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A Rapid Prototyping Tool for Suspended Biofilm Growth Media

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Abstract : Biofilms play an essential role in treating water in biofiltration systems. The biofilm morphology and function are inextricably linked to the hydrodynamics of flow through a filter, and yet engineers rarely explicitly engineer this interaction. We develop a system that links computer simulation and 3-D printing to optimize and rapidly prototype filter media to optimize biofilm function with the hypothesis that biofilm function is intimately linked to the flow passing through the filter. A computational model that numerically solves the incompressible time-dependent Navier Stokes equations coupled to a model for biofilm growth and function is developed. The model is imbedded in an optimization algorithm that allows the model domain to adapt until criteria on biofilm functioning are met. This is applied to optimize the shape of filter media in a simple flow channel to promote biofilm formation. The computer code links directly to a 3-D printer, and this allows us to prototype the design rapidly. Its validity is tested in flow visualization experiments and by microscopy. As proof of concept, the code was constrained to explore a small range of potential filter media, where the medium acts as an obstacle in the flow that sheds a von Karman vortex street that was found to enhance the deposition of bacteria on surfaces downstream. The flow visualization and microscopy in the 3-D printed realization of the flow channel validated the predictions of the model and hence its potential as a design tool. Overall, it is shown that the combination of our computational model and the 3-D printing can be effectively used as a design tool to prototype filter media to optimize biofilm formation.

Keywords : biofilm, biofilter, computational model, von karman vortices, 3-D printing.
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