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In situ precipitation of aluminum and organic matter as a geo-engineering tool to reduce soil permeability – a field test

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Using naturally occurring processes to modify the engineering properties of the subsurface has gained increasing attention from industrial and research communities as they aid in the development of cost-effective, robust and sustainable engineering technologies. In line with this trend, we propose to use the interaction between aluminum (Al) and organic matter (OM) to reduce soil permeability in situ. This is inspired by podzolization: a soil stratification process where the mobilization of Al, iron and OM in the topsoil is followed by their precipitation at greater depth. In this study this newly developed engineering technique has been applied for the first time in the field.

The aim of the field test was to create a cylindrical flow barrier (5 m i.d.) in a sand layer, located at a depth between 7 to 13 m below ground surface (bgs). A 3D reactive transport model was developed via the coupling between Darcy's law and solutes transport, meanwhile Al-OM precipitation and its impact on permeability are included. The model was used to design and analyze the results from the field test. At the site Al and OM solutions were injected separately through 20 injection wells distributed in two circles with a radius of 2.5 m for Al injection and 3 m for OM injection. An extraction well was placed in the center of these two circles to control in situ mixing and precipitation of Al and OM and precipitation of these two components in a specific zone.

Results demonstrated that after a period of 8 days, we successfully created a cylindrical flow barrier where precipitates formed in close vicinity of the injection filter screens. The permeability of the treated sand was reduced to 2.3 % of its original value. Pumping tests conducted 6 months after the treatment showed no change in the achieved permeability reduction, indicating the stability of the Al-OM precipitates during this period. Further investigation is however necessary to evaluate the long-term stability of the flow barrier.

This field study demonstrates the viability of using Al and OM complexation and precipitation as an in situ engineering tool to reduce soil permeability. By separate injection of the two components and a combined injection/extraction strategy, we were able to induce in situ mixing of Al and OM and control the geometry of the formed flow barrier.