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Mathematical modeling of biofouling formation on a membrane filtration system

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Microfiltration is a promising approach for water production and wastewater treatment. However, a primary challenge associated with this technology is the formation of fouling layers, predominantly composed of organic substances such as bacteria and extracellular polymeric substances (EPS). These layers contribute to increased hydraulic resistance and a decline in flux during membrane operation. In wastewater treatment, the development of such biological layers, named biofouling, represents a significant operational cost due to the energy and chemical requirements for cleaning procedures.

Since biofouling is fundamentally a biofilm-related problem, the ability to predict biofilm growth and evolution on membrane surfaces is crucial for optimizing membrane reactor performance and backwashing strategies under different filtration regimes. To address this problem, a one-dimensional mathematical model has been developed, formulated as a free boundary value problem that describes biofilm dynamics and EPS production during microfiltration. This study integrates classical in-series filtration theory (e.g., based on Darcy's Law) with multispecies biofilm growth modeling.

The proposed model, and it's future modifications, serves as a mathematical tool for describing backwashing effects and biofouling kinetics during microfiltration, thereby supporting wastewater treatment facilities in system design and operational management.

Keywords: biofouling, boundary value problem, microfiltration

References

[1] V. Luongo, M. R. Mattei, L. Frunzo, B. D'Acunto, K. Gupta, S. Chellam, N. Cogan, A transient biological fouling model for constant flux microfiltration, *Mathematical Biosciences and Engineering*, 20:1274–1296, 2023.

[2] L. Frunzo, V. Luongo, M. R. Mattei, A. Tenore, Qualitative analysis and simulations of the biological fouling problem on filtration membranes, *Partial Differential Equations in Applied Mathematics*, 8:100557, 2023.