Fate of nitrate in the capillary fringe and shallow groundwater of a sandy soil

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It is commonly assumed that nitrate (NO$_3^-$) and other anions entering the soil move downward through the vadose zone, and then move horizontally in the groundwater. Recent laboratory studies, however, indicate that water movement and transport of pollutants can also take place in the capillary fringe (CF) above the water table (WT). This field study evaluated the fate of NO$_3^-$ in the CF and shallow groundwater (SGW) for a sandy soil (Aeric Alaquod) with shallow water table. Ten L of a solution containing approximately 18 mmol L$^{-1}$ nitrate [2.66 g L$^{-1}$ Mg(NO$_3$)$_2$] and 77 mmol L$^{-1}$ bromide (9.12 g L$^{-1}$ KBr) were applied to the soil above the CF. The movement of both NO$_3^-$ and Br$^-$ was monitored for 84 days by using tension lysimeters installed at depths between 45 and 105 cm at radial distances of 20, 60, 120, 220 and 320 cm from the application point. Nitrate and Br$^-$ plumes that entered the CF from the unsaturated zone moved horizontally in the CF until both species were partially carried into the groundwater by the fluctuating WT following rain events. Normalized concentrations of NO$_3^-$N and Br$^-$ remained comparable as they moved horizontally in the CF up to 320 cm from the tracer application spot. However, below the WT the detected normalized concentration of Br$^-$ was higher than that for NO$_3^-$ indicating nitrate loss, perhaps due to denitrification. When monitoring subsurface NO$_3^-$, solely relying on collection of groundwater samples may lead to an underestimation of the extent of NO$_3^-$ contamination and transport in the subsurface.