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Monitoring the fate and transport of deicing chemicals in lysimeter experiments

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Large amounts of the deicing chemicals (DIC) propylene glycol (PG) and formate are spread for removal of snow and ice on the aircrafts and airfields every winter. A considerable amount of these chemicals are carried into surrounding areas, where they mix with snow and infiltrate in the soil during snowmelt. Even though DIC are easily degradable, the high mobility and the high biological oxygen demand of PG in particular can influence the hydrogeochemistry of the unsaturated and saturated zone. The aims of the study were to evaluate and quantify transport of deicing chemicals during snowmelt under field conditions, and to study effects of DIC degradation on the hydrogeochemistry of the unsaturated zone. Eight undisturbed soil cores (0.3 m x 1 m, 0.071 m3) were retrieved at the Gardermoen Airport, Norway, and installed as non-weighable small scale lysimeters at a nearby field site. Before snowmelt in March 2010, a mix of snow containing 350 g/m2 PG, 71 g/m2 formate, and 17 g/m2 of bromide were added to the lysimeters. To determine the fate and transport of PG we monitored PG and its metabolites, bromide, manganese, and iron in the seepage water.
High cumulative infiltration and marginal degradation of PG during the snowmelt period allowed up to 50 % of the PG to leave the upper, microbially most active, region of the soil. Only marginal concentrations of formate were analysed in all lysimeters, indicating fast degradation and favoured metabolism by soil bacteria compared to PG. Low contents of metabolites and the concurrent breakthrough of PG and Br in the seepage water even imply that PG was not significantly degraded before June. Redox values down to 200 mV in April, the detection of propionate and manganese, as well as a rise in pH, suggest partially anearobic localities in the soil, not only during high soil water saturation in April and May but also during summer when PG degradation was very efficient. In the longterm, the intense depletion of electron acceptors such as Mn oxides lowers the potential of the unsaturated zone to buffer high loads of DIC. Therefore, it is necessary to carefully assess the buffering capacity of the soil and to develop suitable remediation techniques to sustain the natural redox buffer system.