Environmental Quality*, 24, 707-718.

Beek, C.L. van, Clevering O., Kleef J. van & Heinen M. (2005).
Nitraatconcentraties in het bovenste grondwater naast en onder een bufferstrook. Resultaten van twee jaar experimenteel onderzoek aan een gras bufferstrook op zandgrond op akkerbouwbedrijf Vredepeel (in Dutch). Alterra-rapport, Alterra, Wageningen, the Netherlands.

Hooghoudt, S.B. (1937)
Contribution to the knowledge of some physical quantities of the soil. 6 (in Dutch). Verslagen van Landbouwkundige Onderzoekingen No. 43 (13) B, p. 461-676, Algemene Landsdrukkerij, 's-Gravenhage, the Netherlands.

Hooghoudt, S.B. (1940)
Contribution to the knowledge of some physical quantities of the soil. 7 (in Dutch). Verslagen van Landbouwkundige Onderzoekingen No. 46 (14) B, p. 515-707, Algemene Landsdrukkerij 's-Gravenhage, the Netherlands.

Mayer, B., Boyer E.W., Goodale C.L., Jaworski N.A., Breemen N. van, Howarth R.W., Seitzinger S.P., Billen G., Lajtha K., Nadelhoffer K.J., Dam D. van, Hetling L.J., Nosal M. & Paustian K. (2002)
Sources of nitrate in rivers draining sixteen watersheds in the northeastern U.S.: isotopic constraints. *Biogeochemistry*, 57/58, 171-197.

Mengis, M., Schiff S.L., Harris M., English M.C., Aravena R., Elgood R.J. & MacLean A. (1999)
Multiple geochemical and isotopic approaches for assessing ground water NO3 elimination in a riparian zone. *Ground Water*, 37, 448-457.

RIVM (2002)
MINAS en MILIEU. Balans en verkenning (in Dutch). RIVM-rapport 718201005, RIVM, Bilthoven, the Netherlands.