Modeling of the foam injection in porous media: application to treatment of the polluted soils

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ABSTRACT

Foam injection represents an innovative alternative of great interest for in-situ remediation of polluted soils. The potential benefits of the use of foams compared to conventional surfactant injection include better control of the volume of injected fluid, better homogeneity contact between pollutants/surfactants, and a better ability to dissolve and desorb pollutants. Foam can also be used to vectorize the nutrients in the case of bioremediation. Furthermore, foams improve transport efficiency of surfactants, even in a heterogeneous porous medium, resulting in higher purification efficiency [1]. It has even been found that the foam injection is more efficient than the conventional surfactant injection, based on the weight of contaminants removed per gram of surfactants used [2].

Several mechanisms make it difficult to understand the foam transport phenomena in porous media, including the number of bubbles that governs the flow characteristics such as viscosity, relative permeability, phase distribution, and interactions between phases. This study focuses on modeling the remediation process by foam injection to better understand the various interactions between foams and pollutants in porous media. In this study, the foam injection was also compared with the conventional injection of air (air sparging technique).

Generalized Darcy's equations were used to calculate the phase flow velocity (foam / water) in porous media, considering the pollutant phase immobile. The mass balance of pollutants dissolved in the solution and in equilibrium with its vapor expresses the pollutant transfer by diffusion and advection. The numerical simulations were performed to model an experimental column filled with fine sand and initially saturated with water. A part of the soil at the bottom of the column was polluted by DNAPL. To clean up the soil, foams containing surfactants and water (10% by volume) and air (90% by volume) are injected at the bottom center of the column. Numerical modeling of multiphase flows and transfer of pollutants was made using Comsol Multiphysics®.

The efficiency of the foam injection was compared with the conventional air sparging method in the saturated zone. The simulation results show a greater vertical and lateral propagation front for the foam injection case (Graphic1). This wide difference in lateral spreading comes from the difference between the mobility of the foam and air as well as the difference between the capillary forces that exists at the air / water and foam / water interfaces. Furthermore, the vapor concentration of the pollutant components in the column outlet is much higher for the injection of foam (vs air injection). This phenomenon is due to increasing the solubility of the pollutants in the foam solution (Graphic2).

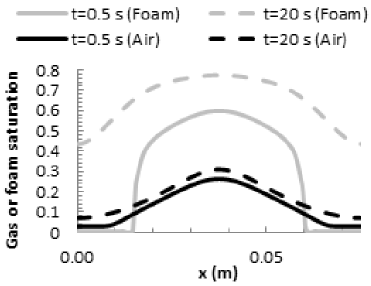
The theoretical results will be validated using a foam injection laboratory test which is in progress. Future modeling integrates the bubble population balance model and the change in viscosity as a function of the injection flow rate and the surfactant concentration.

REFERENCES

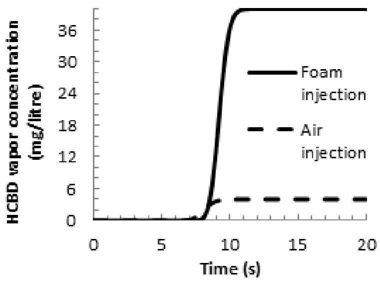
[1] Jeong S.W., Corapcioglu M.Y., Roosevelt S.E., Micromodel Study of Surfactant Foam Remediation of Residual Trichloroethylene, Environ. Sci. Technol, 34, 3456–3461 (2000).

[2] Tanzil D., Hirasaki G.J., Miller C.A., Mobility of Foam in Heterogeneous Porous Media: Flow Parallel and Perpendicular to Stratification, Soc. Petrol. Eng. J. 7:203–212 (2002).

GRAPHICS



Graphic1



Graphic2