Abstract

Vertisols cover a hydrologically very significant area of semi-arid regions, and thus understanding of water flow and solute accumulation is very relevant to agricultural activity and water resources management. Previous works suggest a conceptual model of desiccation-crack-induced salinization where salinization of sediment in deep section of the vadose zone (up to 4 m) is induced by subsurface evaporation due to convective air flow in desiccation cracks. This thesis presents a conceptual model of water flow and solute transport in vertisols, and its numerical implementation. The model uses a single-porosity material but unconventionally prescribes a boundary condition representing a deep crack in soil and uses the unsaturated hydraulic conductivity as one of the fitting parameters. The numerical model is bound to one location close to a dairy farm waste pond, but the application of the suggested conceptual model could be possibly extended to all semi-arid regions with vertisols.

Simulations were conducted using several modelling approaches with an ultimate goal of fitting the simulation results to the controlling variables measured in the field: water content, and chloride salinity of pore water. The development of the model was engineered in numerous steps; all computed as forward solutions by trial-and-error approach.

The crack boundary condition allows chloride to accumulate due to subsurface evaporation on the crack wall, and subsequently rainwater pushes the solute further down the sediment. In order to prescribe the suggested function, HYDRUS 2D/3D code had to be modified by its developers. The main fitting parameters were: the saturated hydraulic conductivity and infiltration distribution of rainwater. The model supports previous findings that significant amount (more than 80%) of water from rain events must infiltrate through the crack rather than through land surface, and that the desiccation cracks are responsible for more than 70% of overall actual evaporation. It was also noted that infiltration from the crack has to be increasing with depth and that the highest infiltration rate should be between 1-3 m below land surface.

In conclusion, this thesis supports previous findings about vertisols: especially, the utmost importance of soil cracks as preferential pathways for both water and contaminants, and soil cracks as deep evaporators.

Keywords
desiccation crack, salinization, subsurface evaporation, semi-arid climate, preferential flow, numerical model, vadose zone, vertisols, retention curve, HYDRUS, modelling