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Nitrogen distribution in the vadoze zone and estimation of its transport parameters in the vicinity of a small stream, Ontario

Fumi Sugita[1], Michael C. English[2], Sherry L. Schiff[3]

[1] CUC, [2] WLU, [3] UW

Agricultural nitrogen is widely recognized as a source of nitrate contamination in groundwater as well as in surface waters. Due to non-point nature of the source distribution, the nitrogen transport processes and its pathways from ground surface to groundwater/surface water are extremely complicated and are not clearly understood. In this study, nitrate distribution above groundwater table in five different land uses in the vicinity of a small stream (Strawberry Creek) in an agricultural area was investigated. The purposes of this study are to identify major nitrate contributing areas/land-uses to the underground in the watershed, and also to estimate the transport parameters.

The Strawberry Creek is located approximately 100km southwest of Toronto, Ontario, and is the first-order stream flowing through a typical agricultural areas. Its watershed (3.5km2) is covered mainly with various croplands (corns, soy beans, strawberry, wheat and barley), and also with patches of woodland and narrow stripes of uncultivated land along the Creek (the buffer zone). In the growing season of 1999 (July to November), five to seven soil cores were obtained from 0.2m below the ground surface to the saturated zone which was around 1.2m below the surface in barely field, corn field, soy bean field, woodland and uncultivated buffer zone along the creek. The soil water was extracted and was analyzed for NO3-, NH4+, Cl- and DOC concentrations.

The differences between the stream water head and that of under streambed indicated groundwater was discharging into the creak all along from upstream to downstream. NO3- exists in low concentrations (less than 15mg/l in NO3-) in most profiles obtained from the creek buffer zone and the woodland. The concentration in the underlying saturated zone was higher than those fond in the unsaturated zone in these areas, indicating that the lateral groundwater flow from adjacent crop lands brought in high concentration of NO3- underneath these uncultivated areas.

Highest NO3- concentrations were found at the top (0.2m below the surface) of the profiles of barely and cornfields and the concentration decrease with depth. Depletion of NO3- with depth is probably partly due to crop uptake near surface, but mainly due to denitrification to nitrogen gas that could take place in anaerobic loam patches exist in the vadoze zone. The concentrations found in soy bean field was relatively low, suggesting corn and barely fields were the main nitrate contributing area to the underground among the five land-uses investigated in this study.

The NO3- profiles in barley and cornfields were fitted to analytical solution of the advection-dispersion equation with the first-order decay using CXTFIT (Toride et al., 1995) and the infiltration velocity, the dispersivity and the denitrification rate were estimated for each profile. The average denitrification rates obtained by the fitting were 0.0108 mg/l/day for the barley and 0.0064 mg/l/day for the corn. Though these rates are almost one-order of magnitude smaller than most fond in saturated zone (Korom, 1992), they suggest considerable denitrification is taking place even in vadoze zone and this process is not negligible. The average infiltration rates estimated were 0.0045m/day for the barley and 0.0067m/day for the corn, which are a few times larger than expected from meteological data. This high average infiltration rates may indicate effect of preferential flow. The dispersivity obtained by the fitting ranged 0.73m for the barley and 0.34m for the corn, which were comparable to those typically found in fields.

References:

Korom,S.F.(1992) Water Resources Research, 28, 6, 1657-1668

Toride,N.,F.J.Leih, and M.Th.van Genuchten(1995) U.S.Salinity Lab.Research Rep.138, Riverside CA.