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Microalgal and activated sludge processing for biodegradation of textile dyes☆

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ABSTRACT

The textile industry contributes substantially to water pollution. To investigate bioremediation of dye-containing wastewater, the decolorization and biotransformation of three textile azo dyes, Red HE8B, Reactive Green 27, and Acid Blue 29, were considered using an integrated remediation approach involving the microalga *Chlamydomonas mexicana* and activated sludge (ACS). At a 5 mg L^{-1} dye concentration, using *C. mexicana* and ACS alone, decolorization percentages of 39%–64% and 52%–54%, respectively, were obtained. In comparison, decolorization percentages of 75%–79% were obtained using a consortium of *C. mexicana* and ACS. The same trend was observed for the decolorization of dyes at higher concentrations, but the potential for decolorization was low. The toxic azo dyes adversely affect the growth of microalgae and at high concentration 50 mg L^{-1} the growth rate inhibited to 50–60% as compared to the control. The natural textile wastewater was also treated with the same pattern and got promising results of decolorization (90%). Moreover, the removal of BOD (82%), COD (72%), TN (64%), and TP (63%) was observed with the consortium. The HPLC and GC-MS confirm dye biotransformation, revealing the emergence of new peaks and the generation of multiple metabolites with more superficial structures, such as *N*-hydroxy-aniline, naphthalene-1-ol, and sodium hydroxy naphthalene. This analysis demonstrates the potential of the *C. mexicana* and ACS consortium for efficient, eco-friendly bioremediation of textile azo dyes.

1. Introduction

The release of toxic waste, including heavy metals and dyes, into the environment is directly attributed to industrialization and technological advancement (Tripathi et al., 2023a). The textile industry is a major stakeholder in the contemporary era of human civilization. Fashion is a global industry that has been shown to bring in USD 2.5 trillion each year and employ 75 million people worldwide (Chen et al., 2021) and recent statistics have revealed that global textile industries economic market share of $610.91 billion, with an estimated projection of $755.38 billion by 2027 (Jiménez-Delgado et al., 2023; ŞAHİN & EYÜPOĞLU, 2024). Textile industry effluents are a primary source of severe water pollution because of their potentially harmful effects on ecological niches (Hameed & Ismail, 2018). The presence of dye in wastewater poses threats to the environment, affecting human and ecosystem health. With increased textile manufacturing, residents and other species face hazards from wastewater discharge (Tripathi et al., 2023b). These effluents contain toxic, carcinogenic, and mutagenic compounds. Furthermore, their color adversely affects the aesthetic essence of aquatic ecosystems and jeopardizes aquatic photosynthesis (Lazarova et al., 2023).

Remediation of textile effluents is mandatory before their disposal in aquatic environments. Widely used conventional methods for the treatment of such effluents are precipitation, adsorption, activated biosorbent (Kannaujiya et al., 2021), oxidation flocculation/coagulation, and bioremediation (Przystaś et al., 2018). Physicochemical methods

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