Declaration

I hereby declare that the work presented in this Thesis titled *Remediation of saline wastewater for organic pollutants using halophilic bacteria and Dunaliella salina,* submitted to the Indian Institute of Technology Jodhpur in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy, is a bonafide record of the research work carried out under the supervision of *Professor Meenu Chhabra*. The contents of this thesis in full or in parts, have not been submitted to, and will not be submitted by me to, any other Institute or University in India or abroad for the award of any degree or diploma.



Akanksha Mishra
P19BB003

Certificate

This is to certify that the thesis titled *Remediation of saline wastewater for organic pollutants using halophilic bacteria and Dunaliella salina*, submitted by *Akanksha Mishra* (P19BB003) to the Indian Institute of Technology Jodhpur for the award of the degree of *Doctor of Philosophy*, is a bonafide record of the research work done by him under my supervision. To the best of my knowledge, the contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.



Meenu Chhabra
Ph.D. Thesis Supervisor

Abstract

Industries such as leather, textile, food processing, and petroleum contribute to the rising salinity of freshwater supplies, producing significant quantities of saline wastewater. Conventional water treatment plants face difficulties in treating these effluents for organics removal because the high salinity causes membrane fouling and inhibits the growth of microorganisms. In order to tackle this problem, it is necessary to utilize a specific category of organisms capable of tolerating or thriving in high salt concentrations, known as halotolerant organisms, as biocatalysts. Physicochemical methods can remove salt, but the repeated buildup of organic compounds leads to increased energy consumption and decreased quality of the recovered salts. The Microbial Fuel Cell (MFC) is a suitable method for effectively utilizing saline wastewater. The study describes the cultivation of *Dunaliella salina* at the saline cathode in a photosynthetic microbial fuel cell (PMFC). The alga was isolated from Salt Lake Sambhar, Rajasthan, India, and identified using 18S rDNA sequencing analysis. The alga growth in PMFC was tested at 0.5 M to 1.5 M sodium chloride. The highest power and current density were obtained at 0.5 M NaCl with 213.38 mW/m^2 and 1020.5 mA/m^2, respectively. The specific growth rate of algae was 0.4 day^{-1} with 566 mg/l lipids and 348.9 ± 25.6 µg/ml of glycerol content at 0.5 M PMFC. The PMFC operating at 1.0 M NaCl led to high β-carotene production (24.42 ± 1.8 µg/100 mg). The salinity in natural water resources makes it challenging to apply them in bioprocesses. This study establishes the utility of *D. salina* in saline water-based PMFC for generating power and high-value *Dunaliella* biomass. A scaleup PMFC system with a 15-litre cathode and 2-litre anode was developed for the second study, utilizing *Dunaliella* lipid-extracted algae (LEA) biomass as an electron donor substrate at the anode. The operating system with LEA biomass generates a power density of 621.43 ± 129.47 mW/m^2 and a net 0.496 kWh/m^3 energy at 0.5 M salinity under outdoor conditions, reducing reliance on external substrates. Therefore, low-cost PMFCs can potentially treat saline wastewater with concomitant energy and high-value product generation.

Acknowledgements

I begin with deep gratitude to *Baba Vishwanath* for his countless blessings that helped me pursue my dreams. The journey of a Ph.D. is filled with highs and lows. I am immensely thankful to those who have supported me professionally and personally, making this experience as smooth as possible. I want to honor the memory of my late father, *Mr. Dewesh Chandra Mishra* who was a pillar of strength and vital support during my Ph.D. and helped me collect my project algae. His presence was deeply missed, but he was greatly adored.

First and foremost, I owe my heartfelt thanks to my supervisor, *Prof. Meenu Chhabra*. Her unwavering support and guidance were instrumental in shaping my research aptitude and writing skills. I am deeply grateful for her dedication and encouragement and for steering me toward pursuing high-quality research. Her remarkable creativity, interdisciplinary knowledge, and insightful feedback were a constant source of inspiration. I extend my sincere appreciation to my doctoral committee members, *Prof. Samanwita Pal*, *Dr. Shankar Manoharan*, and *Prof. Amit Mishra*. Their valuable comments and scientific suggestions significantly enhanced my thesis work. A special thank you goes to *Bharat Sir* and *Swati Ma'am* from the Department of Bioscience and Bioengineering for their assistance throughout my Ph.D. journey.

I am also profoundly grateful to my friends *Anchal, Aastha, Harshita, Jyoti, Ardhendu, Somank*, *Khushi,* and *Nupur* for their unwavering motivation, happiness, and cherished memories during my time at IIT Jodhpur. My profound appreciation goes to my husband, *Trishant*, for his boundless love, support, and companionship. His encouragement and assistance have been invaluable, and I am particularly grateful for his true support through every challenge. I thank my senior, *Dr. Amitap Khandelwal*, for his continuous help throughout my Ph.D. journey. Additionally, I am grateful to my lab mates *Arti, Jyoti, Chetna, Vishakha, Ritesh*, and *Nikhil* for their assistance and support. Special thanks to *Ashwin*, *Nupur,* and *Khushi* for fostering a positive and peaceful lab environment and aiding me with my work.

My heartfelt gratitude goes to my mother, *Mrs. Asha Mishra*, and my late father, *Mr. Dewesh Chandra Mishra*, for their firm support, love, and guidance through every decision in my life. I am also thankful to my siblings, *Deeksha* and *Adesh*, for their enduring care, love, and support. I appreciate my in-laws, *Mr. Jagdish Kumar Pandey* and *Mrs. Shanti Pandey*, for their constant support and for being like parents to me. A special thanks to my sister-in-law, *Dr. Shubhra Pandey*, for her unwavering support and care, which has felt like that of an elder sister. Finally, I want to express my gratitude once again to my husband, *Mr. Trishant Pandey*, for his love, care, and support, which have been a source of relief and strength throughout this journey. I apologize if I inadvertently missed any names in this section.

Akanksha Mishra
Ph.D. Student

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List of Symbols

Symbol	*Description*
A	Ampere
C	Celsius
E	Cell Potential
F	Faraday Constant
I	Current
M	Molar
P	Power
R	Gas Constant
T	Temperature
V	Volt
W	Watt
cm	Centimeter
d	Day
g	Gram
h	Hour
l	Liter
m	Milli
m^2	Square meter
m^3	Cubic meter
pH	Hydrogen Ion Concentration
β	Beta
μ	Micro
Ω	Ohm
ω	Omega
°	Degree
%	Percentage

List of Abbreviations

Abbreviation	*Full form*
BLAST	Basic Local Alignment Search Tool
CD	Current Density
CE	Coulombic Efficiency
COD	Chemical Oxygen Demand
CV	Cyclic Voltammetry
DI	Deionized Water
DO	Dissolved Oxygen
EC	Electrical Conductivity
EGB	Electrogenic Bacteria
FAO	Food and Agriculture Organization
FTIR	Fourier Transform Infrared Spectroscopy
GHGs	Green House Gases
HPLC	High-Performance Liquid Chromatography
IR	Internal Resistance
LCA	Life Cycle Assessment
LEA	Lipid Extracted Algae
MFC	Microbial Fuel Cell
MJM	Modified Jhonson's Media
MP	Mobile Phase
NaCl	Sodium Chloride
OCV	Open Circuit Voltage
ORR	Oxygen Reduction Reaction
OTU	Operational Taxonomic Unit
PD	Power Density
PEM	Proton Exchange Membrane
PMFC	Photomicrobial Fuel Cell
SEM	Scanning Electron Microscopy
TDS	Total Dissolved Solids