Hydrodynamic behavior of zero-valent iron permeable reactive barriers: effects of permeability loss

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The permeable reactive barrier (PRB) is a widely used technology for in-situ subsurface remediation as it is capable of treating large contaminant plumes cost effectively. Zero-valent iron (ZVI) is a reactive material that has been extensively used as it is highly reactive and suitable for treating various kinds of contaminants, i.e., hydrocarbons and heavy metals. Despite the facts that ZVI-PRB has been used in groundwater remediation technologies, the complex mechanisms that occur in the treatment process need further studies and the longevity of the system is unpredictable. The significant issues that need to be addressed which is intimately related to the hydrodynamic of PRB is the rate of mineral precipitation and permeability/porosity reduction within the PRB as well as the potential of ZVI-PRBs for remediation of contaminants. A series of column experiments has been set up (14 cm inner diameter and length of 90 cm) and operated with the conditions imitating the natural groundwater environment, i.e., flow rate and water constituents. The experimentally measured values of main parameters following Darcy’s law will be used in calculating the permeability and computer simulation. The corroded ZVI will be analysed to identify the composition of the precipitates and to determine the porosity changes using micro X-ray CT scanner (µCT) and X-ray Diffraction (XRD). From the flow column experiment, it can be seen that there is a drop in flow rate and a decrease in the intrinsic permeability relative to time, i.e., total flow. The XRD detected the chemical components of Magenetite and Maghemite which are the iron oxides that occur from the reduction of iron in water. The image from µCT indicated the changes in particle size, pore size and porosity. It can be concluded that the pores have been blocked due to the mineral precipitation thus reducing the flow rate and permeability. The results of the computer simulation can be used to determine the rate of mineral precipitation and support in designing the appropriate PRB, i.e., in term of longevity.

Key Words: Zero-valent iron, permeable reactive barrier, hydrodynamic, mineral precipitation