Chapter 13

Enzyme-Assisted Wastewater Treatment in the Pharmaceutical Industry

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ABSTRACT

The pharmaceutical industry is a significant source of environmental pollution; the main environmental concern being the presence of residues from pharmaceutical products within water bodies. Methods used to treat wastewater traditionally involve physical and chemical processes, which lack desirable characteristics since they result in high costs, consume large amounts of energy, and produce toxic byproducts. The use of enzymes in wastewater treatment appears as an effective and sustainable alternative. For instance, oxidoreductases, lipases, and proteases catalyze at mild

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conditions and could split pharmaceutical complex pollutants into less harmful forms. Enzymatic processes are friendly to the environment and may minimize the creation of toxic byproducts. An illustration is cases that have indicated successful pharmaceuticals, such as diclofenac and triclosan, could be degraded using laccase. Some technical difficulties in the process need to be overcome: complex techniques of enzyme immobilization, for instance, and high setup costs.

INTRODUCTION

The pharmaceutical industry is a major contributor to environmental pollution, with the presence of pharmaceutical residues in surface water and groundwater raising significant concerns. As a result of the increased use of medicines in hospitals, they are discharged into untreated water bodies, resulting in pollution and sewage overflows. Studies have shown that 70% of pharmaceutical residues are released as sludge due to unregulated consumption and discharge without adequate treatment, and more than 200 pharmaceuticals have been detected in surface waters. In facilities designed for other types of wastewaters, the unique characteristics of pharmaceutical wastewater such as its high chemical oxygen demand and variability in flow pose a challenge to treatment. These types of industrial wastewaters contain non-biodegradable organic substances including antibiotics, prescription and over-the-counter drugs, plant and animal steroids, reproductive hormones, beta-lactams, anti-inflammatories, analgesics, lipid-regulating agents, antidepressants, cytostatic, personal care products, detergent by-products, flame retardants, petroleum residues, and other commonly used chemicals such as mercury, cadmium, nickel, and chromium. The presence of pharmaceutical chemicals in the environment is of great concern due to their high toxicity, including genotoxic and mutagenic effects *(Kumari & Tripathi, 2019).* There is a severe problem of aquatic habitat contamination by various pharmaceuticals. In response to the potential impact of drug residues on the ecosystem, several countries have implemented environmental risk assessment frameworks for global drug regulation. The development of the ERA system aims to protect the environment from potential risks posed by pharmaceutical residues *(Samal et al., 2022)*. When choosing a treatment method, specific characteristics of the wastewater are important. High levels of organic compounds, microbial toxicity, elevated salt content and resistance to biodegradability are often complex in pharmaceutical wastewater. In addition, most pharmaceutical plants work on a batch basis and use various raw materials and production methods that lead to significant variation in their water quality. Biopharmaceutical wastewater is characterized by significant fluctuations in quantity, low carbon-to-nitrogen (C/N) ratios, high concentrations of suspended solids (SS) and sulfates, complex composition, biological toxicity, and