Anusandhan National Research Foundation

Government of India
Ministry of Science & Technology
Department of Biotechnology

Ministry of Science and Technology
Department of Scientific and Industrial Research

AAR-2026

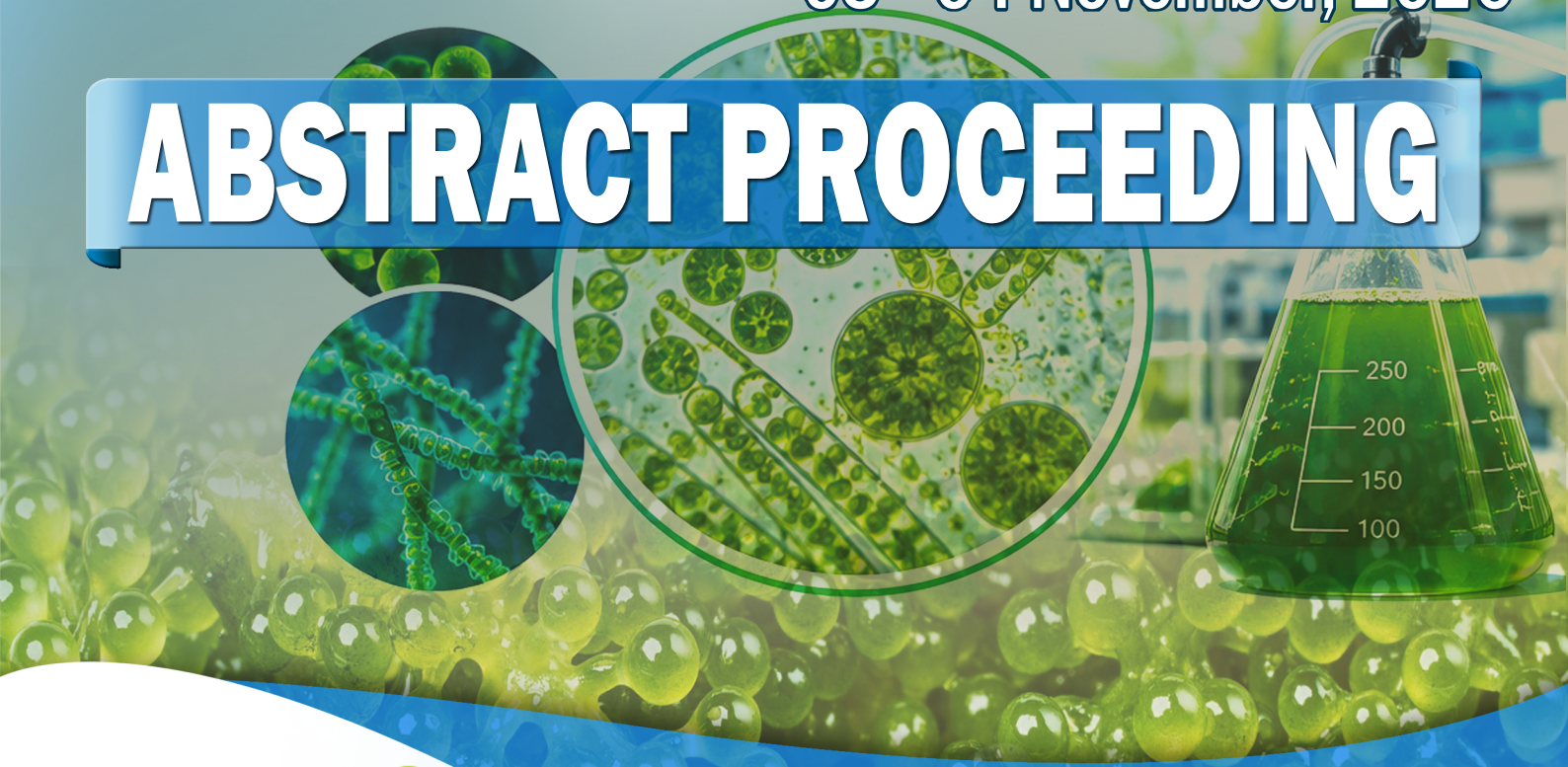
Advances in Algal Research

4th Annual Symposium on

Advances in Algal Research (AAR-2026)

03 - 04 November, 2026

ABSTRACT PROCEEDING



WESTERN COALFIELDS LIMITED

GREEN SPECTRUM TECHNOLOGY Pvt. Ltd.

Venue: CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur

About The Host Institute

CSIR-National Environmental Engineering Research Institute (**CSIR-NEERI**), Nagpur, is a premier research institute under the Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Government of India. Established in 1958, the Institute initially focused on challenges related to water supply, sewage disposal, communicable diseases and industrial pollution. Over the years, CSIR-NEERI has evolved into a leading institution in environmental science and engineering, addressing emerging environmental challenges through research, technology development and consultancy. The Institute also has five regional centers located in Chennai, Delhi, Hyderabad, Kolkata and Mumbai.

CSIR-NEERI works on a wide range of environmental issues, including environmental monitoring, pollution control and mitigation, waste management, climate change, environmental impact assessment, ecosystem services and sustainable resource management. The Institute contributes to several national priorities and programs, including Swachh Bharat Mission, clean air initiatives, river rejuvenation, sustainable waste management, carbon sequestration and the vision of Viksit Bharat. The Institute places a strong emphasis on sustainability, decarbonization, resource efficiency, the circular economy, and nature-based solutions.

Through interdisciplinary research and collaboration with government agencies, industries, academic institutions and international organisations, CSIR-NEERI develops science- and technology-based solutions that address environmental challenges while supporting economic and social development. CSIR-NEERI also contributes to rural and community development through solutions in areas such as safe drinking water, water purification, waste management and clean technologies.

The Institute actively promotes knowledge sharing and capacity building through training programs, workshops, and other outreach initiatives for professionals, students, policymakers, and industry stakeholders. With a multidisciplinary team of scientists, engineers, technical experts and supporting professionals, CSIR-NEERI continues to strengthen its role in advancing environmental science, technology and policy. Through research, innovation, and partnerships, the Institute remains committed to creating practical solutions for a cleaner, healthier, more sustainable, and more resilient future.

MESSAGE FROM THE DIRECTOR



It is a privilege to host the **4th Annual Symposium on Advances in Algal Research (AAR 2026),** bringing together researchers, academicians, industry professionals, policymakers and young scientists from across India and around the world. Algal research has evolved rapidly in recent decades and is now emerging as an important pillar of global sustainability, climate resilience, circular bioeconomy and bio-innovation. I extend my warm greetings and best wishes to all participants, and I welcome you to this important scientific gathering.

This symposium is being held at a time when the world is seeking innovative and sustainable solutions to some of its most pressing challenges, including climate change, resource scarcity, environmental pollution, energy security and the transition towards a low-carbon economy. In this context, microalgae and macroalgae offer remarkable opportunities. Their ability to capture carbon, recover resources, treat wastewater, produce biofuels and biochemicals, generate high-value bioproducts, and support circular and regenerative bioeconomy models makes algal systems highly relevant to the sustainability agenda.

The future of algal research, however, extends well beyond cultivation and biomass enhancement. The next generation of advances will depend on a deeper understanding of algal physiology and metabolism, improved strain development, precision cultivation, process intensification, biorefinery approaches and efficient downstream processing. The integration of artificial intelligence, machine learning, advanced analytics, synthetic biology and digital technologies can further accelerate discovery, optimisation and scale-up. Equally important is the development of techno-economically viable and environmentally sustainable pathways that can translate laboratory innovations into solutions with real-world impact. Collaboration across institutions and countries will be equally important for sharing knowledge, infrastructure, resources, and best practices while addressing region-specific environmental and societal needs.

India, with its rich biodiversity, diverse climatic conditions, extensive coastal resources, growing biotechnology capabilities and strong scientific institutions, is well positioned to make significant contributions to the global algal research landscape. The work being undertaken across the CSIR system and other academic and research institutions is opening new avenues in algal biotechnology, environmental remediation, carbon management, resource recovery and sustainable bioprocessing. CSIR-NEERI, with its expertise in environmental science and engineering, is committed to advancing research that connects biological innovation with environmental sustainability and societal needs.

AAR 2026 provides an excellent platform for exchanging scientific knowledge, presenting emerging technologies, identifying new research directions, and fostering meaningful collaborations. I am confident that the deliberations during the symposium will generate new ideas and perspectives, strengthen national and international partnerships, and help accelerate the translation of algal research into sustainable technologies and applications. I am confident that AAR 2026 will be a stimulating and productive scientific forum that will advance the frontiers of algal research and its applications. I wish the symposium every success and hope that it leads to new insights, meaningful collaborations and new commitments towards a greener, healthier, circular and more resilient future. My best wishes to all participants, speakers, organisers and young researchers for a successful andmemorable AAR 2026.

(S. Venkata Mohan)
Director, CSIR-NEERI, Nagpur

MESSAGE FROM THE CHAIR, AAR SYMPOSIUM SERIES



It gives me immense pleasure to welcome all distinguished delegates, eminent scientists, academicians, researchers, industry professionals, and young scholars to the **4th Annual Symposium on Advances in Algal Research (AAR 2026)**, being held on 3–4 November 2026 at CSIR–National Environmental Engineering Research Institute (NEERI), Nagpur, India.

Since its inception in 2023 at IIT Guwahati, the AAR Symposium Series has evolved into an important platform for bringing together the global algal research community to exchange knowledge, foster collaborations, and explore emerging opportunities in algal science and technology. The successful continuation of this series reflects our collective commitment to advancing algae-based research and translating scientific innovations into meaningful societal and industrial applications.

The theme of AAR 2026, ***"Redefining Phycofactories: Algal Innovation for Sustainable Development,"*** is both timely and relevant in the context of global sustainability challenges. Algae offer immense potential in addressing critical issues related to food and nutritional security, renewable energy, climate change mitigation, carbon capture, wastewater treatment, high-value bioproducts, and the transition towards a circular bioeconomy. Harnessing this potential requires interdisciplinary research, technological innovation, industry engagement, and strong collaborations between academia, research institutions, and policymakers. I am particularly delighted that AAR 2026 is bringing together an enthusiastic and diverse community of researchers, experts, entrepreneurs, and students. I am confident that the scientific deliberations, keynote lectures, technical sessions, poster presentations, and interactive discussions will stimulate new ideas, strengthen existing partnerships, and open avenues for future collaborations.

I sincerely acknowledge the support and cooperation of CSIR-NEERI, Nagpur, IIT Guwahati, our sponsors, funding agencies, industry partners, invited speakers, scientific committee members, and all those who have contributed to making this symposium possible. My special appreciation goes to the organizing team for their dedication and tireless efforts.

As we continue this journey through the AAR Symposium Series, let us work collectively towards transforming the immense potential of algae into sustainable solutions for the benefit of society and the environment. I wish all participants a stimulating, productive, and memorable experience at AAR 2026. I look forward to meaningful scientific interactions and the beginning of many fruitful collaborations.

With best wishes,

Prof. Kaustubha Mohanty
Chair, AAR Symposium Series

ORGANIZING COMMITTEE

MESSAGE FROM THE CONVENER



I welcome you all to the **4th Annual Symposium on Advances in Algal Research (AAR 2026)** in our beautiful CSIR-NEERI Campus! It gives us immense pleasure to extend a warm greeting to all esteemed participants joining us for this collaborative endeavor.

Algae today represent one of the most versatile biological resources available to humanity. Their extraordinary diversity, rapid growth rates, and biochemical richness position them at the forefront of solutions for some of our most pressing challenges-clean energy, carbon sequestration, wastewater treatment, nutraceutical development, and sustainable materials. As nations collectively work toward low carbon development pathways, algal technologies offer a unique convergence of environmental and economic opportunities.

This Symposium serves as a dynamic platform where experts, scholars, and enthusiasts can explore the complex interplay between algal growth, harvesting and values addition in the context of environmental conservation and sustainability. Throughout our time together, we will aim to discuss, exchange insights and foster a multidisciplinary dialogue. The partnerships and collaborative research are pivotal in this domain. We anticipate engaging discussions, illuminating presentations, and the forging of new connections.

I extend my deepest gratitude to all participants including delegates, invited speakers and students for their presence at Nagpur. Let us embark on this journey of exploration, discovery and active collaboration, shaping the future of environmental and sustainable future.

(Amit Bafana)
Convener, AAR 2026
CSIR-NEERI, Nagpur



Dr. (Mrs.) N. Kalaiselvi
PATRON
Director General, CSIR & Secretary DSIR



Dr. S. Venkata Mohan
CHAIR
Director, CSIR-NEERI, Nagpur



Dr. Kaustubha Mohanty
CHAIR, AAR SYMPOSIUM SERIES
Professor, IIT-Guwahati, Guwahati



Dr. K. Krishnamurthi
CO-CHAIR
Scientist-G & Head EHT,, CSIR-NEERI, Nagpur



Dr. Amit Bafana
CONVENER
Scientist-F, CSIR-NEERI, Nagpur



Dr. Pravin K. Naoghare
CONVENER
Principal Scientist, EHTD, CSIR-NEERI



Dr. Satya Sundar Mohanty
CO-CONVENER
Assistant Professor, Karunya Institute of Technology & Sciences (KITS), Coimbatore

SUB-COMMITTEES

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OUTREACH	MEDICAL
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LIST OF VOLUNTEERS

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Ms. Ankita Bagde

Ms. Sangita Yelane

Mr. Subramani Shanmugavel

Mr. Thirumalan K S

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Mr. Diwakar Maurya

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Ms. Namita Mane

Ms. Pratibha Ghasoliya

Ms. Dhanshri Badwaik

Ms. Khushi Chandra

Mr. Abhishek Yadav

Mr. Ronald Jaffrey B

PROGRAMME SCHEDULE

Venue: CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur

DAY 1: 3rd November 2026		
08:00-09:00	**Registration& Breakfast** **Registration Venue: Foyer, Main Building** **Breakfast Venue: Guest House, CSIR-NEERI**	
09:00 – 09:45	**Inaugural Session& AAR 2026 Awards Presentations** **Venue: Auditorium**	
09:45 – 11:30	**IL Session I** **Venue: Auditorium** Chairs: Anushree Malik &N.S. Sampath Kumar	
09:45 – 10:05	Mid-Career Award	**Krishna Mohan Poluri**, IITRoorkee *Molecular Signatures of Microalgal Adaptation to PVC Nanoplastic Exposure*
10.05 – 10.23	IL001	**R. Vinu,**IIT Madras *Macroalgae Seaweed to Platform Chemicals via Thermochemical and Catalytic Pathways*
10:23– 10:41	IL002	**Balendra Singh**, DBT *Advancing Low-carbon Transitions through Integrated Biorefinery Innovations*
10:41 – 10:59	IL003	**Gunjan Prakash**, Institute of Chemical Technology, Mumbai *Algal based cultivation for economic value and environment friendlypractices*
10:59 – 11:17	IL004	**Nilotpala Pradhan**, CSIR-IMMT, Bhubaneswar *Algae-Nanomaterial biohybrid system for enhanced yield of biomass and valuable metabolites*
11:17 – 11:30	Q&A Session	
11:30– 12:00	**Tea Break & Networking** **Venue: Guest House, CSIR-NEERI**	
12:00 – 13:30	**IL Session II (Parallel Session)** **Venue: Auditorium** Chairs: Anjani Devi Chintagunta & Nirmal Renuka	
12:00 – 12:18	IL005	**Sabeela Beevi Ummalyma**, RCSS, Kochi *Bioremediation Potential of Micractinium sp. for Bisphenol A Removal in Brackish Water: A Sustainable Strategy for Emerging Contaminant Management*
12:18 – 12:36	IL006	**Venkata Subhash**, Reliance Industries Limited, R&T, Navi Mumbai *Algae Biorefinery: A Sustainable Platform for Value Addition*
12:36 – 12:54	IL007	**Rajasri Yadavalli**, Chaitanya Bharathi Institute of Technology, Hyderabad *From Seaweed to Sustainable Bioplastics: Opportunities, Challenges, and Translational Pathways for Commercial Manufacturing*
12:54 – 13:12	IL008	**Dineshkumar Ramalingam**, CSIR-CSMCRI Bhavnagar *Marine Microalgae for Flue Gas CO_2 Sequestration: From Laboratory Optimization to Pilot-Scale Demonstration Optimization to Pilot-Scale Demonstration*
13:12 – 13:30	Q&A Session	
12:00 – 13:30	**IL Session III (Parallel Session)** **Venue: Committee Room-II** Chairs:Mona Sharma & Monika Prakash Rai	
12:00 – 12:18	IL009	**N. S. Sampath Kumar**, Vignan's Foundation for Science, Technology & Research *Microalgal Polysaccharide-Based Synbiotic Encapsulation of Shrimp-Associated Probiotics: A Novel Strategy for Disease Management in Whiteleg Shrimp (Litopenaeus vannamei)*
12:18 – 12:36	IL010	**Manupati Hemalatha**, KL University, Andhra Pradesh *Integrated Photosynthetic Biorefinery Platforms for Sustainable Biomass and Multi-Product Valorisation*
12:36 – 12:54	IL011	**Rajagopal Subramanyam**, University of Hyderabad *Deciphering Acclimation Strategies and Photosystem I Remodelling in Dunaliella salina under Hypersaline Conditions*
12:54 – 13:12	IL012	**Nirmal Renuka**, Central University of Punjab *Microalgal bioinoculants for sustainable agriculture: Effect on soil fertility, microbiome diversity and crop yield*
13:12 – 13:30	Q&A Session	
13:30 – 14:30	**Lunch & Networking** **Venue: Guest House, CSIR-NEERI**	
14:30– 15:20	**AAR 2026 Award Lectures** **Venue: Auditorium** Chair: R. Vinu	

14:30– 14:50	Early Career Award	**Sanjeev Mishra**, SSS-NIBE, Kapurthala *Biodegradable Algal Biofilms for Wastewater Remediation and Biomass Valorization*
14:50 – 15:10	Emerging Career Award	**Mohit Singh Rana**, SRM Institute of Technology, Kattankulathur, Chennai *Nanoparticle – Microalgae interaction for bioenergy application*
15:10 – 15:20	Q&A Session	
15:20 – 16:45	**IL Session IV (Parallel Session)** **Venue: Auditorium** Chairs:Gunjan Prakash & Sabeela Beevi Ummalyma	
15:20 –15:38	IL013	**Kalyan Gayen**, National Institute of Technology Agartala *Microalgae based pharmaceutical products: A case study on extracellular polysaccharide (EPS)*
15:38 –15:56	IL014	**Sangram K. Lenka**, Gujarat Biotechnology University *Engineering the Light-Driven Algal Cell: From Metabolic Reprogramming and Nanobiotechnology to Next-Generation Phycofactories*
15:56 – 16:14	IL015	**Mona Sharma**, Central University of Haryana *Exploration of North Indian Hot Springs for Revealing the Potential of Thermophilic Cyanobacteria for Industrial Applications*
16:14 – 16:32	IL016	**Rishiram Ramanan**, Central University of Kerala *Unveiling unconventional products, processes, and feedstock for advancing algal biorefineries*
16:32 – 16:45	Q&A Session	
15:20 – 16:45	**IL Session V (Parallel Session)** **Venue: Committee Room-II** Chairs: Dineshkumar Ramalingam & V. Veeragurunathan	
15:20 –15:38	IL017	**Monika Prakash Rai**, MNNIT Allahabad *Integration of Nanomaterials in Microalgae System for Carbon capture, Waste utilization and Sustainable Bioproducts*
15:38 –15:56	IL018	**Anjani Devi Chintagunta**, Vignan's Foundation for Science, Technology & Research *From Native Cyanobacterial Diversity to Functional Potential: Neowollea manoromensis VU24*
15:56 – 16:14	IL019	**Prangya Ranjan Rout,** Dr B R Ambedkar National Institute of Technology Jalandhar *Algal Biotechnology for Tackling PFAS Contamination: Current Advances and Future Opportunities in Remediation and Biomass Valorization*
16:14 – 16:32	IL020	**Shailendra Pratap Singh**, BHU, Varanasi *Uncovering the broad physiological impact of cyanobacterial glutaredoxins*
16:32 – 16:45	Q&A Session	
16:45 – 18:15	**POSTER SESSION with Tea & Networking** **Venue: Besides Auditorium**	
18:15 – 19:15	**Short Oral Presentations I (Parallel Session): *Wastewater Bioremediation and Resource Recovery*** **Venue: Committee Room-II** Chairs:Rajasri Yadavalli & Manupati Hemalatha	
18:15– 18:25	SOP 001	**Rupal Singh Tomar,** IPS Academy, Indore *Microalgal Bioremediation of Polycyclic Aromatic Hydrocarbons: Linking Pollutant Removal with Photosynthetic Responses*
18:25 – 18:35	SOP 002	**Amit Dobhal,** IITRoorkee *Sequential Aeration and Chitosan Pretreatment of Liquid Anaerobic Digestate for Enhanced Spirulina Cultivation*
18:35 – 18:45	SOP 003	**Dhanasekaran Subashri,** RCSS, Kochi *Algal-Based Biostimulants for Climate-Resilient Agriculture: Preliminary Evaluation of Wastewater-Grown Algal formulation for Seed Priming*
18:45 – 18:55	SOP 004	**Pratiksha Laxmikant Baingane,** IIT Delhi *Edible Agaricus bisporus Mycelia: A Novel Tool for Harvesting Chlorella pyrenoidosa and Generating Nutrient-Rich Composite Biomass*
18:55 – 19:05	SOP 005	**Gautam Venkatrayalu,** IITRoorkee *Molecular adaptations of microalgae to PVC-nanoplastics stress from a metabolomic and lipidomic perspective*
19:05 – 19:15	SOP 006	**Anuj Sharma**, MNIT, Allahabad *Deciphering Microalgal Responses to As (III), Cd (II) and Pb (II) Stress: Insights from Growth, Oxidative Stress and Surface Characterization*
18:15 – 19:05	**Short Oral Presentations II (Parallel Session): *Carbon Capture, Climate Mitigation and CO_2 Utilization*** Chairs:Rishiram Ramanan & Shailendra Pratap Singh	

	Venue: Auditorium	
18:15– 18:25	SOP 007	**Ananya Mukherjee,** Azim Premji University, Bhopal *Thylakoid localized bestrophin-like proteins are essential for the CO_2 concentrating mechanism of Chlamydomonas reinhardtii*
18:25 – 18:35	SOP 008	**Vedavarshini N,** IIT Tirupati *Multi-Criteria Decision Framework for Algal Strain Selection for Carbon Capture and Biofuel Production*
18:35 – 18:45	SOP 009	**Rohinish Grover,** IITRoorkee *An Integrated Microalgal Photobioreactor for Air-Quality Improvement, CO_2 Utilization and Biomass Generation*
18:45 – 18:55	SOP 010	**Bharmjeet Singh,** ICGEB, New Delhi *Flipping the Metabolic Switch: CO_2-Enriched Nitrogen Restriction Drives Dual-Phase Astaxanthin Accumulation in Chromochloris zofingiensis*
18:55 – 19:05	SOP 011	**Kanagathara K C,** SASTRA, Thanjavur *Carbon-Negative Biorefineries from Microalgae and Cyanobacteria: A CCUS Perspective*
19:30 – 20:00	**Cultural Program** **Venue: Auditorium**	
20:00 Onwards	**Dinner& Networking** **Venue: Guest House, CSIR-NEERI**	

Day-2 Program

DAY 2: 4th November 2026		
08:00 – 09:00	**Breakfast** **Venue: Guest House, CSIR-NEERI**	
09:00 – 10:30	**IL Session VI** **Venue: Auditorium** Chairs:Nilotpala Pradhan&Sourish Bhattacharya	
09:00 – 09:18	IL021	**Anushree Malik,** IIT Delhi *Amazing Interactions of Microalgae: The drivers & Practical Implications*
09:18 – 09:36	IL022	**Pannaga Pavan Jutur**, ICGEB New Delhi *Redefining Phycofactories: Algal Innovation for Sustainable Development through Omics-level Metabolic Rewiring*
09:36 – 09:54	IL023	**Sachitra Kumar Ratha,** CSIR-National Botanical Research Institute, Lucknow *Integrated Assessment of Photosynthetic Efficiency, Carbon Capture, Energy Potential and dewatering of biomass of Microalgae for Sustainable Biomass Production*
09:54 – 10:12	IL024	**Datta Madamwar**, Charotar University of Science & Technology *Characterization and Therapeutic Applications of Cyanobacterial Phycobiliproteins*
10:12 – 10:30	IL025	**V. Veeragurunathan**, CSIR-CSMCRI *Seaweed Resources, Cultivation and Utilization in India*
10:30 – 10:45	Q&A Session	
10:45 – 11:30	**Poster Session with Tea Break & Networking** **Venue: Besides Auditorium**	
11:30 – 12:40	**IL Session VII (Parallel Session)** **Venue: Auditorium** Chairs:Pannaga Pavan Jutur & Sachitra Kumar Ratha	
11:30 – 11:48	IL026	**Paramasivan Balasubramanian,** NIT-Rourkela *Current trends of AI/ML in Algal Biotechnology*
11:48 – 12:06	IL027	**Amritpreet Kaur Minhas**, The Energy and Resources Institute, New Delhi *Fungal Cell-Free Extract-Mediated Biotransformation of Cyanobacterial Biomass for Enhanced Bioavailability of Nutrients*
12:06 – 12:24	IL028	**Amit K. Bajhaiya**, Central University of Tamil Nadu *Deciphering Salt-Stress Adaptation in Microalgae: From Metabolic Remodeling to Molecular Regulation*
12:24 – 12:40	Q&A Session	
11:30 – 12:40	**IL Session VIII (Parallel Session)** **Venue: Committee Room-II** Chairs: Nitin Trivedi &Azam Sheikh	
11:30 – 11:48	IL029	**Shireesh Srivastava**, ICGEB, New Delhi *Adaptive Laboratory Evolution of cyanobacteria for sustainability on Earth and Space*
11:48 – 12:06	IL030	**Soumya Sasmal**, Visva-Bharati, Santiniketan *Engineering Algal Bio-actives into Smart Functional Food Ingredients*
12:06 – 12:24	IL031	**Sourish Bhattacharya**, CSIR-CSMCRI *Bioprospecting of Marine Resources for Biofuels, Biopolymers and Nutraceutical Production*
12:24 – 12:40	Q&A Session	
12:40 – 13:20	**AAR 2026 Award Lectures** **Venue: Auditorium** Chair:Krishna Mohan Poluri	
12:40 – 12:50	Best PhD Thesis Award	**Sumit Dhali**, IIT Delhi *Development of diatom based nanobiopesticide for crop and grainpest control*
12:50 – 13:00	Best Master's Thesis Award	**Nikita Debnath**, Central University of Punjab *Assessing the impact of different nitrogen and phosphorus sources on biomass and lipid production in Desmodesmus sp.*
13:00 – 13:20	**Ms. Swati Sharma**, Associate Editor - Books, Life Sciences, Springer Nature *Advancing Research Through Scholarly Publishing: From Manuscript to Global Reach.*	
13:20 – 14:30	**Lunch Break & Networking** **Venue: Guest House, CSIR-NEERI**	

14:30 – 15:30	**Short Oral Presentations III (Parallel Session): *Algal Bioenergy, Biofuels and Bioconversion*** **Venue: Auditorium** Chairs:Pravin K. Naoghare&Prangya Ranjan Rout	
14:30 – 14:40	SOP 012	**Ajay Kumar Kataria,** Netaji Subhas University of Technology, New Delhi *Physiochemical Evaluation of Algal Oil for its Potential Use as Lubricating Base Oil*
14:40 – 14:50	SOP 013	**M. V. Rohit,** Sardar Patel Renewable Energy Research Institute, Gujarat *Biomanufacturing Lipids from Photosynthetic Cell Factories for Sustainable Next-Generation Biolubricants*
14:50 – 15:00	SOP 014	**R. Sathish,** CSIR-IMMT, Bhubaneshwar *Microalgae as a Carbon-to-Value Platform: Biomass, Bio products and Hydrothermal Conversion*
15:00 – 15:10	SOP 015	**Deepak Sharma,** SSS-NIBE,Punjab *Biochemical Interaction-Based Kinetic Modelling of Algal Biomass Hydrothermal Liquefaction for Biocrude Production*
15:10 – 15:20	SOP 016	**Kaviya Ravi,** IIT Madras *Production of Levulinic acid from Eucheuma denticulatum via sulphuric acid catalyzed hydrolysis: Effect of process parameters on hydrolysis efficiency*
15:20 – 15:30	SOP 017	**Tribhuwan Kumar,** MNNITAllahabad *Comparative Analysis of Different Transesterification Methods Leading to Biodiesel Production from Microalgae Cultivated on Sewage Wastewater*
14:30 – 15:30	**Short Oral Presentations IV (Parallel Session): *Algal Biorefineries and Circular Bioeconomy*** **Venue: Committee Room-II** Chairs: Venkata Subhash & Sanjeev Mishra	
14:30 – 14:40	SOP 018	**Neha Goel,** IIT Roorkee *Selective Recovery and Fractionation of Polychromatic Proteins from Spirulina platensis through an Integrated Circular Biorefinery Approach*
14:40 – 14:50	SOP 019	**Gourav Kumar,** ICGEB, New Delhi *Uncoupling Biomass Loss from Neutral Lipid Hyperaccumulation in Chlorella sorokiniana: Interorganellar Metabolic Crosstalk Between Endoplasmic Reticulum Kennedy and Plastidial TGD Pathways*
14:50 – 15:00	SOP 020	**Dig Vijay Singh,** IITRoorkee *Deep Eutectic Solvent-mediated β-Carotene recovery from Dunaliella salina for an integrated algal biorefinery approach*
15:00 – 15:10	SOP 021	**Sampa Bhowmik,** NIT Agartala *Utilization of protein-based bio- waste derived media for enhancement of microalgal biomass and pigment production*
15:10 – 15:20	SOP 022	**Avinash Singh,** IITBHU *Nano-Enabled Circular biorefinery: Upcycling Algal Biomass into Nitrogen-Doped Carbon Dots for Accelerated Photosynthesis and Lipid Hyper-Accumulation in Monoraphidium neglectum*
15:20 – 15:30	SOP 023	**Maddipatla Naga Sai Karthik,** BITS Pilani, Hyderabad *Metabolic Reprogramming of Chlorella sorokiniana Cultivated in Optimized Food Waste Anaerobic Digestate: Comparative Metabolomics*
15:30 – 16:20	**Short Oral Presentations V (Parallel Session): *Algal Food, Nutrition, Health and High-Value Bioproducts*** **Venue: Committee Room-II** Chairs: Shireesh Srivastava & Soumya Sasmal	
15:30 – 15:40	SOP 024	**B R Sreelekshmy,** RCSS, Kochi *Seaweed-Derived Sulfated Polysaccharides: Unlocking Their Potential for Next-Generation Cosmetics*
15:40 – 15:50	SOP 025	**Poonam Kumari,** CSIR-IICT, Hyderabad *Proteomic Characterization and Functional Bioinformatic Mining of Food-Grade Chlorella Sorokiniana for Potential Bioactive Peptides*
15:50 – 16:00	SOP 026	**Siya Battla,** Gujarat Biotechnology University *Sequential Extraction-Guided Metabolomic Profiling of Marine Algae for Discovery of Anticancer Bioactives*
16:00 – 16:10	SOP 027	**Swati Pawar,** CSIR-NIIST, Thiruvananthapuram *Selenium-Enriched Exopolysaccharides from Nannochloropsis oceanica: Structural Characterization and Functional Evaluation*
16:10 – 16:20	SOP 028	**Akshaya Suresh,** ICAR-CIFE, Mumbai *Cyanobacteria-Derived Vegan Peptone from Spirulina (Arthrospira) platensis as an Animal-Free Component of Microbiological Growth Media: Microbiological Validation and Biochemical Characterization*
15:30 – 16:20	**Short Oral Presentations VI(Parallel Session):*Algal Genomics, Molecular Biology and Microbial Interactions*** **Venue: Committee Room-II** Chairs:Kalyan Gayen & Sangram K. Lenka	
15:30 – 15:40	SOP 029	**Vitasta Jad,** CSIR-NIO, Goa *Taxonomic and functional profiling of microbiomes associated with seaweed habitats across the west and southeast coast of India using Nanopore long-read metagenomics*

