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Regionalisation of nitrate leaching on pasture land in cold climates

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Nitrogen is a key agricultural input which is considered to be crucial for crop growth, development, and yield. However, an excess application of anthropogenic nitrate in the form of fertilizers may result in the nitrate contamination of groundwater. A critical time in cold climates in Canada is nitrate leaching during soil thawing since fast soil water fluxes may occur during that time. The objective of this research was to estimate leaching of nitrate upon the application of liquid hog manure on a pasture land in Southern Manitoba using physically based modeling and to further regionalise the point estimates of nitrate leaching fluxes at the field scale.

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 done using Cokriging which is a geostatistical interpolation approach. 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%, NSE between 0.39 and 0.99 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 of recharge out of 150 mm (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 0.023 and 5.12 mg NO_3-N L^{-1}, NSE between 0.66 and 0.96 and the ME between -1.03 mg NO_3-N L^{-1} and 1.05 mg NO_3-N L^{-1}. 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^{-1}. Overall, the cumulative nitrate leaching fluxes for control-hayed, full-hayed and control-grazed plots were below 2 kg NO_3-N ha^{-1} for both years. However, for full-grazed plots, the cumulative nitrate leaching flux was about 11 kg NO_3-N ha^{-1} and 6 kg NO_3-N ha^{-1} for 2008 and 2009 respectively. The cumulative leaching fluxes in BEAs were about 100 times larger than those in grassed areas.