

**Biodegradation-Based Strategies for Textile Effluent
Treatment: Statistical Modeling, Hybrid Treatment Approach,
and Techno-Economic Assessment**



**Thesis Submitted in partial fulfillment
For the Award of Degree**

DOCTOR OF PHILOSOPHY

by

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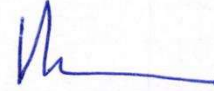
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I dedicated this Ph.D. thesis to the 140 crore Indians who paid for this study; I am deeply grateful to them, as well as to nature for always providing a positive environment for me.

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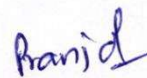
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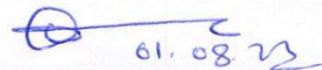


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ABBREVIATIONS

| Abbreviation | Nomenclature |
|----------------|--|
| BG | Brilliant Green |
| CR | Congo Red |
| BOD | Biochemical Oxygen Demand (mg/L) |
| DO | Dissolved oxygen (mg/L) |
| PBBR | Packed bed bioreactor |
| LDPE | Low-density polyethylene |
| PUF | Poly urethane foam |
| RMSE | Root mean square error |
| SEP | Standard error of prediction |
| MAE | Mean absolute error |
| HRT | Hydraulic retention time (h) |
| RE | Removal efficiency (%) |
| EC | Elimination capacity (mg/L.d) |
| ILR | Inlet loading rate (mg/L.d) |
| MSM | Minimal salt medium |
| ANN | Artificial Neural Network |
| RSM | Response surface methodology |
| COD | Chemical oxygen demand (mg/L) |
| BBD | Box-Behnken design |
| μ_{max} | Maximum specific growth rate (day^{-1}) |
| K_s | Half-saturation constant (mg/L) |
| K_i | Substrate inhibition constant |
| C_i, B_{in} | Initial substrate concentration (mg/L) |
| C_f, B_{out} | Final substrate concentration (mg/L) |
| X | Biomass concentration (mg/L) |
| V | Volume of the bioreactor (L) |
| Q | Feed flow rate (mL/h) |

PREFACE

Textile and dyeing industries are considered the most polluting industries based on both the amount and the toxic content of effluents. Dye-contaminated effluents discharged from industries are considered one of the major concerns among environmentalists. The carcinogenic, mutagenic, and teratogenic properties of the pollutants make researchers to explore cost-effective and eco-friendly technology for the degradation of such pollutants. In this direction, the biodegradation process is preferred as an effective tool for the mineralization of xenobiotic compounds.

The adopted microorganisms which have a history of exposure to the contaminated site exhibit higher biodegradation rates than other microorganisms. However, several studies have shown the existence of non-biodegradable or low-biodegradable compounds in textile effluent. The existence of these non-biodegradable compounds causes a lower biodegradability index ($BOD_5 : COD < 0.2$) and makes biological treatment ineffective for the majority of industrial wastewater, including textile industry. The objective of this study is to develop cost-effective hybrid treatment technology for textile wastewater treatment, which involves integration of biological and advanced oxidation process. In addition, this study employed the low-density polyethylene and polyurethane foam, a packaging waste, in bioreactors for the purpose of bacterial immobilization. Process optimization and kinetic studies were also performed.

The present thesis is categorized into **7 chapters**. **Chapter 1** embeds a general introduction (sources and toxic effect) of azo dye and its derivatives, treatment methods, various factors affecting the biodegradation process, and application of ozonation for textile effluent treatment. **Chapter 2** contains a detailed analysis of the literature review, research gaps, and objective of my research work. **Chapter 3** contains common materials and method used in biodegradation

and hybrid treatment processes. In **Chapter 4**, Biodegradation study was performed for the degradation of Brilliant green dye in a packed bed biofilm reactor: Statistical modelling, kinetic evaluation, and toxicity assessment. **Chapter 5** focuses on mass transfer assessment for the biodegradation of brilliant green dye in PBBR using LDPE as bio carrier. In **Chapter 6** an attempt has been made for the development of a hybrid treatment technique for the complete mineralization of textile wastewater. The summary and scope of future work is described in **Chapter 7**.