15:40 – 15:50	SOP 030	**Priti Kumari,** IITGuwahati *Multimodal Morphological and Biochemical Characterization of Green Microalgae for Optimizing Whole-Cell Biosensors*
15:50 – 16:00	SOP 031	**Bijaya Nag,** ICGEB, New Delhi *Decoding Cell's Survival: Omics-based Integration of TOR Signalling and Autophagy in Marine Oleaginous Alga Parachlorella kessleri*
16:00 – 16:10	SOP 032	**Vaidehi A Nair,** CSIR-NIO, Goa *Genomic and transcriptomic characterization of macroalgae to understand their biosynthetic pathways for the production of its biomolecules.*
16:10 – 16:20	SOP 033	**Anjali Gupta,** Banaras Hindu University, Varanasi *Functional characterization of bolA from a cyanobacterium Synechococcus elongatus PCC 7942: Enhanced stress tolerance in Escherichia coli*
16:20 – 17:10	**Short Oral Presentations VII (Parallel Session): *Smart Algae, Bioprocess Engineering and Digital Technologies*** **Venue: Auditorium** Chairs: Nitin Trivedi & Azam Sheikh	
16:20 – 16:30	SOP 034	**Supratim Ghosh,** BITS Pilani, Hyderabad *Development of an IoT-Enabled Smart Photobioreactor Integrated with Artificial Intelligence and Digital Twin Technology for Real-Time Monitoring and Predictive Cultivation of Microalgae*
16:30 – 16:40	SOP 035	**Rajalakshmi Elumalai,** SRM University, AP *Explainable AI-Based Hyperspectral Imaging for the Non-Destructive Identification of Diverse Microalgal Species*
16:40 – 16:50	SOP 036	**Mohneesh Kalwani,** Dr. Ghanshyam Singh Mahavidyalaya, UP *Optimizing Chlorella sp. Cultivation Supplemented with TargetedNutrient Doses for Enhanced Biomass Production*
16:50 – 17:00	SOP 037	**R. Dinesh Kumar,**CSIR-NEERI *Linking Strain-Specific Physiology with Reactor-Dependent Biomass Productivity in Limnospira (Spirulina)*
17:00 – 17:10	SOP 038	**Bhavitha Ala,** KL Education Foundation, AP *Phycosynthesis of Silver Nanoparticles: Antibacterial Activity and Growth-Modulating Effects on Freshwater Algae*
16:20 – 17:00	**Short Oral Presentations VIII (Parallel Session): *Algal Lipids, Aquaculture Feed and Sustainable Biomaterials*** **Venue: Auditorium** Chairs: Amit K. Bajhaiya & Rajagopal Subramanyam	
16:20 – 16:30	SOP 039	**Boda Ravi Kiran,** CSIR–IICT, Hyderabad *Metabolic Engineering of Microalgae for Sustainable Omega-3 Fatty Acid Production through Integrated Wastewater Biorefineries*
16:30 – 16:40	SOP 040	**Shovon Mandal,** TERI, New Delhi, *Improving Shelf-Life of Nannochloropsis oceanica Feed Formulations for Sustainable Omega-3 Enriched Egg Production*
16:40 – 16:50	SOP 041	**Nikhil Laxman Kadalag,** ICT Mumbai *Tailoring Fish Oil–Like EPA:DHA profiles through controlled co-cultivation of Phaeodactylum tricornutum and Aurantiochytrium limacinum*
16:50 – 17:00	SOP 042	**Abhishek Sahu,** IIT Delhi *Development of Algal-Derived PHA Nanofibers for Sustainable Food Packaging Applications*
17:15 – 18:00	**Valedictory & Best Oral/Poster Awards Presentations; Declaration of venue for AAR 2027** **Venue: Auditorium**	
18:00 onwards	**High Tea** **Venue: Guest House, CSIR-NEERI**	

POSTER SESSION

Venue: Besides Auditorium

Poster No	Name & Affiliations	Title
PP 001	Mahesh Vemula ICGEB, New Delhi	Upcycling Volatile Fatty Acids as Sustainable Carbon Sinks for Producing Omega-3-Enriched Edible Oils in Aurantiochytrium sp.
PP 002	Soumajit Ghosh GITAM University, Visakhapatnam, Andhra Pradesh	R-Phycoerythrin from Gracilaria edulis: Seasonal Variation, Stability, Degradation Kinetics, and Food Matrix Compatibility
PP 003	Sneha Sengupta GITAM University, Visakhapatnam, Andhra Pradesh	Agro-Industrial Waste Valorization for Exopolysaccharide Production by Aurantiochytrium limacinum GG03 and its Application in Hydrocarbon Bioremediation
PP 004	Devargya Ganguly GITAM University, Visakhapatnam, Andhra Pradesh	A Marine Protist for Wastewater Remediation: The Versatility of Aurantiochytrium limacinum GG01
PP 005	Nitesh Prasad Banaras Hindu University, Varanasi	Agrobacterium mediated In planta transformation of Dunaliella salina phytoene synthase (DsPSY) gene confers salinity tolerance in Solanum lycopersicum
PP 006	R.P.G. Rachitha Jayatissa Banaras Hindu University, Varanasi	Selenium-fed microalga, Dunaliella salina, isolated from hypersaline Sambhar Lake: A source of pharmaceutical and nutraceutical potential
PP 007	Medha Reddy CSIR-IICT, Hyderabad	Waste-to-Value Biorefinery using Nannochloropsis sp. for Industrial Wastewater Remediation and Omega-3 Fatty Acid Production
PP 008	M. Lipika CSIR-IICT, Hyderabad	Integrated Experimental and Data-Driven Approaches for Microalgal Bioprocess Optimization, Carbon Sequestration, and Biomass Valorisation
PP 009	Anuradha Tripathi Siddharth University, Kapilvastu, Siddharth Nagar,	Phytoplankton Biodiversity and Multi-Parameter Assessment of Ecological Health in the Kuwano River, Uttar Pradesh, India
PP 010	Prachi Meshram IIT Tirupati, A.P	Comparative Investigation of Biohydrogen Production from Microalgal Biomass via Biological and Thermochemical Routes
PP 011	Seju Thomas Christ Deemed to be University, Bengaluru	Diatom Community Dynamics as Bioindicators of Hydrochemical and Heavy Metal Stress in Freshwater Ecosystems of Kottayam, Kerala
PP 012	Shreya Mishra Siddharth University, Kapilvastu, Siddharth Nagar	Enhancing Stress Tolerance and Lipid Production in Chlorella variabilis Through Adaptive Laboratory Evolution Using Dairy Wastewater
PP 013	Anushka Kudale Gujarat Biotechnology University	Sequential Bioprocessing of Marine Algae into Industrially Important Products
PP 014	Bhavika Mehta CSIR-CSMCRI, Gujarat	Process intensification of marine microalgal cultivation through optimized CO2 fixation efficiency, biomass productivity and bio-chemicals
PP 015	Tanvi Bhatt Gujarat Biotechnology University	Exploring Gujarat's Marine Microalgae for Sustainable Smart Protein
PP 016	Mariam Thomas Mahima CSIR-NIO, Goa	Metagenomic understanding of the functional profiles in bacterial communities associated with healthy and bleached seaweeds during off-shore cultivation for their role in carbon utilisation and storage pathways
PP 017	Neha Naijo Areekal IIT-Tirupathi	Omega-3 Fatty Acids from Microalgae: Extraction, Optimization and Characterization
PP 018	Sanskruti Panda CSIR-IMMT, Bhubaneshwar	Exploring the Metal-Binding Potential of Cyanobacterial EPS for sustainable Rare Earth Elements recovery
PP 019	Meenal Khare Centre for Scientific and Applied Research, IPS Academy, Indore, India	Harnessing Engineered Microalgae as a Sustainable Platform for Vitamin B6 Production
PP 020	Himanshi Gujarat Biotechnology University	Exploring Marine Microalgae For Smart Protein Applications
PP 021	Aaditay Malviya Central University of Tamil Nadu	Exploring UV-Induced Mutagenesis for Strain Diversification and Biotechnological Enhancement of

		Chlamydomonas reinhardtii
PP 022	Priyanka Gehlot IIT-Roorkee	Tracking to Tackling: Native Microalgae for Emerging Microplastic and Antibiotic-Resistant Bacterial Challenges in Wastewater
PP 023	Rajat Pant IIT-Roorkee	Microalgae-Mediated Removal of Pathogens and Nutrient from Sewage Wastewater
PP 024	Prashant Kumar Srivastava IIT-Roorkee	Industrial Waste-Derived Nanoparticles for Wastewater Treatment and Lipid-Based Petrochemicals Production From Microalgal Consortia
PP 025	Somesh Prajapati IIT-Roorkee	Microalgal Photogranules as a Sustainable Framework for Wastewater Treatment, Carbon Capture, and Resource Recovery
PP 026	Dhanusri A SASTRA, Thanjavur	Microalgal Biomass with EPS Matrices for Modern Feed Formulations
PP 027	Loghashri M SASTRA, Thanjavur	Decoding Microalgal Growth: Integrating Growth and Biochemical Data
PP 028	S Dhanushya IIT-Roorkee	Algae-Integrated Sodium Alginate-Fly Ash Beads for Wastewater Treatment
PP 029	P. Manoj Varma CSIR-IICT, Hyderabad	Bio-Electrochemical Optimization of Microalgae Growth and Value-Added Bio- Product Synthesis Through Controlled Low-Voltage Stimulation
PP030	Padma Punnam, Kallem Manish Koneru Lakshmaiah Education Foundation, AP	Exploring Spirulina as a Living Cell Factory for Extracellular Polysaccharide Production
PP031	Kriti Singh Azim Premji University, Bhopal	Algae Surviving Under Stress: Do Linker Proteins Make any Difference?
PP032	Hanny Azim Premji University, Bhopal	Growth response of Chlamydomonas reinhardtii strains with edited CCM related genes under different CO2 concentrations
PP033	Swati kumari Sardar Swaran Singh, National Institute of Renewable Energy, Punjab	Turning green water into gold: a raceway grown consortium driving biogas, bio crude and biofertilizer in a circular bioeconomy
PP034	Shivakshi Netaji Subhas University of Technology (NSUT), New Delhi	Anaerobic co-digestion of algal biomass with fly ash for biogas production
PP035	Kaavya S Hassan Institute of Chemical Technology, Mumbai	A Novel Biorefinery Approach For Sequential Recovery Of Value-Added Compounds From Diatoms
PP036	Pankaj Chelak Dr B R Ambedkar National Institute of Technology, Jalandhar,	Turning Liquid Anaerobic Digestate into a Microalgal Growth Medium through Biochar Treatment
PP037	Anand Sagar IITGuwahati	Integrated Genetic and Process Engineering Strategy for Enhanced CO_2 Fixation and Biomass Productivity in *Scenedesmus obliquus*
PP038	Ronald Jaffrey B Karunya Institute of Technology and Sciences	Fabrication of Magnetic Alginate-Based Biohybrid Janus Particles Incorporating Microalgae for Wastewater Remediation

Mid-Career Award for Excellence in Algal Research 2026



Dr. Krishna Mohan Poluri

IIT Roorkee

Prof. Krishna Mohan Poluri has made outstanding contributions to microalgal research through mechanistic insights into bioremediation and bioenergy, NMR-based and integrated omics approaches, and development of algal and seaweed-derived polysaccharide-based technologies for sustainable environmental and health applications. The award is a recognition of Prof. Poluri's work that advances molecular understanding, circular bioeconomy, environmental remediation, and innovative biomaterial development.

Presented on 3rd November 2026 at Nagpur
During the 4th International Symposium on Advances in Algal Research (AAR 2026)

Prof. Kaustubha Mohanty
Chair, AAR 2026

Early Career Award for Excellence in Algal Research 2026



Dr. Sanjeev Mishra

SSS-NIBE

For outstanding contributions to microalgal research, particularly the development of integrated algal biorefinery approaches for wastewater remediation, nutrient recovery, and sustainable biofuel production, advancing hydrothermal liquefaction of algal biomass and promoting resource recovery, circular bioeconomy, and environmentally sustainable energy technologies.

Presented on 3rd November 2026 at Nagpur
During the 4th International Symposium on Advances in Algal Research (AAR 2026)

Prof. Kaustubha Mohanty
Chair, AAR 2026

Emerging Researcher Award for Excellence in Algal Research 2026



Dr. Mohit Singh Rana

SRM Institute of Science and Technology, Kattankulathur

For his significant contributions to algal biotechnology through the development of algal biofilm technologies and nature-based solutions for resource recovery, bioremediation, and sustainable energy generation.

Presented on 3rd November 2026 at Nagpur
During the 4th International Symposium on Advances in Algal Research (AAR 2026)

Prof. Kaustubha Mohanty
Chair, AAR 2026

Best PhD Thesis in Algal Research Award 2026



This is to certify that ***Dr. Sumit Dhali****, PhD graduate from the Centre For Rural Development & Technology, Indian Institute of Technology Delhi is awarded the Best PhD Thesis entitled "Development of Diatom-Based Nano Bio-Pesticide for Crop and Grain Pest Control".*

Presented on 3rd November 2026 at Nagpur
During the 4th International Symposium on Advances in Algal Research (AAR 2026)

Prof. Kaustubha Mohanty
Chair, AAR 2026

Best Masters Thesis in Algal Research Award 2026



This is to certify that ***Ms. Nikita Debnath****, Masters graduate from the Department of Botany, Central University of Punjab, Bhatinda is awarded the Best Masters Thesis entitled "Assessing the impact of different nitrogen and phosphorus sources on biomass and lipid production in Desmodesmus sp.".*

Presented on 3rd November 2026 at Nagpur
During the 4th International Symposium on Advances in Algal Research (AAR 2026)

Prof. Kaustubha Mohanty
Chair, AAR 2026

Abstracts of Invited Speakers

IL001

MACROALGAE SEAWEED TO PLATFORM CHEMICALS VIA THERMOCHEMICAL AND CATALYTIC PATHWAYS

Prof. R. Vinu
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Dr. R. Vinu leads an active research group at IIT Madras focusing on thermochemical& thermocatalytic conversion of a diverse renewable and non-renewable feedstocks. He is also the Director & Co-founder of the deep tech start-up company, X2Fuels & Energy Pvt. Ltd., incubated at IIT Madras Research Park, that works on the scale-up of hydrothermal liquefaction and other thermochemical conversión technologies. He has published 180+ research articles in reputed journals, and 5+ patents. He is the recipient of Young Engineer Award of the IEI, Young Scientist/Associate Awards of the INSA, NASI, IAS, ICT Mumbai, and Early Career Recognition Awards for Teaching and Research from IIT Madras. He serves as one of the Editors of Journal of Analytical and Applied Pyrolysis, and in the Editorial boards of Biomass & Bioenergy, and Scientific Reports.

ABSTRACT

Macroalgae or cultivated seaweeds are renewable, sustainable and scalable feedstocks for the production of bio-products and bio-fuels. With a vast coastline of over 11,000 km, the Indian states like Tamil Nadu, Andhra Pradesh, Odisha and Gujarat have some of the best climatic conditions for cultivating tropical seaweeds. As aquaculture does not require the irrigation water or fertilizer unlike agriculture, the process can be sustainably scaled using mechanized farming systems that improve labour productivity. This presentation will focus on the conversion of the seaweed, *Eucheuma denticulatum* (Spinosum), to a range of platform chemicals like levulinic acid, 5-hydroxymethyl furfural (HMF) and xylose through thermocatalytic routes. Dilute acid hydrolysis of the seaweed conducted in the temperature range of 160-200 ^{o}C and 0.5-2 h, and the resulting organic and inorganic products were thoroughly analysed. The effects of temperature, time, acid concentration and seaweed loading were also studied. A maximum seaweed conversion of 70% was achieved along with 40% selectivity to xylose, 10-11% levulinic acid, 8-9% HMF, and other C5 and C6 sugars. Alongside homogeneous catalytic conversion, heterogeneous catalytic conversion using phosphate-functionalized activated carbon was also evaluated. The results demonstrated varying levels of hydrolysates whose yields followed the trend: xylose > HMF > cellobiose > levulinic acid > furfural. The reaction pathways involved in homogeneous and heterogeneous catalytic conversions will be discussed.

Keywords: Macroalgae seaweed; Spinosum; Levulinic acid; Xylose; Hydrolysis

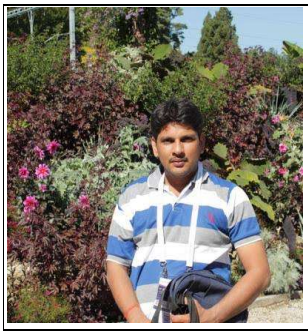
Co-authors names: Kaviya Ravi, Mariappan Mani, Vandhana Jain

IL002

ADVANCING LOW-CARBON TRANSITIONS THROUGH INTEGRATED BIOREFINERY INNOVATIONS

BALENDRA SINGH

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Dr. Balendra Singh is an Indian scientist serving as Scientist 'D' in the Department of Biotechnology (DBT) under the Ministry of Science & Technology, Government of India. Based in New Delhi, his core scientific expertise spans sustainable biotechnology, clean energy, carbon capture, and advanced biofuels. He plays a pivotal role as a programme officer driving research initiatives aligned with India's national BioE3 Policy for a circular bioeconomy. Officially stationed at the CGO Complex, he can be reached for academic and administrative collaborations at balendra.singh@dbt.nic.in.

ABSTRACT

The Government of India is focusing on green industrial growth with net-zero goals by 2070. As evident from the Union Budget over the last decade, the Government has come out with new and innovative missions, initiatives, schemes, and programs in biotechnology and bio-related sectors, including but not limited to the biopharma, bioenergy, biochemicals, biofertilizers, climate resilient agriculture etc. The efforts are culminating in a more structured implementation mechanism for achieving net-zero goals. This is built on the very strong policy push by the Government of India, whether it is the National Biofuel Policy, the renewable energy policy, the National Green Hydrogen Mission, or the recently announced CCU Mission. Announced in 2024, the BioE3 (Biotechnology for economy, environment, and employment) policy has envisioned a path to a greener industrial transition through High Performance Biomanufacturing in the country. These innovations and biomanufacturing for fuels, chemicals, and materials may need to be integrated across feedstocks, processes, and end products to really bring down costs and achieve efficiency on par with chemical manufacturing. Algae-based biorefinery systems are emerging globally as a carbon-neutral biomass source for a resilient and regenerative bioeconomy. Yet there are challenges in economics, adaptability, the consortial approach, and sustainability that hamper the just transition to the real world and core manufacturing industries. So, this talk will focus on connecting the efforts of the Government of India to integrate innovations into an integrated biorefinery approach while advancing large-scale, sustainable manufacturing of fuels, chemicals, and materials through a refinery approach.

Keywords: Algal Biorefinery; BioE3 Policy; Biotechnology; CCU Mission; Net-zero goal

IL003

ALGAL BASED CULTIVATION FOR ECONOMIC VALUE AND ENVIRONMENT FRIENDLY PRACTICES

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Dr. Gunjan Prakash received PhD in Biochemical Engineering and Biotechnology from IIT Delhi. She has extensive research experience in academic and industrial bioprocessing. She is working as Associate Professor at the DBT-ICT Centre for Energy Biosciences, Institute of Chemical Technology (ICT), Mumbai. Her research area includes algal biotechnology, molecular biology, and industrial heterotrophic fermentation. She is a recipient of prestigious international fellowships, including the Indo-Queensland, EMBO, and TWAS fellowships. To her credit she has multiple patents and over 30 peer-reviewed international publications with high overall citation impact. Several students are pursuing their research under her guidance, and she is actively handling multiple government and industrial biomanufacturing projects under India's BioE3 Policy.

ABSTRACT

Microalgae, enriched with diverse bioactive compounds, present significant potential in fuel, food, functional molecules and feed (4F's). Despite rapid advancements, the total cost of production of biomass/biomolecules continue to pose barrier for their wider use. The talk will focus on gradual scale-up of *Haematococcus pluvialis* (from 1L to 300L photobioreactor) to produce Astaxanthin, the most potent antioxidant, high value molecule and its residual liquid extract (HRLE) from the left-over biomass as a plant bio-stimulant (liquid fertilizer) in a biorefinery framework. Cost dynamics of astaxanthin production from *H. pluvialis* cultivation from economical point of view as well as eco-friendly alternative to synthetic liquid fertilizers contributing to the advancement of sustainable agronomic practices will be discussed.

Keywords: *H. pluvialis* , Astaxanthin, Biostimulant, Plant growth, Sustainable agriculture

Co-Author: Vinay Patil, Kanchan Sambhwani

IL004

ALGAE-NANOMATERIAL BIOHYBRID SYSTEM FOR ENHANCED YIELD OF BIOMASS AND VALUABLE METABOLITES

Nilotpala Pradhan

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Dr Nilotpala Pradhan received PhD in Biochemistry from Nagpur University. She has research experience of 23 years. She is working as Scientist- G at CSIR-Institute of Minerals and Materials Technology, Bhubaneswar. Her research area includes mineral bio processing and algal CO2 sequestration. She is recipient of prestigious "National Geosciences Award-2012" awarded by Ministry of Mines. To her credit she has 2 patents and 83 SCI publication with above 6970 citations. Twelve students have already completed their PhD while 8 are continuing. She is currently working on 7 ongoing projects while completed 24 projects in her research career. Details https://www.immt.res.in/environment-sustainability-people

ABSTRACT

Photosynthetic microorganisms like microalgae and cyanobacteria are significant sources of aquatic primary productivity and earth's carbon sequestration. Photosynthesis in microalgae involves highly controlled process of pigment synthesis, light absorption, and electron transport in its photosystems. Research in area of nanomaterials is growing at fast pace and also landing into environment. Many studies have examined the toxicity of nanoparticles in algae and most of them focus on negative effects like growth suppression and oxidative stress. But non-inhibitory lower concentrations of nanomaterials (NMs) may exert beneficial effects on microalgal metabolism and growth. Having highly sensitive photosynthetic coordination, make algae effective model systems for studying nanoparticle-biological interactions. The biological response is strongly dependent on the type, size, shape, surface chemistry, functionalization, concentration, and stability of the nanomaterial, as well as the species and physiological state of the microalgae.

When engineered nanomaterials are associated with or incorporated into microalgal or cyanobacterial cells, an Algae-Nanomaterial bio-hybrid system can be established. This system combines the biological capabilities of living photosynthetic cells with the physicochemical properties and effect of nanomaterials. The interaction can occur through several possible mechanisms like surface association, cellular uptake, interaction with photosynthetic components, modification of cellular redox processes, light harvesting and energy transfer etc. The nanomaterial with suitable optical properties could potentially alter the local light environment around or within a cell. This raises the possibility of developing artificial light-harvesting components that complement the natural photosynthetic apparatus. Improved photosynthetic activity could potentially increase the availability of carbon and energy for cellular growth, resulting in increased biomass productivity. This is particularly relevant for microalgal biotechnology because microalgae are important sources of proteins, lipids, carbohydrates, pigments, antioxidants, vitamins, and other bioactive compounds.

Keywords: Algae, nanomaterials, Algae-Nanomaterial bio-hybrid, artificial light-harvesting materials

Co-authors names: Ms Aparna Nayak, AcSIR PhD student, Environment & Sustainability Department, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar -751013,

IL005

BIOREMEDIATION POTENTIAL OF *MICRACTINIUM SP.* FOR BISPHENOL A REMOVAL IN BRACKISH WATER: A SUSTAINABLE STRATEGY FOR EMERGING CONTAMINANT MANAGEMENT

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Dr. Sabeela Beevi U is a scientist-E at the Department of Bioscience of Rajagiri College of Social Sciences (autonomous), Kalamassery, Kochi. She obtained her PhD degree in biotechnology from Cochin University of Science and Technology and completed her PhD studies at CSIR-National Institute for Interdisciplinary Science and Technology, Trivandrum. She received several national and international awards. She has 60 publications in SCI journals, including book chapters. 40 international conference communications, and 17 invited talks, along with an h-index of 24. She edited/authored two books (international). She was recognized as one of the top 2% of scientists in lists published by Stanford University, USA and Elsevier. Her areas of research interest include biorefinery platform chemicals and the circular bioeconomy from biomass (lignocellulose/microalgae), carbon capture and sequestration, sustainable bioengineering, environmental bioremediation, waste-to-wealth, wastewater treatment and industrial enzymes.

ABSTRACT

Bisphenol A (BPA) is an emerging contaminant and a typical endocrine disruptor with estrogenic properties. It has detrimental effects not only on the environment and ecosystem but also on human and animal health. It is an hour to investigate the sustainable process of BPA degradation for diminishing its persistent effect on the ecosystem. The objective of the present study is to investigate the toxic effect and potential of microalgae *Micractinium sp* VSS for the removal of BSA spiked in the Brackish water. *Micractinium* sp. VSS acclimatized to 7 mg/L BPA was subsequently exposed to concentrations of 0–100 mg/L. The strain maintained comparatively stable growth and pigment profiles at BPA concentrations of 10–30 mg/L. Maximum BPA removal of 96% was achieved at 10 mg/L, whereas higher concentrations adversely affected cell density, pigmentation pattern, and removal efficiency. Enzymatic analyses indicated the role of laccase and peroxidase in BPA biotransformation. SEM analysis revealed surface irregularities and cellular deformation in *Micractinium sp.* following exposure to BPA, indicating cellular stress and biomass interaction. FTIR showed changes in O–H/N–H, C=O, C–H and C–O bands, suggesting functional-group involvement and changes in bonding pattern. The biotransformed products of BPA were further analysed using LC-MS to elucidate potential degradation pathways. Biotransformed products are less toxic than the parent BPA. GC- MS showed that predominant fatty acids are oleic acids (20%), palmitic acid (30%), followed by stearic acid (16.8%) and linolenic acid (12.8%). Overall, the findings demonstrate the potential of indigenous microalgae for BPA remediation via biofilm-mediated interactions, adsorption, and enzyme-assisted transformation, offering a sustainable platform for pollutant abatement and biomass valorisation.

Keywords: Bisphenol A, Biotransformation, Environmental remediation, Microalgae biomass, Sustainable Bioprocess

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IL006

ALGAE BIOREFINERY: A SUSTAINABLE PLATFORM FOR VALUE ADDITION

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Dr. G. Venkata Subhash is a biotechnology researcher and senior R&D professional with over 13 years of industrial experience and 15 years of expertise in algae cultivation and value-added product development. He holds a Ph.D. from AcSIR, CSIR-IICT, Hyderabad. He has authored scientific publications and holds 6 granted patents focusing on algal lipid enhancement and improving algal biomass production by physical strategies. Currently, he serves as Deputy General Manager at Reliance Industries Limited, leading the Algae Oil for Cosmetics project. His expertise includes microalgal biotechnology, Algae metabolomics, integrated biorefineries, process development, technology demonstration and commercialization of sustainable algae-derived products.

ABSTRACT

The growing demand for sustainable raw materials, renewable energy, and high-value bio-based products has accelerated interest in algae as a versatile resource for integrated biorefinery applications. Algal biomass contains diverse biochemical components, including proteins, lipids, fatty acids, pigments, carbohydrates, vitamins, and bioactive compounds, offering opportunities for multiple value-added products across food and nutrition, cosmetics and personal care, healthcare, animal feed, agriculture, bioenergy, and biomaterials. Sequential fractionation and efficient utilization of algal biomass can maximize resource recovery, minimize waste generation, and support circular bioeconomy principles. Algae-derived ingredients, such as proteins, pigmented oils, natural pigments, and bioactive extracts, offer potential for functional foods, cosmetic formulations, healthcare research, and agricultural applications. Additionally, residual biomass can be explored for animal feed, biostimulants, biofuels, biocomposites, and nanocellulose. Successful commercialization requires optimization of cultivation, harvesting, dewatering, extraction, product quality, safety, regulatory compliance, and techno-economic feasibility. Overall, integrated algae biorefineries offer a promising platform for sustainable resource utilization, industrial value addition, and the development of circular bio-based value chains.

Keywords: Algae biorefinery, algal biomass, value addition, circular bioeconomy, bioproducts.

IL007

FROM SEAWEED TO SUSTAINABLE BIOPLASTICS: OPPORTUNITIES, CHALLENGES, AND TRANSLATIONAL PATHWAYS FOR COMMERCIAL MANUFACTURING

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E-mail: rajasriy_biotech@cbit.ac.in



Dr. Rajasri Yadavalli is an Associate Professor and Associate Director–Innovation & Incubation at CBIT, Hyderabad, with 21 years of academic and research experience. Her research focuses on microalgal biotechnology, photobioreactor design, algal biomass and biofuel production, value-added products, wastewater treatment, and seaweed-based bioplastics. She has led funded research projects, published extensively in algal biotechnology, developed intellectual property, and contributed to sustainable bioproduct development through translational research.

ABSTRACT

Petroleum-based packaging films pose serious environmental challenges due to their non-biodegradability, microplastic pollution, and dependence on fossil resources. Consequently, global research has increasingly focused on renewable alternatives, including starch, cellulose, and polylactic acid (PLA). Recently, under India's BioE3 (Biotechnology for Economy, Environment and Employment) policy, the Government of India launched the commercial use of bio-based PLA plastics, supported by a ₹75 crore BIRAC grant for establishing a 100-tonne-per-annum pilot-scale facility in Uttar Pradesh. This initiative demonstrates India's growing commitment to promoting bioplastics and bio-based products derived from renewable resources, emphasizing sustainable biomanufacturing and reducing dependence on petroleum-based plastics. However, conventional PLA production faces challenges related to agricultural feedstock dependence, production costs, processing limitations, and industrial composting requirements. In this context, seaweed-derived biopolymers offer promising alternatives owing to their renewability, abundance, biodegradability, and minimal dependence on agricultural land and freshwater. This presentation explores the opportunities and challenges associated with converting seaweed biomass into sustainable bioplastic packaging films, emphasizing biopolymer extraction, formulation development, mechanical performance, moisture-barrier properties, biodegradation, and manufacturing scalability. Particular attention will be given to translational research strategies bridging laboratory-scale innovations and commercial manufacturing through process optimization, pilot-scale production. Furthermore, technological bottlenecks, standardization requirements, regulatory considerations, and commercialization opportunities will be discussed, providing a roadmap for transforming marine biomass into high-value, environmentally sustainable packaging materials within India's emerging circular bioeconomy.

Keywords: Biodegradable packaging; Biomanufacturing; Circular bioeconomy; Seaweed-based bioplastics; Translational research.

Co-authors names: Dr. Dharmalingam K*, Kashyap P*

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IL008

MARINE MICROALGAE FOR FLUE GAS CO_2 SEQUESTRATION: FROM LABORATORY OPTIMIZATION TO PILOT-SCALE DEMONSTRATION

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ABSTRACT

The increasing concentration of atmospheric CO_2 and the need to decarbonize fossil-fuel-based industries necessitate sustainable and scalable carbon capture approaches. Marine microalgae offer a promising biological route for CO_2 sequestration, particularly in regions where freshwater availability is limited. Their ability to utilize industrial flue gas while simultaneously generating biomass and value-added bioproducts provides an opportunity to integrate carbon capture with a circular bioeconomy.

This lecture presents the major findings from the CSIR-CCUS Mission Mode Project undertaken in collaboration with Adani Power Limited (APL), Mundra, for the development and demonstration of marine microalgae-based flue gas CO_2 sequestration. Initially, suitable marine microalgal strains were identified based on their biomass productivity and CO_2 tolerance. The effects of 15% CO_2 enrichment and photobioreactor illumination area were systematically evaluated, followed by optimization of different CO_2 feeding strategies, including time-dependent, linear fed-batch, growth-phase and co-cultivation approaches. Under laboratory photobioreactor conditions, CO_2 fixation efficiencies of 5–8% and biomass productivities of 0.3–0.4 g/L/d were achieved.

The selected *Dunaleillasalina* strain was subsequently evaluated under outdoor conditions at APL Mundra using a 2 m^3 open pond across winter and summer seasons. Pilot-scale cultivation was ultimately demonstrated using a 25 m^3 raceway pond directly integrated with coal-fired flue gas at a flow rate of 20 m^3/h during April–May 2025. The system achieved a biomass yield of 1.5 kg/m^3, productivity of 30 $g/m^2/d$, CO_2 sequestration of 44 $g/m^2/d$ and fixation efficiency of 8.7%, with biomass containing approximately 40% carbon. The lecture will also discuss scale-up challenges, process integration, product valorization and ongoing life-cycle assessment.

Keywords: Carbon capture; Flue gas; Marine microalgae; Photobioreactor; CO_2 sequestration.

