A HEAT AND DYE TRACER TEST FOR CHARACTERIZING AND MODELLING HEAT TRANSFER IN AN ALLUVIAL AQUIFER

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Abstract

Using heat as an active tracer is a topic of increasing interest with regards to characterizing shallow aquifers for ATES (Aquifer Thermal Energy Storage) systems. In this study, we investigate the potential interest of coupling simultaneous heat and dye tracer injection tests for characterization of an alluvial aquifer. The study site is located near Liege in the alluvial aquifer of the Meuse River, Belgium. The tracing experiment consisted in simultaneously injecting heated water and a dye tracer in a piezometer and monitoring the evolution of groundwater temperature and tracer concentration in the recovery well and in nine monitoring wells located according to three transects with regards to the main groundwater flow direction.

The breakthrough curves measured in the recovery well showed that heat transfer in the alluvial aquifer is slower and more dispersive than solute transport. Recovery is very low for heat while in the same time it is measured as relatively high for the solute tracer. This shows how heat diffusion is larger than molecular diffusion, implying that exchange between groundwater and the porous medium matrix is far more significant for heat than for solute tracers.

In a first step, temperature and concentrations in the recovery well are used for estimating the specific heat capacity with an energy balance calculation and the estimated value is found to be consistent with those found in the literature. Then, the measured temperature breakthrough curves in the piezometers are used for constraining the heat transport model. They are highly contrasted with what would be expected in an ideal layered aquifer. They reveal strongly unequal lateral and vertical components of the transport mechanisms. A preliminary interpretation of these temperature breakthrough curves is provided with first results from the model. Then it will allow for estimating the entire set of heat transfer parameters and their spatial distribution by inverse modelling.

The developed concepts and tests may lead to real projects of various extents that can be now optimized by the use of a rigorous and efficient methodology at the field scale.

Keywords

Groundwater, ATES, tracer test, heat transport, solute transport, modelling, heterogeneity, inverse modelling

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