Field experiments and numerical modelling to investigate nitrate leaching due to different land use and slurry applications

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ABSTRACT
Swine slurry is a source of nutrients to grasslands. However, accumulation of nitrate can lead to its movement to groundwater. A critical time in cold climates of Canada is nitrate leaching during soil thawing since fast soil water fluxes may occur during that time. The objective of this research was to investigate nitrate leaching rates in the field and numerically under different management scenarios on pasture and the impact on the rates by different slurry applications.

A pasture in La Broquerie, Southern Manitoba, was divided into six different management techniques namely - control-hayed, control-grazed, full-hayed, full-grazed, split-hayed and split-grazed treatment plots. The control, full and split treatments plots represented no application of manure, one-time application in a year with full rate and two-times application in a year with half rates each time respectively. Haying and grazing were two types of forage harvesting treatments carried on in the study site. Data on climate, soil texture, soil moisture, soil temperature, and nitrate concentrations in groundwater at 16 sensor stations during different manure application rates were observed for years 2008 and 2009. One-dimensional physically based modeling was applied using HYDRUS-1D to determine continuous recharge and nutrient leaching estimates from these data. The regionalisation of simulated leaching estimates was carried out using Cokriging.

Results showed a good agreement of the simulated and observed soil moisture contents at 15, 45, 75 and 105 cm depths in the soil profile having RMSE between 0.7% and 5% and ME nearly equal to zero. On an average, the recharge was estimated as 157 mm and 254 mm for the years 2008 and 2009, respectively. It was observed that about 42 mm recharge (about 28%) occurred during the snow-melt period of the year 2008. The difference in simulated and observed nitrate concentrations in groundwater was expressed in terms of RMSE between 0.02 and 5.12 mg NO_3-N/L and the ME between -1.03 mg NO_3-N/L and 1.05 mg NO_3-N/L. The areas which posed a risk to nitrate contamination of groundwater were the bare earth areas (BEA). The observed and simulated results showed that the groundwater nitrate concentrations in BEAs of both control-grazed and full-grazed plots were consistently higher than 10 mg NO_3-N/L. Overall, the cumulative nitrate leaching fluxes for control-hayed, full-hayed and control-grazed plots were below 2 kg NO_3-N/ha for both years. However, for full-grazed plots, the cumulative nitrate leaching flux was about 11 kg NO_3-N/ha and 6 kg NO_3-N/ha for 2008 and 2009 respectively. The cumulative leaching fluxes in BEAs were about 100 times larger than those in grassed areas.