Denitrification under Pastures on Permeable Soils Helps Protect Ground Water Quality

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Denitrification under pastures on permeable soils helps protect ground water quality

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Introduction Pastures have been implicated in ground water contamination by nitrate, especially in humid regions with thin or sandy soils (Stout *et al*., 2000). Significant losses can occur even under low N input, because available N from excreta patches often exceeds plant uptake capacity. Lack of evidence that appreciable nitrate leaching was occurring in established Midwestern USA pastures led us to test the hypothesis that denitrification was preventing or remediating nitrate loading. Higher denitrification rates have been found in the relatively limited number of trials since Ball & Ryden (1984) first reported the significance of this process in pastures.

Materials and methods At three grazing dairy farms located on soils with high hydraulic conductivity in central Wisconsin, USA, multiport ground water wells were established on the up-gradient and down-gradient edges of at least one paddock and in a field under corn-soybean management on a nearby confinement dairy farm. Inorganic N was determined in the upper 1.2m of soil. In one paddock and in the corn-soybean field, an intensive grid of mini-piezometers was established to determine the range of variation in *in situ* dissolved solids and gases in ground water, sampled by pumping-induced ebullition (Browne, 2004). Two independent experiments were conducted in a growth chamber on intact soil cores (6-cm diam. by ~60-cm long) from one paddock, with or without fresh dairy cow excreta applied at the start of each 28- to 31-d incubation period.

Results Ground water samples from the multiport wells indicated that nitrate was leaching at substantially smaller rates than under other agricultural practices in the area. Although differences in soil nitrate concentration were evident between excreta spots and background areas on several sampling dates, no differences in dissolved organic carbon were detected. The intact soil core experiments provided convincing evidence that urine increased denitrification. Soil pH, ammonium, and nitrate concentrations followed patterns reported by others, the first two increasing rapidly after urine application, and nitrate increasing after about 7 days. Smaller changes occurred under fresh dung than fresh urine. Nitrous oxide emission over 4 weeks was 3-fold higher with dung and 9-fold higher with urine than the control soil. Methane emission was 20-fold higher with dung than either urine or no treatment, whereas CO_2 emission quadrupled with either excreta. In the field, there was tremendous spatial variability in ground water chemistry (dissolved nutrients and gases). Figure 1 shows that the dissolved denitrified N (measured as dissolved N_2 gas in excess of atmospheric N_2) was higher as a percentage of total nitrate (nitrate + denitrified N) in groundwater beneath the pasture (n >60 sites per sampling time) than beneath the arable field (n >20 per sampling time), and ancillary measurements (e.g., dissolved organic C and dissolved O_2) supported this result. In contrast, dissolved N_2O was lower under the pasture than corn. Further research is underway to determine the variation in dissolved gas concentrations in ground water under other grazed paddocks and arable fields, the sources of the dissolved organic carbon, the proportion of N lost as N_2 in these systems, and the potential of denitrification to reduce nitrate loading of ground water in the region.

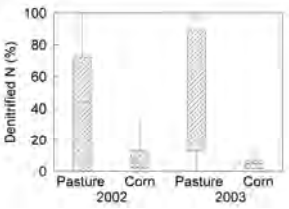

Figure 1 Denitrified N (excess N_2 as a percent of nitrate+denitrified N) in ground water [percentiles of data are shown by whiskers (10^{th} and 90^{th}), boxes (25^{th} and 75^{th}), and horizontal line (50^{th})]

Conclusions This is the first report of the wide variation in dissolved gas composition in ground water under pastures. The field evidence and results from intact soil cores lend support to the hypothesis that denitrification may remove substantial amounts of N from pastures. Enhanced denitrification may benefit water quality more generally as ground water moves from or toward adjacent arable cropland.

References

Ball, P. R. & J. C. Ryden (1984). Nitrogen relationships in intensively managed temperate grasslands. *Plant and Soil*, 76, 23-33.

Browne, B. A. (2004). Pumping-induced ebullition: A unified and simplified method for measuring multiple dissolved gases. *Environmental Science and Technology*, 38, 5729-5736.

Stout, W. L., S. L. Fales, L. D. Muller, R. R. Schnabel, & S. R. Weaver (2000). Water quality implications of nitrate leaching from intensively grazed pasture swards in the northeast USA. *Agriculture, Ecosystems, and Environment*, 77, 203-210.