Transport and Retention of Metal Reducing Motile Bacteria in Idealized Pore Geometries

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Project Abstract:

For several species of motile microorganisms, encompassing strictly anaerobic, facultatively anaerobic, and facultatively autotrophic bacteria, with capacities to reduce a range of metals and radionuclides, micromodel experiments were conducted in idealized pore networks under both flow and no-flow conditions. The micromodels were designed as chambers with small depth (10 µm and 20 µm) and properties of bacterial transport and retention (biofilm formation) were studied in the horizontal plane. The density of the bacterial solution was kept low to minimize the interaction between individual cells. Videos of bacterial motion were recorded at various magnifications and frequencies. Trajectories of individual cells ranging from several seconds to few minutes in duration were extracted in neutral conditions (in the absence of any chemical or redox gradient). Position of individual cells in the videos were found by filtering the difference in pixel intensity between the current video frame and the mean image over the duration of the video. Groups of pixels in the species size range were merged to estimate the location of the cell center. Locations of cell centers were connected to create motion paths, which were extracted by categorizing cells based on their previous speed. Cell trajectories that were collected from the videos were then analyzed to determinine the suitability of Fickian and non-Fickian transport models as a function of timescale and pore structure. Growth of biofilm in the micromodel was studied which includes determination of biofilm morphology and its relation to pore structure, and its effect on fluid properties such as porosity, velocity, and development of preferential channeling. The micromodel experiments and related model to study motile microorganisms' transport and retention is expected to provide pathway for development of methodologies to include upscaled bacterial motion properties in bioremediation implementations.