Bacterial dispersion in groundwater

Understanding the transport of bacteria in saturated porous media is crucial for many applications in water management, ranging from the control of bio-clogging in pumping wells to the design of new bioremediation schemes for subsurface contamination. However, little is known about the spatial distribution of bacteria at the pore scale, particularly when small-scale heterogeneities – always present even in seemingly homogeneous aquifers – lead to preferential pathways for groundwater flow. In particular, the coupling of flow and motility has recently been shown to strongly affect bacterial transport, and this leads us to predict that subsurface flow may influence the dispersal of bacteria and the formation of biofilms in saturated aquifers. The specific scope of this project is to study bacterial dispersion in a sinusoidal microchannel, a simplified model that can provide great insight into the basic mechanisms that occur at the pore scale. Although natural media are in general not so simple (and certainly not periodic), the sinusoidal channel represents the simplest system to analyze the effect of the convergence and divergence of streamlines on dispersion, a mechanism that plays a central role for transport in heterogeneous porous media. Furthermore, at fracture scale, the channel model is relevant to understand the role of fracture wall roughness on transport properties.

In this project, the student will have the opportunity to learn the basics of numerical modeling and to become acquainted with microfluidic technology and optical microscopy applied to the study of bacterial transport. Flow in sinusoidal channels with different dimensions will first be studied with numerical methods (e.g., in COMSOL Multiphysics). Depending on the time available, the same geometries will then be modeled using microfluidic channels, where the transport of passive and active tracers will be visualized with an optical microscope and quantified with particle tracking techniques.

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