Contribution ID: **621**

Type: **Oral Presentation**

4D Study of Groundwater Remediation Techniques at Pore-scale

Monday, 22 May 2023 14:45 (15 minutes)

Groundwater remediation is a pressing issue in the modern world. Some regions of the UK, such as Southeast England, take more than 75% of their public water supply mainly from Chalk aquifer (Groundwater resources in the UK, 2022). In Brazil, almost 37% of the cities are supplied exclusively with groundwater. Study by Lunardi et al., (2021) highlighted high susceptibility to groundwater pollution of regions, where pollutant source, such as industry, is present. The studies performed on methods similar to ones studied in this work usually do not study what is happening on pore-scale. Such study is performed by Pandey, Sharma and Saha (2022) on nZVI nanoparticle production techniques, or by Chen et al., (2021) on slow-release potassium permanganate. This highlights a knowledge gap in the modern understanding of these remediation techniques.
In this work, a dataset on nZVI nanoparticle reaction with TCE (trichloroethane) is studied. TCE is a DNAPL –Dense non-aqueous phase liquid. These compounds are challenging to be removed from groundwater reservoirs via conventional means, as they are almost immiscible in water, and are difficult to remove from the porous medium. Therefore, nanoparticles used for remediation of such reservoirs have to be able to reach the contaminant. The dataset was obtained via X-ray microtomographic scanning (X-ray micro-CT) and allows for 4D (3D + time) study of the processes, happening on the pore-scale. The dataset was captured at Diamond Light source by Dr. Tannaz Pak. This study is performed via specialised software, such as Fiji (ImageJ), Avizo and MatLab.
In addition to this, a new setup has been developed for column experiments. This setup gave us the possibility to investigate liquid and particle dynamics on a larger scale, across a column of approximately 36 cm long 3.5 cm in diameter. With this setup we were able to measure particle distribution through the column after several nZVI injections on different porosities. Particle distribution was assessed via magnetic susceptibility sensor. Each material loaded into the column is initially characterised by a breakthrough curve, evaluated via conductivity of NaCl brine. Subsequent breakthrough curves for nanoparticle injections are evaluated via magnetic susceptibility sensor. The experimental data of the breakthrough curves is then analysed with MnMs, to confirm the results of the experiment and get a better insight into nanoparticle mobility.
In addition to that, the experiment on porosity influence on the efficiency of nanoparticle remediation was performed. This experiment involved saturating porous medium with nitrate-contaminated water and injecting nanoparticle suspension into the column. Parallel to the column experiment, a reference batch test was performed, with the same concentrations of nitrates and nZVI, but in absence of any porous medium. The results of this experiment were then compared with each other, to assess the influence of presence of porous medium and porosity on decontamination efficiency.

Participation

In-Person

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Session Classification: MS18

Track Classification: (MS18) Innovative Methods for Characterization, Monitoring, and In-Situ Remediation of Contaminated Soils and Aquifers