IL009

MICROALGAL POLYSACCHARIDE-BASED SYNBIOTIC ENCAPSULATION OF SHRIMP-ASSOCIATED PROBIOTICS: A NOVEL STRATEGY FOR DISEASE MANAGEMENT IN WHITELEG SHRIMP (*LITOPENAEUS VANNAMEI*)

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Dr. N. S. Sampath Kumar is Professor (O) and Deputy Dean (HR) at Vignan's Foundation for Science, Technology & Research (VFSTR), with over 18 years of experience in academia, research, and academic administration. His research focuses on the extraction and characterization of bioactive compounds from underutilized fish resources, with potential applications in the food and biomedical industries. His research also extends to aquaculture, particularly the use of herbal extracts to enhance the health of cultured fish and shrimp. His team is currently developing synbiotics using microalgal polysaccharides as prebiotics to promote aquaculture health and sustainability. Dr. Sampath has published over 60 peer-reviewed articles, garnering 2,785 citations, with an h-index of 30 and an i10-index of 54. He currently oversees one ANRF-funded project, mentors Ph.D., M.Tech., and B.Tech. students, and has successfully awarded two Ph.D. Degrees.

ABSTRACT

Intensive shrimp aquaculture faces increasing disease outbreaks and antimicrobial resistance, necessitating sustainable strategies for disease management. This study investigates microalgal polysaccharide-based synbiotic encapsulation and its potential to enhance disease resistance in whiteleg shrimp (Litopenaeus vannamei). A native freshwater green microalga was identified through polyphasic characterization, attaining a maximum biomass of 0.84 ± 0.02 g L^{-1} with 25.7 ± 1.5% carbohydrate content. Purified non-starch polysaccharides (PCP), obtained through ultrasonication-assisted hot-water extraction and enzymatic pretreatment, were characterized using GC–MS and FTIR, confirming their monosaccharide composition and sulphated heteropolysaccharide structure. *In vitro* fermentation demonstrated enhanced growth of shrimp-associated probiotics, Lactobacillus plantarum and Bacillus subtilis, alongside inhibition of Vibrio sp. and Cytophaga hutchinsonii by 36.09% and 27.65%, respectively. The probiotic consortium exhibited up to 83.61% inhibition in co-culture assays. Building on these findings, PCP and the probiotic consortium were successfully co-encapsulated within a biocompatible polymer matrix to develop synbiotic beads, exhibiting high encapsulation efficiency, enhanced probiotic viability, and favourable physicochemical properties. The encapsulated formulation demonstrated controlled probiotic release and retained substantial inhibitory activity against Vibrio sp.*In vivo* bacterial challenge experiments in Litopenaeus vannamei revealed improved survival and growth performance in synbiotic-treated shrimp, accompanied by favourable modulation of gut microbial composition and enhanced immune and digestive responses. These findings highlight the potential of microalgal -derived polysaccharides as functional prebiotics and effective carriers for probiotic delivery, offering a promising synbiotic strategy for improving shrimp health and promoting sustainable aquaculture.

Keywords:

Non-starch polysaccharides; Synbiotics; Encapsulation; Probiotics; Prebiotics; Aquaculture.

IL010

EXPLORING SPIRULINA AS A LIVING CELL FACTORY FOR EXTRACELLULAR POLYSACCHARIDE PRODUCTION

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ABSTRACT

Spirulina (*Arthrospira* sp.) is widely cultivated as a sustainable source of proteins, pigments, and nutraceutical compounds, its extracellular polymeric substances (EPS), particularly extracellular polysaccharides, remain comparatively untapped. This study aims to investigate the strategy of physiological stress to enhance EPS production while enabling non-destructive recovery. Spirulina cultures has been cultivated with selective metabolic stresses, including nutrient (varying C and N source) modulation, salinity, and precursor-associated conditions, to assess their effects on biomass growth, photosynthetic performance, and extracellular carbohydrate accumulation. Cell-free culture supernatants were quantitatively analyzed for extracellular carbohydrates and further characterized using biochemical and spectroscopic approaches to elucidate their polymeric composition and functional groups. Over the repeated cycles the stress conditions were optimized for enhanced extracellular carbohydrate production by relative to the control, while maintaining biomass viability and productivity. Enabling extracellular biopolymer harvesting without cell disruption, the proposed approach seeks to transform Spirulina into a reusable living cell factory for sustainable biopolymer production. This non-destructive biorefinery strategy has the potential to minimize biomass loss, reduce downstream processing requirements, and improve resource efficiency, by contributing to a sustainable development of low-waste and circular algal biorefineries.

Keywords: Algal biorefinery; Biopolymer biogenesis; Cell-free harvesting; Exo-polysaccharides; **Physiological stress**

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IL011

DECIPHERING ACCLIMATION STRATEGIES AND PHOTOSYSTEM I REMODELLING IN *DUNALIELLA SALINA* UNDER HYPERSALINE CONDITIONS

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ABSTRACT

Dunaliella (D.) salina is a photosynthetic microalga renowned for its ability to thrive in extreme saline conditions, tolerating a range of salinities from 0.5M to 5M NaCl. This unique adaptability offers a compelling opportunity to explore the photosynthetic machinery, which has evolved to function optimally under these challenging conditions. Sucrose density gradient separation of photosystem supercomplexes using the thylakoid sample, followed by SDS-PAGE analysis of fractions and Western blot analysis of D1, PsaA, Lhcb2, and CP47 proteins from different fractions, showed that the effects of hyper salinity on LHC proteins are more significant than that of the core proteins. However, studies on supercomplexes suggest that *D. salina* maintains stable photosystems even under hypersaline conditions compared with optimal salt conditions. Furthermore, our integrative omics approach study revealed distinctive features of the Dunaliella chloroplast, particularly at the photosystem supercomplex level. Our transcriptomic and biophysical studies revealed remodelling at the supercomplex level in photosystem (PS) I under hypersaline conditions (3M NaCl). Transcriptomic analysis unveiled a possible remodelling at the supercomplex level with the addition of chloroplast TIDI, flavodoxin IsiB, and CBR proteins. The same has been confirmed using proteomics. Here, we explored the remodelled cryo-electron microscope structure of PS I supercomplexes and other distinct features of photosystems in their native phase, and this in-depth structural elucidation study provides novel insights into PSI structural plasticity under extreme environmental conditions.

Keywords: Cryo-electron microscope; *Dunaliella salina*; salt stress; supercomplexes; thylakoids

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IL012

MICROALGAL BIOINOCULANTS FOR SUSTAINABLE AGRICULTURE: EFFECT ON SOIL FERTILITY, MICROBIOME DIVERSITY AND CROP YIELD

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ABSTRACT

The excessive use of chemical fertilizers has led to soil degradation and adverse environmental impacts, necessitating sustainable alternatives for improving soil fertility and crop productivity. Microalgal bio-inoculants consortia comprising cyanobacteria and green microalgae have shown promise as an eco-friendly strategy; however, their influence on native soil microbiomes and plant performance remains insufficiently explored. In this study, indigenous nitrogen-fixing cyanobacteria and non-nitrogen-fixing green microalgae were isolated from agricultural soils and evaluated for agriculturally important metabolites to develop efficient microalgal consortia under nitrogen-deficient conditions. Cyanobacterial isolates (*Calothrix* sp. and *Nostoc* sp.) produced significantly higher indole-3-acetic acid (IAA) than green microalgae (*Chlorella* sp. and *Desmodesmusarmatus*). Consortium development led to a significant enhancement of biostimulant potential, with the highest IAA production (21.06 ng g^{-1}) observed during the late log phase. Further, the consortium was evaluated in a pot experiment using *Capsicumannuum* to assess its effects on plant growth, soil fertility, and soil microbial dynamics. Microalgal inoculation significantly improved plant morphometric parameters, yield, and soil dehydrogenase activity ($p < 0.05$). Additionally, soil organic carbon, chlorophyll, total polysaccharides, and essential macro- and micronutrients (C, N, P, K, and Mn) were significantly enriched compared to the chemical fertilizer control. Metagenomic analysis revealed an increase in microbial diversity and a pronounced shift in community composition. The study demonstrated that microalgal consortia can function as effective biofertilizers and biostimulants, enhancing crop yield and improving soil health and microbial diversity.

Keywords: Green microalgae; Cyanobacteria; Consortia; Biostimulants; Metagenomics

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IL013

MICROALGAE BASED PHARMACEUTICAL PRODUCTS: A CASE STUDY ON EXTRACELLULAR POLYSACCHARIDE (EPS)

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ABSTRACT

Microalgae are regarded as the green source for the production of high-value pharmaceutical and nutraceutical compounds. Microalgae have rapid growth, high photosynthetic efficiency, ability to utilize carbon dioxide and able to synthesize diverse bioactive compounds for pharmaceutical applications. Extracellular polysaccharides or exopolysaccharides (EPSs) are one of the biopolymers secreted by microalgae on the cell surface attributing to the stabilization of the cell membrane structure. These secreted EPSs construct a layer around cells to protect them against adverse environmental condition such as extreme temperature, osmotic pressure, dehydration, phagocytosis and antibiotics. In recent days, investigators have concentrated on the synthesis of EPSs due to its promising applications in different domains like: (i) therapeutics and biopharmaceuticals in the medicinal sector, (ii) pesticides and herbicides in the agricultural sector, (iii) different additives in food industries and (iv) alternative to the synthetic polymers in fabric industries. The aim of the current work is to explore, characterize, and compare extracted extracellular polysaccharides EPSs derived from selected microalgae and cyanobacteria from Tripura for their compositional diversity and biological activity such as antibacterial, antioxidant activity. The present research seeks to provide scientific evidences to establish the relationship between chemical composition and biological function of EPSs derived from *Asterarcys quadricellulare*, *Oscillatoria* sp., and *Microcoleus* sp.

Keywords: Extracellular polysaccharides (EPS); Isolated microalgae; Physicochemical characterizations; Selective antimicrobial activity

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IL014

ENGINEERING THE LIGHT-DRIVEN ALGAL CELL: FROM METABOLIC REPROGRAMMING AND NANOBIOTECHNOLOGY TO NEXT-GENERATION PHYCOFACTORIES

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ABSTRACT

Microalgae are promising platforms for sustainable biomanufacturing, yet industrial translation remains constrained by inefficient light utilization, self-shading, and photo-oxidative stress. This talk presents an integrated framework combining spectral quality, photon dynamics, green nanobiotechnology, and multi-omics to elucidate and redirect carbon partitioning in fast-growing microalgae. In *Scenedesmus* sp. GSB9, integrated transcriptomics, LC-HRMS metabolomics, and GC-FID fatty-acid profiling revealed continuous blue light as a potent metabolic regulator, enriching fatty-acid biosynthesis and enhancing acetyl-CoA carboxylase expression, accompanied by increased palmitic acid accumulation. Conversely, dynamic blue-to-red illumination activated stress-responsive pathways, revealing a marked disconnect between transcriptional responses and metabolic output. Temporal photon delivery through micro- to millisecond flashing light reduced high-intensity photostress while enhancing biomass, pigments, and fatty-acid accumulation across diverse microalgae. Furthermore, green-synthesized platinum nanoparticles under blue light accelerated *Scenedesmus* growth and selectively remodelled lipid metabolism toward complex lipids, including triacylglycerols and phosphatidylserine. Collectively, these findings establish spectral quality, photon dynamics, and nanoscale interventions as programmable inputs for controlling algal carbon flux. Looking forward, integrating precision photobioprocessing with genome engineering, chloroplast synthetic biology, and rational rewiring of carbon-fixation and metabolic pathways could enable algal cells to be programmed as high-efficiency phycofactories for targeted bioproduct synthesis, carbon capture, and circular bioeconomy applications.

Keywords: Carbon flux; Chloroplast synthetic biology; Microalgae; Nanobiotechnology; Photobioprocessing

IL015

EXPLORATION OF NORTH INDIAN HOT SPRINGS FOR REVEALING THE POTENTIAL OF THERMOPHILIC CYANOBACTERIA FOR INDUSTRIAL APPLICATIONS

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ABSTRACT

Thermal environments formed by volcanic eruptions, hot springs, and hydrothermal vents are naturally inhabited by thermophilic and hyperthermophilic microorganisms. The remarkable diversity of these microbes has brought a significant shift in scientific research by demonstrating their ability to survive and adapt to extreme and unfavorable conditions. Exploration of thermal ecosystems provides valuable opportunities to investigate microbial diversity, ecological adaptation, evolution, and the discovery of novel species. In addition, these environments serve as important sources for the cultivation and utilization of thermophiles in industrial and biotechnological applications.

Among thermal microorganisms, cyanobacteria are particularly important because of their ability to thrive under high-temperature conditions. Their long-term adaptation to extreme environments involves physiological and genetic modifications that support survival and productivity. Thermophilic cyanobacteria produce a wide range of primary and secondary metabolites with distinctive biochemical properties, making them promising sustainable bioresources. Their high photosynthetic efficiency, growth potential, metabolic versatility, and production of bioactive compounds increase their relevance for various biotechnological and industrial applications.

Thermophilic cyanobacterial strains are therefore of considerable interest for interdisciplinary research involving morphology, physiology, genetics, genomics, bioinformatics, biochemistry, and metabolomics. Understanding their adaptive mechanisms and metabolic potential can facilitate the development of valuable products and processes. The present study focuses on exploring selected hot springs located in the Himalayan region and the Aravalli ranges to investigate the diversity and characteristics of thermophilic cyanobacteria. Furthermore, the study aims to evaluate the biotechnological potential of isolated cyanobacterial strains and their metabolites for possible applications in industries such as cosmetics, food, and other emerging sustainable technologies.

Keywords: Hot springs, thermophilic cyanobacteria, food, secondary metabolites.

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IL016

UNVEILING UNCONVENTIONAL PRODUCTS, PROCESSES, AND FEEDSTOCK FOR ADVANCING ALGAL BIOREFINERIES

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ABSTRACT

Microalgae serve as a source of fuels, industrial chemicals, nutraceuticals, especially carotenoids and polyunsaturated fatty acids (PUFA), and feed. This study outlines the feasibility of using microalgae to produce unconventional and conventional bioproducts through novel processes and new microalgal feedstocks. We report employing green microalga, *Graesiella emersonii* , isolated from multi-HM contaminated waterbody in the textile industry belt of India known for dye contamination of surface and ground waters, for phycoremediation of copper (Cu), zinc (Zn), chromium (Cr) and lead (Pb). Subsequently, the Cu- and Zn-laden microalgal biomass was valorised to synthesize functional nanoparticles (NPs) and demonstrated for environmental applications. To further investigate the high tolerance of the microalga to heavy metal stress, the stress-based modulation and optimization of carotenoid and fatty acid metabolism was undertaken. The analyses confirmed that *G. emersonii* had remarkably high lutein production of 29.48 ± 0.09 mg/g DCW, higher than even marigold. The production of other valuable carotenoids such as astaxanthin and zeaxanthin in considerable quantities under normal, stress and in carbon- supplemented conditions was also demonstrated. The strain also produced ω -3 PUFAs under nutrient depletion. In addition, we report two cyanobacterial strains capable of producing polyhydroxybutyrate (PHB) and extracellular polymeric substances (EPS) while growing in and remediating dairy wastewater. Taken together, we unveil a closed-loop process for phycoremediation, demonstrating the conversion of remediated biomass into useful products, and the production of high-value products from microalgae and cyanobacteria. These findings advance the techno-economic feasibility of algal biorefineries, in particular, and advances algal research, in general.

Keywords: Carotenoids; Nutraceuticals; Algae; Biorefinery; Phycoremediation; Nanotechnology; Material Synthesis; Biopolymers; Heavy Metals

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IL017

INTEGRATION OF NANOMATERIALS IN MICROALGAE SYSTEM FOR CARBON CAPTURE, WASTE UTILIZATION AND SUSTAINABLE BIOPRODUCTS

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ABSTRACT

Microalgae possess remarkable properties including carbon dioxide mitigation, accruing intracellular lipids and pigments including carotenoids, which makes them a potential feedstock for biofuel and value-added products. However, narrow photosynthetic light absorption and limited CO_2 capturing and retention capacity are major bottlenecks that remain key obstacles to practical commercialization. Nanomaterials including metal oxide nanoparticles, carbon nanomaterials and nanocomposites are known to overcome these restrictions. Their extraordinary physicochemical characteristics, as well as an enormous surface area, can be exploited in practical applications. Some nanomaterials are reported to promote the photosynthetic efficiency of microalgal cells, which in turn increases biomass production. Furthermore, by using specific nanoparticles, a solution for the microalgae mediated wastewater treatment along with advancement in lipid production can also be achieved. A specific group of nanomaterials like quantum particles target the upregulation of the key enzymes involved in the carbon capture and lipid synthesis pathway, which in turn leads to higher biomass and lipid accumulation. However, most of the studies deciphered their toxic behaviour and troublesome waste management. The present study endeavours to deliver an overarching insight into the impact of nanomaterials on microalgae photosynthesis, production of lipids and other bioactive compounds. The study also focuses on the use of algal residue in possible applications that makes the process largely sustainable with zero waste. It surveys the state of the combination of nanotechnology and microalgae via nano-bionic approach to propose sustainable industries.

Keywords: Microalgae; Nanomaterials; Carbon capture; Lipids; Value-added products

IL018

FROM NATIVE CYANOBACTERIAL DIVERSITY TO FUNCTIONAL POTENTIAL: *NEOWOLLEA MANOROMENSIS* VU24

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ABSTRACT

Cyanobacteria associated with agricultural soils represent an underexplored resource for developing biological inputs for sustainable crop production. In this study, a heterocytous cyanobacterial strain, VU24, was isolated from native paddy-field soil and investigated for its taxonomic identity and plant growth-promoting potential. Morphological examination revealed straight, unbranched trichomes, barrel-shaped vegetative cells, spherical heterocytes, solitary oval akinetes and proakinetes associated with heterocytes. Phylogenetic analysis based on the 16S rRNA gene placed VU24 close to *Neowollea manoromensis*, supporting its affiliation with this lineage. The strain was further evaluated for production of indole-3-acetic acid (IAA), an important plant growth regulator. TLC, FTIR and HPLC analyses provided evidence for the presence of IAA in the cyanobacterial extract. Application of the extract to paddy seeds enhanced germination and early seedling development. The highest germination recorded was 95.55%, compared with 82.44% in the untreated control. At the effective concentration, the treatment also increased root length, shoot growth, chlorophyll accumulation and seedling biomass. The response varied with extract concentration, with higher concentrations showing a decline in some growth parameters. These findings demonstrate the bioactive potential of the native cyanobacterial isolate and indicate that its metabolites can contribute to early plant establishment. The study provides a basis for exploring native cyanobacterial resources as biological inputs for sustainable rice production.

Keywords: Cyanobacteria; IAA; Paddy; Plant growth promotion; Sustainable agriculture

IL019

ALGAL BIOTECHNOLOGY FOR TACKLING PFAS CONTAMINATION: CURRENT ADVANCES AND FUTURE OPPORTUNITIES IN REMEDIATION AND BIOMASS VALORIZATION

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ABSTRACT

Per-and polyfluoroalkyl substances (PFAS) represent a growing environmental concern due to their exceptional persistence, widespread occurrence, and resistance to conventional degradation. Their strong C-F bonds and structural diversity, particularly among short-chain and emerging PFAS create significant barriers to efficient and sustainable remediation. Algal biotechnology is emerging as a sustainable nature-based strategy for PFAS mitigation, wastewater treatment, CO2 capture, and the generation of value added products from algal biomass. This review critically examines recent progress in algal-based PFAS remediation, with emphasis on adsorption, bioaccumulation, biotransformation, and algal-derived adsorbents as well as differences in PFAS responses among algal species. Recent strategies including PFAS-tolerant algal strains, optimized cultivation conditions, immobilized algal systems, and algal-microbial consortia are discussed for improving PFAS removal and transformation. The integration of omics, advanced analytical techniques, and artificial intelligence/machine learning provides new opportunities to identify PFAS responsive pathways, understand algal-PFAS interactions, and guide the selection of effective biological systems. Since PFAS may accumulate in algal biomass during remediation, its direct reuse may raise environmental and safety risks. Therefore, valorization of PFAS accumulated algal biomass through conversion into value added products such as biochar and other carbon-based materials represents a potential route for biomass valorization and sustainable resource recovery. However, the behavior, transformation, and potential release of PFAS during biomass processing must be carefully evaluated to ensure the safety and environmental sustainability of the resulting products. Major challenges include incomplete degradation, limited defluorination, formation of transformation products, lower removal of short-chain PFAS, toxicity, and limited pilot scale studies. Future research should focus on combining algal systems with other treatment methods while considering cost, environmental impact, and safe biomass management for real world application.

Keywords: Biomass valorization; Defluorination; Microalgae; Per- and polyfluoroalkyl substances (PFAS); Sustainable remediation

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IL020

UNCOVERING THE BROAD PHYSIOLOGICAL IMPACT OF CYANOBACTERIAL GLUTAREDOXINS

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ABSTRACT

Cyanobacteria are photoautotrophic organisms that use light and water as a source of energy and electrons, respectively, to fix atmospheric carbon dioxide and release oxygen as a by-product during photosynthesis. However, photosynthesis and fitness of organisms are challenged by seasonal and diurnal fluctuations in light environments. Also, the distribution of cyanobacteria in a water column is subjected to changes in the light regime. The quality and quantity of light change significantly in low and bright light environments that either limit photochemistry or result in photoinhibition due to an excess amount of light reaching reaction centers. Therefore, cyanobacteria have to adjust their light-harvesting machinery and cell morphology for optimal light harvesting. Thioredoxins (Trxs) and Glutaredoxins (Grxs) regulate several cellular processes by controlling the redox state of their target proteins. Trxs and Grxs belong to the thioredoxin superfamily and possess characteristic Trx/Grx fold. Grxs, the oxidoreductase proteins, are involved in several cellular processes, including the maintenance of cellular redox potential, iron-sulfur homeostasis, nucleotide biosynthesis, etc. The analysis of 503 amino acid sequences from 167 cyanobacterial species led to the identification of four classes of cyanobacterial Grxs, i.e., class I, II, V, and VI Grxs. Class III and IV Grxs were absent in cyanobacteria. Class I and II Grxs are single-module oxidoreductases while class V and VI Grxs are multimodular proteins having additional modules at their C-terminal and N-terminal end, respectively. Furthermore, class VI Grxs are exclusively present in marine cyanobacteria. Grxs genes are upregulated under different environmental stress conditions in a cyanobacterium *Synechococcus elongatus* PCC 7942. Deletion of Grxs genes in the same cyanobacterium affected the developmental process by altering the morphology, pigmentation, protein, carbohydrate, and lipid content, etc. Detailed analysis suggested knockout strains have compromised genomic DNA which could be responsible for the observed pleiotropic effect. My presentation will include recent work on cyanobacterial Grxs that demonstrate their importance in the normal developmental program of *S. elongatus* PCC 7942.

Keywords: Cyanobacteria; Glutaredoxins; Photosynthesis; Redox; Thioredoxins

IL021

AMAZING INTERACTIONS OF MICROALGAE: THE DRIVERS & PRACTICAL IMPLICATIONS

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AM, is Dr. Rita Duggal Chair Professor at CRDT, IIT Delhi who has led several carbon negative-integrated algal biorefinery projects, product formulation and technology development for on-site municipal and industrial effluent's treatment coupled with renewable energy generation. Supervised 29 PhDs, earned 6 patents, >200 high impact publications with 16710 citations, h-i: 63, i-10-193. She holds a PhD from IITD followed by JSPS and a recent Fulbright-Kalam Visiting Professorship at Princeton University. Weaved international collaborations with Netherland, Sri-lanka, Brazil, France, besides industrial collaborations. Received DST-Lockheed Martin IIGP Award, BRSI Fellow Award, Prof. K.L. Chopra Applied Research Award, TOP 75 women in STEAM, Springer Nature Award. She has been Highlighted in Top 2% scientists by Scopus and Stanford list in Biotechnology.

ABSTRACT

Here I describe the interesting interactions among diverse microalgae and fungi. Driven by curiosity of what drives these interactions, several questions prompt up: Why microalgae and fungi fail to come together under certain conditions? What actually matters? Is fungal agent the driver of this attraction or it is the microalgal cell? Is the trigger present on the surface, inside the cell or could it be extracellular? Are these interactions pair specific? What advantages could be derived from these associations?

The answers to these questions lead to the understanding of mechanism of algal-fungal interactions. The results establish that young exponential phase fungal hyphae with high metabolic activity can attract the algal cells efficiently while the stationary phase hyphae fail to do so. Also, turbulent mixing negatively impacts these interactions. The most interesting observation is the failure of algal-fungal interaction when washed fungal pellets are used pointing to the requirement of certain key molecules present on fungal cell surface or the spent. The talk describes, how we track this key molecule and complete the story. On the practical side, algae harvested using the fungal agent has significantly higher biogas yield as it is enzymatically treated *in-situ* due to vicinity to the fungal hyphae. becomes a more suitable substrate. This technology package involving simultaneous bioharvesting of algal biomass and its pretreatment by *in-situ* enzymes for enhanced biogas production has been tested at pilot scale and patented (Indian patent no. 324527). On the similar lines, algal-bacterial interactions in oxygenic photogranules not only lead to process advantages but also superior functionalities in complex environment.

Keywords: Algae; Fungi; Interactions; Harvesting, Bacteria, Biogas

IL022

REDEFINING PHYCOFACTORIES: ALGAL INNOVATION FOR SUSTAINABLE DEVELOPMENT THROUGH OMICS-LEVEL METABOLIC REWIRING

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ABSTRACT

A fundamental bottleneck in microalgal phycofactories is the operational trade-off between biomass accumulation and stress-induced synthesis of high-value biocommodities. To bypass this limitation, we investigated the omics-level metabolic rewiring of *Chromochloris zofingiensis* cultured across six combinatorial regimes of nitrogen availability (replete, limited, and deplete) with and without CO_2 supplementation. Coupling regulated nitrogen limitation with continuous CO_2 enrichment (NLc) promoted rapid cellular proliferation prior to target compound induction, effectively decoupling growth kinetics from secondary metabolite synthesis. Under NLc, cultures achieved 894.6 mg · L^{-1} of dry biomass by day 9, vastly exceeding the 202.2 mg · L^{-1} produced under nitrogen depletion with CO_2 (NDc). The total exhaustion of extracellular nitrate by day 6 triggered an uninhibited physiological shift that drove concurrent production, yielding maximum volumetric productivities of astaxanthin (2.7 mg · L^{-1} d^{-1}), lipids (24.7 mg · L^{-1} d^{-1}), and carbohydrates (31.2 mg · L^{-1} d^{-1}). High-resolution untargeted LC-MS metabolomics annotated 508 metabolites, of which 320 were significantly altered ($p < 0.05$). Multivariate pathway analysis revealed that dynamic C:N stoichiometry orchestrates a hierarchical nitrogen-scavenging cascade marked by early polyamine catabolism and amino acid pool exhaustion, alongside active thylakoid galactolipid and glycerophospholipid turnover that funnels acyl moieties into triacylglycerols. Concurrently, reciprocal regulation between astaxanthin and methionine sulfoxide established an integrated antioxidant-protective system. These findings provide a mechanistic blueprint for harnessing industrial CO_2 capture and precision nutrient modulation, establishing a robust paradigm for next-generation sustainable algal biorefineries.

Keywords: Astaxanthin; Biorefinery; *Chromochloris zofingiensis*; Metabolomics; Sphingolipids

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IL023

INTEGRATED ASSESSMENT OF PHOTOSYNTHETIC EFFICIENCY, CARBON CAPTURE, ENERGY POTENTIAL AND DEWATERING OF BIOMASS OF MICROALGAE FOR SUSTAINABLE BIOMASS PRODUCTION

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ABSTRACT

Moving towards the production of carbon-neutral products and the use of renewable fuels involves the need for efficient biological carbon capture and biomass production. In this study, an indigenous, low-cost, modular flat-panel photobioreactor designed by CSIR–NBRI was assessed for use in carbon capture and utilization (CCU) by means of cultivating microalgae. Five strains, *viz*. *Synechococcuselongatus*, *Chlorellasorokiniana*, *Desmodesmusmultivariabilis*, *Euglenagracilis* and *Diacronemalutheri*, were examined under CO_2 concentrations ranging from 0 to 2,000 ppm and light intensities from 0 to 2,000 µmol photons m^{-2} s^{-1}. Net photosynthetic rates increased withincreasing CO_2 concentration, with the highest rates observed at 1,400 ppm, and the productivity trends generally matched the light-response curves. Chlorophyll *a*-normalized photosynthetic rates of 1.6 ± 0.2 and 4.4 ± 0.8 µmol CO_2 μg^{-1} chlorophyll *a* h^{-1} were obtained, the cell concentrations being between 1.3 × 106 and 2.0 × 106 cells mL^{-1}. *D. multivariabilis* did not show any signs of photosynthetic saturation over the range of light intensities tested. The effectiveness of post-harvest preservation was investigated using cold drying, sun drying and spray drying at intervals of 2 to 48 h. Cold drying, which was started within 2 to 4 h of harvest, preserved the biochemical composition without any detectable loss; in contrast, spray drying led to losses of 1 to 1.2% of biomolecules and sun drying caused losses of 5 to 28%. After 48 h, the ash content was above 40% for all the strains. The microbial load was lowest when cold processing was started 2 h after harvest. The results show that it is important to combine the evaluation of photosynthetic performance with prompt dewatering of the biomass in order to achieve sustainable carbon utilization and to promote the development of microalgal biorefineries.

Keywords: CO_2 assimilation; Carbon capture; Flat-panel photobioreactor; Drying methods; Microalgae; Photosynthetic efficiency.

IL024

CHARACTERIZATION AND THERAPEUTIC APPLICATIONS OF CYANOBACTERIAL PHYCOBILIPROTEINS

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ABSTRACT

Phycobiliproteins (PBPs) are water-soluble light harvesting proteins found in cyanobacteria and red algae. They facilitate efficient capturing and controlled-transfer of sunlight energy downhill towards photosystem by holding the water insoluble chromophores very precisely in aqueous cell environment. Crystal structures of various sub-classes (phycoerythrin, phycocyanin and allophycocyanin) of phycobiliproteins from fresh water and marine cyanobacteria have been solved using X-ray crystallography in order to understand the underlying light harvesting principle. The crystal structure of unique single peptide phycoerythrin (PDB ID: 3MWN), produced under prolonged starvation condition have been solved, which depicts no role of first 31st N-terminal amino acids in structure assembly and functionality of phycoerythrin. The geometry and arrangement of chromophores and the energy transfer pathway in marine phycoerythrin (showing distinct sequence features) have been recognized through solution of its high-resolution crystal structure (PDB ID: 5AQD, 5FAB). Crystal structure of scarily found phycobiliprotein, allophycocyanin (which makes core of cyanobacterial light harvesting complex) is solved (PDB ID: 4RMP). This structure described the importance of some 'amino acid substitutions' in marine cyanobacteria providing the extra hydrophobic environment to the chromophore. Moreover, some therapeutically important properties (including antioxidant, anti-aging and anti-Alzheimeric activity) of phycobiliproteins that have been noticed in eukaryotic cell line and *Caenorhabditis elegans* model, is validated using homology-based protein structure modelling and protein-proteins docking.

IL025

SEAWEED RESOURCES, CULTIVATION AND UTILIZATION IN INDIA

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ABSTRACT

Seaweeds have been extensively utilized as a source of food and phycocolloids for over a century. Global aquaculture production reached 141.6 Mt in 2024, with an estimated farm-gate value of USD 391.5 billion, an increase of 10.3 Mt and USD 39.8 billion from 2022. This included 38.9 Mt of algae encompassing seaweeds and microalgae, with an estimated market value of 19.9 billion. India harbours 844 seaweed species, but only a limited number are commercially exploited for phycocolloid production, including *Gelidiella acerosa* and *Gracilaria edulis* (agar), *Hypnea* spp. (carrageenan), and *Sargassum* spp. and *Turbinaria* spp. (alginate). Currently, Indian phycocolloid industry comprises 26 factories, largely dependent on natural resources. Overexploitation of natural seaweed beds has intensified resource depletion, leading to degradation of wild stocks. The growing demand for raw seaweed by processing industries has outstripped the supply from natural sources. Suitable species must be identified for mariculture to ensure a reliable supply of seaweed biomass for domestic requirements. CSIR-CSMCRI has pioneered the development of cultivation technologies for commercially important seaweeds in Indian waters. The longline method was first attempted for *G. edulis* in 1970, followed by the Single Raft Floating Technique (SRFT) in 1990 and subsequent raft-based cultivation of *Kappaphycus alvarezii*, *Gracilaria debilis*, *G. dura*, and *G. edulis* in sheltered coastal waters. Tube-net technology was developed for *K. alvarezii* and *G. dura* in rough open-sea conditions, while net-bag systems enabled seed-stock maintenance during lean periods. All technologies developed by CSIR-CSMCRI attained the global standard Daily Growth Rate (DGR) of 3.5% day^{-1}.

