

Does management intensive grazing protect groundwater by denitrification?

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Annual Report to SARE - December 2002

Summary

Denitrification is being assessed at four farms in Wisconsin; three management intensive grazing farms and one conventional farm. Assessment is being accomplished by collecting groundwater from monitoring wells, sampling soil, and measuring soil and groundwater gases.

Preliminary data suggest that denitrification differs between the MIG and conventional sites, with the MIG site showing less total dissolved nitrogen, nitrate, and nitrous oxide than the conventional site. Dissolved carbon dioxide and organic carbon was higher in groundwater at the MIG site, suggesting higher microbial respiration in groundwater and greater source of electron donor for the denitrification process.

Objectives/Performance Targets

The primary objective of this research is to determine whether denitrification is higher in soil and groundwater under MIG than annual cropping. We are focusing on coarse- and medium-textured soils, where nitrate loading potential is higher than fine-textured soils.

Accomplishments/Milestones

The sites have been selected for this study and include four farms in Wisconsin. Management intensive grazing (MIG) farms include the Bestul Farm in Waupaca County, the Onan Farm in Portage County, and the Breneman farm in Sauk County. The conventional cropped field (currently in corn) is near the Bestul Farm in Waupaca County and is being farmed by the Rambos. During this first year of study groundwater monitoring wells were installed near the paddocks/field that did not already have them and groundwater and soil samples were collected for analyses. The soil/groundwater gas component of the study was conducted at the Rambo and Bestul farms. The denitrification study was discussed at the Breneman farm at a pasture walk in August. Participants included farmers and agency personnel. Following are specific details regarding the three primary study components.

Soils

Soil cores were obtained from the grazed fields three times during 2002 and from the cornfield two times. Cores were taken to a depth of 1.2 m, except where subsurface conditions (i.e., gravel, dryness, or saturation) caused refusal of the coring device. Two 4.1-cm diam. cores were taken under 4 to 6 replicates of dung pats, in suspected urine spots, and in background areas. Soil was divided into 15- to 30-cm increments, the two cores were bulked by depth, crushed and mixed, and sub-sampled into plastic bags. Sub-samples were stored in coolers until they could be refrigerated. Soil moistures and pH were determined on all samples and the other analyses are underway. Additional soil cores were taken to determine dry bulk density of the soil at each site.

Larger cores (7.5-cm) were taken in six locations of one grazed field and the cornfield after harvest. These were stored in PVC sleeves in a refrigerator and will be sampled by horizon for the presence roots, mottling, and other regions where organic C supply may be elevated. Analysis is underway at this time.

Soil and Groundwater Gases

1. A grid network of 91 shallow miniature wells was established during May/June within a paddock at the Bestul MIG farm site. Vertical and horizontal coordinates of the grid nodes were incorporated into a GIS for the paddock.
2. Soil gas wells were established at three depths at each of the 91 grid nodes at the same time.
3. Shallow miniature wells (n=3) were establish in a radial pattern at each of six dung and six urine patches within the paddock at the Bestul MIG Farm site during August. Elevations and positions were incorporated into the GIS.
4. Ground water samples, collected in July and September from the grid nodes, patches and six monitoring wells, were analyzed for dissolved and gaseous constituents.
5. Soil samples from the dung and urine patches and control locations were collected for denitrification potential measurements. Analyses are not yet complete.
6. A similar grid network of 26 shallow miniature wells and soil gas profiles was established in a cornfield at the Rambo farm site for comparison to the Bestul MIG farm site. The Rambo farm site is physically similar the Bestul MIG paddock. Horizontal coordinates of the grid nodes were incorporated into a GIS. Vertical coordinates remained to be surveyed.
7. Ground water samples, collected in August and September, from the grid nodes at the Rambo farm site were analyzed for dissolved and gaseous constituents.
8. Static chambers were used to measure nitrous oxide fluxes to the atmosphere at each node or patch at the two study sites. Analytical sensitivity was insufficient to quantify the low level fluxes N_2O . A higher sensitivity method will be used in the next sampling round.

Groundwater Monitoring Wells

All monitoring wells are in place. Two multi-level monitoring wells are located up-gradient and 4 multi-level wells are down-gradient of the study paddocks and fields. During each sampling round depth to the water table is measured and groundwater samples are obtained. Samples were collected from these wells twice during the growing season. These samples were delivered on ice to the laboratory for analysis of NO_2+NO_3-N and chloride

On Farm Data Collection and Outreach

The cooperating farmers are collecting study-related data on their respective farms. Dates, time, and number of animals on the study paddocks along with addition of nutrients and mechanical removal of forage are being recorded by the MIG farmers. Nutrient addition and approximate yield are being recorded at the conventional site. The study was discussed at a pasture walk on the Breneman farm in August.

Impact and Contributions/Outcomes

Soil and Groundwater Gasses

Data analysis is in the early stage. Upon completion of the analysis modifications/improvements will be made to the approach for the next field season. Several major differences between MIG and conventional agriculture are qualitatively evident in the data at this point. The following preliminary data highlights indicate that denitrification improves groundwater quality to a much greater extent under MIG than annual cropping.

- Total dissolved nitrogen, nitrate and nitrous oxide were seven to 10 times higher in concentration in shallow groundwater at the conventional site than at the MIG site.
- Ground water was generally oxygenated at both study sites. However the incidence rate of anaerobic grid nodes, conducive to denitrification, was higher at the MIG site than at the conventional site. Overall dissolved oxygen was slightly lower at the MIG site than at the conventional study site, suggesting greater microbial respiration in the soil and ground water there than at the conventional site.
- Dissolved carbon dioxide was higher in groundwater at the MIG site than at the conventional site, again suggesting higher microbial respiration in soil and ground water at the MIG site than at the conventional site.
- Dissolved organic carbon was much higher in ground water at the MIG site than at the conventional site suggesting a greater supply of electron donor for denitrification in ground water.
- Denitrified N (excess N_2-N) was similar to but slightly higher in groundwater at the MIG site than the conventional site. The concentration of denitrified N appeared to be strongly a function of recharge temperature at the MIG site but unrelated to temperature at the conventional site, suggesting different processes control denitrification at the two sites.
- Denitrified N as a percentage of total nitrate ($NO_3-N + \text{excess } N_2-N$) was about tenfold greater at the MIG site than the conventional site (based on the median denitrification rates of about 60% of total nitrate at the MIG site and 5% of the total nitrate at the conventional site)

Groundwater Monitoring Wells

Nitrate concentrations from site to site and within the sites are quite variable. These variations may be due to differences in management practices, soil types, depth to groundwater and the quantity of denitrification. In general, the nitrate concentrations in groundwater below the study MIG paddocks are lower than the conventional site. The exception to this is the MIG site in Portage County, which has nitrate concentrations above the 10 mg/L drinking water standard and as high as 21.5 mg/L. Nitrate concentrations below the conventional site ranges from 0.8 to 34 mg/L. Nitrate concentrations at the MIG site closest to the conventional site ranges from <0.01 to 5.8 mg/L. Nutrient balances need to be calculated to do detailed comparisons.