Biofilm growth and development are influenced by hydrodynamic conditions and the availability of nutrients. Therefore, for the purpose of understanding biofilm macro-scale dynamic, it is essential to adopt a modeling approach, which takes into account all the relevant aspects, like fluid flow, structure deformation, mass transport and their effect on biofilm growth and erosion. In this paper, we propose a novel growth model based on a finite element approach for the numerical simulation of a sequential one-way coupling of the fluid-structure interaction (FSI) and the scalar transport models. Due to the different time-scales of the involved phenomena, the growth of the biofilm structure is coupled with the FSI and mass transport through a multi-scale approach in time. In each hydrodynamic time step, first the non-linear FSI problem is solved followed by the scalar transport equations, using the information on velocities and deformations obtained in the FSI step. After a steady state solution is reached, information on mass fluxes and stresses are passed to the growth model. At this point, the growth is calculated for a biological time step larger than the hydrodynamic one and
based on the mass flux through the interface and on normal and shear stresses on it. First numerical examples are run with the purpose of demonstrating the suitability of the proposed growth model to catch the main features of a growing biofilm structure. This type of approach can significantly contribute to the understanding of biofilm development in moving fluid flows and can permit the understanding of the influence of operating conditions on the development of complex three-dimensional structure shapes often seen in nature and industry.

Stichworte: biofilm growth, fluid-structure interaction, mass transfer, finite element method

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