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RESEARCH ARTICLE

Biofouling controls using air bubbles—a review of various applications

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Abstract
Biofouling poses a significant challenge in aquatic, marine, and maritime settings, leading to increased corrosion rates and functional impairments of structures and equipment. Conventional fouling control methods have limitations, prompting the exploration of unconventional approaches to manage biofouling and enhance corrosion resistance. This paper presents a review of employing air bubbles for fouling control in various applications, with a particular focus on marine industries and ecological considerations. By comparing different fouling control techniques, including the use of air bubbles, the paper offers valuable insights into their effectiveness and applicability. Suggestions for future research to develop more efficient techniques for biofouling control using air bubbles are also discussed. This review aims to contribute to the advancement of fouling control strategies and their impact on biofouling characteristics and mitigation efforts.

Keywords Biofouling control · Air bubble · Fouling technique · Biofouling characteristics

Introduction

Biofouling remains a persistent challenge in marine industries, aquaculture, and wastewater treatment systems. Conventional antifouling methods, such as biocidal coatings, mechanical cleaning, and chemical treatments, have demonstrated varying degrees of effectiveness. However, these methods present significant limitations, including environmental toxicity, high operational costs, and long-term maintenance challenges. As a result, there is growing interest in alternative antifouling strategies, particularly the use of air bubble curtains and aeration-based systems.

While existing studies have demonstrated the potential of air bubbles in mitigating biofouling, several gaps remain in the literature. First, the effectiveness of air bubble techniques under different environmental conditions, particularly in tropical fouling environments, is not well understood. Most studies have focused on temperate regions, leaving a knowledge gap regarding their adaptability to higher temperatures and increased fouling pressures. Second, while intermittent use of air bubbles has been proposed as a strategy for energy savings, there is limited research on the optimal frequency and duration required to balance effectiveness and efficiency. Third, the interaction between air bubble curtains and various hull shapes remains insufficiently explored, raising questions about their suitability for different vessel designs. Additionally, the compatibility of air bubble methods with existing antifouling coatings, such as self-polishing polymers, requires further investigation to enhance their combined efficacy. Finally, crossflow disturbances and their impact on the stability and performance of air bubble curtains in dredging and dynamic marine environments remain a significant challenge that needs to be addressed. This review aims to bridge these gaps by synthesizing recent advancements in air bubble antifouling techniques and identifying key areas for future research. By critically evaluating the effectiveness, adaptability, and limitations of air bubble applications across different domains, this study provides a

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