Keywords: Agar, Alginic acid, Carrageenan, Cultivation, *Gracilaria*, *Kappaphycus*

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IL026

CURRENT TRENDS OF AI/ML IN ALGAL BIOTECHNOLOGY

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ABSTRACT

Artificial intelligence and machine learning (AI/ML) are rapidly reshaping the research paradigm of algal biotechnology, with applications expanding from early statistical optimization to process control, strain screening, and bioprospecting. In cultivation process optimization, the integration of artificial neural networks (ANNs) with genetic algorithms has been successfully employed to predict and regulate microalgal growth conditions and lipid accumulation. Ensemble decision-tree models are used to decipher nonlinear relationships between culture conditions and lipid productivity significantly reducing the experimental search space. Similarly, the ANN-driven photobioreactor enabled real-time regulation of lipid accumulation achieving higher lipid yield under optimized conditions. In real-time monitoring and species identification, deep learning networks have demonstrated near-expert performance. A microalgal detection network based on neural architecture classifies the algal species, substantially outperforming manually designed models. Furthermore, AI/ML applications in harmful algal bloom (HAB) prediction are maturing, with models such as Random Forest and XGBoost used to reconstruct bloom dynamics from sparse monitoring data, while interpretability tools like SHAP help identify key environmental drivers. Nevertheless, the field still faces several bottlenecks: the scarcity of high-quality omics and cultivation data limits model generalizability, many models remain "black boxes," and a significant gap persists between computational prediction and experimental validation. Future trends point toward digital twins and hybrid modeling frameworks that integrate mechanistic models with data-driven approaches to achieve more robust predictions under data-limited conditions, driving algal biotechnology from experience-driven practice toward predictive engineering.

Keywords: artificial intelligence; machine learning; algal biotechnology; microalgae; process optimization; strain screening; photobioreactor; harmful algal blooms; deep learning; digital twins; hybrid modeling

IL027

FUNGAL CELL-FREE EXTRACT-MEDIATED BIOTRANSFORMATION OF CYANOBACTERIAL BIOMASS FOR ENHANCED BIOAVAILABILITY OF NUTRIENTS

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Dr. Amritpreet Kaur Minhas has been passionately involved in microalgal research for over 10 years after her Ph.D in the area of microalgal biotechnology, research in the field of Bioprospecting and Biorefining of algal metabolites for aqaufeed and biostimulant application. She is leading the industrial projects for developing algae based feed products. She has been actively involved with centre of excellence project on advanced biofuel and is expert DBT member. She is the editorial board member of journal of microbiology and biotechnology. She has published 17 research and magazine article having 900+citations.

ABSTRACT

Microalgae and cyanobacteria are sources of big molecules like polysaccharides, peptides, polyunsaturated fatty acids, lipids, vitamins, minerals, carbohydrates, oligosaccharides and dietary fibers that help people stay healthy. Many of these substances are, in complicated forms or locked inside the cell membrane, which makes it hard for the human body to break them down and use them properly. Traditional solvent-based and chemical methods for extracting valuable metabolites from microalgae and cyanobacteria are associated with low efficiency, leading to unacceptable losses of target compounds, as well as high costs and environmental risks. One promising approach is the use of microbial cell-free extracts (CFEs) enzymatic process bioprocessing of algal biomass. The study aimed to evaluate a green process, cell-free extract (CFE) from fungi *Aspergillus* sp., containing lignocellulolytic and carbohydrate-active enzymes, for bioleaching of cyanobacterial cell walls. *Spirulina* sp. and *Synechocystis* sp. PCC 6803 biomass were subjected to five treatment regimens combining CFE, pretreated biomass or supernatant, and citric acid, and evaluated over 24-48 hours. Dynamic light scattering revealed significant decreases in particle sizes ranging from 1065 to 236 nm, indicating cell wall destruction. There was increase in yield of carbohydrate and protein vs unfermented biomass. Thus, the bioleaching strategy using CFE from *Aspergillus* sp. could be a cost-effective way to increase the nutrients' bioavailability from cyanobacterial biomass. The next step of this research is to perform a metabolomics and proteomics analysis of the obtained extracts.

Keywords: Biomass; *Spirulina*; Bioleaching; Fungus

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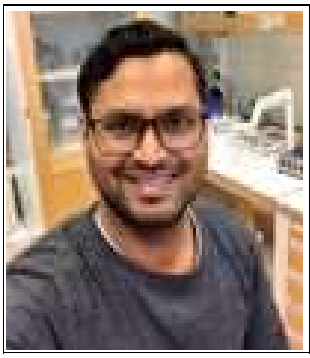
IL028

DECIPHERING SALT-STRESS ADAPTATION IN MICROALGAE: FROM METABOLIC REMODELLING TO MOLECULAR REGULATION

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ABSTRACT

Microalgae dynamically remodel their intracellular and extracellular metabolites to adapt to fluctuating environmental conditions. Salinity is one such stress that affects cell physiology and metabolism. Our research explores salt-stress adaptation in selected freshwater microalgae from an integrated biochemical and molecular approach. We investigate how salinity affects major intracellular metabolites while simultaneously influencing the production of Extracellular Polymeric Substances (EPS). These extracellular responses contribute to cellular interactions, aggregation, and protection, highlighting the importance of EPS in stress adaptation. The observations from biochemical estimations were validated using FTIR spectroscopy coupled with multivariate analysis, which demonstrated species-specific biochemical remodelling. Further, GC-FID showed alterations in fatty acid composition under salt stress. Collectively, these findings indicate that salt stress induces coordinated carbon redistribution between intracellular storage metabolites and extracellular protective matrices. To further investigate the molecular regulation underlying this adaptive response, we extended the study to a genetic approach using *C. reinhardtii*. A salt-induced bZIP Transcription factor (SiTF1), was selected for functional characterisation, and a corresponding mutant was examined alongside the wild type under control and prolonged salt-stress conditions. Comparative analysis under prolonged salt-stress conditions helps to investigate how transcriptional regulation influences the coordination of intracellular metabolism and extracellular matrix dynamics in salt-induced cellular acclimation. By integrating biochemical and molecular perspectives, our study helps to connect the metabolic phenotypes observed under salinity with their underlying regulatory mechanisms. Overall, this work establishes a framework linking intracellular and extracellular metabolite remodelling and its molecular regulation under salt stress in freshwater microalgae. Understanding these interconnected adaptive mechanisms provides new opportunities for improving stress tolerance and directing metabolite production in microalgal biotechnology.

Keywords: Microalgae, Salt stress, Metabolic remodelling, Extracellular polymeric substances, Molecular regulation.

IL029

ADAPTIVE LABORATORY EVOLUTION OF CYANOBACTERIA FOR SUSTAINABILITY ON EARTH AND SPACE

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ABSTRACT

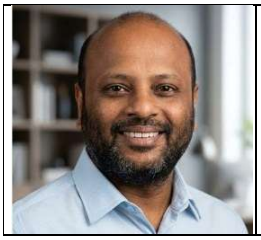
The circularization of CO2 and the utilization of waste nitrogenous compounds are essential for sustainability on Earth and in Space. Phototrophic organisms that can effectively utilize CO2 and waste nitrogenous compounds are essential biological catalysts for the design of sustainable systems. Cyanobacteria are the oldest living phototrophs with the fastest growth rates, can utilize urea, and possess the robustness needed for industrial applications. However, as with many microalgae, elevated carbon dioxide levels can cause stress, reducing carbon fixation. As with many other organisms, cyanobacteria can utilize urea for growth but are sensitive to elevated urea levels. We have developed a native marine Synechococcus strain capable of growing at elevated CO2 levels through adaptive laboratory evolution (ALE) and medium engineering. The strain efficiently captured > 90% of the CO2 from a simulated flue gas. The biomass produced was used to extract food-grade phycocyanin, a high-value pigment. This strain can serve as an important biocatalyst for Carbon Capture and Utilization from industrial flue gases. Another Synechococcus strain was adapted to grow on urea. An experiment was also conducted aboard ISS in the Axiom-4 mission to demonstrate, for the first time, the growth of cyanobacteria on urea in space. Further ALE and medium engineering have led to a strain capable of growing at urea levels ~10 times higher than previously reported concentrations. Such strains will serve as important biocatalysts in the development of life-support systems for long-term space travel and space stations.

Keywords: Carbon capture; Life support systems; Marine cyanobacteria; Nutrient recycling; Pigment production

IL030

ENGINEERING ALGAL BIO-ACTIVES INTO SMART FUNCTIONAL FOOD INGREDIENTS

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ABSTRACT

Algal bioactive compounds have many functional benefits but are limited by low temperature and light stability, rapid lipid oxidation, and poor gastrointestinal bio accessibility. This study reports two novel strategies to transform the fragile algal bioactive molecules into robust, high-efficiency functional food ingredients. A Box-Behnken response surface methodology was employed to optimize the supramolecular complexation between PC proteins and PT polyphenols. The best processing conditions yielded a colloidal complex of 113 nm. FTIR spectroscopic analysis showed the formation of hydrogen bonding contacts between the hydroxyl groups of phloro-tannins and the carbonyl groups of the protein backbone (shifting of Amide I and II bands), causing changes in the secondary structure of the protein. Fluorescence quenching kinetics confirmed static ground-state complex formation with an apparent quenching rate constant of . The supramolecular complex was integrated in a dairy yoghurt matrix and used as an active particle filler. After 28 days of storage (4°C), phycocyanin retention was noted at 70.6%, resulting in enhanced antioxidant activities and 59% intestinal bio accessibility. Algal oil droplets rich in DHA/EPA were stabilized by interfacial engineering with a protein-rutin conjugate layer wrapped in a protective outer polysaccharide barrier. This interfacial structure effectively suppressed primary lipid oxidation and maintaining the peroxide values below 1.5 meq/kg. This enhanced DHA retention to 67.7% resulting in 72% intestinal DHA bio accessibility. These findings enable predictive structure-function engineering of stable algae functional components for emulsion food systems.

Keywords: Bioactive Compounds, Phycocyanin, Phloro-tannins, Lipid Oxidation, Food Matrix Modification

IL031

BIOPROSPECTING OF MARINE RESOURCES FOR BIOFUELS, BIOPOLYMERS AND NEUTRACEUTICAL PRODUCTION

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Sourish Bhattacharya has completed his B. Tech in Biotechnology from West Bengal University of Technology and M.Tech in Fermentation Technology from Institute of Chemical Technology, Mumbai and PhD from AcSIR-CSMCRI. Presently he is working as a Scientist at CSIR-Central Salt and Marine Chemicals Research Institute, India. He is having a strong background in the area of biopolymers for therapeutic applications and nutraceuticals. He has published 49 papers, 15 book chapter and 4 patents to his credit. .

ABSTRACT

West coast of India can be considered as important area for collecting diverse marine microorganisms with biopolymer producing capacity. In this attempt, more than 200 marine microalgal isolates from west coast of India was obtained, out of which one strain *Chlorella variabilis* was found to be potential for producing microalgal biomass having average biomass productivity of 20-25 g/m^2/d with non polar lipid content of 10-12% with respect to dry weight.

Further, A sustainable process was developed for production of γ-linolenic acid through biorefinery model wherein ε-polylysine and protein rich powder was produced as by-product using CSIR-CSMCRI's strain CSMCRI's *Coelastrella thermophila*.

CSIR-CSMCRI has developed a cost effective and sustainable process for Microalgal Mass Cultivation and utilization of autosettled microalgal biomass for crude oil generation and the technology was transferred to Tata Chemicals for its successful commercialization. As per CSMCRI's process, the cost of microalgal biomass is ₹ 35 per Kg and ₹ 60-80 per Kg microalgal oil. Further, in order to make the microalgal biofuel cost effective and sustainable, one of the CSMCRI's marine isolate *Bacillus licheniformis* PL26 was found to be potential for producing ε-polylysine and polyhydroxyalkanoate simultaneously in same fermentation medium. The PHA produced by *Bacillus licheniformis*was found to be poly-3-hydroxybutyrate (P3HB). Further, in order to improve the ε-polylysine production, the carbon source was replaced with glucose which yielded 1.2 g L-1 ε-polylysine as oxygen transfer rate is very low in the medium containing crude glycerol.

Keywords: Microalgal Biofuel, Biopolymers; Polyhydroxyalkanoates (PHA); γ-Linolenic Acid; *Coellastrella thermophila;* ε-polylysine.



Abstracts of Award Lectures

Mid-Career Award

HARNESSING ALGAE AS VERSATILE BIOLOGICAL PLATFORMS FOR ADDRESSING THE ENERGY–ENVIRONMENT–HEALTH NEXUS

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Dr. Krishna Mohan Poluri is currently working as a Professor at Department of Biosciences and Bioengineering IIT-Roorkee. He completed his PhD from TIFR-Mumbai, and Post-doc from Rutgers University & University of Texas Medical Branch (UTMB-Texas). His areas of expertise are Structural and Computational Biology, Biological NMR Spectroscopy,, Bionanotechnology and Algal Biotechnology etc. He has published ~ 230 publications publications in various reputed SCI Journals and filed 7 patents (3 granted). He has supervised 16 PhD scholars, and received several National level awards including: H S Atreya Award by NMRS (2023), SERB-STAR Award (2022), Innovative Young Biotechnologist Award (IYBA)-2013 by DBT, NASI-Platinum Jubilee Young Scientist (2013), and Young scientist Award by Indian Science Congress Association (ISCA)-2009.

ABSTRACT

Algae offer versatile biological platforms for addressing interconnected challenges in sustainable energy, environmental protection, and healthcare. This lecture presents an integrated research vision spanning four complementary themes: (i) microalgae-based bioenergy and value-added products (ii) algal bioremediation of heavy metals and emerging environmental pollutants; (iii) integrated omics and genetic engineering to elucidate stress-response mechanisms and identify targets for enhanced lipid accumulation and environmental resilience; and (iv) environmental and biomedical applications of algal polymers, particularly alginate/carrageenan-based functional nanomaterials and porous beads/membranes/aerogels. By combining molecular biology, metabolomics, materials science, and data-driven approaches, our research resolves these research directions to establish connections between fundamental biological insights and practical technological solutions.

Keywords: Microalgae; Biorefinery; Bioremediation; Circular economy; Biomedical Technologies

Early Career Award

BIODEGRADABLE ALGAL BIOFILMS FOR WASTEWATER REMEDIATION AND BIOMASS VALORIZATION

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Dr. Sanjeev Mishra is working as a Scientist-D, Biochemical Conversion Division, Sardar Swaran Singh National Institute of Bio-Energy (An Autonomous Institute of MNRE, GOI), Kapurthala, Punjab. His research focuses on the "Production of 3rd generation biofuels and value-added products from organic waste via algal biorefinery approach". Dr. Mishra has a PhD from the School of Energy Sciences and Engineering, IIT Guwahati (supervisor: Prof. Kaustubha Mohanty), and a Postdoc from Nanyang Technological University Singapore.

ABSTRACT

The growing demand for sustainable wastewater management and renewable energy solutions has stimulated interest in microalgae-based bioremediation systems that integrate pollutant removal with biomass production. In this context, the present study focuses on the development of an attached algal biofilm reactor for the simultaneous treatment of municipal wastewater and sustainable microalgal biomass generation. The developed system aims to provide an environmentally friendly and resource-efficient approach by harnessing the ability of selected microalgal strains to form biofilms on suitable support materials, facilitating efficient nutrient assimilation, wastewater remediation, and biomass harvesting. To enhance reactor performance and process efficiency, different support materials and biofilm-forming microalgal strains are being systematically evaluated based on biofilm development, biomass productivity, and wastewater treatment efficiency. The harvested algal biomass is further investigated for its biochemical characteristics and valorization potential, particularly as a renewable feedstock for biohydrogen production. Suitable biomass pretreatment and fermentation strategies are being explored to improve substrate availability and enhance biohydrogen generation. Overall, the study aims to establish a sustainable algal biorefinery platform that couples municipal wastewater remediation with biomass production for biofuel conversion, contributing to circular bioeconomy principles, resource recovery, and the development of low-carbon wastewater treatment technologies.

Keywords: Attached biofilm reactor; Biomass valorization; Municipal wastewater; Nutrient removal

Emerging Career Award

NANOPARTICLE-MICROALGAE INTERACTION FOR BIOENERGY APPLICATIONS

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ABSTRACT

Microalgae is one of the most promising platforms for production of biofuels, particularly, biodiesel. However, the commercial viability of microalgal biofuel is constrained by low biomass productivity, high harvesting costs, contamination risks, and low economic returns. Nanoparticles interaction with microalgae has attracted attention due to their potential to influence cellular physiology, metabolic activities, and biomass productivity. We investigated the interaction between iron oxide nanoparticles (IONPs) and selected Chlorella species under phototrophic and mixotrophic conditions, with particular emphasis on species-specific responses, oxidative stress, and biofuel potential. Our findings revealed contrasting cellular responses to IONPs exposure. Under phototrophic conditions, IONPs supplementation at 20 mg L-1 enhanced biomass concentration of Chlorella pyrenoidosa by approximately 34% whereas inhibited the growth of Chlorella sorokiniana even at 2 mg L-1. Under mixotrophic conditions, IONPs supplementation increased C. pyrenoidosa biomass by 16% and enhanced lipid production by 53%, attaining 26% dry cell weight on the offset of protein. Under IONPs exposure, the cellular stress increased by up to 306%, suggesting reactive species generation and changes in cellular carbon allocation. Along with changes in biochemical composition, the IONPs were noted to alter fatty acid composition of lipids. Additionally, the IONPs, retained with biomass influenced anaerobic digestion process, improving biogas production and methane content by approximately 25%. Overall, the findings species-specific responses, which should be considered for developing controlled nanoparticle assisted microalgal system for sustainable biomass production, resource recovery and bioenergy application.

Keywords: Algae, Iron oxide nanoparticles, Reactive oxygen species, Biodiesel, Biogas

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Best PhD Thesis Award

DEVELOPMENT OF DIATOM BASED NANO BIO-PESTICIDE FOR CROP AND GRAIN PEST CONTROL

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ABSTRACT

My thesis attempted to address sustainable pest management and environmental bioremediation by optimising diatom cultivation in waste-derived media, extracting biogenic silica from diatoms using surfactants, bleach, and hydrothermal liquefaction (HTL), and obtaining biocrude as a co-product from HTL. In the first objective, various attempts were made to obtain an aqueous silica hydrolysate from agro-residues for diatom cultivation. Next, the abiotic factors were optimised to maximise diatom growth and silica removal in industrial wastewater. A novel rice straw hydrolysate (RSH) at 30% dilution achieved the highest growth rate (μ_{max} = 0.46 day^{-1}) for diatom *Navicula* cultivation. A combination of pH 7 and magnetic stirring with blue-wavelength light enhances biomass productivity to 95.15 ± 1.34 mg L^{-1} d^{-1}. Further, in bioremediation of cooling tower blowdown water, a silica removal rate of 13.90 ± 0.26 mg L^{-1} d^{-1} was achieved (3.69-fold greater than the control). The biogenic silica cargo from the diatom was extracted using surfactants and bleach treatments. The bleach-treated frustules were found mesoporous, with a surface charge of -17.6 ± 0.9 mV, a surface area of 19 m^2 g^{-1}, and an average pore diameter of 31.99 ± 0.5 nm. A life cycle assessment indicated that the process reduced environmental impact by 99% compared with conventional acid treatment. The HTL process was optimised, and a 60- minute reaction time yielded 5.5% (1.1 g) extracted biocrude and 19% residual biocrude (3.8 g), accounting for a total yield of 24.5% (4.9 g) with a HHV of 31.90 MJ Kg^{-1}. A temperature-dependent controlled release formulation was developed by frustule functionalisation, followed by clove oil (CEO) loading and capping with biopolymer (DF- APTES-30-CEO-300-Temp-Cap). The DF-APTES-30-CEO-300-Temp-Cap was found to have strong fumigant activity against *Oryzaephilus surinamensis*, achieving 100% mortality at 500 mg L^{-1} (air) with temperature-dependent efficacy. A pH-responsive antifungal formulation was also developed using functionalised diatom frustule, followed by loading of CEO and chitosan oating (DF-APTES-30-CEO-300-Chi-Cap). The DF-APTES-30-CEO-300-Chi-Cap at a dose of 500 mg L^{-1} found a complete mycelial inhibition against *Fusarium oxysporum*, with an LC_{50} of 170 mg L^{-1}. The formulation was biocompatible, had a shelf life of two years, and was also UV-B stable. In conclusion, the current study successfully develops diatom-based pH-dependent controlled- release biofungicide and temperature-dependent controlled-release bioinsecticide for sustainable pest management. Additionally, the current study developed a bioremediation process for treating agro-waste and industrial silica wastewater simultaneously. The HTL process yielded high-value biocrude and aqueous fractions, illustrating a potential biorefinery approach targeting multiple sectors such as bioenergy, pharmaceuticals, and more.

Keywords: Diatoms; wastewater treatment; Biofuel; biogenic silica cargo; Control release agroformulation

Co-authors: Anushree Malik, Satyawati Sharma, Ramesh Raliya

Best Master's Thesis Award

ASSESSING THE IMPACT OF DIFFERENT NITROGEN AND PHOSPHORUS SOURCES ON BIOMASS AND LIPID PRODUCTION IN *DESMODESMUS* SP.

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ABSTRACT

Although microalgal oil offers tremendous potential for application in the nutraceutical sector. However, nutrient cost and the efficiency of producing specific fatty acids limit their widespread use. The nutrient supplies of phosphate (P) and nitrogen (N) are the main costs associated with microalgae production. Thus, this study evaluated the impact of different N and P sources on the growth, biomass, and polyunsaturated fatty acid (PUFA) production in *Desmodesmus multivariabilis*, followed by cost analysis. Sixteen random combinations of different standard and low-cost N sources ($NaNO_3$ (N1), $Ca(NO_3)_2$ (N2), KNO_3 (N3), and $CO(NH_2)_2$ (N4)) and P sources (NaH_2PO_4 (P1), KH_2PO_4 (P2), K_2HPO_4 (P3), and $Ca(HPO_4)_2$ (P4)) were selected. The highest biomass productivities were observed in N1P2 (92.06 mg L^{-1} d^{-1}), N2P4 (89.64 mg L^{-1} d^{-1}), N4P2 (86.90 mg L^{-1} d^{-1}), and N4P3 (89.43 mg L^{-1} d^{-1}), respectively, comparable to the BG-11 control (89.29 mg L^{-1} d^{-1}), which were selected for further analysis. The treatments N4P2 and N4P3 showed significantly higher lipid productivity (19.10 and 21.15 mg L^{-1} d^{-1}, respectively) and PUFA content (38.15% and 30.69% of total fatty acids (TFA), respectively) compared to the control (18.63% TFA). Whilst the low values of the atherogenic and thrombogenic indices indicated the suitability of N1P3 (BG-11 control) and N2P4 as functional foods. The nutrient cost was reduced by 46.92% and 46.29% in treatments N4P3 and N4P2, respectively, as compared to the standard BG-11 medium. Thus, the findings demonstrate that N4P2 and N4P3 treatments were appropriate for microalgae-based PUFA production, providing a basis for future large-scale studies to enhance the practical utility of the optimized, low-cost media for nutraceutical applications.

Keywords: Microalgae, Nitrogen and phosphorus sources, Cost effectiveness, Fatty acid profiling, Nutraceutical applications

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Abstracts of Short Oral Presentations

SOP 001

MICROALGAL BIOREMEDIATION OF POLYCYCLIC AROMATIC HYDROCARBONS: LINKING POLLUTANT REMOVAL WITH PHOTOSYNTHETIC RESPONSES

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are persistent and toxic pollutants of aquatic ecosystems, and microalgae offer a promising, sustainable route for their removal. This summary presents a series of studies examining the bioremediation potential of Chlorella vulgaris and Scenedesmus acutus against PAHs of varying ring numbers and structural configurations, including naphthalene (NAP), anthracene (ANT), phenanthrene (PHE), pyrene (PYR), and fluoranthene (FLT). C. vulgaris removed 90–94% of NAP and FLT, 92% of ANT and 70% of PYR within 7 days, using catechol 2,3-dioxygenase (C2,3D), identified as a key enzyme driving PAH metabolism, the first such report in a eukaryotic alga. Comparative work across ring structures revealed that degradation efficiency and toxicity depend not only on molecular weight but also on ring arrangement, with angular PAHs (PYR and PHE) proving more resistant to degradation and more physiologically damaging than their linear counterparts (ANT and NAP), affecting growth, photosynthetic efficiency, and biomolecule composition. Environmental and physicochemical modulators further shaped bioremediation outcomes, mild NaCl-induced salinity stress enhanced PYR removal in both species, though with differing trade-offs in growth, light intensity governed the resilience of S. acutus over C. vulgaris under pyrene stress via photoprotective quenching mechanisms and silicon oxide nanoparticles (SiO_2) NPs enhanced both algal growth and pyrene biodegradation by upregulating C2,3D activity. Collectively, these findings establish C. vulgaris and S. acutus as effective, tunable platforms for PAH bioremediation, highlight the C2,3D pathway as a central metabolic route, and demonstrate that ring geometry, oxidative stress responses, and external factors can be strategically leveraged to optimize pollutant removal in aquatic systems.

Keywords: Bioremediation, catechol 2,3-dioxygenase, microalgae, polycyclic aromatic hydrocarbons, photosynthetic efficiency

SOP 002

SEQUENTIAL AERATION AND CHITOSAN PRETREATMENT OF LIQUID ANAEROBIC DIGESTATE FOR ENHANCED *SPIRULINA* CULTIVATION

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ABSTRACT

Liquid anaerobic digestate (LAD) is nutrient rich by-product of anaerobic digestion that can cause significant environment challenge if discharge without adequate treatment. However, because of its high nutrient content, it can be used as a substitute culture medium for the sustainable development of *spirulina platensis*. However, high ammonia concentrations and the bright color of LAD may have adverse effects on spirulina growth by producing ammonia toxicity and reducing light penetration, which reduces photosynthetic activity. Therefore, appropriate LAD pretreatment is necessary to reduce color and ammonia while preserving sufficient nutrients for spirulina growth. In this study a sequential strategy was developed in which aeration was initially employed for ammonia removal followed by chitosan treatment for colour reduction. Aeration pretreatment achieved 100% ammonia removal from LAD under optimized conditions. Subsequently hydrochloric acid (HCl) and acidic acid activated chitosan were evaluated at different concentration for colour removal based on absorbance. The colour reduction obtained with HCl activated chitosan ranged from 45.30 to 49.96% whereas acidic acid activated chitosan achieved 50.04–59.48% colour reduction. The sequential pretreatment subsequently improved the quality of LAD by removing ammonia and reducing colour, thereby improving its suitability for *spirulina* cultivated. The pretreated digestate can facilitate better light penetration and provide a more favourable environment for algal growth while retaining the nutrient recovery potential of the digested. Overall, the integration of LAD pretreatment with microalgal cultivation provides a promising strategy for LAD remediation nutrient recovery waste valorisations and sustainable *spirulina* biomass production contributing to a circular bioeconomy.

Keywords: Aeration; Ammonia removal; Chitosan; circular Bioeconomy; Colour removal, Liquid anaerobic digestate; *Spirulina* cultivation; Sustainable microalgal cultivation

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SOP 003

ALGAL-BASED BIOSTIMULANTS FOR CLIMATE-RESILIENT AGRICULTURE: PRELIMINARY EVALUATION OF WASTEWATER-GROWN ALGAL FORMULATION FOR SEED PRIMING

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ABSTRACT

Sustainable approaches to improve crop establishment and effective utilisation of resources are needed for climate-resilient agriculture. The aim of the present study is to investigate whether Secondary-Treated Wastewater (STWW)- grown microalgal cultures can be utilised as a biostimulant for seed priming of leafy vegetables. The microalgal cultures were scaled up from a lab-scale to 30L mass culture using wastewater. During cultivation, algal growth and biochemical changes were measured. The steam-sterilised whole-culture broth of five algae-based biostimulants (BS1-BS5) used for seed-priming experiments with Amaranthus and Lettuce. Germination% and Germination Index (GI) were evaluated in the early germination period compared with positive and negative controls. Among the treatments, BS4 recorded the highest germination% for *Amaranthus sp.* (79.55%) and for *Lactuca sativa* (87.06%), while BS5 showed the highest germination percentage for Lactuca sativa var. crispa (93.83%). BS5 also exhibited the highest GI in Amaranthus (80.5) and green lettuce (66), whereas BS4 recorded the highest GI in red lettuce (62). These responses were higher than control (WW). The data show that wastewater-grown algal biomass can be formulated as a biostimulant for seed priming, demonstrating effective, crop-dependent responses. This research ideology promises sustainable crop productivity in a circular bioeconomy approach.

Keywords: Algal biostimulant; Circular bioeconomy; Microalgae; Seed priming; Treated wastewater

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SOP 004

EDIBLE *AGARICUS BISPORUS* MYCELIA: A NOVEL TOOL FOR HARVESTING *CHLORELLA PYRENOIDOSA* AND GENERATING NUTRIENT-RICH COMPOSITE BIOMASS

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ABSTRACT

The rising demand for sustainable food and feed resources has increased interest in microalgae due to their high nutritional value and diverse bioactive components. However, harvesting of microalgae remains challenging because of their small cell size and poor sedimentation properties. Conventional methods can be energy- and chemical-intensive, highlighting the need for sustainable and food-compatible alternatives. Fungus-assisted harvesting offers a biological approach in which fungal mycelia interact with algal cells, promoting aggregation and facilitating biomass recovery. However, the use of edible mushroom mycelia for microalgal harvesting remains relatively underexplored. In this study, *Agaricus bisporus* mycelia were investigated for harvesting *Chlorella pyrenoidosa* and generating an algal-fungal composite biomass. Different *A. bisporus*: *C. pyrenoidosa* ratios (0:1-4:1) were evaluated on a dry cell weight basis under controlled mixing at 100 rpm and 28 °C. The 1:1 ratio achieved the highest harvesting efficiency of 80.44% after 21 h. The resulting composite biomass contained 51.19% protein, 16.49% carbohydrate and 7.34% lipid, indicating integration of nutritional constituents from both biomasses. This nutritional integration may enhance the overall value of the composite biomass for potential food and feed applications. Overall, the findings demonstrate the potential of edible *A. bisporus* mycelia as a sustainable harvesting agent while generating a nutritionally complementary biomass with potential for future food and feed applications.

Keywords:*Agaricus bisporus*; *Chlorella pyrenoidosa*; Composite biomass, Edible fungus-assisted harvesting; Microalgae

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SOP 005

MOLECULAR ADAPTATIONS OF MICROALGAE TO PVC-NANOPLASTICS STRESS FROM A METABOLOMIC AND LIPIDOMIC PERSPECTIVE

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ABSTRACT

Plastic wastes are categorized as persistent environmental pollutants but nanoplastics (NPs) are classified as an alarming class of emerging contaminants, due to their capacity for bioaccumulation and the subsequent transfer of toxic effects throughout trophic levels of the food chain. Studies proved that the natural occurrence of NPs from micro/macroplastics are detected mostly in aquatic environment where the synergy of physical abrasions and high biochemical activity is observed notably. Microalgae are primary producer in aquatic ecosystem also known for their bioremediation capabilities with industrial significance for the high value secondary metabolite production. Due to their bioadsorption and bioaccumulation potential they are prone to the interaction with free pollutants like NPs in the aquatic environment. This study examines the molecular response of *Chlorella sp.* when exposed to polyvinyl chloride (PVC-NPs) was analysed using integrated omics comprising of metabolomics, lipidomics. The metabolomic study revealed enhancement of tricarboxylic acid cycle and redirection to stress reliving metabolites. Further the lipidomics and showed significant compositional change in the total lipids. These claims were further substantiated with gene expression analysis using RT-PCR. These series of metabolic shift due to NPs stress triggered the compromise in cellular architecture as evident from atomic force microscopic imaging of cell surface and membrane fluidity study. Altogether, this study unveils molecular response of *Chlorella sp.* to PVC-NPs stress through integrated omics approach establishes the toxic nature of NPs to aquatic ecosystem, and the resilience of microalgae in adapting to the stress through metabolic rewiring.

