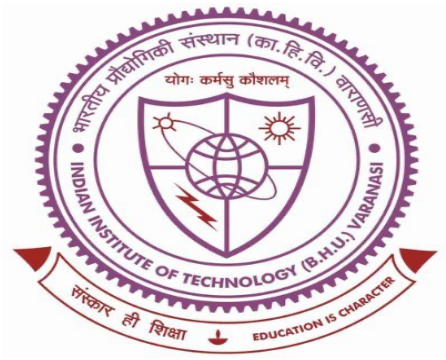
"Process Design, Optimization, and Evaluation of Microalgal Bioremediation and Value Addition"



Thesis submitted in partial fulfilment for the

Award of Degree

Doctor of Philosophy

By

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Certificate

It is certified that the work contained in the thesis titled **"Process Design, Optimization, and Evaluation of Microalgal Bioremediation and Value Addition"** by **Virendra Singh** has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

It is further certified that the student has fulfilled all the requirements of Comprehensive Examination, Candidacy, RPEC and SOTA for the award of Ph.D. Degree.

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Declaration by the Candidate

I, **Virendra Singh**, certify that the work embodied in this thesis is my own bona fide work a carried out by me under the supervision of **Prof. Pradeep Srivastava** and **Prof. Abha Mishra** from July, 2019 to Sep, 2023, at the School of Biochemical Engineering, Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not wilfully copied any other's work, paragraphs, text, data, results, *etc.*, reported in journals, books, magazines, reports dissertations, theses, *etc.*, or available at websites and have not included them in this thesis and have not cited as my own work.

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Al last, to the almighty God

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Abbreviations

ABS	Algal-bacterial symbiosis
ADP	Adenosine diphosphate
AIC	Akaike information criterion
AICc	Corrected Akaike's information criterion
AL	Artificial lights
AM	Amplitude modulation
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
ATP	Adenosine triphosphate
BBD	Box-Behnken Design
BBM	Bold Basal Media
BIC	Bayesian information criterion
BOD	Biological oxygen demand
BP	Biomass production
CC	Co-cultivation
CCD	Central Composite Design
Cd^{2+}	Cadmium ion
CE	Carpet effluent

CDTe	Cadmium telluride
Chl a	Chlorophyll a
Chl b	Chlorophyll b
Co	Cobalt
CO_2	Carbon Dioxide
COD	Chemical oxygen demand
Conc.	Concentration
CP	*Chlorella pyrenoidosa*
CPCB	Central Pollution Control Board
$Cr_2O_7^{2-}$	Chronate ion
Cr^{3+}& Cr^{6+}	Chromium ions
CSA	Crow search algorithm
Cu	Copper
Cu^{2+}	Copper ion
D	Dilution Factor
DNA	Deoxy ribonucleic Acid
DE	Domestic Effluent
DFC	Dual flocculation-coagulation
Dip	*Diplosphaera Mucosa VSPA*
DM	*D. mucosa* VSPA
DW	Dry Weight
DWE	Domestic waste effluent
EPS	Extracellular Polymeric substances
Exp.	Experimental Concentration
FBN	Feed-forward back-propagation neural network

FSC	Forward-scattered light
Fd	Ferredoxin
Fe^{3+}	Ferrous ion
FL	Fluorescent tubes
GA	Genetic algorithm
GP	Gompertz Model
H_2O	Water molecule
$H_2PO_4^-$	Dihydrogen phosphate
HCO_3^-	Bicarbonate
Hg^{2+}	Mercury ion
HMs	Heavy metal
HPO_4^-	Hydrogen phosphate
HRT	Hydraulic retention time
IIL	Initial inoculum level
INC	Initial nitrogen concentration
IPC	Initial phosphorus concentration
LED	Light emitting diodes
LHC	Light-harvesting complex
LI	Light intensity
Low-e	Low emissivity
MBWT	Microalgae based wastewater treatment
MFC	Microbial fuel cell
$MSCO_2$	Microalgae-based CO_2 sequestration
MSE	mean square error
N	Nitrogen

NCIM	National Collection of Industrial Microorganisms
NCL	National Chemical Laboratory
NiR	Nitrite Reductase
NN	Neural Network
NR	Nitrate Reductase
NRE	Nitrogen Removal Efficiency
N/P ratio	Nitrogen/Phosphorus ratio
NADP	Nicotinamide adenine dinucleotide phosphate
NER	Net energy ratio
NH_4-N^+	Ammonium nitrogen
Ni^{2+}	Nickel ion
NO_3^--N	Nitrate nitrogen
NRE	Nitrogen removal efficiency
O_2	Oxygen
OD	Optical Density
P	Phosphorus
PAR	Photosynthetically active radiation
PRE	Phosphorus removal efficiency
Pb^{2+}	Lead ion
PBR	Photobioreactor
PhBT	Photobiotreatment Model
POME	Palm Oil Mill Effluent
PO_4^{3-}-P	Phosphate phosphorus
PPB	Purple phototrophic bacteria
PPFD	Photosynthetic photon flux density

PRE	Phosphorus removal efficiency
PRW	Petroleum Refinery Waste effluent
PWW	Piggery wastewater
PS	Photosystem
R^2	Coefficient of regression
RE	Removal efficiency
RNA	Ribonucleic Acid
rpm	Rotation per minute
RMSE	Root mean square error
RSM	Response Surface Methodology
RuBisco	Ribulose-1,5-bisphosphate carboxylase/oxygenase
SBBR	Sequencing batch biofilm reactor
Sce	*Scendesmus obliquus*
Si	Silicon
SMPBR	Submerged membrane photobioreactor
SSR	Side-scattered light
STP	Sewage Treatment Plant
SVR	Surface to Volume ratio
SVR	Support vector regression
Temp.	Temperature
TE	Textile effluent
Th	Theoretical concentration
TKN	Total kjedahl nitrogen
TN	Total nitrogen
TOC	Total organic carbon

TP	Total phosphorus
TxE	Toxic effluents
WW	Wastewater
$Y_{x/ph}$	Biomass yield on light
Zn^{2+}	Zinc ion