

# Integrated Biotechnological Strategies for Sustainable Dye Remediation: Exploring Synergistic Approaches and Enhanced Bioreactor Performance



Thesis submitted in partial fulfillment for the  
Award of Degree

**Doctor of Philosophy**

By

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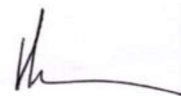
## **Dedication**

*In profound gratitude and with heartfelt appreciation, this thesis is dedicated to my loving family whose support and encouragement have been the guiding light of my academic journey. Their belief in me has been the source of strength and inspiration, and I cherish the love and blessings that have led me to this milestone.*

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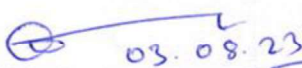
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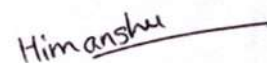
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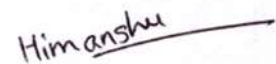
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## List of Abbreviations and Symbols

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Abbreviation	Nomenclature
$^1\text{H}$ NMR	Proton Nuclear Magnetic Resonance
AB 113	Acid Blue 113
BG	Brilliant Green
BOD/COD	Biodegradability Index
ECs	Emerging Contaminants
FBBR	Fluidized Bed Bioreactor
FBR	Fixed Bed Bioreactor
GO	Graphene Oxide
HRT	Hydraulic retention time
ICPB	Intimate Coupling of Photocatalysis and Biodegradation
ISLR	Inlet shock loading rates
ISPB	Independent Sequence of Photocatalysis and Biodegradation
KG-GO-CA	<i>Klebsiella grimontii</i> entrapped Graphene Oxide-Calcium Alginate Hydrogel Beads
LDPE	Low-Density Polyethylene
OLR	Organic Loading Rates
OUR	Oxygen Uptake Rate
PBBR	Packed Bed Bioreactor
PC-FBR	Photocatalytic reactor followed by a fixed bed bioreactor
PdI	Polydispersity index
PO	Photocatalytically Oxidized
PP-PUF	Polypropylene-Polyurethane foam
PUF	Polypropylene foam
RE	Removal Efficiency
rGO	Reduced Graphene Oxide
ROS	Reactive Oxidative Species
RPBBR	Recirculating Packed Bed Bioreactor

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<b>Symbol</b>	<b>Nomenclature</b>
$\mu$	Specific growth rate (per day)
$\mu_{max}$	Maximum specific growth rate of microorganism (per day)
$k_{approx}$	The approximate reaction rate constant ( $\text{min}^{-1}$ )
$k_c$	Langmuir reaction rate constant ( $\text{min}^{-1}$ )
$K_{Th}$	Rate constant of the Thomas model ( $\text{mL}/\text{min}.\text{mg}$ )
$K_C$	Adsorption equilibrium constant for dye ( $\text{L}/\text{mg}$ )
$K_I$	Adsorption equilibrium constant for the intermediate compound I
$K_i$	Substrate inhibition constant ( $\text{mg}/\text{L}$ )
$K_s$	Half-saturation rate constant ( $\text{mg}/\text{L}$ )
$Q$	Volumetric flow rate ( $\text{mL}/\text{h}$ )
$R_p$	Rate of reaction
$V$	Bioreactor Volume (L)