COMPUTATIONAL FLUID DYNAMICS SIMULATION OF MEMBRANE FOULING MITIGATION USING 3D PRINTED TURBULENCE PROMOTERS

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Abstract
Filtration systems are fundamental to water treatment, where achieving an optimal balance between effective contaminant removal and sustainable operation is essential. Computational Fluid Dynamics (CFD) offers a powerful approach for simulating fluid behavior within these systems, allowing researchers to assess and optimize design parameters prior to experimental validation. In this study, CFD simulations were conducted on a laboratory-scale ultrafiltration unit (Millipore), configured to process 100 mL of dairy wastewater. The setup comprised several key components: a plastic mesh, a filter membrane, a 3D-printed flow promoter, and a rotating magnetic stirrer. A static pressure of 2 bar, applied via nitrogen gas at the liquid surface, was used to drive filtration. The primary objective was to characterize the hydrodynamic behavior of the system, with emphasis on flow patterns, pressure distribution, and shear stress profiles. Results revealed that the plastic mesh and Millipore filter were the principal sources of hydraulic resistance, with the greatest pressure drop occurring across these elements. The rotating stirrer improved mixing efficiency, while shear stress analysis identified localized high-stress regions. Notably, the integration of the 3D-printed spacer enhanced permeate flux and reduced overall resistance, highlighting its potential for improving ultrafiltration performance.

Keywords: Computer Fluid Dynamics**,** Mitigation Membrane Fouling, Turbulence Promoters, Ultrafiltration.

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