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Effect of biofilm permeability on flow and transport in three-dimensional porous media: A geostatistical study

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Bacterial biofilms can form in porous media that are of interest in industrial and particularly environmental applications such as in situ groundwater remediation. The presence of biofilms modifies pore-scale and bulk hydrodynamics and consequently solutes transport and reaction kinetics. Porous media consist of highly heterogeneous flow fields and thus biofilm growth is also highly variable resulting in spatially variable biofilm permeabilities. Random processes are often invoked in hydrogeology to model variable quantities. Geo-statistical simulations require numerous realizations of a stochastic process over a grid. Our study leverages highly resolved three-dimensional X-ray computed microtomography images of bacterial biofilms in a tubular reactor to numerically compute pore scale flow and solute transport on a fine grid by considering various realizations of the biofilm permeability field. Using a conservative tracer experiment we first validate our flow and transport model which is then used to understand the impact of a heterogeneous permeability field on fluid-fluid and biologically driven reactions.