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Innovative Field Investigations in Limestone using a FACT-FLUTe

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Published in:
Book of abstracts - 13th International UFZ-Deltares Conference on sustainable Use and Management of Soil, Sediment and Water Resources (AquaConSoil) 2015

Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

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Background and objective

The understanding of chlorinated solvents behavior in fractured limestone aquifers is a challenging task because of the preferential flow of contaminants in fractures and the exchange with the limestone matrix. Characterization of the contaminant distribution, particularly in the matrix, is challenged by difficulties in intact sample collection (coring) for sufficiently discretized data. The characterization is important for the development of a conceptual understanding, for risk assessment and for the choice and operation of an appropriate remediation strategy. The FACT (FLUTe activated carbon technique) is an innovative monitoring technique, which allows determining the distribution of a contaminant in the surrounding of a borehole with a higher resolution than conventional monitoring methods. The FACT technique proved to be a helpful tool for characterization of contaminant distribution in the limestone aquifer at Naverland, a contaminanted site in Denmark (Janniche et al. 2013, Broholm et al. 2013, Kerrn-Jespersen et al. 2013). While the sorbed concentration of contaminant in the carbon felt is obviously related to concentrations in the formation, there is no direct relation between measured sorbed concentration (mg/g AC) and the aqueous pore water concentration (mg/L). The objective of the research presented was to develop a tool for the interpretation of FACT measurements and apply it to the Naverland dataset for comparison with concentrations in groundwater samples sampled from the Water-FLUTe multilevels (Janniche et al. 2013 and 2013b) at the site.

Method and technique

The FLUTe Activated Carbon Technique was described e.g. in Janniche et al. (2013). The sorption of chlorinated ethenes on activated carbon was determined in laboratory experiments as described in Sørensen et al. (2014) to obtain equilibrium sorption coefficients (Kd) for individual and mixed chlorinated ethenes on activated carbon from aqueous solution. As the uptake on FACT in limestone aquifers will depend on transport (advection and/or diffusion and retardation by sorption) in the limestone matrix and fractures as well as on the sorption to activated carbon, a modeling tool was developed (Mosthaf et al. 2014) which allows for the interpretation of field data and the analysis of the influence of various aquifer parameters. The model provides a link between sorbed concentrations on the FACT and the prevailing aqueous pore water concentrations for a range of hydraulic parameters and conditions typical for limestone aquifers.

Results and outlook

The sorption experiments showed very strong sorption with reasonably linear sorption isotherms over a very large concentration range for individual chlorinated ethenes. At high PCE concentrations, competition for sorption sites resulted in non-linearity and much lower sorption of the less hydrophobic compounds TCE and particularly c-DCE. The model simulation results demonstrate the influence of common aquifer parameters on the observed sorbed concentrations on the FACT. The influence of the porosity and of the positioning of the FACT with respect to the flow is comparably small (factor 2-3), whereas the influence of sorption coefficients is increasing with the sorption coefficients and is particularly important for Kd-values above 10-3 L/kg. The hydraulic conductivity has only little influence for values below 10-5 m/s, but up to orders of magnitude influence above that until diffusion within the FACT is limiting the transport processes. For given hydraulic parameters, conditions and exposure time of the FACT, a linear relation between activated carbon concentration and aqueous concentration can be established. This allows the FACT-FLUTe technology to be employed for the characterization of contaminant distribution in limestone aquifers. A comparison between the aqueous (pore water) concentrations calculated with the model from the FACT-FLUTE data with groundwater concentrations from the Water-FLUTe multilevels at the Naverland site showed good correspondence. An advantage of the FACT technique is that it provides discretized data for the matrix and is less influenced by the preferential flow in high conductive zones than multilevel water sampling. It can also be applied in a matrix with strong variation in the hardness (e.g. softer limestone with interbedded chert layers). Furthermore, DNAPL presence in hydraulically active fractures can potentially be identified by high concentration peaks on the FACT.

Literature

Broholm, M.M. et al., 2013. Udvikling af konceptuel forståelse af DNAPL udbredelse i moræneler og kalk ved integreret anvendelse af direkte og indirekte karakteriseringsmetoder. ATV Vintermøde, Vingsted, 5-6. marts 2013.

Janniche, G.S., Fjordbøge, A.S., Broholm, M.M., 2013. ”DNAPL i moræneler og kalk. Vurdering af undersøgelsesmetoder og konceptuel modeludvikling. Naverland 26AB, Albertslund.” DTU Miljø og Region Hovedstaden. www.sara.env.dtu.dk.

Janniche, G.S. et al., 2013b. ”Anvendelse af Water FLUTe multi-level vandprøvetagning til DNAPL karakterisering.” Jordforurening.info 2-13, p. 4-8. Videncenter for Jordforurening. www.jordforurening.info

Kerrn-Jespersen et al., 2013. ”Undersøgelsesmetoder til karakterisering af DNAPL i kalk.” Jordforurening.info 1-13, p. 20-23. Videncenter for Jordforurening. www.jordforurening.info

Mosthaf, K., Broholm, M.M., Binning, P., 2014. ”The FACT-FLUTe technology. A modeling tool for interpreting field data.” DTU Environment and Region Hovedstaden. To appear on www.sara.env.dtu.dk

Sørensen, M.B., Broholm, M.M., 2014. ”Sorption af chlorerede opløsningsmidler på FACT.” DTU Miljø and Region Hovedstaden. www.sara.env.dtu.dk.