Apply THMC to simulate the porosity reduction in a permeable reactive barrier-aquifer system

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Abstract

Permeable reactive barrier (PRB) involving zero-valent iron (ZVI) is an in-situ technique for treating groundwater contaminants. Chemical reactions take place inside the PRB, promoting secondary mineral precipitation and leading to a decrease in the porosity of the PRB. When the porosity is reduced, flow path reorientation, residence time changes, and bypassing occur. In this research, Thermal-Hydrology-Mechanic-Chemical (THMC) software was used to determine porosity reduction through flow modeling and the chemical reactions occurring within the PRB. According to the groundwater flow model, PRB is more permeable than the neighboring aquifer materials, allowing water to pass through it easily and preserving the groundwater's hydrogeology despite removing contaminants. THMC results indicate that porosity loss is greatest at the entrance face (0.0138), while aragonite, siderite, and ferrous hydroxide reduce porosity by more than 99%. By illustrating porosity losses for high and low concentrations of bicarbonate and sulfate in the entering groundwater, my model also highlights the relative effect of concentration. Due to the formation of carbonate minerals, a decrease in bicarbonate concentration causes a considerable drop in porosity. Therefore, the objective of this study is to use THMC to model the decrease of porosity in PRB, investigate the factors that should be considered when modeling porosity loss caused by mineral fouling in PRB, and analyze the reduction of porosity over time.

Keywords: Permeable reactive barrier (PRB), Zero-valent iron (ZVI), Thermal-Hydrology-Mechanic-Chemical (THMC), Porosity reduction.