Keywords: Gene expression, Lipidomics, Metabolomics, Microalgae, Nanoplastics

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SOP 006

DECIPHERING MICROALGAL RESPONSES TO AS (III), CD (II) AND PB (II) STRESS: INSIGHTS FROM GROWTH, OXIDATIVE STRESS AND SURFACE CHARACTERIZATION

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ABSTRACT

Improper disposal of industrial wastewater carrying toxic heavy metals and other anthropogenic constituents are contaminating our limited freshwater resources. Heavy metals significantly affect the physiological and biochemical responses of plants and other organisms in aquatic ecosystem. The microalgae have intrinsic potential to uptake heavy metal ions through bioaccumulation, biotransformation, biosorption etc. The present study provides an integrated approach of three environmentally relevant toxic metals As (III), Cd (II) and Pb (II) on *Chlorella sp*. Effect of metals were studied on microalgae growth by varying their concentration in the range of 0-10 mg/L. The highest microalgae growth was observed in presence of 2.5 ppm As (III) as compared to Pb (II) and Cd (II), even higher than control culture media. The microalgae biomass was harvested from heavy metals supplemented medium and analyzed for carbohydrate content. Total carbohydrate accumulation exhibited a metal-specific response, reaching its maximum at 2.5 ppm under Pb (II), Cd (II) stress and under As (III) stress at 10 ppm. Furthermore, the metal induced alteration of cell morphology was studied by scanning electron microscopy and the change of cell surface charge, interaction among cell surface and metal ions were investigated by zeta-potential analysis. The metal exposures resulted in concentration-related changes in microalgal growth and biochemical properties, supporting the notion of cellular stress. The changes in ROS levels, chlorophyll content suggested oxidative and photosynthesis stress, respectively, and changes in the accumulation of carbohydrates indicated metabolic reprogramming under metal exposure.

Keywords: Bioremediation, Biochemical response, Carbohydrates accumulation, Heavy metal stress, Microalgae.

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SOP 007

THYLAKOID LOCALIZED BESTROPHIN-LIKE PROTEINS ARE ESSENTIAL FOR THE CO_2 CONCENTRATING MECHANISM OF *CHLAMYDOMONAS REINHARDTII*

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ABSTRACT

The green alga Chlamydomonas reinhardtii possesses a CO_2 concentrating mechanism (CCM) that helps in successful acclimation to low O_2 conditions. Current models of the CCM postulate that a series of ion transporters bring HCO_3^- from outside the cell to the thylakoid lumen, where the carbonic anhydrase 3 (CAH3) dehydrates accumulated HCO_3^- to CO_2, raising the CO_2 concentration for Ribulose bisphosphate carboxylase/oxygenase (Rubisco). Previously, HCO_3^- transporters have been identified at both the plasma membrane and the chloroplast envelope, but the transporter thought to be on the thylakoid membrane has not been identified. Three paralogous genes (BST1, BST2, and BST3) belonging to the bestrophin family have been found to be up-regulated in low CO_2 conditions, and their expression is controlled by CIA5, a transcription factor that controls many CCM genes. YFP fusions demonstrate that all three proteins are located on the thylakoid membrane, and interactome studies indicate that they might be associated with chloroplast CCM components. A single mutant defective in BST3 has near-normal growth on low CO_2, indicating that the 3 bestrophin-like proteins may have redundant functions. Therefore, an RNA interference (RNAi) approach was adopted to reduce the expression of all 3 genes at once. RNAi mutants with reduced expression of BST1–3 were unable to grow at low Ci concentrations, exhibited a reduced affinity to inorganic carbon (Ci) compared with the wild-type cells, and showed reduced Ci uptake. We propose that these bestrophin-like proteins are essential components of the CCM that deliver HCO_3^- accumulated in the chloroplast stroma to CAH3 inside the thylakoid lumen.

Keywords: CCM, Photosynthesis, RNAi, bestrophins

Co-authors: Chun Sing Lau, Charlotte E. Walker, Ashwani K. Rai, Camille I. Prejean, Gary Yates, Thomas Emrich-Mills, Spencer G. Lemoine, David J. Vinyard, Luke C. M. Mackinder and James V. Moroney

SOP 008

MULTI-CRITERIA DECISION FRAMEWORK FOR ALGAL STRAIN SELECTION FOR CARBON CAPTURE AND BIOFUEL PRODUCTION

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ABSTRACT

Carbon dioxide (CO_2), one of the major greenhouse gases (GHGs) driving global warming and climate change, necessitates innovative approaches to carbon sequestration to achieve carbon neutrality. Among the various carbon capture, utilization, and storage (CCUS) technologies, algae-based biological sequestration offers unique advantages, such as photosynthetic carbon fixation and biomass upgrading into useful biofuels and biochemicals. Despite significant technological advances in algal biorefinery development, the selection of an appropriate algal strain remains a critical challenge hindering its large-scale adoption. The extensive diversity of algal species presents a complex selection problem that strongly influences CO_2 capture capacity and downstream product targeting. Factors like carbon fixation rate, photosynthetic efficiency, algal growth rate, and CO_2 tolerance affect the effectiveness of algal-based CCUS, while the biochemical composition of the biomass governs the suitability of the targeted products. Hence, this study employs several multi-criteria decision methods (MCDM) to formulate a structured decision-making framework that enables optimal selection of a suitable algal strain, considering CCUS, technical, economic, and environmental factors. Ten potential microalgal strains were identified from the literature and further evaluated against ten relevant criteria. Three types of objective weighting methods (EQUAL, ENTROPY, CRITIC) were employed to account for the relative importance of the criteria. Subsequently, four MCDM ranking methods, namely TOPSIS, VIKOR, PROMETHEE II, and GRA, were applied to rank the candidate microalgal strains. The proposed framework helps in identifying the optimal strain for carbon fixation and biofuel production, and a comprehensive sensitivity analysis is subsequently performed to assess the robustness of the framework.

Keywords: Algae; Biofuels; CCUS; MCDM; Sensitivity analysis.

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SOP 009

AN INTEGRATED MICROALGAL PHOTOBIOREACTOR FOR AIR-QUALITY IMPROVEMENT, CO_2 UTILIZATION AND BIOMASS GENERATION

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ABSTRACT

Poor indoor air quality is increasingly associated with inadequate ventilation and accumulation of CO_2 and other airborne contaminants in occupied spaces. Conventional approaches largely depend on ventilation to dilute these pollutants, while biological systems offer the additional possibility of utilizing CO_2 through photosynthesis. The present work explores microalgal cultivation as an active approach for improving air quality while simultaneously converting CO_2 into biomass.

A compact microalgal photobioreactor was developed using easily accessible materials, with controlled illumination and aeration to support algal cultivation. A key feature of the system was the integration of programmed semiconductor-based MQ-7 and MQ-135 gas sensors for continuous monitoring of CO_2 and CO concentrations, enabling changes in air composition to be tracked during reactor operation. Over 14 days, CO_2 concentration decreased from approximately 345 ppm on Day 1 to 215 ppm on Day 14, representing a 37.7% reduction. CO concentration also declined from approximately 45 to 38 ppm during the monitoring period.

The novelty of the developed system lies in integrating microalgal-based air-quality improvement with programmed, real-time monitoring of CO_2 and CO within a single compact platform. Importantly, CO_2 reduction is coupled with microalgal biomass generation, creating an opportunity to recover the assimilated carbon as a renewable biological resource. The The resulting biomass was then characterized for its carbohydrate, lipid, and protein content to explore for its value-added applications such as animal-feed ingredients, subject to appropriate nutritional, safety and regulatory evaluation. The developed platform therefore combines air-quality improvement, environmental monitoring, biological CO_2 utilization and biomass generation, providing a basis for further development of compact and modular systems for decentralized air-quality management.

Keywords: Algal photobioreactor; Animal feed; poor indoor air quality; Real-time monitoring

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SOP 010

FLIPPING THE METABOLIC SWITCH: CO_2-ENRICHED NITROGEN RESTRICTION DRIVES DUAL-PHASE ASTAXANTHIN ACCUMULATION IN *CHROMOCHLORIS ZOFINGIENSIS*

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ABSTRACT

Background: Conventional astaxanthin accumulation methods in the microalga *Chromochloris zofingiensis* rely on absolute nitrogen starvation, which severely limits biomass production. To bypass this bottleneck, a novel approach combines regulated nitrogen restriction with CO_2 supplementation to promote robust biomass growth before inducing rapid astaxanthin production.

Methodology: To analyze the primary metabolic profile during nitrogen depletion, untargeted LC-MS metabolomics was performed on day 6 of cultivation. The *C. zofingiensis* cultures were subjected to three different nitrogen conditions—nitrogen-replete (NR), nitrogen-limited (NL), and nitrogen-deplete (ND)—and maintained under either 6% CO_2 enrichment or ambient air.

Results: Supplemental CO_2 significantly enhanced biomass accumulation under both nitrogen-replete and nitrogen-limited regimes. By day 9, the CO_2-enriched nitrogen-limited system (NLc) achieved a biomass yield of 894.6 mg L^{-1}, contrasting sharply with the 202.2 mg L^{-1} produced by the nitrogen-deplete system (NDc). Total consumption of dissolved nitrate in the NLc culture by day 6 triggered a smooth physiological transition from nitrogen limitation to total depletion without reducing biomass volume, accelerating pigment accumulation to reach a maximum astaxanthin productivity of approximately 2.7 mg L^{-1} d^{-1}. Furthermore, metabolomic analysis identified 508 metabolites, of which 320 showed significant differential regulation, demonstrating that nitrogen availability is the primary regulator of cellular metabolism. This control was reflected in the profound remodeling of amino acid, nitrogen, glycerophospholipid, and carotenoid/isoprenoid pathways as cells shifted from active growth toward nutrient storage and pigment biosynthesis.

Conclusion: Nitrogen availability serves as a metabolic control lever, where initial mild limitation under elevated CO_2 promotes cell growth, while subsequent total nitrate depletion triggers stress-induced astaxanthin production, effectively separating biomass generation from compound activation.

Keywords: Astaxanthin biosynthesis, C:N balance, Metabolic reprogramming, Untargeted metabolomics

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SOP 011

CARBON-NEGATIVE BIOREFINERIES FROM MICROALGAE AND CYANOBACTERIA: A CCUS PERSPECTIVE

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ABSTRACT

Microalgae and cyanobacteria represent a promising biological platform for advancing the circular economy by converting industrial gaseous emissions and anthropogenic CO_2 into renewable biomass and value-added products. By utilizing CO_2 and transforming waste-derived resources into biomass, algae facilitate the conversion of environmental pollutants into renewable resources, thereby integrating carbon mitigation and waste valorization within a circular production system. The harvested algal biomass can subsequently be fractionated through biorefinery approaches to obtain high-value products such as proteins, lipids, pigments, polysaccharides and bioactive compounds thereby maximizing resource utilization. Residual biomass and extracellular polymeric substances (EPS) can be further valorized for applications in biostimulants, biofertilizers, biomaterials, functional coatings, emulsifiers, and other value-added products, thereby minimizing waste generation and improving overall biomass utilization. Thus, integrating algae into circular production systems establishes a closed-loop pathway encompassing carbon capture, biomass generation, bioproduct production, EPS valorization, and residual biomass recycling, thereby supporting resource efficiency, waste minimization, and sustainable industrial development.

Keywords: Algal biorefinery; Carbon capture, utilization, and storage (CCUS); Circular economy; Extracellular polymeric substances (EPS); Sustainable bioprocessing.

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SOP 012

PHYSIOCHEMICAL EVALUATION OF ALGAL OIL FOR ITS POTENTIAL USE AS LUBRICATING BASE OIL

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ABSTRACT

The global lubricant industry is dependent on petroleum derived base-oil for lubricant production, and the demand of lubricants is increasing 2% every year.

The first analysis of pyrolytic algal oil was done using FTIR (analyzed using PCA), in which the resemblance was found with AP3-grease and highly viscous 75W90 gear oil. Thereafter, the algal oil was subjected to rheology where the viscosity at different temperatures (-20°C, 40°C, and 100°C) was tested, frequency sweep from 0.1 Hz to 100 Hz, amplitude sweep from 0.01 s^{-1} to 100 s^{-1}, time sweep till 240 mins and oscillatory measurements were recorded. Consequently, tribology studies were conducted which focused on the wear and friction monitor and traction force behaviour of algal oil in comparison with reference bio-oil (*castor oil*).

The results indicated that the algal oil showed a kinematic viscosity of 78.911cSt at 40°C and 8.839 cSt at 100°C, with a viscosity index of 80.731. Additionally, the viscosity remained constant at 40°C and at 100°C the viscosity stabilized after a while whereas at -20°C the viscosity increased significantly. No significant difference in viscosity was seen within 240 mins. The tribological studies showed a wear of only 4mm in comparison with 141mm scar at dry run. However, there was no scratch resistance observed during the testing. This was, therefore, concluded that pyrolytic algal oil can serve as potential alternative of lubricant base oil, after modification as per usage-based necessity.

Keywords: Algal-Oil, Bio-Lubricant, Pyrolysis, Rheology, Tribology

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SOP 013

BIOMANUFACTURING LIPIDS FROM PHOTOSYNTHETIC CELL FACTORIES FOR SUSTAINABLE NEXT-GENERATION BIOLUBRICANTS

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ABSTRACT

Bio-based lubricants from microalgae are gaining significant interest as renewable and environmentally friendly products. Among various lipid fractions, neutral lipids or triacylglycerols (TAGs) from the photosynthetic route act as a favorable precursor for lubricant base oil. Once the base oil is synthesized, they it can be further upgraded into lubricants using antioxidants, additives and transesterification reactions. In the present study, microalgal strains isolated from water sources near dairy facilities were identified through 18S rRNA sequencing as *Poteriospumella* sp., *Nephrocytium* sp., and *Tetradesmus* sp. Laboratory screening identified *Nephrocytium* sp. as the most promising strain due to its high lipid content. Further cultivation using dairy wastewater with optimized nitrogen and carbon supplementation, including NPK, increased biomass concentration from approximately 2.5 to 4.7 g/L, while maintaining about 35% total lipid content. The recovered microalgal lipids were further explored for biolubricant production through esterification and transesterification. The methyl esters were then treated with trimethylolpropane (TMP), neopentyl glycol (NPG), and pentaerythritol (PE) to produce biolubricants with enhanced viscosity. The synthesized products were characterized for tribological properties and found within ISO VG 11 and ISO VG 32 grades, demonstrating their potential for light-duty industrial, hydraulic, compressor, and machinery lubricant applications.

Keywords: Microalgae, Biolubricants, Hydroprocessing, Sustainable Biorefinery, Transesterification, Sustainable Biomanufacturing

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SOP 014

MICROALGAE AS A CARBON-TO-VALUE PLATFORM: BIOMASS, BIO PRODUCTS AND HYDROTHERMAL CONVERSION

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ABSTRACT

Rising industrial CO_2 emissions necessitate sustainable approaches that combine carbon mitigation with resource generation. Microalgae can efficiently utilize CO_2 for biomass production while generating a versatile, nutrient rich feedstock containing proteins, lipids, pigments, and antioxidant with potential applications in biofuels, biochemical, nutraceuticals, and other bio refinery products. Demonstrating this potential under realistic cultivation conditions is essential for practical and sustainable biomass valorisation.

In this study, *Scenedesmus* sp. was cultivated at pilot scale (~3m^3) under real outdoor conditions with CO_2 supplementation, biomass productivity, and CO_2 fixation were evaluated. The biomass generated under this conditions was comprehensively characterized for biochemical compositions, pigments, antioxidants, physicochemical properties to assess its valorisation capacities. The cultivated biomass was further subjected to hydrothermal processing and the resulting products were evaluated and characterized to understand their compositions, properties, and potential applications. The study integrates industrial CO_2 utilizations, real condition biomass production, biochemical valorisations and hydrothermal conversion, demonstrating a practical pathway for developing a sustainable microalgae bio refinery

Keywords: Bioenergy; Carbon dioxide; Cultivation; Hydrothermal Conversion; Microalgae; Valorisation

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SOP 015

BIOCHEMICAL INTERACTION-BASED KINETIC MODELING OF ALGAL BIOMASS HYDROTHERMAL LIQUEFACTION FOR BIOCRUDE PRODUCTION

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ABSTRACT

Hydrothermal liquefaction (HTL) offers a promising pathway for converting wet algal biomass into biocrude, but the complex interactions among carbohydrates, proteins, and lipids present challenges for predicting conversion behavior and optimizing process conditions. This study presents a biochemical interaction-based kinetic modeling framework for predicting biocrude production from algal biomass with varying biochemical compositions. The model incorporates component-specific conversion pathways and interaction coefficients to describe the effects of carbohydrate, protein, and lipid interactions during HTL. COMSOL Multiphysics was employed to simulate HTL behavior across temperatures ranging from 250 to 400 °C and residence times of 5–20 min. A systematic ternary-composition study comprising 36 compositions of biomass was carried out to examine the effect of biomass compositions on biocrude production. An Effective Biocrude Quality Index (EBQI) was developed as a comparison tool for analyzing biocrude production efficiency of various biomass compositions and operating parameters. It was predicted that biocrude production will be favorable around 350 °C by the model and lipidous biomass showed favorable potential for biocrude production. Model prediction results were found to agree strongly with the selected benchmark data taken from literature; where the reported validation with balanced biomass resulted in R^2 of 0.998 and RMSE of 0.617%. The developed framework can be used as a mechanistic tool for studying biochemical interaction and algal biomass screening for use in HTL based biorefineries.

Keywords: Algal biomass; Biochemical interactions; Biocrude; Hydrothermal liquefaction; Kinetic modelling

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SOP 016

PRODUCTION OF LEVULINIC ACID FROM *EUCHEUMA DENTICULATUM* VIA SULPHURIC ACID CATALYZED HYDROLYSIS: EFFECT OF PROCESS PARAMETERS ON HYDROLYSIS EFFICIENCY

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ABSTRACT

Platform chemicals derived from renewable resources are receiving considerable attention as environmentally friendly alternatives to petroleum-derived chemicals. Among the various biomass-derived platform chemicals, Levulinic acid (LA) has been identified by the United States Department of Energy (US DOE) as one of the top value-added chemicals. In the present study, *Eucheuma denticulatum* was investigated as the feedstock for the production of levulinic acid through dilute sulfuric acid hydrolysis. The biomass was characterised by proximate and compositional analyses which revealed 4.3 ± 0.1% cellulose, 20.7 ±0.4% hemicellulose, 12% lignin, 5% extractives, 43 ± 2.2% ash, and 0.13% moisture with 54.6% volatile matters and 2.27% fixed carbon. Carrageenan quantification revealed a total carrageenan content of 5.31%, with ι-carrageenan identified as the predominant carrageenan type. (The reactions were carried out in a stainless-steel hydrothermal reactor with Teflon lining operated at various reaction parameters such as sulfuric acid concentrations of 0.1 - 0.4 M, reaction temperatures of 160-200 °C, reaction time of 30-120 min and feed to catalyst ratio. Following hydrolysis, the liquid hydrolysate was analysed with HPLC equipped with an Aminex HPX-87H column and RI detector. Under optimized reaction conditions, a maximum LA yield of 11.6% was obtained accompanied by a biomass conversion of approximately 70% at 180°C for 90mins. In the same conditions only 3.5% of HMF, 0.4% glucose, 1% cellobiose were obtained. The formation of LA was attributed to acid-hydrolysis of seaweed polysaccharides to soluble sugars, followed by dehydration of hexose to 5-HMF and rehydration of 5-HMF to LA and formic acid. Increased reaction severity beyond the optimum promoted secondary reactions, including humin formation, thereby limiting LA selectivity. Overall, the results, demonstrate the potential of *E.denticulatum*as renewable feedstock for LA production and provide an effective approach for converting marine biomass into value added platform chemicals.

Keywords: Biomass, *Eucheuma denticulatum*; Levulinic acid; Platform chemical; 5-HMF

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SOP 017

COMPARATIVE ANALYSIS OF DIFFERENT TRANSESTERIFICATION METHODS LEADING TO BIODIESEL PRODUCTION FROM MICROALGAE CULTIVATED ON SEWAGE WASTEWATER

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ABSTRACT

Biodiesel, is an emerging alternative to fossil and non-renewable energy resource. It reduces the viscosity and molecular weight of the lipid and increases its volatility similar to diesel. The synthesis of biodiesel derived from microalgae has the potential to grow on sewage wastewater and recycle atmospheric CO_2. Hence, we tried to transform the laboratory-scale cultivation of *Chlorella sorokiniana 2B3* into a tub cultivation using sewage wastewater under controlled parameters. Growth of the culture was monitored by taking absorbance at every five-days interval. The scaled-up cultivation in a tub system led to successful growth of microalgae in the primary sewage wastewater. Before the onset of the stationary phase, the biomass was harvested manually and oven dried at 55°C, and finally biomass productivity equivalent to 1.2 g/L was attained. Lipid was extracted from biomass and trans-esterified into fatty acid methyl esters (FAME) by different methods; direct and indirect. Overall, the comparative analysis demonstrated that both direct and indirect transesterification methods produced biodiesel with FAME profiles specific to *Chlorella*. However, the direct transesterification method produced the least biodiesel/gram biomass enriched in saturated fatty acid methyl esters and comparatively lower concentrations of polyunsaturated fatty acids. The indirect methods, particularly the ZnO nanocatalyst-mediated process, achieved marginally higher transesterification efficiency with the highest yield/gram biomass. The composition of FAME was more or less similar, characteristics associated with enhanced oxidative stability and storage performance. Moreover, the ZnO nano-catalyst is reusable, and therefore this technology can be refined for cost-effective biodiesel synthesis in the future.

Keywords: Biodiesel; *Chlorella*; Nanocatalyst; Transesterification; Wastewater

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SOP 018

SELECTIVE RECOVERY AND FRACTIONATION OF POLYCHROMATIC PROTEINS FROM *SPIRULINA PLATENSIS* THROUGH AN INTEGRATED CIRCULAR BIOREFINERY APPROACH

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ABSTRACT

Algal proteins are increasingly recognized as a valuable resource for low-carbon and circular bioeconomy models; yet, their industrial utilization remains constrained by inefficient extraction and incomplete biomass valorization. One of the major challenges is absence of selective cell disruption techniques. Conventional high-energy disruption methods may denature target proteins and compromise their functionality, while single-step extraction approaches fail to recover high-value fractions from residual biomass. Protein recovery depends strongly on process parameters and the development of an empirically designed fractionation system based on protein properties remains a technical hurdle. To address these limitations, an integrated thermo-mechano-chemical biorefinery model was developed to enable selective protein recovery from algal biomass. The sequential extraction process achieved recovery of 90.80% (w/w) total soluble proteins and 14.03% (w/w) phycobiliprotein. This approach enabled the fractionation of three distinct polychromatic proteins-designated as Classic Blue, Deep Olive, and Olive Yellow. Protein characterization further demonstrated that processing conditions markedly influenced functional properties, underscoring the role of process control in tailoring protein functionality. These findings demonstrate the potential of resource-efficient fractionation strategies to support scalable production of specialized algal protein ingredients within a circular biorefinery framework.

Keywords: Biorefinery model; Cell Disruption; Fractionation; Polychromatic Proteins; Sequential extraction

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SOP 019

UNCOUPLING BIOMASS LOSS FROM NEUTRAL LIPID HYPERACCUMULATION IN *CHLORELLA SOROKINIANA*: INTERORGANELLAR METABOLIC CROSSTALK BETWEEN ENDOPLASMIC RETICULUM KENNEDY AND PLASTIDIAL TGD PATHWAYS

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ABSTRACT

Microalgal triacylglycerols (TAGs) serve as key feedstocks for advanced biomanufacturing, yet their yield remains limited by a fundamental growth tradeoff. High-capacity lipid synthesis requires efficient interorganellar precursor trafficking between the endoplasmic reticulum (ER) and the chloroplast, mediated by the trigalactosyldiacylglycerol (TGD) complex across the aqueous plastidial intermembrane space. While this transport machinery is well defined in land plants, the regulatory mechanisms governing galactoglycerolipid partitioning through prokaryotic and eukaryotic pathways in microalgae under nitrogen starvation remain unclear. In this study, we integrated phylogenomics, subcellular localization, quantitative RT-PCR expression profiling, and untargeted metabolomics to map the dynamic lipid remodeling in *Chlorella sorokiniana* UTEX 1230 during nitrogen deprivation. Our findings show that nitrogen deficiency triggers a synchronized transcriptional shift driving thylakoid membrane turnover and reorganization. This breakdown resulted in an accumulation of free fatty acids alongside a marked reduction in central respiratory activity. Notably, metabolic flux profiling highlighted TGD3 as a key bottleneck in intermembrane lipid transport. We further show that dual expression of TGD3 and ER-targeted diacylglycerol acyltransferase 2 (DGAT2) successfully uncouples high neutral lipid accumulation from cellular biomass reduction, offering an effective metabolic engineering strategy for microalgal biotechnology.

Conclusion

Multi-omics analysis of *Chlorella sorokiniana* under nitrogen starvation revealed thylakoid degradation, free fatty acid accumulation, reduced respiration, and transport bottlenecks at TGD3 and DGAT2. Furthermore, our study demonstrates that co-expressing TGD3 with ER-targeted DGAT2 enables neutral lipid hyperaccumulation while maintaining cellular biomass.

Keywords: *Chlorella sorokiniana*; DGAT2; Interorganellar transport; Kennedy pathway; Lipid remodeling; TGD complex.

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SOP 020

DEEP EUTECTIC SOLVENT-MEDIATED B-CAROTENE RECOVERY FROM DUNALIELLA SALINA FOR AN INTEGRATED ALGAL BIOREFINERY APPROACH

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ABSTRACT

β-carotene is valuable compounds that has gained substantial attention due to its unique biological properties and eventual industrial applications. However, extraction from *Dunaliella salina* using conventional solvents is hampering its application for food and pharmaceutical applications; therefore, the focus is shifting towards "Deep eutectic solvents (DESs). In the present study; binary DESs were prepared using menthol, and variety of fatty acids in different molar ratio for β-carotene extraction from *Dunaliella salina*. The DESs examined through differential scanning calorimetry showed single melting and crystallization peak, indicating homogenous nature and DES formation. The results exhibited maximum extraction yield of 4-5 mg/g with octanoic acid : decanoic acid after varying amplitude, biomass : solvent ratio and extraction time. The yield obtained was higher than reported in literature using DES (2.52 mg/g) and organic solvents (3.4 mg/g). Additionally, the pigment–extracted residual biomass exhibited lipid content of 12% in comparison to that of raw biomass (18%). The FTIR analysis further confirmed the presence of lipid, protein, and carbohydrates in residual biomass, reflecting its potential for bioenergy/feed production after β-carotene extraction. Overall, these findings demonstrated that DESs can serve as the alternative solvent for β-carotene extraction from *Dunaliellasalina* and facilitates utilization of residual biomass, thus supporting the approach of integrated algal biorefinery.

Keywords: β-carotene, Deep eutectic solvents, *Dunaliellasalina,* Algal Biorefinery, Circular Bioeconomy

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SOP 021

UTILIZATION OF PROTEIN-BASED BIO- WASTE DERIVED MEDIA FOR ENHANCEMENT OF MICROALGAL BIOMASS AND PIGMENT PRODUCTION

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ABSTRACT

Over the past several years, microalgae have become a prime focus for a sustainable source of natural pigments with potential application as constituents in chemical, pharmaceutical, cosmeceutical and food industry. However, microalgae cultivation in synthetic media such as BG 11 in commercial scale is not economically feasible for its excessive cost. Thus, to overcome the limitations bio-waste derived media can be utilized to enhance the biomass yield and provide a good alternative to synthetic media. This study focuses on the formulation of protein -based bio waste media for the growth enhancement of microalgal biomass with pigment accumulation. We have explored various protein rich bio-waste media as a nutrient resource and supplementation with synthetic media results higher growth of biomass along with pigment production. The study further investigated the changes in biochemical composition of biomass for supplementation with different bio-waste media. This approach can also help to formulate an economical microalgal cultivation system that can reduce production cost for large scale commercial applications. Our goal is to establish the economical and efficient bio-waste derived media formulation with enhanced microalgal pigments. Overall, the utilization of bio-waste resources will promote a promising pathway for waste to wealth generation and provide a sustainable algal biorefinery.

Keywords: Bio-waste media; microalgae; natural pigments; synthetic media; waste to wealth

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SOP 022

NANO-ENABLED CIRCULAR BIOREFINERY: UPCYCLING ALGAL BIOMASS INTO NITROGEN-DOPED CARBON DOTS FOR ACCELERATED PHOTOSYNTHESIS AND LIPID HYPER-ACCUMULATION IN *MONORAPHIDIUM NEGLECTUM*

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ABSTRACT

The mutually exclusive trade-off between biomass accumulation and lipid synthesis remains a defining bottleneck in microalgal biorefinery. Here, we report a circular bioeconomy paradigm that overcomes this constraint through a strategically decoupled, two-stage cultivation framework mediated by biomass-derived nanomaterials. Self-nitrogen-doped carbon quantum dots (N-CQDs) were first engineered *via* a green, one-pot hydrothermal treatment of *Scenedesmus* sp. biomass. Comprehensive structural and spectroscopic diagnostics (TEM-EDAX, UV-Vis, FTIR, and XPS) confirmed ultra-small, graphitic cores passivated with intrinsic amine and oxygenated functionalities, exhibiting a photoluminescence quantum yield of 8.43%. In Stage 1, pristine N-CQDs were exogenously deployed (5–100 mg/L) as bio-photonic stimulants for *Monoraphidium neglectum*. Pulse-amplitude-modulated (PAM) fluorometry revealed a marked upregulation in photosystem II maximum photochemical quantum efficiency (Fv/Fm) and chlorophyll a/b synthesis, driving accelerated nutrient depletion dynamics (verified by ion chromatography) and biomass hyper-accumulation. In Stage 2, these primed cultures were transitioned into nitrogen-deplete conditions to redirect carbon flux toward secondary storage metabolites. Flow-cytometric Nile Red assays coupled with FTIR spectral deconvolution revealed sharp amplifications in neutral lipid fractions, denoted by intense ester carbonyl stretching. Thermogravimetric analysis and differential scanning calorimetry (TGA/DSC) further confirmed distinct shifts in thermal pyrolysis kinetics toward high-energy triacylglycerol (TAG) decomposition regimes. By strategically decoupling nanoparticle-stimulated photosynthetic biomass generation from stress-induced lipogenesis, this closed-loop process delivers unprecedented biomass and lipid productivities over conventional monocultures, presenting an atom-economic blueprint for high-efficiency algal biofuel platforms.

Keywords: Biofuels, Carbon quantum dots, Circular bioeconomy, Metabolic reprogramming, Microalgal biorefinery

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SOP 023

METABOLIC REPROGRAMMING OF *CHLORELLA SOROKINIANA* CULTIVATED IN OPTIMIZED FOOD WASTE ANAEROBIC DIGESTATE: COMPARATIVE METABOLOMICS

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ABSTRACT

Microalgal metabolism is highly responsive to cultivation environments, leading to dynamic biochemical adaptations that influence biomass productivity and metabolite synthesis. This study investigated the metabolic reprogramming of Chlorella sorokiniana cultivated in food waste anaerobic digestate under optimized conditions (pH 6.0, temperature 25°C, C/N ratio 5.5, and 10% inoculum concentration) and compared the resulting metabolic profile with cells grown in Tris Acetate Phosphate (TAP) medium. Metabolite extraction followed by GC-MS analysis enabled the characterization of intracellular metabolic changes associated with digestate cultivation. Multivariate statistical analysis revealed clear discrimination between digestate-grown and TAP-grown cultures, indicating substantial shifts in cellular metabolism. Differential metabolite analysis demonstrated significant alterations in metabolites associated with central carbon metabolism, amino acid biosynthesis, nitrogen assimilation, organic acid turnover, and energy metabolism. Pathway enrichment analysis further suggested the reorganization of metabolic networks involved in carbon utilization and nutrient assimilation, reflecting adaptation to the complex nutrient composition of anaerobic digestate.

The metabolomic data indicate that digestate-derived nutrients induce a distinct physiological state characterized by enhanced metabolic flexibility and efficient resource allocation. Such metabolic adjustments may contribute to the improved biomass productivity previously observed under optimized digestate cultivation conditions. This work demonstrates the utility of metabolomics as a tool for elucidating algal responses to alternative nutrient sources and advances our understanding of the physiological basis of microalgal cultivation in anaerobic digestate. The findings support the development of sustainable algal bioprocesses that integrate wastewater valorization with biomass production.

