Biodegradable polymer-mediated denitrification for sustainable nitrogen removal in recirculating aquaculture systems

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Abstract

The growing global population has led to a rise in protein demand, increasing reliance on aquaculture for efficient fish production. However, conventional aquaculture methods such as seawater and inland flow-through systems-face serious challenges including environmental degradation, rising sea surface temperatures, and pathogen risks. As a sustainable alternative, recirculating aquaculture systems (RAS) offer a promising solution by minimizing environmental impact, conserving water, and ensuring stable fish production. A critical component of RAS is the removal of nitrogen compounds by efficient filtration and particularly together with biological nitrification and denitrification. This biological system consists of nitrification converting toxic ammonia into nitrate and the subsequent denitrification step requiring a reliable electron donor. Conventional electron donors like methanol pose risks of secondary pollution due to their diffusibility. This study investigated the use of biodegradable polymers (BPs) as solid, slow-release carbon sources to support denitrifying bacteria in RAS. Poly (butylene succinate adipate) (PBSA) was found as effective BP for promoting nitrate reduction. Aquaculture trials using PBSA as electron doner in denitrification demonstrated efficient NO removal from nitrate-accumulated water. To elucidate the microbial communities involved, biofilms attached to BPs were analyzed using denaturing gradient gel electrophoresis (DGGE) based on 16S rDNA and *nirS* gene, alongside next-generation sequencing (NGS). Results showed that β-Proteobacteria is the dominant group with existence of γ-Proteobacteria and that Comamonadaceae being the most abundant family. These findings suggest that BPs like PBSA can effectively support denitrifying microbial community, offering a promising and environmentally friendly strategy for enhancing nitrogen removal in sustainable aquaculture.

Keywords: Recirculating Aquaculture Systems (RAS), biodegradable polymers (BPs), denitrification

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