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Experimental study of coupling between bacterial growth and solute transport in biofilm coated porous media

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Aquifers contamination by xenobiotics is a major environmental issue. The fate of these pollutants depends on both their physical-chemical properties and soil intrinsic properties. If the soil matrix can physically remove contaminants by working as a natural filter, soil microfauna are also involved in the natural attenuation of subsurface pollution. Microorganisms grow as a biofilm using a wide range of organic compounds as sole source of carbon and energy. This process called biodegradation leads to the mineralization of target compounds and the transformation of others contaminants which are used by other microorganisms. This idea has led to the development of in situ bioremediation methods.
However, it is well known at this date that microbial production can impact on porosity and hydraulic conductivity (Baveye et al., 1998; Thullner et al., 2002), and hence on transport of dissolved organic compound by feedback. Biofilm accumulation, indeed, decreases free pore space thereby decreasing media porosity and permeability while increasing hydrodynamic dispersion. This mechanism commonly referred to as bioclogging may thus influence the success of bioremediation methods in polluted aquifers (Anderson and Lovley, 1997).
The overall goal of this work is to better understand how the microscopic dynamics due to the presence of the biofilm affect macroscopic flow and transport properties. The underlying idea is to apply such understanding toward prediction and beneficial manipulation of permeability and mass transport properties for in situ bioremediation techniques. If mathematical modelling plays here a crucial role in understanding biofilm dynamics and predicting efficiency of these decontamination methods, lab-scale experiments are required to validate these numerical results.
With this aim in view, experimental observation of biomass development has been performed in transparent packed flow cell. Transport of an organic solute (biodegradable or not) in presence of biofilm has been studied under various hydrodynamic conditions and the resulting breakthrough curves have been analysed. Variations of permeability and dispersion coefficients as a function of the biofilm volume fraction are discussed and compared to numerical results issued from upscaling methods.