Keywords: Algae; Anaerobic digestate; Biomass; Metabolomics; Wastewater Valorizarion.

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SOP 024

SEAWEED-DERIVED SULFATED POLYSACCHARIDES: UNLOCKING THEIR POTENTIAL FOR NEXT-GENERATION COSMETICS

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ABSTRACT

Sulphated polysaccharides derived from marine macroalgae have gained considerable attention recently as promising natural bioactive materials due to their biological and functional properties. Consumers are shifted towards nature-based solutions for food ingredients and cosmetic products rather than synthetic additives. Marine algae are rich in sulphated polysaccharides and have many health-beneficial nutraceutical properties, such as antioxidant, anti-allergic, antiviral, antibacterial, anticancer and wound healing properties. In the present study, sulphated polysaccharides were successfully extracted from the marine alga *Ulva fasciata* using a hot-water extraction method, producing a maximum yield of 20-25%. Fourier transform infrared [FTIR] spectroscopy revealed characteristics stretching bands corresponding to sulphate groups [S=O] and sulphate ester linkages [C-O-S], confirming the presence of sulphated polysaccharides. The extracted polysaccharides exhibited a total carbohydrate content of approximately 76%, with galactose, rhamnose and uronic acid identified as the major carbohydrate constituents. The presence of sulphate groups, associated protein components and uronic acid contributed to the pronounced antioxidant activity of the extracted polysaccharides. Furthermore, the polysaccharides exhibited superior moisture adsorption and retention compared to glycerol, highlighting their potential as effective natural humectants. These properties suggest that Ulva sp.-derived sulphated polysaccharides could serve as a promising multifunctional, naturally derived ingredient formoisturisers and cosmetic formulations.

Keywords: Antioxidant activity; Cosmetics; seaweed; Sulphated polysaccharide, Sustainable bioproducts

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SOP 025

PROTEOMIC CHARACTERIZATION AND FUNCTIONAL BIOINFORMATIC MINING OF FOOD-GRADE *CHLORELLA SOROKINIANA* FOR POTENTIAL BIOACTIVE PEPTIDES

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ABSTRACT

The search for sustainable sources of food-derived bioactive peptides has increased with the growing burden of metabolic disorders. This study investigated food-grade *Chlorella sorokiniana* SVMIICT8 as a source of peptides with potential ACE and DPP-IV-inhibitory activities using a proteomics-guided workflow. Photoautotrophic cultivation produced 0.55 ± 0.03 g L^{-1} biomass, corresponding to an estimated CO_2 fixation of 1.01 ± 0.06 g CO_2 L^{-1}. Protein profiling by nano-LC-MS/MS followed by BIOPEP-UWM mining identified 177 potential bioactive peptide fragments representing 22 activities, with ACE and DPP-IV-inhibitory peptides being predominant. DH, AE, and V parameters were used to prioritize peptide precursors, followed by allergenicity prediction and molecular docking against DPP-IV and ACE. MYAFLDR showed the most favourable predicted DPP-IV binding (-8.853 kcal mol^{-1}) and also showed favourable ACE binding (-10.07 kcal mol^{-1}), while QGMFVLPFMTR also interacted favourably with both targets. Overall, the study demonstrates a practical route for narrowing a complex microalgal proteome to specific bioactive peptide candidates, reducing the need for broad experimental screening. Linking CO_2-utilizing food-grade microalgal cultivation with targeted recovery of high-value peptides may further support the development of sustainable microalgal nutraceutical biorefineries.

Keywords: Antidiabetic; Antihypertensive; Bioactive peptides; Nutraceuticals; Proteomics

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SOP 026

SEQUENTIAL EXTRACTION-GUIDED METABOLOMIC PROFILING OF MARINE ALGAE FOR DISCOVERY OF ANTICANCER BIOACTIVES

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ABSTRACT

Marine algae represent an underexplored reservoir of structurally diverse metabolites with therapeutic potential; however, conventional single-solvent extraction may limit the recovery of bioactive compounds across different polarity ranges. This study investigates the anticancer potential of sequential solvent fractions from the marine microalga *Dunaliella salina* and brown macroalga *Turbinaria* sp. Biomass was sequentially extracted using n-hexane, ethyl acetate, methanol and water, followed by untargeted LC–HRMS metabolomic profiling and biological evaluation against HeLa cervical carcinoma cells. Multivariate analysis revealed distinct metabolomic profiles among solvent fractions, demonstrating solvent-dependent partitioning of algal metabolites. Ethyl acetate fractions exhibited the highest antiproliferative activity, with the *Turbinaria* sp. fraction producing an IC_{50} of 21.63 µg/mL, while *D. salina* exhibited an IC_{50} of 253.50 µg/mL. Annexin V/PI flow cytometry further demonstrated substantial treatment-associated cell death in the active fractions. LC–HRMS analysis identified pharmacologically relevant metabolites, including diosgenin, safingol and spisulosine, alongside previously uncharacterised metabolites. Selected metabolites were further investigated using network pharmacology, molecular docking and SwissADME analysis, revealing potential interactions with cancer-associated targets and favourable predicted drug-like properties. Overall, the findings demonstrate that sequential extraction can generate chemically distinct fractions with differential biological activity and function as a metabolite-enrichment strategy for prioritising bioactive metabolites from marine algae.

Keywords: Anticancer; Marine algae; Metabolomics; Natural products, Sequential extraction

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SOP 027

SELENIUM-ENRICHED EXOPOLYSACCHARIDES FROM *NANNOCHLOROPSIS OCEANICA*: STRUCTURAL CHARACTERIZATION AND FUNCTIONAL EVALUATION

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ABSTRACT

Selenium-enriched microalgae represent a promising approach for converting inorganic selenium into biologically relevant organic forms. Our laboratory has established a selenium-tolerant *Nannochloropsis oceanica* platform through adaptive exposure to selenite. Previous studies from the laboratory demonstrated selenium-associated biological responses and the safety of the selenium-enriched biomass, while subsequent work led to the isolation of selenium-enriched exopolysaccharide (Se-EPS) fractions.

The present study focuses on the structural and functional characterization of Se-EPS obtained from the selenium-enriched *N. oceanica* biomass. The Se-EPS was isolated by aqueous extraction, followed by purification steps, and subsequently investigated to determine the chemical nature and association of selenium with the polysaccharide fraction. Multiple complementary approaches were employed to examine its structural characteristics and selenium speciation. The selenium-enriched polysaccharide showed evidence of organically associated selenium and exhibited distinct physicochemical characteristics compared with the corresponding polysaccharide fraction from the non-selenium-enriched biomass. Spectroscopic and surface-chemical analyses further supported the association of selenium with the polysaccharide matrix. Functional evaluation indicated redox-active properties of the Se-EPS, highlighting the potential contribution of selenium incorporation to its biological functionality.

Overall, the study provides a comprehensive characterization of an algal selenium-enriched exopolysaccharide and demonstrates the potential of *N. oceanica* as a source of organic selenium-associated polysaccharides. The findings contribute to understanding the relationship between selenium incorporation, polysaccharide structure, and functional properties, supporting the development of value-added algal ingredients for nutritional applications.

Keywords: Antioxidant activity; Exopolysaccharide; *Nannochloropsis oceanica*; Organoselenium; Selenium enrichment

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SOP 028

CYANOBACTERIA-DERIVED VEGAN PEPTONE FROM *SPIRULINA (ARTHROSPIRA) PLATENSIS* AS AN ANIMAL-FREE COMPONENT OF MICROBIOLOGICAL GROWTH MEDIA: MICROBIOLOGICAL VALIDATION AND BIOCHEMICAL CHARACTERIZATION

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ABSTRACT

Peptones are the major cost drivers of microbiological media and are primarily animal-derived, causing biosafety and ethical concerns. Thestudy aimed to valorise *Spirulina platensis* biomass into a high-quality peptone and subsequently evaluate its performance as a microbiological media component. A novel downstream processing protocol was employed, in which the biomass cultured in a cost-effective medium was further pretreated with repeated freeze-thaw and enzymatically hydrolysed. When compared with commercial peptone (CP), Spirulina peptone (SP) was found to be superior for cell growth performance and productivity of both Gram-positive and Gram-negative bacteria in both solid and liquid media. Biochemical tests were done to validate the biological reactivity of the peptone. SP-based enrichment medium and selective media were also used in selective media preparation for Vibrio spp. The low molecular weight of peptides indicated effective hydrolysis. The amino acid composition of SP was comparable to that of commercial peptone. FTIR analysis revealed a complex composition of protein, carbohydrate, phenols, and amino acids, indicating peptone's utility as a carbon and protein source in media. A protein hydrolysate prepared via subsequent freeze-thawing and enzymatic hydrolysis was tested for the first time as a peptone source. The protocol can be adapted to produce a high-performance vegan peptone alternative with low input costs, making it viable for biotechnological innovations, industrial fermentations, and clinical microbiology.

Keywords: Biomass; Microbiological Media; Papain; Peptone; Spirulina;

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SOP 029

TAXONOMIC AND FUNCTIONAL PROFILING OF MICROBIOMES ASSOCIATED WITH SEAWEED HABITATS ACROSS THE WEST AND SOUTHEAST COAST OF INDIA USING NANOPORE LONG-READ METAGENOMICS

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ABSTRACT

Seaweed habitats harbour complex microbiomes that mediate carbon transformation, nutrient cycling, and responses to environmental change, yet their organisation along the Indian coast remains poorly characterised. This study presents a comparative Nanopore metagenomic assessment of nine intertidal seaweed habitats spanning Goa on the west coast and Ramanathapuram in Tamil Nadu, on the southeast coast of India. Bacteria dominated in both regions, with Pseudomonadota, Bacteroidota, and Actinomycetota consistently prominent. Cyanobacteriota showed spatial variation with higher abundance at Mandapam and Dhanushkodi, whereas Rameshwaram and South Goa showed greater representation of heterotrophic bacteria. Diverse bacteriophages, archaea and microeukaryotes further contributed to the multidomain community structure. Despite taxonomic variation, functional profiles revealed a conserved core centred on carbohydrate metabolism and polysaccharide transformation, supported by diverse carbohydrate active enzymes (CAZymes). Variation in xenobiotic degradation, elemental transformations, and secondary metabolite biosynthesis indicated substantial metabolic flexibility. Multidrug resistance genes were widespread, suggesting long-term environmental persistence and adaptive responses in these seaweed habitats. Biomarker patterns further differentiated locations according to taxa associated with contrasting environmental conditions and metabolic strategies. North Goa was associated with taxa that support stable carbon cycling, whereas South Goa and Rameshwaram were abundant in metabolically versatile bacteria and phytoplankton typical of eutrophic and disturbed habitats. Results reveal taxonomic turnover alongside functional conservation, suggesting that geographically separated seaweed habitats can maintain overlapping core functions through distinct microbial assemblages. This comparative framework provides a baseline for linking microbial community organisation with coastal ecosystem functioning and environmental change across Indian seaweed habitats.

Keywords: Antibiotic resistance, CAZyme, Metagenomics, Microbiome, Seaweed habitat

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SOP 030

MULTIMODAL MORPHOLOGICAL AND BIOCHEMICAL CHARACTERIZATION OF GREEN MICROALGAE FOR OPTIMIZING WHOLE-CELL BIOSENSORS

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ABSTRACT

The escalation of environmental heavy metal pollutants, particularly arsenic, necessitates the development of rapid, continuous-flow detection platforms. Microalgae-based whole-cell biosensors offer a highly sensitive, label-free approach to real-time environmental monitoring. However, optimizing these bio-recognition elements requires a fundamental understanding of baseline cellular architecture and biochemical composition prior to device integration. This study presents the comprehensive characterization of four distinct microalgal species, *Chlorella thermophila*, *Monoraphidium sp.* (KMC4), *Monoraphidium contortum* (KMC7), and *Micratinium pusillum* (KMC8), selected for their unique stress-response mechanisms, which range from rapid reactive oxygen species (ROS) bursts to distinct morphological deformations.

The inherent structural and molecular profiles of the selected species were established utilizing a multimodal analytical framework. Cellular topography, membrane integrity, and intracellular organization were mapped using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Surface chemical states, functional groups, and overarching biomolecular compositions were quantified through X-ray Photoelectron Spectroscopy (XPS), Fourier-Transform Infrared (FTIR), and Raman spectroscopy. Furthermore, baseline physiological stability was determined via pigment quantification, lipid content analysis, and pH tolerance assays.

This detailed mapping correlates species-specific cell wall properties and molecular signatures with their capacity for stress-induced signal transduction. Establishing these definitive pre-exposure fingerprints is critical for anticipating surface interaction dynamics and cellular degradation pathways under heavy metal stress. Ultimately, these characterization profiles will dictate the selection and immobilization protocols for microfluidic architectures, establishing the groundwork for advanced integration with cyclic voltammetry and machine learning models to achieve highly specific, real-time continuous pollutant sensing.

Keywords: Biosensor; Green microalgae; Biochemical profiling; Environmental monitoring

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SOP 031

DECODING CELL'S SURVIVAL: OMICS-BASED INTEGRATION OF TOR SIGNALLING AND AUTOPHAGY IN MARINE OLEAGINOUS ALGA *PARACHLORELLA KESSLERI*

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ABSTRACT

Autophagy is a crucial cellular recycling mechanism for stress survival, but its regulatorydynamics and metabolic footprint in oleaginous microalgae remain largely unknown.The Target of Rapamycin (TOR) pathway serves as a master hub for nutrient sensingand energy balance, controlling cell proliferation versus catabolic survival.This study used an integrated omics framework—combining transcriptomics,proteomics, and metabolomics—to map the functional cascade induced by suppressionof the TOR pathway in the native marine oleaginous alga Parachlorella kessleri.A chemical-based inhibitory approach employing AZD8055 triggered comprehensive,coordinated modifications in nutrient sensing, vesicular transport, autophagy initiation,membrane restructuring, and protein turnover. Transcriptomic analysis revealed distinctchanges in the expression of core autophagy components and stress pathways, whichwere further corroborated by proteomic data indicating restructured protein networksinvolved in organellar recycling, intracellular trafficking, and proteostasis. Concurrently,metabolomic profiling highlighted substantial changes in central carbon intermediates,amino acid pools, and membrane lipids, underscoring an active metabolic realignmentin response to nitrogen starvation and TOR inhibition.Quantitative real-time PCR (qPCR) confirmed the transcription dynamics of keyautophagy-related targets under these conditions. Together, these multi-omics insightsdefine the crosstalk between microalgal nutrient-sensing and recycling pathways,revealing adaptation mechanisms that can aid metabolic engineering and stress-resilience strategies.

Keywords: Cellular recycling, lipid remodeling, Omics biology, Parachlorella kessleri, Target of Rapamycin (TOR)

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SOP 032

GENOMIC AND TRANSCRIPTOMIC CHARACTERIZATION OF MACROALGAE TO UNDERSTAND THEIR BIOSYNTHETIC PATHWAYS FOR THE PRODUCTION OF ITS BIOMOLECULES.

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ABSTRACT

Macroalgae or seaweeds is a major source of various active pharmaceutical ingredients and widely used as functional foods and for nutraceutical applications. They various biomolecules including polyphenols, phlorotannin's, polyunsaturated fatty acids, carotenoids, flavonoids, pigment and unique polysaccharides are well studied for their antioxidant, anticoagulant, antiglycemic, prebiotic, immunomodulatory, anti-inflammatory and antiviral activity. Despite increasing demand, most seaweeds used for their biomedical and healthcare applications are sourced predominantly from the wild harvest. Only a limited number of seaweed species are explored for aquaculture and studied for large-scale commercial cultivation. Many of the seaweed species cannot be widely cultivated due to biological, environmental and technological limitations. Offshore farming systems are often constrained due to habitat specificity, sensitivity to abiotic stressors, and susceptibility to herbivory. They also require significant infrastructural investments and are often challenged by biofouling, epiphytes and fluctuating environmental conditions that reduce the productivity and biomass yield. Omics approach provides an advanced platform for understanding the regulatory and metabolic genes involved in the production of the unique biomolecules in seaweeds. Hence, in this study, results obtained from a comprehensive analysis of seaweed genome and transcriptome to identify metabolic pathways, based on the functional annotation of genes and the identification of putative transcripts associated with the biosynthetic pathways of industrially important bioactive molecules will be presented.

Keywords: genomics, marine bioinformatics, seaweed, synthetic biology

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SOP 033

FUNCTIONAL CHARACTERIZATION OF BOLA FROM A CYANOBACTERIUM SYNECHOCOCCUS ELONGATUS PCC 7942: ENHANCED STRESS TOLERANCE IN ESCHERICHIA COLI

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ABSTRACT

Cyanobacteria are commonly known as blue-green algae that play fundamental roles in biogeochemical cycling. However, their photosynthetic lifestyle exposes them to fluctuating environmental stresses, necessitating efficient mechanisms for maintaining cellular homeostasis. BolA family proteins are widely recognized as morphogenes and stress-responsive factors in bacteria, yet their functional diversification across taxa poorly understood. In this study, we characterize the cyanobacterial BolA homolog from *Synechococcus elongatus* PCC 7942 (SeBolA) and examine its structural, biochemical, and physiological roles in *Escherichia coli*. Unlike *E. coli* BolA (EcBolA), which induces a spherical morphology during stationary phase, SeBolA overexpression maintained rod-shaped cells and prevented aggregation, suggesting functional divergence in morphogenesis. Under salinity and oxidative stress, SeBolA-expressing cells exhibited enhanced structural integrity, reduced ROS accumulation, and lower lipid peroxidation, correlating with improved cell viability and colony-forming capacity. Enzymatic analyses revealed differential modulation of key antioxidant defenses, including superoxide dismutase, catalase, glutathione reductase, and ascorbate peroxidase, indicating a coordinated SeBolA-mediated redox homeostasis. Comparative structural analysis demonstrated that SeBolA lacks the extended C-terminal α-helix and positively charged DNA-binding surface present in EcBolA, instead displaying an acidic and hydrophilic surface favoring protein-protein interactions rather than transcriptional regulation. In *S. elongatus*, *bolA* transcription was upregulated during stationary phase and under combined photooxidative and salinity stress, concomitant with cell elongation and modulation of division-related genes, suggesting a conserved role in coordinating morphology and stress responses. Collectively, our findings reveal that SeBolA functions primarily as a cytosolic stress-protective factor rather than a transcriptional regulator, enabling maintenance of cellular integrity under environmental challenges.

Keywords: Antioxidant defense, Blue green algae, BolA, Morphology, Oxidative stress

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SOP 034

DEVELOPMENT OF AN IOT-ENABLED SMART PHOTOBIOREACTOR INTEGRATED WITH ARTIFICIAL INTELLIGENCE AND DIGITAL TWIN TECHNOLOGY FOR REAL-TIME MONITORING AND PREDICTIVE CULTIVATION OF MICROALGAE

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ABSTRACT

The transition from laboratory-scale microalgal cultivation to intelligent and autonomous bioprocessing requires the integration of advanced sensing, data analytics, and predictive modelling tools. In this study, an Internet of Things (IoT)-enabled smart photobioreactor platform was developed for real-time monitoring and optimisation of microalgal cultivation. The system consists of a bubble column photobioreactor integrated with multiple sensors, including pH and temperature probes, along with a continuous optical density (OD) monitoring unit based on an in-line flow-through measurement system. Sensor data are transmitted to a cloud-based dashboard, enabling remote visualisation and process monitoring from any location. To establish reliable biomass estimation, calibration models were developed using cultures grown in various media. The acquired data streams were further integrated with an Artificial Neural Network–Particle Swarm Optimisation (ANN-PSO) framework. The ANN model was trained using historical cultivation data and calibration datasets to predict biomass growth dynamics, while PSO was employed to identify optimal operating conditions for enhanced cultivation performance. To extend the predictive capabilities of the platform, a digital twin architecture was implemented to create a virtual representation of the physical photobioreactor. The digital twin continuously synchronizes with real-time sensor inputs and AI-generated predictions, allowing simulation of cultivation scenarios, performance forecasting, anomaly detection, and process optimization without disrupting reactor operation. The proposed smart photobioreactor demonstrates the potential of combining IoT, artificial intelligence, and digital twin technologies to advance precision cultivation of microalgae and represents a significant step toward autonomous and scalable microalgal bioprocessing systems.

Keywords: Artificial Neural Networks; Artificial Intelligence; Bio-processing; Microalgae; Photobioreactor.

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SOP 035

EXPLAINABLE AI-BASED HYPERSPECTRAL IMAGING FOR THE NON-DESTRUCTIVE IDENTIFICATION OF DIVERSE MICROALGAL SPECIES

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ABSTRACT

Microalgae cultivation is often compromised by microbial contamination, which consequently causes rapid culture crashes and economic losses. To address this bottleneck, the present study developed a non-destructive classification framework integrating portable reflectance hyperspectral imaging (HSI) with advanced algorithms to identify 20 distinct microalgal taxa. Specifically, 1,860 images were captured using a Specim IQ hyperspectral camera to generate 37,200 spectral observations across 204 wavebands within the 400–1000 nm range. Following data acquisition, ten classification architectures, comprising five machine learning and five deep learning models, were evaluated for their predictive performance. Among these, the one-dimensional convolutional neural network (1D-CNN) demonstrated superior performance, achieving a test accuracy of 99.18% and a weighted receiver operating characteristic area under the curve (ROC-AUC) of 1.000. Notably, this deep learning architecture significantly outperformed traditional machine learning classifiers. Furthermore, model generalizability was confirmed using 2,000 unseen samples, yielding a 98.40% certain-prediction rate. To provide essential model interpretability, SHapley Additive exPlanations (SHAP) Analysis was employed to identify key diagnostic wavelengths corresponding to the absorption features of chlorophyll-a, phycocyanin, and phycoerythrin. The successful identification of these biopigments confirms the validity of the classification framework. Finally, this study represents the first simultaneous classification of 20 microalgal taxa using portable HSI, offering a robust, high-throughput, and non-invasive tool for real-time photobioreactor monitoring and industrial microalgal biotechnology.

Keywords: Artificial intelligence, Convolutional neural network, Hyperspectral imaging, Microalgae, Species classification

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SOP 036

OPTIMIZING *CHLORELLA* SP. CULTIVATION IN MUNICIPAL WASTEWATER SUPPLEMENTED WITH TARGETED NUTRIENT DOSES FOR ENHANCED BIOMASS PRODUCTION AND LIFE CYCLE ASSESSMENT

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ABSTRACT

Municipal wastewater remediation integrated with microalgal cultivation presents a sustainable approach for simultaneous nutrient sequestration and biomass valorization. This study investigates the cultivation and growth performance of *Chlorella* sp. in municipal wastewater supplemented with varying doses of specific salts, including sodium chloride, magnesium sulphate, potassium nitrate and calcium carbonate. Among the evaluated supplements, *Chlorella* sp. exhibited exceptional growth, enhanced biomass accumulation, and improved nutrient uptake from wastewater enriched with potassium nitrate. The targeted addition of key chemicals significantly optimized bioprocess parameters, improving the overall metabolic output of the microalgal system. Furthermore, a comprehensive Life Cycle Assessment (LCA) was conducted to evaluate the environmental impacts, energy efficiency, and overall sustainability of entire process. The findings demonstrate that strategic nutrient supplementation not only boosts microalgal productivity for high-value bioproduct applications but also validates the environmental viability of wastewater phycoremediation processes

Keywords: Chlorella sp.; Municipal wastewater; Nutrient supplementation; Life cycle assessment; Phycoremediation

SOP 037

LINKING STRAIN-SPECIFIC PHYSIOLOGY WITH REACTOR-DEPENDENT BIOMASS PRODUCTIVITY IN *LIMNOSPIRA* (SPIRULINA)

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ABSTRACT

Limnospira spp. (Spirulina), a blue-green microalga, is widely recognized for its rich nutritional profile, with applications in dietary supplements and functional foods. Industrial cultivation of *Limnospira* commonly relies on generalized cultivation conditions, despite physiological differences among closely related strains. In this study, two *Limnospiraplatensis* strains (S1 and S2), isolated from freshwater sources near Nagpur, India, were compared under different pH, light and nutrient conditions to identify strain-specific cultivation responses. The strain S1 showed better growth than S2 across wide pH range of 7–9, and enhanced biomass accumulation under increased light intensity. Red light produced the highest biomass accumulation reaching 9.6 g L^{-1}, while Zarrouk's medium supported sustained growth.

S1 was subsequently cultivated under identical operating conditions in a 25-L tubular photobioreactor (PBR) and 25-L closed raceway pond to evaluate reactor-dependent scale-up performance. The PBR showed substantially faster initial biomass accumulation, reaching 8.42 g L^{-1} by day 6 with a productivity of 1.4 g L^{-1} day^{-1}. In contrast, raceway cultivation exhibited slower but sustained biomass accumulation reaching a final biomass concentration of 9.96 g L^{-1}. Reactor configuration also altered biomass composition: PBR-derived biomass contained 43.39% carbon and exhibited a higher calorific value of 20.28 MJ kg^{-1}, compared with 22.28% carbon and 6.23 MJ kg^{-1} for raceway-derived biomass.

These results demonstrate that both strain-specific physiological screening and reactor configuration are important determinants of *Limnospira* biomass productivity and quality, highlighting the need to align cultivation strategy with the intended biomass application.

Keywords: Cultivation conditions; *Limnospira*; Photobioreactor; Raceway pond; Spirulina

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SOP 038

PHYCOSYNTHESIS OF SILVER NANOPARTICLES: ANTIBACTERIAL ACTIVITY AND GROWTH-MODULATING EFFECTS ON FRESHWATER ALGAE

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ABSTRACT

Silver nanoparticles (AgNPs) have gained significant attention because of their broad-spectrum antimicrobial properties and potential applications in biomedical and environmental fields. However, conventional physical and chemical synthesis methods have been imposing serious environmental hazards. Green synthesis offers an eco-friendly and sustainable alternative by employing biological sources as reducing agents. Thus in the present study, silver nanoparticles were synthesized using different species of algae viz. *Chlorella sp.*, *Scenedesmus sp.*, mixed algal culture and *Arthrospira sp*. The formation of AgNPs was confirmed using UV-Visible spectroscopy, TEM and the elemental composition was confirmed by EDX spectroscopy. The results showed that the rate of synthesis, yield and absorption maxima of AgNPs was dependent on the algal species used as reducing agents. Later, the synthesized AgNPs were employed for the assessment of antimicrobial activity to determine their inhibitory potential towards *Bacillus subtilis*. Furthermore, the influence of the biosynthesized AgNPs on algal growth was investigated at different exposure concentrations to evaluate their biological and ecological effects. Changes in growth parameters, including cell density, biomass accumulation, growth rate, and photosynthetic performance, were monitored to determine concentration-dependent responses. Thus the current study provides a comparative assessment of the efficiency of different algal species in the green synthesis and biological performance of AgNPs. Overall, this work contributes to the development of sustainable nanoparticle synthesis approaches while providing important insights into both the potential applications and ecological implications of algae-derived silver nanoparticles.

Keywords: Algae, Antimicrobial activity, Biomass, Green synthesis, Silver Nanoparticles

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SOP 039

METABOLIC ENGINEERING OF MICROALGAE FOR SUSTAINABLE OMEGA-3 FATTY ACID PRODUCTION THROUGH INTEGRATED WASTEWATER BIOREFINERIES

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Abstract

Omega-3 dietary supplements, second to vitamin D in popularity, are consumed daily at 200-500 mg. ω-6 fatty acids are common in regular foods, while essential ω-3 FAs like Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) mainly come from fish and other seafoods. Changes in dietary habitats have led to increased consumption of saturated and omega-6 fatty acids, resulting in an imbalance ω-3/ω-6 ratios, contributing cardiovascular, prothrombotic and proinflammatory diseases. Overexploitation and climate change constrain fish oil supply, and oilseed crops/plants are poor substitutes due to limited α-linolenic acid conversion to EPA and DHA. Integrating microalgae cultivation with industrial wastewater and exogenous supplements produces bioactive molecules for functional foods and nutraceuticals. This market, valued at USD 4.1 billion in 2019, is projected to reach USD 8.5 billion by 2025, with a CAGR of 13%. The present study envisages growth hormones and abiotic stress factors to enhance polyunsaturated fatty acids (PUFA) and uses genetic engineering to identify novel genes in lipid biosynthesis, steering metabolic pathways toward EPA and DHA production. Aligning with India's "Make in India" initiative, the project aims to enhance nutritional well-being and envision a disease-free future, contributing to Sustainable Development Goals (SDGs) 2, 3, and 13.

Keywords:*Long-chain polyunsaturated fatty acids (LC-PUFA), Industrial Wastewater, Genetic and non-genetic modification, Photosynthetic efficiency, Nutrient Recovery, Microalgae Biorefinery*

SOP 040

IMPROVING SHELF-LIFE OF *NANNOCHLOROPSIS OCEANICA* FEED FORMULATIONS FOR SUSTAINABLE OMEGA-3 ENRICHED EGG PRODUCTION

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ABSTRACT

The incorporation of microalgal biomass into poultry feed represents a sustainable strategy for producing omega-3 enriched eggs; however, oxidative degradation of polyunsaturated lipids during feed storage remains a critical barrier to commercial adoption. This study investigated the storage stability of dried *Nannochloropsis oceanica* biomass as poultry feed ingredients under two storage atmospheres (air vs. nitrogen flushing), two antioxidant treatments (with vs. without rosemary oil), and three temperatures (4, 25, and 40 °C) over 56 days.

Nitrogen flushing proved highly effective in retarding lipid oxidation, extending EPA shelf life at 25 °C from 79.8–111.6 days under air to 155–201 days, ensuring greater omega-3 retention in feed reaching layer hens. Rosemary treatment provided additional protection at 4 and 25 °C, making it a practical, natural antioxidant option compatible with poultry feed formulations. At 40 °C, however, oxidative deterioration accelerated markedly, highlighting the importance of temperature-controlled storage throughout the poultry feed supply chain.

A preliminary layer hen feeding trial confirmed the nutritional efficacy of algal feed supplementation. Egg productivity increased from 72.2% to 77.7%, while DHA content per egg nearly tripled from 23.4 mg to 67.5 mg, directly meeting consumer demand for omega-3 enriched eggs. Improved shell thickness, potentially attributable to enhanced calcium bioavailability from algal biomass, further contributed to egg quality and reduced handling losses. These results demonstrate that nitrogen flushing combined with rosemary extract effectively preserves *Nannochloropsis oceanica* as a stable, high-quality omega-3 poultry feed ingredient.

Keywords: Egg; Omega-3 fatty acids; Oxidative stability, Poultry feed; Shelf life

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SOP 041

TAILORING FISH OIL–LIKE EPA:DHAPROFILES THROUGH CONTROLLED CO-CULTIVATION OF *PHAEODACTYLUM TRICORNUTUM* AND *AURANTIOCHYTRIUM LIMACINUM*

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ABSTRACT

Demand for sustainably sourced long-chain omega-3 fatty acids requires microbial alternatives capable of reproducing balanced EPA:DHA profiles found in fish oil. This study developed a binary co-cultivation strategy combining the marine diatom *Phaeodactylum tricornutum*, an eicosapentaenoic acid (EPA) and monounsaturated fatty acid producer, with the thraustochytrid *Aurantiochytrium limacinum*, a docosahexaenoic acid (DHA) rich organism. Initial inoculum ratios were modulated to prevent the rapid overgrowth of *A. limacinum* and support regulated proliferation of both species. Subsequent media engineering through nitrate and glycerol optimization enabled tailoring of the final fatty-acid composition. The co-culture was designed to synthesize EPA:DHA ratios of 2:1 (56.44 and 30.11 mg g^{-1}, respectively) and 1:1 (47.43 and 49.61 mg g^{-1}, respectively), comparable with desired fish-oil profiles. The biomass additionally contained the monounsaturated fatty acids palmitoleic acid (2.65 mg g^{-1}) and oleic acid (1.25 mg g^{-1}), together with high-value pigments: fucoxanthin (367.18 µg g^{-1}), β-carotene (8.98 µg g^{-1}), and astaxanthin (0.77 µg g^{-1}).

These findings demonstrate that controlling population balance and nutrient availability can direct lipid quality in mixed microbial cultures. Co-cultivation of complementary EPA and DHAproducing marine microorganisms therefore offers a promising route to customized omega-3 oils and pigment-enriched biomass for nutraceutical and aquaculture-feed applications.

