Chapter 11
Biological Treatment Methods for Pharmaceutical Wastewater

P. Selvakumar
https://orcid.org/0000-0002-3650-4548
Department of Science and Humanities, Nehru Institute of Technology, Coimbatore, India

Ravi Kumar Gande
https://orcid.org/0009-0001-7264-4513
Department of Chemistry, Vardhaman College of Engineering, Hyderabad, India

Reshma Jaweria
Department of Biotechnology, Maulana Azad College of Arts, Science, and Commerce, Aurangabad, India

Abhijeet Das
https://orcid.org/0000-0003-4599-5462
Department of Civil Engineering, C.V. Raman Global University, Bhubaneswar, India

Sumanta Bhattacharya
https://orcid.org/0000-0003-2563-2787
Maulana Abul Kalam Azad University of Technology, Howrah, India

ABSTRACT

The burgeoning pharmaceutical industry, marked by rapid advancements and high

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INTRODUCTION

The burgeoning pharmaceutical industry, marked by rapid advancements and high production volumes, has created a significant environmental challenge in the form of pharmaceutical wastewater. This wastewater, which contains a complex cocktail of active pharmaceutical ingredients (APIs), excipients, and by-products, poses a formidable risk to aquatic ecosystems and human health. As pharmaceuticals are designed to be biologically active at low concentrations, their presence in wastewater can lead to unintended consequences, such as the development of drug-resistant microorganisms and disruptions in the endocrine systems of aquatic species. The challenge is further compounded by the limitations of traditional wastewater treatment technologies, which often fall short in effectively removing these contaminants. Conventional methods such as activated sludge and secondary treatment processes are typically designed to handle organic matter and nutrients but are not always equipped to tackle the specific challenges posed by pharmaceutical compounds. To address this issue, a multi-faceted approach is required. One key strategy is the advancement and implementation of more specialized treatment technologies. In addition to technological advancements, there is a growing emphasis on source reduction and pollution prevention. By adopting practices such as green chemistry and process optimization, pharmaceutical manufacturers can minimize the generation of hazardous wastes and reduce the concentration of pharmaceuticals in wastewater. For instance, the development of more sustainable drug formulations and the implementation of closed-loop systems can significantly lower the volume and toxicity of wastewater produced. Furthermore, regulatory frameworks and industry guidelines play a crucial role in driving improvements in wastewater management practices. Governments and international bodies are increasingly recognizing the

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