Location : Laboratoire des Ecoulements Géophysiques et Industriels

Subject: Experimental and numerical study on biofilm structure formation under controlled hydrodynamics conditions

Key words: biofilter, biofilm, modeling, adhesion, microstructure

Context and objectives

Biofiltration is a pollution control technique with numerous advantages: compacity, few by-product, low sludge production, high adaptability to emerging contaminants. A biofilter is a column filled with granular packing material with a high specific surface, on which is fixed a layer of microbes. As liquid/gas effluent flows over this attached biofilm, pollutants are removed by the biofilm. Purification capacities are impacted by the development of the biofilm. However, the hydrodynamics of the system evolves in return with the growth of the biofilm that alters the porosity of the matrix. Excess accumulation of biomass may result in operational problem such as clogging, excessive head loss which leads to performance deterioration. An approach coupling fluid hydrodynamics, biofilm growth and purification capacity is necessary to obtain a proper mathematical model of biofiltration. The objective of this thesis is therefore to provide a thoroughly comprehension of the coupling between hydrodynamics and physiology of biomass in the biofilm, which will then allow us to simulate the evolution of the microstructure of the biofilm in a porous medium.

Methodology and program of thesis

This project is divided into two parts:

- Experimental study will consist in the measurement of the microstructure of biofilm and biological kinetic parameters under well controlled hydrodynamic conditions. The experimental measurements will be performed in a Hele-Shaw cell equipped with a high resolution fluorescence microscope and an optical tweezer in order to obtain 3D visualization of biofilm formation in continuous as well as to characterize the rheological behavior, the composition and structure evolution of biofilm.
- Numerical study will be the direct numerical simulation of the liquid flow through the 3D structure of biofilm. 2D images obtained by microscopy will be used to reconstruct the 3D simulation grid corresponding to the biofilm. These simulations will allow us to get the velocity field, the local shear rate, and determine the mass transfer coefficient, the medium permeability etc.

At the end of this thesis, a comprehensive database on the structure of the biofilm, its spatial and temporal evolution for the couple "Pseudomonas Putia / Phenol" according to the hydrodynamic conditions will be established, from which the effect of hydrodynamics on the physiology of the biofilm will be identified and a closure law on biofilm growth will be proposed and integrated in an 1D mathematical description of biofiltration.

Candidate's profile

Applications are welcome from all suitable qualified candidates (a high quality first degree in physics, engineering or an associated discipline). He (She) must have a solid background in fluid mechanics or process engineering or rheology and be motivated by highly technical measurement and modeling. An experience in bioprocess is not necessary, but welcomed and encouraged.

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