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Modelling transport and degradation of de-icing chemicals in soil, assuming Monod kinetics with multiple electron-acceptors

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De-icing chemicals that contain propylene glycol are used at Oslo airport during winter time. A fraction of these chemicals is spilled on the runway and can be transported rapidly in the sandy soil in spring during snowmelt. Better insight into the chemical and physical processes that govern the fate of these chemicals in soil will help to estimate potential effects on the large unconfined aquifer in this area, and makes it possible to evaluate potential remedial actions.

Micro-organisms in the soil can degrade propylene glycol, for which they need electron-acceptors. Under aerobic conditions, oxygen will be used as an electron-acceptor. From experiments, it is known that also anaerobic degradation occurs in this soil. During snowmelt, high infiltration rates can lead to locally saturated soil. In these parts, oxygen diffusion is limited and thus anaerobic conditions will occur. In these anaerobic regions, other electron-acceptors, such as manganese-oxides that are present in this soil, are used. However, frequent propylene glycol application may lead to a depletion of manganese-oxides and so to increased persistence and migration of propylene glycol in soil. To prevent this depletion and to enhance biodegradation, other electron-acceptors can be applied at the soil surface. Examples are the application of nitrate to the soil surface, and air injection. Model calculations could help to estimate required concentrations.

The objectives of this study are 1) to create the reactive model, 2) to use this model to evaluate which parameters are determining leaching fluxes of propylene glycol from the soil, and 3) to evaluate the effectiveness of the different remediation strategies.
Therefore, transient water flow, kinetic degradation, and redox chemistry were combined in one model. Degradation is modelled with Monod kinetics using multiple electron-acceptors. Oxygen diffusion in the gas phase, biomass growth, and oxidation and reduction of the important electron-acceptors are included.