

Optimization of Methylene Blue Dye Removal From Aqueous Solution Using Lemongrass Powder

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Structured Abstract

Background: Synthetic dyes are widely used in various industries due to their stability and vibrant colours; however, they pose significant environmental risks when discharged into water bodies. Among them, methylene blue (MB), a cationic dye, is commonly found in textile effluents. In search of eco-friendly and cost-effective adsorbents, this study investigates the potential of *Cymbopogon citratus* (lemongrass) leaf powder as a sustainable biosorbent for MB dye removal from aqueous solutions.

Methods: The lemongrass leaves were washed, oven-dried at 80 °C for 24 hours, ground into powder, and sieved. The adsorbent was characterised using Scanning Electron Microscopy (SEM) to observe surface morphology and Fourier Transform Infrared Spectroscopy (FTIR) to identify functional groups. Batch adsorption experiments were conducted by varying pH (3–11), adsorbent dosage (0.2–1.0 g), contact time (20–60 min), and initial dye concentration (20–100 ppm). The concentration of methylene blue was measured using UV-Visible spectrophotometry at $\lambda_{\text{max}} = 662 \text{ nm}$.

Results: Optimal dye removal (99.84%) was observed at pH 11, suggesting that alkaline conditions favour electrostatic attraction. The best performance was also achieved using 0.2 g of adsorbent dosage and 50 minutes contact time (99.92%), 80 ppm initial dye concentration, resulting in 99.97% removal. FTIR analysis confirmed that functional groups like O–H, C–H, C=C, and C–O were involved in adsorption, possibly through hydrogen bonding and electrostatic interactions. SEM images revealed morphological changes post-adsorption. Isotherm analysis showed better fit with the Freundlich model ($R^2 = 0.9944$), indicating multilayer adsorption on a heterogeneous surface ($n = 1.144$; $K_F = 6.921$), while the Langmuir model also fitted reasonably well ($R^2 = 0.9671$), with a maximum adsorption capacity of 19.91 mg/g.

Conclusion: In conclusion, the findings suggest that lemongrass leaf powder is a highly effective, low-cost, and sustainable biosorbent for removing methylene blue dye from water, highlighting its potential in green wastewater treatment applications.

Keywords: Methylene blue, lemongrass, adsorption, freundlich isotherm, biosorbent

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