Chapter 14
Synergistic Approaches for Wastewater Treatment

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ABSTRACT

Innovative wastewater treatment is becoming increasingly critical in addressing global water scarcity and pollution challenges. This abstract explores synergistic approaches that integrate advanced technologies, resource recovery, and collaborative frameworks to enhance wastewater treatment efficiency and sustainability. Advanced treatment technologies, including anaerobic membrane bioreactors (AnMBRs) and bioelectrochemical systems, are highlighted for their ability to effectively remove contaminants while recovering valuable resources such as energy and nutrients. These systems not only improve effluent quality but also reduce the environmental footprint of treatment processes. Moreover, decentralized and nature-based solutions,

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such as constructed wetlands, are gaining traction for their cost-effectiveness and ecological benefits. The integration of advanced technologies, resource recovery practices, and collaborative approaches represents a holistic strategy for enhancing wastewater treatment, ensuring sustainable water management, and protecting public health and the environment.

INTRODUCTION

One of the most important aspects of a sustainable approach to water management is wastewater treatment, particularly when it comes to safeguarding the environment and public health. However, in terms of effective performance, resource recovery, and environmental effects, conventional methods frequently fall short of expectations. Thus, there is an increasing need to establish synergistic approaches by integrating advanced technologies, resource recovery strategies, and collaborative frameworks. These synergistic approaches will hopefully contribute to improving efficiency and sustainability in wastewater treatment, valorising a number of advanced technologies that include anaerobic membrane bioreactors and bioelectrochemical systems. Anaerobic membrane bioreactors (AnMBRs) combine the anaerobic digestion process with filtration by means of membranes that remove pollutants while producing renewable biogas. In contrast, with BES, electrochemically active microorganisms help to generate electricity or hydrogen during the treatment of wastewater. Integration of an MBR with a BES may be a promising synergistic approach since it can lead to better contaminant removal, a reduced fouling problem, and improved resource recovery. Coupled with these advanced technologies, the aim of the researchers is the maximum overall efficiency and sustainability within the wastewater treatment processes. In addition to the advanced technologies, the synergistic approaches (Table 1) emphasize that the solution has to be decentralized and nature-based. Decentralized systems are economical in ways which are environmentally friendly, unlike conventional centralized plants, a good example being constructed wetlands. Such systems use natural processes and vegetation to remove impurities, thus enhancing biodiversity and ecological stability. The second indispensable aspect in creating the right and workable strategy for wastewater treatment is stakeholder involvement. Involvement and liaison among the local communities, industries, and governmental bodies ensure that with such active involvement, there is a creation of an integrated management system which will help in addressing a multiplicity of challenges. Coordinative management allows for knowledge, resource, and best practice sharing to efficiently create more holistic and effective plans regarding wastewater management.