

Performance Evaluation of Biofilm-Engineered Rotating Reactor for Microplastic Treatment

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Abstract

Microplastic contamination in wastewater has emerged as a critical environmental issue due to the persistence and resistance of synthetic polymers to conventional treatment processes. Conventional removal approaches, largely based on physical separation methods such as filtration and sedimentation, often fail to achieve complete removal or degradation, especially for smaller particles, and may result in secondary contamination [1], [2]. In this study, an advanced biofilm-assisted rotating reactor system is developed and evaluated for enhanced microplastic biodegradation under controlled operational conditions. Unlike traditional removal techniques that rely on physical separation, the proposed system promotes direct microbial interaction with polymer surfaces through dynamic biofilm formation and improved mass transfer.

The influence of key parameters such as rotational speed, hydraulic retention time (HRT), and aeration intensity was systematically investigated to identify optimal degradation conditions. The reactor achieved a maximum degradation efficiency under optimized conditions, demonstrating improved performance compared to conventional suspended systems. Surface characterization confirmed progressive polymer breakdown, indicating effective biofilm-mediated degradation.

In addition, a kinetic analysis based on pseudo-first-order modeling and a preliminary techno-economic assessment were incorporated to evaluate process feasibility. The results highlight the potential of biofilm-based rotating reactors as a sustainable, low-energy alternative for microplastic remediation in wastewater treatment applications.

Keywords

Microplastic degradation, biofilm-based reactor, biodegradation systems, biofilm engineering, rotating carrier bioreactor, sustainability, wastewater treatment.