Geophysical Research Abstracts
Vol. 17, EGU2015-7729, 2015
EGU General Assembly 2015

Transport of carboxymethyl cellulose stabilized nanoscale zerovalent iron in porous media, an experimental and modeling study

Brent Sleep (1), Pulin Mondal (1), Paul Furbacher (1), Ziteng Cui (2), and Magdalena Krol (3)

(1) Civil Engineering, University of Toronto, Toronto, Canada (sleep@ecf.utoronto.ca), (2) School of Earth Science and Engineering, Hohai University, Nanjing, China, (3) Civil Engineering Lassonde School of Engineering,York University, Toronto, Canada

Nano-scale zero valent iron (nZVI) is capable of reacting with a wide variety of groundwater contaminants. Therefore, during the last decade nZVI has received significant attention for application in subsurface remediation, particularly for sites contaminated with chlorinated compounds and heavy metals. However, due to agglomeration of the nZVI, delivery into the contaminated subsurface zones is challenging. Polymer stabilization of nZVI can enhance the mobility of the iron particles in the subsurface. In this study, a set of laboratory-scale transport experiments and numerical simulations were performed to evaluate carboxymethyl cellulose (CMC) polymer stabilized nZVI transport in porous media. Experiments were conducted in a two-dimensional water-saturated lab-scale glass-walled sandbox, uniformly packed with silica sand, to identify the effects of water specific discharge and CMC concentration on nZVI transport. Experiments were also performed using Lissamine Green B (LGB) dye as a non-reactive tracer to characterize the sand media. The CMC stabilized nZVI was synthesized freshly at a concentration of 1000 mg/L before each transport experiment. The synthesized CMC-nZVI mixture was characterized using transmission electron microscopy, dynamic light scattering, and UV-visual spectrophotometry. The movement of the LGB dye and nZVI in the sandbox during the experiments was monitored using time-lapsed images captured using a light source and a dark box. The transport of LGB, CMC, and CMC-nZVI was evaluated through analysis of the breakthrough curves at the outlet and the retained nZVI in the sandbox. The LGB, CMC, and nZVI transport was also modeled using a multiphase flow and transport model considering LGB and CMC as solutes, and nZVI as a colloid.

Analysis of the breakthrough data showed that the mass recovery of LGB and CMC was greater than 95 % indicating conservative transport in silica sand. However, the mean residence time of CMC was significantly higher than that of LGB due to CMC viscosity effects. Increasing the CMC concentration from 0.2 % to 0.8 % increased nZVI stability, but caused higher pressure drops in the sand box, indicating that use of high CMC concentration may limit the injection rates. The images captured during transport experiments and the total iron analysis of the sand after the transport experiments showed that a significant amount of nZVI was retained in the sandbox. The mass recovery of nZVI was lower than 40 % due to the attachment onto the sand surfaces. The simulation results of LGB, CMC, and nZVI matched the experimental observations and allowed estimation of transport parameters that could be used to predict CMC stabilized nZVI transport under a variety of conditions.