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Aquifer modification: an approach to improve the mobility of nanoscale zero-valent iron particles used for in situ groundwater remediation

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Successful emplacement of nanoscale zero-valent iron (nZVI) within the contaminated source zone is a prerequisite for the use of nZVI technology in groundwater remediation. Emplacement of nZVI is influenced i.e. by the injection technique and the injection velocity applied, as well as by the mobility of nZVI in the subsurface. Whereas processes linked to the injection can be controlled by the remediation practitioners, the mobility of nZVI in the subsurface remains limited.
Even though mobility of nZVI is somewhat improved by surface coating with polyelectrolytes, it is still greatly affected by the groundwater composition and physical and chemical heterogeneities of aquifer grains.
In order to promote mobility of nZVI it is needed to alter the surface charge heterogeneities of aquifer grains. Modifying the aquifer grain's surfaces by means of polyelectrolyte coating is an approach proposed to increase the overall negative surface charge of the aquifer grain surfaces, hinder deposition of nZVI onto aquifer grains, and finally promote nZVI mobility. In this study the effect of different polyelectrolytes on the nZVI mobility is tested in natural sands deriving from real brownfield sites that are proposed to be remediated using the nZVI technology. Sands collected from brownfield sites were characterized in terms of grain size distribution, mineralogical and chemical composition, and organic carbon content. Furthermore, surface charge of these sands was determined in both, low- and high ionic strength background solutions. Finally, changes of the sand's surface charges were examined after addition of the proposed aquifer modifiers, lignin sulfonate and humic acid.
Surface charge of brownfield sands in low ionic strength background solution is more negative compared to that in high ionic strength background solution. An increase in negative surface potential of brownfield sand was recorded when aquifer modifiers were applied in a background solution with low ionic strength, indicating their potential to improve nZVI mobility under comparable environmental conditions. In contrast, no significant change of the surface potential of brownfield sand was observed when aquifer modifiers were applied in a background solution with high ionic strength. The potential of the aquifer modifiers to promote the mobility of nZVI was furthermore tested in flow-through columns, starting with the one filled with natural quartz sand with rough surface, low ionic strength background solutions and pre-injecting lignin sulfonate in concentration of 50 mg/L. The preliminary results showed that the pre-injection of lignin sulfonate does increase mobility of nZVI under this experimental condition. Further mobility tests will be carried out in order to elucidate the potential of the aquifer modifiers to promote the mobility of nZVI in sands with a complex mineralogy and in the background solutions with varying ionic strength, in order to account for the condition that resemble those at polluted sites.

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