Contribution ID: **527** Type: **Oral 20 Minutes**

Effects of Groundwater Circulation Well to contaminant Back-Diffusion from low-permeability layers: investigation by laboratory test and numerical simulations.

Wednesday, 16 May 2018 11:35 (15 minutes)

The presence of contaminants in low permeability zones of aquifer can represent a real limitation for a complete and effective groundwater restoration. When dissolved plume encounter low permeability layers, concentration gradient between low and high-permeability zones determines storage of dissolved pollutants into the lower permeability layers by molecular diffusion (Forward-Diffusion). After the end of the plume passage there is an inversion of the gradient direction that leads to a slow re-distribution of contaminant from the lower permeability zones back to the higher permeability zones (Back-Diffusion). The low-permeability zones become therefore secondary contamination sources that cause long plume tail.
The aim of this study was to evaluate by laboratory test and by numerical simulations the suitability of Groundwater Circulation Well (GCW) to restore contaminated low permeability zones of aquifer. GCW is a well characterized by a different number of screens with extraction induced from one screen and injection from another. The use of GCW develops a circulating flow field near the well, increasing the vertical component of groundwater flow.
A sand aquifer with two low-permeability lenses was reconstructed inside a tank containing a GCW model. The lenses were saturated with a known quantity of tracer and a circulating flow field was generated inside the aquifer injecting clean water from the upper GCW screen and extracting contaminated water from the lower screen. During the test, images of the box model were acquired and using an image analysis procedure the tracer mass released by the two lenses was estimated.
A numerical model was developed to reproduce the Back-Diffusion process and to investigate effects of pumping technologies to contaminant redistribution process from low to high permeability zones of aquifer. The model was validated comparing the numerical results with those obtained experimentally by laboratory test. Numerical simulations were carried out to evaluate effects of innovative GCW technology and traditional Pump and Treat system on the Back-Diffusion process. To achieve the goal, numerical tests were performed considering various injection/extraction water flow rates and different features of polluted low permeability layers.
Results demonstrate the more suitability of the GCW technology to restore contaminated low permeability zones than the traditional Pump and Treat system. However, the efficiency of GCW appear to depend on features of low-permeability layers, as their geometry and their position inside the aquifer.

References

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Session Classification: Parallel 7-A

Track Classification: MS 1.11: Conservative and Reactive Transport of Charged Species in Permeable and Impermeable Porous Media