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Enhanced volatilization and redistribution of volatile organic compounds (VOCs) in contaminated aquifers subject to borehole thermal energy storage: Model development and applications

Boyan Meng[1,2], Christof Beyer[3], Olaf Kolditz[1,2], and Haibing Shao[1]
[1]Helmholtz Centre for Environmental Research – UFZ, Germany
[2]Faculty of Environmental Sciences, Dresden University of Technology, Germany
[3]Institute of Geosciences, University of Kiel, Germany

In urban areas where the shallow subsurface is used for thermal energy storage (TES), interactions between the introduced heat and groundwater pollution caused by toxic organic contaminants can be expected. Temperature elevations may affect the transfer of these volatile organic compounds (VOCs) from the groundwater to the unsaturated zone, creating a redistribution or release of the contaminants in/from the subsurface environment. Such effects are particularly important considering the intersection of the unsaturated zone with the land surface and the remediation capacity of polluted aquifers. In this work, a non-isothermal multi-component two-phase flow model was developed to investigate the thermally induced volatilization and migration of the VOCs in contaminated aquifers. The numerical model, which is implemented in the open source framework *OpenGeoSys*-6, is able to simulate temperature-dependent mass and heat transfer processes in partially-saturated soils while allowing for phase change. Verification of the model against various benchmark problems and experimental data showed good accuracy. Simulation results revealed that a temperature-driven migration of dissolved trichloroethylene (TCE) from the groundwater to the drier regions of the unsaturated zone can be observed in general. A temperature increase of 20 K around the borehole led to a maximum decline of the total TCE concentration by 63% assuming zero TCE concentration at the soil surface. In addition, the TCE concentration distribution varied considerably with the depth-dependent water saturation. Further investigations were carried out to study the effects of different parameters, e.g. groundwater velocity, contaminant type and boundary conditions. Based on our analysis, the planning of subsurface TES systems can be optimized to account for the possible interactions with pre-existing groundwater contamination.

References:

Kolditz, O., Bauer, S., Bilke, L., Böttcher, N., Delfs, J. O., Fischer, T., ... & Zehner, B. (2012). OpenGeoSys: an open-source initiative for numerical simulation of thermo-hydro-mechanical/chemical (THM/C) processes in porous media. *Environmental Earth Sciences*, *67*(2), 589-599.