Keywords: *Aurantiochytrium limacinum*; Co-cultivation; Omega-3 fatty acids; *Phaeodactylum tricornutum*; Polyunsaturated fatty acids

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SOP 042

DEVELOPMENT OF ALGAL-DERIVED PHA NANOFIBERS FOR SUSTAINABLE FOOD PACKAGING APPLICATIONS

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ABSTRACT

Cyanobacteria are viable options for sustainable polyhydroxyalkanoates (PHA) synthesis owing to their photosynthetic capacity to effectively harness CO_2 and sunlight. This study investigates a sustainable biotechnology approach for the large-scale production of biopolymers from microalgal biomass and subsequent processing of the materials for eco-friendly food packaging. The growth of *Synechocystis pevaleikii* in a 100 L raceway reached a peak biomass on day 20, with an optical density of 1.37, a chlorophyll-a concentration of 12.45 µg/mL, and a dry cell mass of 4.95 g/L. Following biomass synthesis, the Soxhlet extraction of PHA was optimized across different time intervals (1-10 hours), with a 5-hour cycle identified as optimal, yielding a total PHA yield of 13.4% by weight. FTIR spectroscopy confirmed the presence of essential functional groups associated with PHA, whereas GC-MS analysis identified medium- to long-chain fatty acid esters (C16-C20), primarily methyl hexadecenoate. Differential Scanning Calorimetry (DSC) examination revealed a semi-crystalline PHA configuration, exhibiting a glass transition temperature (Tg) of 5°C and a melting point (Tm) of about 175°C.

Interestingly, mixing algal PHA with commercial PHA in specific proportions, along with cellulose nanopowder as a filler, yields biocomposites with superior electrospinnability, consistent fiber quality, and robust structural integrity. Electrospun nanofiber sheets produced from the refined formulation exhibited remarkably enhanced barrier and surface characteristics, including a reduced water vapor transmission rate (WVTR), increased hydrophobicity, and superior water stability, underscoring their suitability for eco-friendly food packaging.

Keywords: Cyanobacteria, Poly-β-hydroxybutyrate (PHB), Polyhydroxyalkanoates (PHA), Electrospinning, Raceway cultivation, etc.

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Abstracts of Poster Presentations

PP 001

UPCYCLING VOLATILE FATTY ACIDS AS SUSTAINABLE CARBON SINKS FOR PRODUCING OMEGA-3-ENRICHED EDIBLE OILS IN *AURANTIOCHYTRIUM* SP.

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ABSTRACT

To address the rising global need for sustainable omega-3 polyunsaturated fatty acids (PUFAs), such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), cost-effective fermentation processes must be developed that bypass refined sugar feedstocks. Heterotrophic thraustochytrids, specifically *Aurantiochytrium* sp., possess strong lipid accumulation capabilities, rendering them suitable candidates for substrate valorization. In this study, short-chain volatile fatty acids (VFAs; C2–C6) were investigated as substitute carbon sources to support biomass expansion and lipid production in *Aurantiochytrium* sp. The strain demonstrated high metabolic flexibility across different VFA regimes: propionate and acetate sustained cellular growth up to 1.5% (v/v), whereas butyrate supported growth up to 1.0% (v/v). Analysis of substrate utilization showed complete consumption, with overall productivity dictated primarily by total VFA concentration rather than the precise molar proportions of individual acids in ternary combinations. Furthermore, joint supplementation with glucose offered no notable synergistic advantage over VFA-only treatments, indicating that refined sugar inputs can be eliminated entirely. Optimization of bioprocess hydrodynamics further improved culture performance: increasing agitation to 150 rpm elevated biomass accumulation by 31% over 120 rpm while boosting cellular lipid levels. Under these optimized conditions, a tailor-made mixed-VFA regime achieved a maximum dry cell density of 10.27 g L^{-1}, capturing 68% of biomass and 83% of lipid yield relative to a 3% glucose control. The resulting single-cell oil will be characterized by GC-MS to determine its DHA and EPA composition. Overall, these findings present a scalable, glucose-free pathway for upcycling waste-derived VFAs into high-value nutraceutical lipids rich in omega-3 PUFAs.

Keywords:*Aurantiochytrium* sp.; Polyunsaturated fatty acids.; Single-cell oil: Substrate valorization; Volatile fatty acids.

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PP 002

R-PHYCOERYTHRIN FROM *GRACILARIA EDULIS*: SEASONAL VARIATION, STABILITY, DEGRADATION KINETICS, AND FOOD MATRIX COMPATIBILITY

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ABSTRACT

Algae-derived pigments are promising natural alternatives to synthetic food colorants; however, their practical application is constrained by limited stability during processing and storage. In this study, seasonal variation in R-phycoerythrin (R-PE) content in *Gracilaria edulis* was investigated, followed by evaluation of the stability and degradation kinetics of the purified pigment under different storage conditions and in model food systems. R-PE content varied seasonally, with the highest content (0.39±0.002 mg g^{-1}) recorded during the monsoon months (June-July). Optimized extraction by homogenization yielded 1.14±0.016 mg g^{-1} R-PE. Purified R-PE exhibited characteristic absorption maxima at 498, 540, and 565 nm. The pigment showed maximum stability at pH 6.8-7.0 at both 4 and 25 °C, with greater retention under refrigerated conditions. Elevated temperature and light exposure accelerated R-PE degradation. Among the tested additives, EDTA provided the greatest stabilization, with a degradation rate constant (k) of 0.0011 day^{-1} and a half-life ($t_{1/2}$) of 630 days. To assess its applicability in food matrices, R-PE stability was further evaluated in polysaccharide- and protein-based model systems at 4 and 25 °C. Aloe vera gel exhibited greater pigment retention and slower degradation (k = 0.0032 day^{-1}; $t_{1/2}$= 217 days) than egg albumin (k = 0.0035 day^{-1}; $t_{1/2}$= 198 days). These findings demonstrate that harvesting season, storage conditions, and food matrix composition substantially influence R-PE stability and highlight the potential of *G. edulis*-derived R-PE as a natural colorant for food applications.

Keywords: Food model systems; *Gracilaria edulis*; R-Phycoerythrin; Seasonal variation; Stability and degradation kinetics.

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PP 003

AGRO-INDUSTRIAL WASTE VALORIZATION FOR EXOPOLYSACCHARIDE PRODUCTION BY *AURANTIOCHYTRIUM LIMACINUM* GG03 AND ITS APPLICATION IN HYDROCARBON BIOREMEDIATION

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ABSTRACT

A marine thraustochytrid *Aurantiochytrium limacinum* GG03 was evaluated for its potential to produce exopolysaccharide (EPS) using low-cost agro-industrial substrates, with subsequent assessment of its potential in hydrocarbon bioremediation. Among the substrates evaluated, cheese whey supported the highest EPS production (4.02 ± 0.19 g/L) and was selected for further experiments. The resulting EPS was characterized for its biochemical composition and structural properties using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM). The EPS exhibited emulsification activity against a broad range of hydrocarbons, with the highest emulsification index reaching up to 65 ± 0.133 %. The resulting emulsions also exhibited prolonged stability over an extended incubation period, demonstrating the potential of the EPS as a bioemulsifier. The role of EPS in hydrocarbon biodegradation was evaluated in separate biodegradation assays, where GG03, together with the EPS produced, facilitated the degradation of kerosene, diesel, hexadecane, and naphthalene. FTIR profiles of the hydrocarbons indicated shifts in characteristic absorption bands following treatment, suggesting chemical alterations associated with biodegradation. GC-MS analysis revealed reduced intensities of n-alkanes, accompanied by decrease in the peak areas and heights of characteristic hydrocarbon components. The formation or detection of acids, alcohols, aldehydes, and esters further suggested the transformation of hydrocarbon constituents during biodegradation. Overall, these findings demonstrate the potential for valorization of agro-industrial residues as low-cost substrates for EPS production and highlight GG03-derived EPS as a promising bioemulsifier with potential application in hydrocarbon bioremediation.

Keywords:*Aurantiochytrium limacinum* GG03; Bioemulsifier; Exopolysaccharide; Hydrocarbon bioremediation; Valorization of low-cost substrates.

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PP 004

A MARINE PROTIST FOR WASTEWATER REMEDIATION: THE VERSATILITY OF *AURANTIOCHYTRIUM LIMACINUM* GG01

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ABSTRACT

Conventional physicochemical wastewater treatment is energy- and cost-intensive and may generate secondary pollutants, necessitating sustainable biological alternatives. Marine thraustochytrids are predominantly explored for high-value metabolite production, while their environmental remediation potential remains comparatively under investigated. Preliminary laboratory studies demonstrated dye decolorization and heavy-metal removal potential of *Aurantiochytrium limacinum* GG01. In the present study, its remediation efficiency was evaluated in dye-contaminated industrial wastewater, municipal sewage wastewater, and aquaculture wastewater.

GG01 achieved 67.62 ± 0.69% dye decolorization in industrial wastewater within 24 h, increasing to 85.11 ± 0.82% after 48 h. In municipal sewage wastewater, Pb, Zn, and Cd removal reached 78.97%, 80.40%, and 68.79%, respectively, within 24 h. In aquaculture wastewater, Pb, Zn, and Cr(VI) removal reached 78.47%, 75.61%, and 71.66%, respectively. GG01 also reduced organic pollutants, with maximum COD and BOD reductions of 41.23 ± 1.45% and 30.76 ± 5.43%, respectively, in municipal sewage wastewater after 24 h. The laboratory studies provided mechanistic evidence for dye degradation and heavy-metal removal, while the wastewater experiments demonstrated the practical remediation capability of GG01 in complex wastewater environments.

Overall, *A. limacinum* GG01 exhibits broad-spectrum pollutant-removal potential and represents a promising biological platform for sustainable wastewater treatment. These findings expand the environmental applications of marine thraustochytrids beyond high-value metabolite production.

Keywords:*Aurantiochytrium limacinum* GG01, Dye decolorization, Heavy metal removal, Marine thraustochytrid, Wastewater bioremediation.

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PP 005

AGROBACTERIUM MEDIATED *IN PLANTA* TRANSFORMATION OF *DUNALIELLA SALINA* PHYTOENE SYNTHASE (*DSPSY*) GENE CONFERS SALINITY TOLERANCE IN *SOLANUM LYCOPERSICUM*

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ABSTRACT

Soil salinity is a major abiotic stress impacting crop production through hyperosmotic imbalance, ion toxicity and oxidative damage. In the present study, we took advantage of the data of whole genome sequence of the hypersaline green microalga *Dunaliella salina* MCC43 (NCBI Accession No. PRJNA1092387), for identification and transfer of one of the carotenoid biosynthesizing gene, phytoene synthase (*PSY*) as carotenoids are well established photopigments for stress tolerance. As *D. salina* possesses 10-12% carotenoid, therefore, we applied synthetic biology approach to heterologously express the rate-limiting algal phytoene synthase gene (*DsPSY*) in tomato (*Solanum lycopersicum*) to assess its efficacy in conferring salt tolerance. Transgenic tomato lines containing the *DsPSY* construct under a constitutive promoter showed significant metabolic reprogramming under high salinity (150–200 mM NaCl). Genomic integration and stable transcription of *DsPSY* resulted in increased growth in terms of chlorophyll content, relative water content compared to wild-type controls. The relatively low accumulation of reactive oxygen species (ROS) in transgenic plants, the reduced level of malondialdehyde (MDA) and the increased activities of superoxide dismutase, catalase and ascorbate peroxidase demonstrated increased tolerance. Thus, the transfer of functional metabolic drivers from extremophilic algal genomic reservoirs to terrestrial crops significantly enhances cellular redox homeostasis and osmotic adaptation. This is first ever report of microalgal gene transfer in vegetable crop and this study shows the potential of microalgae as powerful synthetic biology building blocks for developing climate-resilient crops.

Keywords:*Dunaliella salina*; Halotolerant; qPCR; Redox; Transgenic

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PP 006

SELENIUM-FED MICROALGA, *DUNALIELLA SALINA*, ISOLATED FROM HYPERSALINE SAMBHAR LAKE: A SOURCE OF PHARMACEUTICAL AND NUTRACEUTICAL POTENTIAL

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ABSTRACT

The global crisis of hunger and malnutrition affected more than 345 million people. Climatic shift and conflict among nations made the situation worse. This led scientists to look to microalgae as a food resource, endowed with various nutraceuticals and pharmaceuticals. *D. salina* is a eukaryotic wall-less halotolerant microalga growing in a 20–30% hypersaline lake, brought to the lab and acclimated to grow at 0.5 M NaCl. Interestingly, 2 M NaCl (~12%) grown *D. salina* was able to withstand selenium (Se) stress with bioaccumulation of Se (65 µg Se mg^{-1}). As Se is a requirement in biomedicine, the idea was that Se-enriched *D. salina* may have unique metabolites of pharmaceutical and nutraceutical importance. We have already evaluated the crude extract along with fractionated extracts, including TLC-purified extracts, against selected pathogenic bacteria using CLSI guidelines. The sensitivity of the TLC-purified fraction was further evaluated against *Cryptococcus* sp., *Candida albicans, and C. tropicalis*. This potential fraction was subsequently subjected to HRAMS analysis. Several putative antifungal biomolecules were identified and further evaluated *via* molecular docking and molecular dynamics (MD) simulation using specific fungal proteins. The genome has been sequenced and submitted to NCBI by the lab, along with transcriptomic data. We are currently analysing the putative numbers of genes PKS (polyketide synthase) and NRPS (non-ribosomal peptide synthetase). Overall, *D. salina* may act as a valuable resource for pharmaceuticals and nutraceuticals and may be explored for its feasibility as an alternative food resource, following appropriate validation, to address hunger and malnutrition worldwide.

Keywords: Halotolerant, microalgae, nutraceutical, pharmaceutical

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PP 007

WASTE-TO-VALUE BIOREFINERY USING *NANNOCHLOROPSIS* SP. FOR INDUSTRIAL WASTEWATER REMEDIATION AND OMEGA-3 FATTY ACID PRODUCTION

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ABSTRACT

Omega-3 dietary supplements, second to vitamin D, are consumed daily at 200-500 mg. Overexploitation and climate change constrain fish oil supply, while oilseed crops/plants are poor substitutes due to limited α-linolenic acid (ALA) conversion to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The present study envisages an integrated wastewater-to-value biorefinery platform using *Nannochloropsis* sp. cultivated mixotrophically with synthetic dairy wastewater (SDWW) to simultaneously remediate wastewater, fix carbon, generate biomass, and produce high-value omega-3 fatty acids. The microalgal system demonstrated 85% removal of organic matter and 70% nutrients, accompanied by an increase in biomass production from 890 to 1360 mg/L. OJIP chlorophyll a fluorescence analysis revealed progressive improvement in photosynthetic performance, with Fv/Fm, ETo/RC, TRo/RC, and ABS/RC serving as sensitive indicators of physiological adaptation to wastewater-based cultivation. Among the tested conditions, 25% SDWW exhibited the highest total lipid accumulation (33%) and protein content (23.45 mg/g), followed by 50% and 75% SDWW treatments. Fatty acid profiling demonstrated a predominance of unsaturated fatty acids, while GC–MS analysis confirmed the presence of 5,8,11,14,17-eicosapentaenoic acid (EPA) in the treatments. These findings underscore the potential of microalgae for nutritional well-being and waste management within a One Health framework.

Keywords:*Chlorophyll fluorescence; Circular Bioeconomy; Industrial Wastewater; Long-chain polyunsaturated fatty acids (LC-PUFA); Mixotrophic cultivation*

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PP 008

INTEGRATED EXPERIMENTAL AND DATA-DRIVEN APPROACHES FOR MICROALGAL BIOPROCESS OPTIMIZATION, CARBON SEQUESTRATION, AND BIOMASS VALORISATION

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ABSTRACT

Atmospheric CO_2 removal through microalgal bioprocesses requires optimization of multiple interacting cultivation parameters, for which AI/ML can provide a data-driven approach to capture nonlinear relationships and improve process efficiency. In this study, a Box-Behnken design (BBD) comprising 15 experimental runs was employed to investigate biological direct air CO_2 capture by the food-grade microalga *Chlorella sorokiniana* SVMIICT 8. Three critical process variables, nitrate concentration (1.5-6.0 mM), phosphate concentration (1.71-5.16 mM), and light intensity (50-150 µmol photons m^{-2} s^{-1}), were systematically varied at three levels. The resulting cultivation responses were evaluated through growth kinetics and biomass production to determine the influence of nutritional and photobiological parameters on carbon sequestration performance. The experimental dataset was subsequently integrated with AI/ML-based modelling to predict process responses and identify the relationships between cultivation conditions and carbon capture efficiency. Model-assisted optimization was used to identify favorable combinations of nitrate, phosphate, and light intensity for enhanced biomass productivity and CO_2 fixation. In addition to carbon sequestration, the generated biomass was evaluated for protein content to assess its potential for downstream valorization toward nutraceutical applications. The integrated experimental and AI/ML framework demonstrated the potential to couple atmospheric carbon capture with simultaneous biomass generation, enabling a more resource-efficient microalgal biorefinery approach. The study provides a data-driven basis for optimizing *C. sorokiniana* cultivation toward enhanced carbon sequestration while retaining biomass quality for high-value applications.

Keywords:*Chlorella sorokiniana; carbon sequestration; bioprocess optimization; Box–Behnken design; AI/ML modelling; biomass valorization; nutraceuticals*

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PP 009

PHYTOPLANKTON BIODIVERSITY AND MULTI-PARAMETER ASSESSMENT OF ECOLOGICAL HEALTH IN THE KUWANO RIVER, UTTAR PRADESH, INDIA

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ABSTRACT

Rivers are dynamic socio-ecological systems that sustain freshwater resources, biodiversity, and human livelihoods, while phytoplankton constitute the fundamental trophic base of aquatic ecosystems and serve as sensitive bioindicators of environmental change and for ecological monitoring. The present study provides an integrated assessment of the ecological condition of the Kuwano River, Basti District, Uttar Pradesh, India, based on physicochemical parameters, phytoplankton biodiversity, microbial indicators, molecular, and heavy-metal analysis. Water and phytoplankton samples were collected from five sites representing contrasting anthropogenic influences across four seasons summer, rainy, winter, and spring. Comprehensive physicochemical characterization revealed substantial spatial and seasonal variability, with phosphorus reaching a maximum concentration of 5.99 mg/L, indicating enhanced nutrient enrichment and potential eutrophication pressure. Phytoplankton communities were evaluated through diversity, chlorophyll-*a*, Fv/Fm, and primary productivity measurements. Maximum productivity reached 5.90 $gCm^{-3}day^{-1}$, while Fv/Fm attained 0.63 in spring season, demonstrating pronounced seasonal variation in phytoplankton physiological performance. Heavy-metal assessment revealed substantial accumulation in phytoplankton biomass, particularly Mn (568 mg/L), Ni (375 mg/L), and Cd (45 mg/L), indicating their potential role as bioaccumulators and ecological indicators of metal contamination. Microbial assessment of faecal coliform, and *E. coli* further demonstrated anthropogenic influence on river quality. Molecular characterization based on 16S and 18S rRNA gene sequencing confirmed the occurrence of *Anabaena cylindrica* and *Fritschiella tuberosa*. One-way ANOVA, Wilcoxon rank-sum test, principal component analysis, and canonical correspondence analysis collectively identified significant spatial–seasonal patterns and associations among environmental variables, pollutants, and phytoplankton communities. The integrated framework establishes a comprehensive ecological baseline for pollution assessment, biodiversity conservation, and sustainable management of the Kuwano River.

Keywords: Phytoplankton biodiversity; physicochemical parameter; Ecological Assessment; Seasonal variation; Kuwano River

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PP 010

COMPARATIVE INVESTIGATION OF BIOHYDROGEN PRODUCTION FROM MICROALGAL BIOMASS VIA BIOLOGICAL AND THERMOCHEMICAL ROUTES

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ABSTRACT

The growing demand for low-carbon energy systems has increased interest in renewable hydrogen production from non-food biomass resources. Microalgae are particularly attractive as a feedstock due to reduced land requirements, high productivity, and no herbicide or pesticide application. Furthermore, microalgae can grow in wastewater and can directly improve air quality by capturing and converting CO_2 to fuels and chemicals. Biohydrogen can be produced from microalgae through different biological and thermochemical conversion routes, each involving distinct operating conditions, energy requirements, process configurations, and economic implications. A systematic comparison of these routes is therefore essential to assess their relative process performance and feasibility. The present work investigates biohydrogen production from microalgal biomass through two distinct conversion pathways, namely dark fermentation and catalytic reactive flash volatilization (RFV). Process simulations for both pathways are developed in SuperPro Designer to establish comparable process flowsheets and quantify material and energy requirements. The assessment considers biomass conversion, hydrogen generation, utility consumption, equipment requirements, and opportunities for energy recovery across the two process configurations. The resulting process models are further evaluated through a techno-economic analysis to determine capital expenditure, operating expenditure, hydrogen production cost, and overall economic performance. By evaluating both pathways using a common basis, the study seeks to elucidate the differences in process, energy, and economic performance and establish the relative suitability of biological and thermochemical conversion for microalgal biohydrogen production.

Keywords: Biohydrogen; Dark fermentation; Microalgal biorefinery; Reactive flash volatilization; Techno-economic analysis

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PP 011

DIATOM COMMUNITY DYNAMICS AS BIOINDICATORS OF HYDROCHEMICAL AND HEAVY METAL STRESS IN FRESHWATER ECOSYSTEMS OF KOTTAYAM, KERALA

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ABSTRACT

The integrity of tropical riverine networks faces growing degradation due to anthropogenic activities and agricultural expansion, representing a critical threat to regional water security. The aims of the study were to assess the water quality monitoring and ecological conditions along with the biodiversity of benthic diatom assemblages in six major drinking water intake sites managed by the Kerala Water Authority (KWA) across the Meenachil and Muvattupuzha river systems in Kottayam, Kerala. We have performed multi-parametric biomonitoring during the pre-monsoon period for the assessment of integrated hydro-chemical analyses, microbiological, and benthic diatom community profiling. Comprehensive hydro-chemical assessments indicated severe ecological degradation across all monitored locations. Severe hypoxia was observed, with dissolved oxygen levels of 0.4- 0.9 mg/L. This hypoxia occurred alongside elevated concentrations of free CO_2 (16–28 mg/L) and nitrite (15–20 mg/L), denoting extensive organic enrichment and disrupted nitrogen cycle. ICP-MS analysis showed high heavy metal contaminations beyond the permissible limits. Station 2 (Mutholi) served as a primary ecotoxicological hotspot, exhibiting maximum recorded concentrations for zinc (145.70 mg/L), lead (1.87 mg/L), cadmium (1.514 mg/L), and arsenic (0.82 mg/L) pollutions. Microbiological evaluation indicated faecal coliform contaminations across all monitored sites ranges between 150 and 1100 MPN/100 mL. To correlate with the diatom as biological indicators for water quality, we have performed diatom population dynamics in all sampling sites. Phase contrast and Scanning Electron Microscopy (SEM) characterization of benthic diatom assemblages demonstrated a distinct taxonomic shift that correlated directly with the pollutions. The observed diatom communities were predominantly composed of saprobiontic and metal-tolerant morphotypes, specifically Achnanthidium sp., Navicula recens, Fragilaria aquaplus, and Cyclotella meneghiniana. The colonies of the resilient taxa were isolated and successfully cultivated as monocultures in silica enriched BG-11 medium, and preliminary genomic DNA extractions were verified for subsequent rbcL-based metabarcoding analysis. This study establishes a foundational baseline data for the development of a regional bio-indicative index, while underscoring the efficacy of these native diatom strains for heavy metal biosorption and targeted phycoremediation and carbon sequestration in regional wastewater and polluted riverine ecosystems.

Keywords: Benthic diatoms; Freshwater biomonitoring; Heavy metal toxicity; Meenachil River; Phycoremediation

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PP 012

ENHANCING STRESS TOLERANCE AND LIPID PRODUCTION IN CHLORELLA VARIABILIS THROUGH ADAPTIVE LABORATORY EVOLUTION USING DAIRY WASTEWATER

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ABSTRACT

Dairy wastewater (DWW) is a nutrient enriched effluent containing organic and inorganic nutrients which can cause environmental pollution if discharged untreated. However these nutrients can be used as valuable resources for growth of microalgae and biomass production. This study, Chlorella variabilis isolated from Banganga Dam (27.39306 N, 82.95667° E) was characterized using 18S rRNA gene sequencing, and its growth and biochemical responses to DWW as an alternative nutrient source were investigated. Microalgae were cultivated in different ratios of BG-11 medium and DWW (70:30, 50:50 and 30:70) to monitor their growth. Furthermore, an adaptive laboratory evolution (ALE) strategy was employed through successive cultivation cycles to improve stress tolerance and lipid production without genetic manipulation. Growth was determined by optical density at 650 nm and fresh biomass, dry biomass, and lipid content were measured to assess physiological and biochemical responses. The concentrations of nitrate, nitrite, ammonia, and phosphate in the wastewater were analyzed before and after cultivation to evaluate nutrient removal by *C. variabilis*. The cultures were compared under control and DWW treatment conditions to evaluate their adaptive responses to DWW-associated stress. The study demonstrates the potential of C. variabilis to naturally adapt to DWW stress and highlights ALE as a non-genetic strategy for developing stress-tolerant microalgal strains with enhanced biomass and lipid productivity. This approach may contribute to the sustainable treatment of DWW while simultaneously supporting microalgal biomass and biofuel production.

Keywords: Microalgae, Lipids, Biofuel, Environmental sustainability, Wastewater bioremediation.

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PP 013

SEQUENTIAL BIOPROCESSING OF MARINE ALGAE INTO INDUSTRIALLY IMPORTANT PRODUCTS

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ABSTRACT

Rising concerns about greenhouse gas emissions and fossil fuel depletion have accelerated demand for sustainable bio-based products. Marine microalgae have emerged as a promising feedstock with *Dunaliella salina* being commercially important source of β-carotene. After pigment extraction, substantial amount of biomass is left behind, presenting opportunities for further valorisation. This present study aimed to develop a sequential bioprocess to maximise utilisation of *D. salina* biomass and assessed environmental performance using Life Cycle Assessment (LCA).

β-carotene was recovered by supercritical fluid extraction (SFE), followed by sequential enzymatic hydrolysis using Alcalase, followed by Viscozyme L, to produce hydrolysate. Resulting hydrolysate was analysed for carbohydrate, protein and mineral content, evaluating biostimulant potential. A cradle-to-gate comparative LCA was conducted in openLCA using ecoinvent database and ReCiPe Midpoint (H) impact assessment method, comparing two scenarios, conventional single product β-carotene extraction and proposed sequential 2-product extraction.

The SFE process gave 15.4 ± 0.55 mg g^{-1} DW β-carotene. The generated hydrolysate contained 6.3 ± 0.36 mg mL^{-1} carbohydrates, 2.46 ± 0.08 mg mL^{-1} proteins, and essential micro- and macronutrients. Comparatively, sequential bioprocess showed increased environmental impacts by approximately 35–43%, primarily due to additional electricity demand of enzymatic hydrolysis. Electricity consumption during SFE and hydrolysis were dominant environmental hotspots, accounting for more than 90% of combined climate change impacts.

Overall, the study demonstrates feasibility of sequential bioprocessing, providing preliminary environmental insights. It provides basis for future optimisation, hydrolysate validation as biostimulant, and comprehensive environmental assessment.

Keywords: β-carotene; Biostimulant; *Dunaliella salina*; Life Cycle Assessment; Sequential bioprocessing

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PP 014

PROCESS INTENSIFICATION OF MARINE MICROALGAL CULTIVATION THROUGH OPTIMIZED CO_2 FEEDING STRATEGY FOR IMPROVED CO_2 FIXATION EFFICIENCY, BIOMASS PRODUCTIVITY AND BIO-CHEMICALS

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ABSTRACT

Microalgae-based carbon capture offers a sustainable approach for mitigating industrial flue-gas CO_2 emissions. However, its CO_2 fixation efficiency strongly depends on CO_2 feeding strategy and microalgal physiology. In this study, four CO_2 feeding strategies — growth-phase-dependent, linear fed-batch, time-dependent intermittent sparging, and continuous supply to co-cultures—were evaluated in a 2-L bubble-column photo-bioreactor operated at a flue-gas-relevant CO_2 concentration (15%, v/v) using marine *Chlorella* sp. and *Dunaliellasalina*. Linear fed-batch feeding at a moderate rate (k = 0.5) achieved the highest biomass productivity of 0.49 ± 0.04 g L^{-1} d^{-1} in *Chlorella* sp. with sequestration rate of 0.86 ± 0.05 g L^{-1} d^{-1}, representing a 69% improvement over the control. The intermittent sparging strategy (10 min h^{-1}) attained the highest CO_2 fixation efficiency — 8.26 ± 0.34% in *Chlorella* sp. and 5.12 ± 0.4% in *D. salina*, representing 8.7- and 6-fold improvements over continuous sparging. A 2:1 (*Chlorella* sp.: *D. salina*) co-culture provided a balanced performance, enhancing carbohydrate accumulation by 180% and lipid content by 5–46% while maintaining comparable lutein (4.23 ± 0.67 mg g^{-1}) and protein (159.11 ± 8.15 mg g^{-1}) levels. Multi-parameter trade-off plot showed that no single CO_2 feeding strategy simultaneously maximized biomass productivity, carbon fixation, and biochemical accumulation, necessitating objective-specific feeding regimes. The novelty of this study lies in the systematic demonstration of four operationally and biologically distinct CO_2 feeding regimes for improving CO_2 fixation efficiency by ~9-fold and altering strain-dependent carbon partitioning, thereby providing a scalable framework for microalgae-based flue-gas CO_2 capture and utilization.

Keywords: Co-culture; CO_2 fixation efficiency; Linear fed-batch; Marine Microalgae; Photobioreactor; Time-and growth-dependent strategy

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PP 015

EXPLORING GUJARAT'S MARINE MICROALGAE FOR SUSTAINABLE SMART PROTEIN

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ABSTRACT

Marine microalgae are emerging as promising sources of sustainable smart proteins due to their rapid growth, high protein content, low land requirements, and nutritional value. The present study investigates marine microalgal diversity along the Gujarat coastline and evaluates its potential as a resource for future smart protein development. Seawater samples were collected from diverse coastal regions, including the Gulf of Khambhat, South Gujarat, and the Saurashtra coast. The collected seawater samples were characterized using physicochemical analyses and subsequently used for the isolation and cultivation of marine microalgal strains under controlled laboratory conditions. The isolated strains were gradually scaled up to 1000 mL to establish stable cultures, resulting in a total of 20 cultures. These cultures were characterized using morphological and molecular approaches, and taxonomic identification revealed six distinct marine microalgal taxa. The protein content of the microalgal biomass was quantitatively estimated using a CHNS analyzer to identify protein-rich strains with potential for further development. The study successfully established marine microalgal cultures from diverse locations along the Gujarat coast and revealed promising strains with protein-rich biomass. These findings highlight the largely underexplored marine microalgal diversity of Gujarat as a potential resource for sustainable protein production. Further nutritional characterization, cultivation optimization, and scale-up of selected strains could facilitate the development of microalgae-based food applications and contribute to sustainable nutrition, future food security, and resource-efficient protein production.

Keywords: Marine microalgae; Protein-rich biomass; Smart protein; Sustainable nutrition; Gujarat coastline

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PP 016

METAGENOMIC UNDERSTANDING OF THE FUNCTIONAL PROFILES IN BACTERIAL COMMUNITIES ASSOCIATED WITH HEALTHY AND BLEACHED SEAWEEDS DURING OFF-SHORE CULTIVATION FOR THEIR ROLE IN CARBON UTILISATION AND STORAGE PATHWAYS

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ABSTRACT

Seaweeds are marine macroalgae that play a vital role in marine ecosystems as primary producers and contribute to food web dynamics and various ecosystem services, such as capturing and sequestering carbon, ameliorating ocean acidification, and protecting shorelines. Besides environmental benefits, seaweeds also have industrial applications, as they are a source of many commercial products. Due to their high demand, harvesting seaweeds beyond their annual or seasonal growth could lead to over-exploitation of wild seaweed beds. Despite management strategies, future demand exceeds the existing wild seaweed biomass. To mitigate this, a safe and sustainable alternative for sustainable seaweed utilisation is aquaculture of seaweeds for their biomass. For successful seaweed cultivation, high-quality, uncontaminated seawater is required, along with appropriate environmental conditions, including temperature, salinity, pH, solar radiation, and nutrient availability. Healthy development of seaweeds also requires the association with symbiotic bacteria that support their growth and development, as well as their metabolic activities and defence responses. In addition to its role in metabolic activities, the bacterial consortium also helps in the normal morphological development of the seaweed. The bacterial community associated with the seaweeds also plays an important role in the utilisation and biotransformation of complex seaweed biomass into recalcitrant carbon for long term storage. Metagenomic characterisation of the functional profiles in bacterial communities associated with healthy and bleached seaweeds during offshore cultivation for their role in carbon utilisation and storage pathways can provide an understanding of their metabolic potential for environmental and biotechnological applications.

