Research Article

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Experimental investigation of biofilm carriers of varying shapes, sizes, and materials for wastewater treatment in fixed bed biofilm reactor: a qualitative study of biocarrier performance

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Abstract

BACKGROUND: Biofilm carriers were introduced in the early 1990s mainly to abate chemical oxygen demand (COD). However, studies have continued investigating few biocarriers repeatedly, without studying a large number of carriers in a single study under similar conditions.

RESULTS: The current study investigated the performance of nine synthetic and eight natural biofilm carriers for 7 days of palm oil mill effluent (POME) treatment in terms of COD removal. A fixed bed biofilm reactor (FBBR) was 100% packed with biocarriers and operated at 35 °C. Performance based on the 7th day COD removal could be ranked in the following order: green ammonia absorption stone (91%), K1 micro (88%), coral sand (87.8%), volcanic stone (86.6%), Micro Media (85.5%), 1.6 cm BioBall (85%), pebble (82.4%), porous ceramic ring (82.3), K1 (82.1%), non-porous ceramic ring (80.9%), brown ammonia absorption stone (78.6%), biological filter (77.7%), Ultra Media (76.8%), blue media (69.3%), 3.0 cm BioBall (68.8%), 2.5 cm BioBall (66.5%), and loofah sponge (63%).

CONCLUSION: The smallest carrier, K1 micro, yielded the highest COD removal (88%) on day 7 among the other synthetic carriers, while green ammonia absorption stones provided the highest quality effluent from day 1 (3565 mg COD L^{-1}) to day 7 (780 mg COD L^{-1}) and delivered the shortest start-up compared with all natural and synthetic carriers. The discussion revealed that all carrier functionalities (i.e., scale, shape, surface pores, roughness, material, surface area, porosity, and durability) play a key role in deciding carrier quality. The current study also introduced 'carrier efficiency limit', which refers to the carrier's capacity to entrap biomass and immobilize microorganisms.

Keywords: biological wastewater treatment; biofilm carriers/media; synthetic biofilm media; natural occurring biofilm support; Kaldnes; palm oil mill effluent (POME)

INTRODUCTION

In 1930, Tausz and Donath presented the concept of using microorganisms to treat contaminated soil, giving rise to wastewater organics and inorganics biodegradation.[1] Today, bioremediation is a commonly used method to degrade, transform, and chelate various toxic compounds as a source of carbon and energy driven by microorganisms.[2,3] Biofilm carriers have been presented to increase biomass retention, reduce the space area required, and colonize microbes without biomass recycling.[4]

Studies have introduced biofilm carriers to remain in continuous movement inside a moving bed biofilm reactor (MBBR) through aeration or mechanical fluid stirring.[5] During the treatment of wastewater, the surfaces of biofilm carriers gradually accumulate an amount of active biofilms that consume substrates and house various microorganisms.[6] Carriers serve as a platform to entrap biomass and grow biofilm, where most biological activities take

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