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Transport of iron oxide nanoparticles in saturated porous media: a large-scale 3D study

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Iron oxide nanoparticles (FeOxNp) have a high potential as electron acceptor for *in situ* microbial oxidation of a wide range of recalcitrant groundwater contaminants (Bosch et al., 2010). Tosco et al. (2012) reported on high colloidal stability of FeOxNp dispersed in water, their low deposition behavior, and consequently improved transport in column experiments compared to extensively studied zerovalent iron nanoparticles. However, determination of FeOxNp transport behavior at the field-relevant conditions has not been done before.

The present work is aimed to evaluate different complementary methods for detection, quantification and transport characterization of FeOxNp in a large-scale three-dimensional (3D) model aquifer. Prior to that, batch-scale experiments were performed in order to elucidate the potential of the selected methods for direct and indirect characterization and detection of FeOxNp. Direct methods included measurements of particle size distribution, particle concentration, Fe_{tot} content and turbidity of the FeOxNp suspension. Indirect methods included measurements of particle zeta potential, as well as TOC content and pH of the FeOxNp suspension. The results of the batch experiments indicated that the most suitable approach for detecting and quantifying FeOxNp was measuring Fe_{tot} content and suspension turbidity, as well as particle size determined using dynamic light scattering principle. These complementary methods were further applied in a large-scale 3D study containing medium and coarse sand in order to 1) assess the transport of FeOxNp in saturated porous medium during injection (V_{FeOx} = 6 m^3, $c_{particle}$ = 20 g/L, Q_{inj} = 0.7 m^3/h), and 2) illustrate their spatial distribution after injection.

The outcomes of the large-scale 3D study confirmed that FeOxNp transport can be successfully investigated applying complementary methods. Monitoring data including Fe_{tot} content, turbidity and particle size showed the transport of particles towards the coarse sand regions creating a radius of influence of 1.5 m. Finally, migration distance of FeOxNp was more than 2 m from injection point towards to high permeability zone indicating that the permeability of porous media does have an important impact on particle transport after injection.

A drawback of all the tested methods is their inability to distinguish between natural and engineered FeOxNp, which might be an obstacle for applying them when the Fe_{tot} concentrations approach the background levels. In this case other techniques need to be applied.

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