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Remediation of multilayer soils contaminated by heavy chlorinated solvents using biopolymer-surfactant mixtures

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The remediation of contaminated soils is an environmental critical issue. A common form of contamination is caused by heavy chlorinated solvents spills, commonly used in industrial processes [1]. Also, remediation is particularly challenging when these pollutants are present in multi-layered soils [2]. A promising approach for the treatment of these soils is the use of polymer solutions [3]. Although polymer solutions can improve the remediation of these pollutants, the residual pollutant after the flushing can still be noticeable. Surfactant solutions can improve the recovery of pollutants by surface tension reduction; however, their efficiency in multilayer systems is limited [4]. Combining polymer and surfactant in a mixture can result in a remarkable improvement in the recovery of the pollutant [5].
In this work, experimental and numerical approaches are used. Xanthan as a biopolymer and sodium dodecylbenzene sulfonate (SDBS) as a biodegradable surfactant are used. To study the interactions between the polymer solution and surfactant, various tools such as rheometer, and scanning electron microscope (SEM) are employed. 1D-column experiments have been used for both single-phase and two-phase flow. To evaluate the performance of the polymer solutions in the remediation of chlorinated solvents in a multilayer system, a decimetric-scale 2D sandbox is used. Two-phase flow in multilayer porous media is simulated to understand the underlying physics behind the experimental results. The continuity equation is coupled with generalized Darcy's Law and the non-Newtonian behavior of the polymer solutions is incorporated into the model.
The xanthan solution exhibited shear-thinning behavior. However, when mixed with SDBS, the viscosity decreased with no correlation between the viscosity of the mixture and the concentration of the surfactant, given a constant concentration of xanthan. This is attributed to the mutual electrostatic repulsive forces and hydrophobic interactions confirmed by SEM images. The analysis of two-phase flow in a 1D-column indicates that incorporating a surfactant in the polymer solution leads to higher recovery efficiency for 15%. Furthermore, the flow of the polymer/surfactant mixture when using a mixture of polymer and surfactant, the flow of pollutants after breakthrough lasts longer and the pressure difference along the column is lower compared to using the polymer solution alone. The experiments in the 2D system illustrate similar results, the higher recovery and lower differential pressure for the mixture of polymer/surfacatant. Another important feature of the 2D experiments is the density-driven flow of the polymer/surfactant solution in the multilayer system. The multilayer experiments for the polymer and heavy pollutants flow visually demonstrate that the density, as well as permeability differences between the layers, have an impact on cross-flow. The simulation of multiphase flow in a multilayer system produced results that matched well with those from the experiments. The simulation results also reveal that if the upper layer in the 2D system is not confined, the polymer solution as the lighter fluid moves mainly vertically. To address this, a set of experiments were conducted in a larger 2D system with a horizontal well injecting a blocking agent, which successfully prevented the vertical movement of the polymer solution.

Participation

In-Person

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