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Microbial growth in confined flow

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Microorganisms in the subsurface environment are involved in a wide range of bio-chemical processes such as respiration of organic or inorganic compounds, bio-mineralisation or act as catalyst of chemical reactions. They grow under two main life-forms: microbes are suspended in a fluid (planktonic), or they are organized in sessile colonies attached to solid surfaces (biofilm). In soils, small scale heterogeneity and confined nature of the subsurface environment controls fluid flow as well as nutrient transport and availability for consumption. A traditional approach is to study microbial communities in a mixed batch reactor, this method is powerful to investigate system response to variation of chemical and biological parameters. However this does not allow to investigate interaction of biofilm growth with physical properties of the surrounding environment. In this work we look at the formation of biofilm under heterogeneous flow and transport in porous media. While growing due to flowing nutrient uptake, the biofilm reduces the pore space available and, thus, confines the fluid flow inducing changes in the hydraulic medium properties, such as permeability. We aim to study how flow heterogeneity, the resulting spatial distribution of nutrient and oxygen affects the spatial distribution and growth of microbial biofilm. In this perspective we developed an experimental set-up to visualize and quantify the growth of a bacteria population (engineered fluorescent Pseudomonas Putida) in a heterogeneous porous medium under a flow of nutrient and its impact on the temporal evolution of medium permeability. Using time-lapse fluorescent microscopy applied to microfluidics chip we visualize the spatial distribution of the biomass and quantify the biofilm growth, while monitoring the overall flow driven by a constant pressure drop.