



Bioremediation of reactive blue 19 dye by laccase-producing *Serratia marcescens* AY4 strain

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ABSTRACT

Laccase-producing bacteria are bioinspired tools for the degradation of textile dyes. Five laccase-producing bacterial strains were isolated from industrial effluent, and a potential bacterial strain, AY4, was identified by 16S rRNA gene amplification as *Serratia marcescens* AY4 (OR625080). It decolorized 96 % (0.98 mg L⁻¹ h⁻¹) of RB-19 (100 mg L⁻¹) at 37 °C and 7.0 pH with 1 mM guaiacol and 2 mM CuSO₄. Machine learning modeling (predictive models: decision trees, random forest, XGBoost, K-nearest neighbors and support vector) showed that the incubation period played a more decisive role in decolorization than the dye concentration, and the removal rate (96.4 %) was statistically significant ($p < 0.05$) after 96 h of incubation. XGBoost outperformed on the training dataset (R^2 of 1.00 and an RMSE of 0.0) and showed comparable results on the test dataset. It was selected for its consistent and robust performance. UV-vis and FTIR analysis confirmed the decolorization and three metabolites were identified by GC-MS analysis as phenol-4,4-(1-methyl ethylidene)bis- (retention time RT, 24.110; m/z , 228.291), bis(2-ethylhexyl) phthalate (RT, 29.59; m/z , 390.564), and 2,4-Di-tert-butylphenol (RT, 13.34 and m/z : 206.1) of Reactive Blue 19. The microbial toxicity study on *Serratia marcescens* and *E. coli* confirmed nontoxic effect of degraded RB-19 metabolites and indicates promising degradation potential of *S. marcescens* strain AY4 to successfully remediate RB-19 dye ecologically sustainably. This outcome promotes an eco-friendly and sustainable approach to eliminating the contaminants from textile wastewater.

1. Introduction

The textile industry has significantly influenced lifestyle changes, mainly through fashion brands adopting eco-friendly practices. A notable trend is the shift towards using natural fiber fabrics in garment production [1]. At the same time, the textile industries are consuming a tremendous amount of fresh water, i.e., 200 L of fresh water is consumed per kilogram of textile products leading to a substantial volume of wastewater containing 10–15 % dyes [2,3]. Synthetic dyes are famously used in different products, with the textile industry using more than 56 % of them [4]. The effluent produced from the dyeing processes

contains relatively high concentrations of various colored materials, raising concerns within the environment [5]. Their findings also show that the impacts of the unprocessed textile effluents discharged into the water bodies include change of acidity or alkalinity, exclusion of sunlight, increased biological oxygen demand, chemical oxygen demand, total organic carbon and solubility of gases respectively [5]. The discharge of unprocessed textile effluents into water bodies has negative consequences, such as changes in pH, inhibited sunlight penetration, and increased BOD, COD, TOC, and gas solubility [6,7]. Textile effluents have cytotoxic, genotoxic, and ecotoxic effects that harm plant, animal, and human health [8] and plant development, seed germination, and

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