19h Predicting Enhanced Dispersion of Bacteria Due to Chemotaxis Using Volume Averaging Methods

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Biodegradation is an important mechanism for contaminant reduction in groundwater environments, and methods such as in-situ bioremediation and bioaugmentation represent alternatives to traditional methods such as pump-and-treat. While attention has been focused on the availability of electron acceptors and donors, bacterial population distributions can also be important in accurately estimating in-situ degradation rates, especially at bioaugmentation sites. Chemotaxis refers to the directed migration of bacteria in the direction of concentration gradients of certain chemical attractants. Chemotaxis has been shown to enhance bacterial transport toward attractant source zones in laboratory experiments, and can significantly increase contaminant flux undergoing degradation at the interfaces of low- and high-permeability regions. While chemotaxis has been demonstrated at micro-scales, efforts to predict the influence of a chemotactic source on the macroscopic transport of bacteria and contaminant in porous media have been limited. Our approach was to start with the point advection-diffusion equation, and use volume averaging methods to develop an advection-dispersion type relationship, in terms of volume-averaged quantities. This relationship was nondimensionalized and numerical simulations were run to predict effective dispersion coefficients relative to bulk diffusion coefficients as a function of certain dimensionless groups, including the Peclet number and appropriate chemotactic dimensionless numbers defined in this work. One result of this model will be the development of an expression for a modified Peclet number that can be used to predict dispersion using previously determined charts for pure dispersion in various packed bed configurations, and tested against experimental observations of bacterial transport.