Keywords: Carbon utilisation and storage; CUS; Metagenomics; Microbiomes; Seaweed

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PP 017

OMEGA-3 FATTY ACIDS FROM MICROALGAE: EXTRACTION, OPTIMIZATION AND CHARACTERIZATION

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ABSTRACT

Omega-3 fatty acids are predominant fatty acids which cannot be synthesized in our body. These high-value bioactive compounds are known for their essential roles in human health, including cardiovascular protection, anti-inflammatory activity, and neurological development. In this regard, a vegan, sustainable and promising alternative such as microalgae needs to be explored. Traditional extraction techniques typically involve petroleum-based solvents such as hexane, which raise concerns related to toxicity, environmental impact, and solvent residues. In this context, extraction using green solvents has gained considerable attention as an environmentally friendly and safe approach for extraction of omega-3 fatty acids from algal biomass. This study focuses on the extraction of omega-3 fatty acids from microalgae and optimization of extraction process parameters such solid-liquid ratio, extraction time, and extraction temperature. The extracted oil was characterized for its functional group and fatty acid composition using fourier-transform infrared spectroscopy(FT-IR) and gas chromatography – flame ionization detector (GC-FID) respectively. In addition, physiochemical properties of algal oil were evaluated to ascertain its quality. The obtained omega-3 rich algal oil is suitable for applications in nutraceutical, functional food, and pharmaceutical industries. Overall, the sustainable extraction employing green solvents represents a promising approach for obtaining high-value omega-3 fatty acids supporting circular bioeconomy and sustainable development goals (SDGs) principles 2,3,7,9,12, 13 and 14.

Keywords: algae, green extraction, omega-3 fatty acids, optimization, sustainability

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PP 018

EXPLORING THE METAL-BINDING POTENTIAL OF CYANOBACTERIAL EPS FOR SUSTAINABLE RARE EARTH ELEMENTS RECOVERY

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ABSTRACT

Rare earth elements are increasingly released through mining, industrial activities, and electronic-waste processing, creating a need for sustainable and low-cost removal strategies. Extracellular polymeric substances (EPS) released by cyanobacteria or blue-green algae possess diverse functional groups capable of interacting with metal ions, making them promising biological materials for metal recovery. The present study aims to evaluate the metal-binding efficiency of EPS and whole-cell biomass of *Synechocystis* sp, with rare earth elements. Bio-recovery performance was assessed under variables such as pH, metal concentration, reaction time, concentration of EPS and biomass. The applicability of the optimized system was subsequently assessed using a complex leach liquor to study the interaction of REE with the biological materials under realistic conditions. Furthermore, the molecular interactions underlying metal binding were investigated through characterization of the EPS–metal complex using FTIR and other complementary techniques where applicable. Changes in functional-group and elemental composition were used to identify the roles of functional groups in REE binding.

These findings underscore the potential of cyanobacterial EPS as a sustainable biopolymer for REE recovery, offering an eco-friendly alternative to conventional extraction methods. The study provides insights into the molecular interactions governing EPS–metal complexation and paves the way for biotechnological applications in rare earth element recovery and wastewater treatment.

Keywords: Extracellular polymeric substances; Metal-EPS complex characterization; Rare earth elements; Sustainable recovery; *Synechocystis*

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PP 019

HARNESSING ENGINEERED MICROALGAE AS A SUSTAINABLE PLATFORM FOR VITAMIN B6 PRODUCTION

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ABSTRACT

Vitamin B6 is conventionally produced through chemical synthesis, which involves toxic chemicals and is energy-intensive. Microbial fermentation using *Escherichia coli* and *Bacillus subtilis* has been explored, but the results are not economically feasible as the low titres aren't able to justify the high input costs. *Synechocystis PCC 6803* is a well-established cyanobacterial chassis that possesses well-defined native vitamin B complex biosynthetic pathways. In this study, we propose harnessing its photoautotrophic metabolism to create a sustainable, green alternative for vitamin B6 bioproduction. Vitamin B6 can be synthesized through either the DXP-dependent pathway or the DXP-independent pathway. The latter involves two main enzymes, PdxS and PdxT, and offers a pathway engineering strategy backed by well-established heterologous expression. We therefore propose introducing the *pdxS* and *pdxT* genes from *B. subtilis* into *Synechocystis PCC 6803* at its slr0168 locus. The transformation was performed using the pUC19 vector with the cyanobacterial constitutive promoter Pcpc560 and a Kanamycin cassette incorporated for selection. We hypothesize that the heterologous expression of these genes will enhance the vitamin B6 biosynthesis potential of *Synechocystis PCC 6803*. This method will help cut back on the biomanufacturing input costs by utilizing light and CO_2 as the primary energy and carbon sources. The residual biomass could be utilized as food, feed or fuel, supporting the integration of vitamin B6 production into a circular bioeconomy. This work therefore aims to establish a sustainable photoautotrophic platform for vitamin B6 bioproduction.

Keywords:*Bacillus subtilis*; PdxS; PdxT; *Synechocystis PCC 6803*; Vitamin B6

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PP 020

EXPLORING MARINE MICROALGAE FOR SMART PROTEIN APPLICATIONS

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ABSTRACT

The growing global and Indian demand for sustainable, complete, and affordable protein has intensified interest in alternative protein sources with high nutritional value and low environmental impact. Marine microalgae represent promising candidates; however, the marine cyanobacterium *Spirulina subsalsa* remains largely unexplored as a protein source. This study provides an integrated evaluation of *S. subsalsa*, from cultivation optimisation to protein recovery and functional assessment. Culture conditions were optimised through medium screening, one-factor-at-a-time studies of pH and salinity, and factorial optimisation of major macronutrients. Zarrouk's medium supported superior performance, while mildly alkaline pH (~9.0) and low salinity favoured protein production. Carbon primarily influenced biomass yield, whereas nitrogen governed protein content. Optimised cultivation in a 3 L photobioreactor produced biomass containing approximately 50% crude protein and 46 mg/g total phycobiliproteins. The biomass showed a favourable nutritional profile, low carbon-to-nitrogen ratio, and no detectable heavy metals. Among five protein-recovery approaches, ultrasonication-assisted enzymatic extraction achieved the highest soluble protein yield (364.8 mg/g), whereas alkaline solubilisation followed by isoelectric precipitation provided the highest isolate recovery (85–86%). The isolate exhibited 4.4-fold protein enrichment, minimum solubility around pH 3 and maximum solubility at pH 11 (547.5 mg/g). Overall, *S. subsalsa* demonstrates considerable potential as an underexplored marine smart-protein source for future food applications.

Keywords: marine microalgae; protein extraction; *Spirulina subsalsa*; smart protein

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PP 021

EXPLORING UV-INDUCED MUTAGENESIS FOR STRAIN DIVERSIFICATION AND BIOTECHNOLOGICAL ENHANCEMENT OF *CHLAMYDOMONAS REINHARDTII*

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ABSTRACT

Microalgae holds great potential for sustainable production of biomass and value-added metabolites including primary and secondary metabolite. However, their industrial application is often limited by strain-specific limitation in growth, biomass productivity and metabolite accumulation. Conventional cultivation of wild-type strains may therefore be insufficient to achieve the physiological performance needed for increased bioprocessing. The current study focuses on ultraviolet (UV)- induced random mutagenesis as a simple and cost-effective strain-improvement strategy to generate phenotypic diversity in the microalgae *Chlamydomonas reinhardtii.* Controlled UV exposure induced random genomic changes via DNA damage, followed by recovery, mutant isolation and systematic screening under predetermined selection conditions. Surviving colonies are comparatively evaluated for growth characteristics and biomass-associated phenotypes to identify mutants exhibiting improved performance relative to the parental strain. The study aims to establish a reproducible workflow integrating mutagen treatment, mutant selection, phenotypic characterization and stability assessment. This approach may simplify the identification of strains with desirable traits that could eventually be utilized to enhance biomass production and metabolite yields. This method provides a cost-effective and feasible substitute to more complex genetic engineering approaches, particularly for laboratories seeking scalable, technically accessible microalgal strain development. Overall, UV assisted random mutagenesis combined with systematic screening represents a promising platform for diversifying microalgae and speeding up the selection of high-performance strains for future applications in algal biotechnology and sustainable bioprocessing.

Keywords: Biomass, *Chlamydomonas*, Microalgae, Mutagenesis, Strain improvement

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PP 022

TRACKING TO TACKLING: NATIVE MICROALGAE FOR EMERGING MICROPLASTIC AND ANTIBIOTIC-RESISTANT BACTERIAL CHALLENGES IN WASTEWATER

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ABSTRACT

Wastewater treatment plants (WWTPs) are critical barriers against environmental release of microbial contaminants and emerging pollutants; however, their removal efficiencies may differ substantially for bacteria and persistent microplastics (MPs). This study investigated the fate of MPs and culturable bacterial populations across a full-scale sewage treatment plant and explored wastewater-derived native microalgae as a nature-based tertiary remediation strategy. MP abundance in influent, sequencing batch reactor (SBR), and treated effluent was 103, 122, and 119 particles/50 L, respectively, indicating substantial persistence across treatment. The effluent was dominated by smaller MPs (≤75 µm; 86 particles/50 L), with fibres as the predominant morphology. In contrast, total heterotrophic bacterial counts decreased from 5.14×10^5 CFU/mL in influent to 4.72×10^2 CFU/mL in the SBR, while antibiotic-resistant bacteria declined from 2.89×10^3 to 2.15×10^2 CFU/mL; culturable bacteria were not detected in the final effluent under the tested conditions. This contrasting fate highlights a critical treatment gap wherein effective bacterial attenuation does not ensure MP removal. To address this gap, native wastewater-derived microalgae are being isolated and screened through batch MP-removal assays for their capacity to promote MP adhesion, aggregation, and capture. This integrated field-to-laboratory approach provides a foundation for developing locally adapted microalgae-based tertiary treatment to reduce residual MPs and associated environmental risks in treated wastewater.

Keywords: Antibiotic-resistant bacteria; Microalgae; Microplastics; Phycoremediation; Wastewater treatment

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PP 023

MICROALGAE-MEDIATED REMOVAL OF PATHOGENS AND NUTRIENT FROM SEWAGE WASTEWATER

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ABSTRACT

Wastewater treatment plants can act as important reservoirs and dissemination pathways for pathogens, highlighting the need for sustainable, low-cost, and energy-efficient approaches for their mitigation. Hence, this study investigated the potential of a mixed microalgal culture for the simultaneous removal of pathogenic bacteria, organic matter, and nutrients from raw sewage. The trials evaluated microbial indicators, including E. coli, total coliforms, and Salmonella, along with COD, nitrate, phosphate, and ammonia. The mixed microalgal culture demonstrated substantial removal of pathogenic bacteria, achieving >90% reduction for most microbial indicators within 48 h, with E. coli, Salmonella, and total coliforms exhibiting approximately 99.9% removal. In addition, the system achieved 75% COD removal, along with 80% nitrate, 75% phosphate, and 88% ammonia removal within the treatment period. These findings demonstrate the potential of mixed microalgal systems to simultaneously mitigate pathogenic bacteria while removing organic matter and nutrients from sewage, supporting their application as a sustainable, low-energy nature-based approach for microbial risk reduction and enhanced wastewater treatment.

Keywords: Emerging contaminants; Microalgae; Nutrient removal; Pathogens; Wastewater treatment.

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PP 024

INDUSTRIAL WASTE-DERIVED NANOPARTICLES FOR WASTEWATER TREATMENT AND LIPID-BASED PETROCHEMICALS PRODUCTION FROM MICROALGAL CONSORTIA

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ABSTRACT

Metal oxide nanoparticles (MoNp) were synthesised using industrial residue as the precursor, and confirmed by FT-IR spectral analysis. To evaluate their applicability, NP dosage levels were optimised based on comparative growth. The nanoparticle doses were subjected to a suspended-growth microalgal consortium, and biomass proliferation was monitored using Chl-a. In parallel, the nanoparticle-dosed cultures were evaluated for wastewater treatment over a 30-day cultivation period, allowing simultaneous assessment of pollutant removal and biomass productivity. The reactive oxygen species (ROS) generated by NPs were investigated as key mechanistic drivers of algal cellular responses, influencing membrane permeability, oxidative stress, and consequent shifts in growth and lipid metabolism. Post- wastewater treatment period, biomass was harvested by centrifugation and subsequently cold-dried. Total lipid content was quantified across all dosage treatment groups, and the elevated lipid accumulation was further confirmed by peak intensity in the FT-IR spectrum, indicative of enhanced ester/carbonyl functional groups associated with lipid bodies. The extracted lipids were converted to fatty acid methyl esters (FAME) via transesterification, and FAME profiles were analysed using GC-MS to determine fatty acid composition and assess suitability for fuel-grade petrochemical applications. The results demonstrate that NP dosing was optimised to enhance growth and lipid production, mediated in part by controlled ROS induction, and can be strategically employed to improve both wastewater remediation and lipid-based biofuel potential.

Keywords: MgO Np's, ROS, wastewater treatment, FAME, GC-MS, petrochemicals

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PP 025

MICROALGAL PHOTOGRANULES AS A SUSTAINABLE FRAMEWORK FOR WASTEWATER TREATMENT, CARBON CAPTURE, AND RESOURCE RECOVERY

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ABSTRACT

A static, oxygenic photogranule (OPG)-type metal–microbe–photogranule (MPG) system was developed and evaluated for its potential to treat nutrient-rich wastewater with an Fe_2O_3 nanoparticle amendment. MPGs were cultivated in sealed vials across a Fe_2O_3 dose gradient (0, 10, 20, 40, 60, 80, and 100 mg/L) without mechanical mixing or external aeration, relying solely on photosynthetically generated oxygen to sustain granule metabolism over a 31-day incubation period. Granule morphology and stability were monitored at regular intervals (days 0, 6, 12, 18, 24, and 31) to assess the influence of nanoparticle dose on photo granulation. Pollutant removal efficiencies for phosphate, chemical oxygen demand (COD), ammonia, and nitrate were subsequently quantified in the control, 20, 80, and 100 mg/L Fe_2O_3 treatments over an 8-day cycle. The 20 mg/L dose consistently outperformed other treatments, achieving the highest removal efficiencies for phosphate (up to ~99.6% on day 1) and COD (up to ~92.4% by day 8), while ammonia and nitrate removal showed treatment- and time-dependent trends, with several doses exceeding 90% removal at select time points. These results indicate that low-dose Fe_2O_3 nanoparticle supplementation enhances the pollutant removal capacity of static, aeration-free OPG-type MPGs, supporting their application as a low-energy alternative for simultaneous nutrient and organic matter removal in wastewater treatment, consistent with the broader MMPG framework under development for combined wastewater treatment, carbon sequestration, and biofuel production.

Keywords: Metal-microbe-photogranule (MPG); Fe_2O_3 nanoparticles; Oxygenic photogranules (OPG); Wastewater treatment; Nutrient removal; Photosynthetic aeration

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PP 026

MICROALGAL BIOMASS WITH EPS MATRICES FOR MODERN FEED FORMULATIONS

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ABSTRACT

Microalgal biomass and its exopolysaccharides (EPS) offer a sustainable source of nutrients and bioactive compounds for use in animal nutrition and functional feed applications. Microalgae can provide proteins, amino acids, minerals, fatty acids, pigments, and other beneficial compounds, while EPS may contribute to improved gut health and overall animal performance. Microalgal biomass or EPS-rich fractions can be processed into stable feed additives using suitable formulation and drying techniques. Such formulations can help improve the stability, handling, and incorporation of bioactive compounds into animal feeds. In aquaculture and livestock production, microalgae-based feed additives can support growth, feed utilization, nutritional quality, and animal health. The presence of bioactive compounds such as EPS and pigments may also provide antioxidant and functional benefits. Overall, microalgae-based feed additives offer a sustainable approach to improving animal nutrition while reducing dependence on conventional feed ingredients and supporting environmentally responsible food production.

Keywords: Blue Economy; Exopolysaccharides (EPS); Microalgae; SDG-aligned supplements; Sustainable nutrition.

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PP 027

DECODING MICROALGAL GROWTH: INTEGRATING GROWTH AND BIOCHEMICAL DATA

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ABSTRACT

Microalgal cultivation requires more than conventional growth measurements to understand changes in biomass and biochemical composition. This study presents a data driven computational framework for analysing growth and biochemical responses in Microalgae during cultivation. Growth kinetic modelling was used to identify and characterize the different phases of growth, while biochemical analyses were performed to monitor changes in biomass, protein, and carbohydrate content throughput the cultivation period. In parallel, FT-IR spectral data were analysed using computational tools to identify changes in major functional groups associated with cellular components. Integrating the growth, biochemical, physiological and biochemical changes occurring during cultivation. This approach offers a predictive and data driven understanding of microalgal growth, which can support the optimization of cultivation conditions and improve microalgal bioprocessing strategies.

Keywords: Computational Framework; Growth and Biochemical characterization; kinetic Modelling; Microalgae

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PP 028

ALGAE-INTEGRATED SODIUM ALGINATE-FLY ASH BEADS FOR WASTEWATER TREATMENT

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ABSTRACT

The increasing discharge of wastewater containing organic matter and nutrients necessitates the development of sustainable, low-cost, and efficient treatment technologies. This study investigated the performance of sodium alginate–fly ash beads integrated with algal biomass for enhanced removal of organic matter and nutrients from wastewater. Two batch-scale treatment systems were comparatively evaluated: (i) algae-only system (control) and (ii) algae-integrated sodium alginate-fly ash beads. The systems were assessed for chemical oxygen demand (COD), ammonia, nitrate, and phosphate removal. The algae-only system achieved 70.09% COD, 82.46% ammonia, 73.38% nitrate, and 69.12% phosphate removal, demonstrating the inherent potential of algal biomass for simultaneous organic matter and nutrient removal. In comparison, the algae-alginate-fly ash bead system achieved 77.29% COD, 87.88% ammonia, 79.16% nitrate, and 76.58% phosphate removal, indicating enhanced treatment performance relative to the control. The improved performance of the integrated system can be attributed to the synergistic contribution of algal assimilation, biodegradation, adsorption, and surface interactions with the fly-ash-containing matrix. Overall, the findings demonstrate the potential of sodium alginate–fly ash beads as a low-cost immobilization and treatment matrix for enhancing algae-based wastewater treatment and provide a promising approach for sustainable removal of organic matter and nutrients.

Keywords: Algae; COD removal; Fly ash; Nutrient removal; Wastewater treatment.

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PP 029

BIO-ELECTROCHEMICAL OPTIMIZATION OF MICROALGAE GROWTH AND VALUE-ADDED BIO-PRODUCT SYNTHESIS THROUGH CONTROLLED LOW-VOLTAGE STIMULATION

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ABSTRACT

Controlled electrical stimulation of microalgae cultures offers a simple, sustainable approach to enhancing algae and biochemical production. By applying defined low-voltage conditions, this study investigates the potential of electrical stimulation to influence microalgae and metabolic responses without additional chemical additives. In this study, microalgae cultures were maintained under control conditions and exposed to 200 mV, 600 mV, and 1000 mV electrical stimulation. Growth and biochemical responses were evaluated over the cultivation period through protein, carbohydrate, and chlorophyll analysis. The study showed that controlled electrical stimulation can influence microalgae growth. the developed bioeconomical algae-integrated electrochemical system provides a simple approach for algal bioprocess optimization and has potential for sustainable production of value-added bio-products within a circular bioeconomy.

Keywords: Bioprocess optimization; Circular bio-economy; Electrochemical system; Electrical stimulation; Microalgae; Value-added bio-products.

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PP 030

EXPLORING SPIRULINA AS A LIVING CELL FACTORY FOR EXTRACELLULAR POLYSACCHARIDE PRODUCTION

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ABSTRACT

Spirulina (*Arthrospira* sp.) is widely cultivated as a sustainable source of proteins, pigments, and nutraceutical compounds, its extracellular polymeric substances (EPS), particularly extracellular polysaccharides, remain comparatively untapped. This study aims to investigate the strategy of physiological stress to enhance EPS production while enabling non-destructive recovery. Spirulina cultures has been cultivated with selective metabolic stresses, including nutrient (varying C and N source) modulation, salinity, and precursor-associated conditions, to assess their effects on biomass growth, photosynthetic performance, and extracellular carbohydrate accumulation. Cell-free culture supernatants were quantitatively analyzed for extracellular carbohydrates and further characterized using biochemical and spectroscopic approaches to elucidate their polymeric composition and functional groups. Over the repeated cycles the stress conditions were optimized for enhanced extracellular carbohydrate production by relative to the control, while maintaining biomass viability and productivity. Enabling extracellular biopolymer harvesting without cell disruption, the proposed approach seeks to transform Spirulina into a reusable living cell factory for sustainable biopolymer production. This non-destructive biorefinery strategy has the potential to minimize biomass loss, reduce downstream processing requirements, and improve resource efficiency, by contributing to a sustainable development of low-waste and circular algal biorefineries.

Keywords: Algal biorefinery; Biopolymer biogenesis; Cell-free harvesting; Exo-polysaccharides; Physiological stress

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PP 031

ALGAE SURVIVING UNDER STRESS: DO LINKER PROTEINS MAKE ANY DIFFERENCE?

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ABSTRACT

CO_2 concentrating mechanism (CCM) is vital for algae to survive in CO_2 related stress conditions. CCM helps in concentrating CO_2 in the vicinity of rubisco enzyme for increasing carbon fixation and reduces energy wastage in the form of photorespiration. Pyrenoids are special sub-organelle of chloroplast which acts as micro compartment for carrying out carbon fixation with help of rubisco enzyme. Pyrenoid matrix formation is generally regulated by linker protein which can bind rubisco enzyme through sticker motifs. Sticker numbers in the case of Chlamydomonas reinhardtii strain naturally range up to 5 stickers and engineered strains have sticker number up to 9. As naturally evolved variants are locked at 5 sticker number currently and engineered versions reaching 9, we want to see with the rise in global atmospheric CO_2 level and temperature, assessing the ability of algae to adapt to the environmental changes become necessary. In this study we explore the effects of increased sticker number above and below the naturally optimized sticker number on pyrenoid stability and algal survival under various stress conditions such as thermal stress, stress due to fluctuating concentrations of CO_2 etc. Our work aims to study whether naturally evolved valancy (i.e. 5) gives an optimal advantage to algae under environmental stress..

Keywords: Algae; Chlamydomonas reinhardtii; Carbon-concentrating mechanism (CCM); Pyrenoid; Linker protein.

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PP 032

GROWTH RESPONSE OF *CHLAMYDOMONAS REINHARDTII* STRAINS WITH EDITED CCM RELATED GENES UNDER DIFFERENT CO_2 CONCENTRATIONS

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ABSTRACT

In *Chlamydomonas reinhardtii* Carbon Concentrating Mechanism (CCM) under different CO_2 concentration captures CO_2 better than higher plants under low CO_2 concentration reducing the wasteful process of oxygenation and thereby photorespiration. In order to understand the CCM better we need to create targeted mutants for both known and putative CCM genes.

We used targeted CRISPR-Cas9 based editing to mutate specific CCM genes of *Chlamydomonas.* Several rounds of method optimisation were performed to get the standard transformation process and designing the target site for guide RNA, primer design, as establishing standard conditions were challenging. Following these optimized rounds, successfully edited algal colonies were obtained. Controlled growth chambers were established with low, high and ambient CO_2 concentrations to study the algal response. Initial growth experiments and spot assay tests showed reduced growth under low CO_2 and good growth under high CO_2, one control sample was placed in all three CO_2 concentration conditions, it showed growth in every CO_2 concentration. The differences in growth under high and low CO_2 concentration suggests that the targeted genes may have a role in CCM and they were knocked out.

The project has now transitioned from protocol optimization to functional examination of genes related to CCM. Future plans will include growth expression studies and detailed growth and study of interactions between carbon transporters.

Keywords: Carbon Concentrating Mechanism (CCM), *Chlamydomonas reinhardtii*, CO_2 Concentration, CRISPR-Cas9, Growth Response

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PP 033

TURNING GREEN WATER INTO GOLD: A RACEWAY GROWN CONSORTIUM DRIVING BIOGAS, BIO CRUDE AND BIOFERTILIZER IN A CIRCULAR BIOECONOMY

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ABSTRACT

The transition to a circular bioeconomy demands integrated systems that convert biomass into energy, agricultural inputs, and fuels with minimal waste. This study presents a cascading biorefinery based on a microalgal consortium cultivated at pilot scale in a 2000 L raceway pond. After screening, the best-performing consortium was selected on the basis of biomass productivity in the range 1.6-2.6 g L^{-1} d^{-1} and nutrient removal efficiency 85-96%. The harvested biomass was then used for anaerobic digestion (AD), both as a mono-substrate and in co-digestion with paddy straw. Co-digestion was tested at carbon-to-nitrogen (C/N) ratios of 20, 25, and 30 to identify the optimal balance for process stability and methane yield. The best C/N ratio was 30, giving a cumulative biogas yield of 424 mL g^{-1} VS and a methane content of 25%, an improvement of 90% over algal mono-digestion. The resulting digestate and its biochar were evaluated as soil amendments in seed germination assays on chickpea (*Cicer arietinum*) and kidney bean (*Phaseolus vulgaris*). The best treatment improved germination percentage by 67-85%, with gains in root and shoot length and seedling vigour index relative to the control.

In parallel, raceway-grown biomass was subjected to hydrothermal liquefaction (HTL) at 325 °C for 45 min and 60 min, with later residence time yielding better bio-crude yield with a higher heating value of 34 MJ kg^{-1}, alongside a nutrient-rich aqueous phase and solid residue.

Together, these findings show that a single raceway-cultivated consortium can supply three valorisation routes: biogas through AD, biofertilizer from the digestate for crop establishment, and bio-crude through HTL.

Keywords: Anaerobic Co-digestion; Hydrothermal Liquefaction; Microalgal Consortium; Raceway Pond; Circular Biorefinery

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PP 034

ANAEROBIC CO-DIGESTION OF ALGAL BIOMASS WITH FLY ASH FOR BIOGAS PRODUCTION

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ABSTRACT

Anaerobic digestion of algal biomass represents a promising route for renewable biogas generation and sustainable biomass valorisation. However, rigid cellular structures and species-specific biochemical composition may restrict substrate biodegradation and methane recovery. Therefore, the present study evaluates rice husk fly ash (RHFA) as a low-cost additive for enhanced biogas production using algal biomass. Different RHFA conc. (20 and 50 mg L^{-1}), along with the algae-only control, were investigated to assess their effects on cumulative biogas production. The control system (algae only) produced a final cumulative biogas yield of 481.4 mL g^{-1} VS, while addition of RHFA at 20 mg L^{-1} increased biogas production to 509.2 mL g^{-1} VS, representing ~5.8% improvement over algae alone. In contrast, increasing RHFA concentration to 50 mg L^{-1} reduced biogas production to 406.7 mL g^{-1} VS. The enhanced performance observed at 20 mg L^{-1} may be attributed to the availability of nutrients and cofactors that support microbial metabolism. In contrast, excessive RHFA addition may induce unfavourable physicochemical conditions, potentially inhibit microbial activity, and limit biogas production. Hence, co-valorisation of algal biomass and RHFA offers a promising waste-to-energy strategy for renewable biogas generation and supports resource recovery.

Keywords: Algal biomass; Anaerobic digestion; Biogas production; Circular bioeconomy; Rice husk fly ash; Resource recovery.

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PP 035

A NOVEL BIOREFINERY APPROACH FOR SEQUENTIAL RECOVERY OF VALUE-ADDED COMPOUNDS FROM DIATOMS

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ABSTRACT

Diatoms represent a promising platform for sustainable biorefineries due to their ability to produce multiple value-added biomolecules like pigments, EPA-enriched lipids along with a structurally unique silica frustule that are source of bio-silica. Existing extraction strategies target individual products, leading to increased unit operations, higher energy consumption and suboptimal biomass utilization. This study presents a novel sequential biorefinery approach for the integrated recovery of pigments, lipids and bio-silica from the marine diatom *Phaeodactylum tricornutum*, with a focus on resource efficiency and industrial relevance. The developed workflow employs a stepwise solvent-based extraction strategy to maximize biomass utilization while minimizing resource and energy inputs. Pigments were recovered first under mild conditions, preserving the residual biomass for lipid extraction, followed by bio-silica recovery from the remaining biomass. The use of wet biomass and simplified processing eliminates energy-intensive drying steps and avoids the need for complex or assisted extraction techniques. This study provides important insights into how sequential extraction strategies can be optimized to reduce processing costs and operational complexity. Overall, the proposed work supports waste minimization and the circular bioeconomy, highlighting the translational potential of diatom-based biorefineries for sustainable production of bioactive compounds and functional biomaterials.

Keywords: Bio-silica; Biorefinery; Diatom; Eicosapentaenoic Acid (EPA); Fucoxanthin; *Phaeodactylum tricornutum*; Sequential extraction

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PP 036

TURNING LIQUID ANAEROBIC DIGESTATE INTO A MICROALGAL GROWTH MEDIUM THROUGH BIOCHAR TREATMENT

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ABSTRACT

Liquid anaerobic digestate (LAD), a nutrient-rich byproduct of anaerobic digestion; however, its direct discharge can pose environmental concerns due to its high organic matter and nutrient concentrations. This study investigated the potential of LAD as a cultivation medium for microalgal biomass production and assessed biochar treatment as a conditioning strategy to improve its suitability for algal growth. Two indigenous microalgal strains, ADA1 and ADA2, were cultivated in different dilutions of LAD and compared with BG11 as the control medium. Biomass concentrations of 0.2-0.4 g L^{-1} and 0.3-0.6 g L^{-1} were obtained for ADA1 and ADA2, respectively; the corresponding control cultures achieved 1.6 and 1.4 g L^{-1}. The comparatively lower biomass production in LAD was primarily associated with its high chemical oxygen demand (COD), high ammoniacal nitrogen concentration, and reduced light penetration. To improve cultivation conditions, LAD was treated with biochar prior to microalgal cultivation. Biochar conditioning resulted in reductions of 67.5% in COD, 22.4% in ammoniacal nitrogen, 56.5% in phosphate, and 92.9% in color (OD_{450}). Following treatment, microalgal biomass production increased in P40 (40% LAD) for ADA2, reaching a biomass concentration 12.94% higher than that of the control BG11 media. The results demonstrate that biochar-conditioned LAD can serve as a suitable cultivation medium for enhanced microalgal biomass production while simultaneously contributing to the treatment of anaerobic digestate and recovery of nutrients.

Keywords: Biochar; Liquid anaerobic digestate; Microalgal biomass; Nutrient recovery

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PP 037

INTEGRATED GENETIC AND PROCESS ENGINEERING STRATEGY FOR ENHANCED CO_2 FIXATION AND BIOMASS PRODUCTIVITY IN *SCENEDESMUS OBLIQUUS*

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ABSTRACT

Microalgae offer a promising route for biological CO_2 fixation while simultaneously generating biomass for downstream valorization. However, improving productivity requires an understanding of the physiological characteristics of the organism and its response to cultivation conditions. This study aims to establish a baseline characterization of wild-type *Scenedesmus obliquus* through growth kinetics, biochemical analysis and CO_2 fixation measurements, followed by process and genetic engineering for enhanced carbon assimilation and biomass productivity. Initial cultivation studies have established reproducible growth of *S. obliquus* and provided a basis for systematic evaluation of biomass accumulation and culture behaviour. Preliminary observations indicate progressive growth and substantial changes in culture pH during cultivation, highlighting the importance of defining suitable operating conditions. Light and CO_2 conditions will therefore be evaluated to establish an appropriate process window for reliable CO_2 fixation measurements and improved biomass productivity. The established physiological baseline will further support downstream molecular and structural characterization and investigation of SBPase as a target for enhancing carbon assimilation. The overall approach integrates physiological characterization with process and genetic engineering to develop a more productive *S. obliquus* platform for biological CO_2 utilization.

Keywords: Biomass productivity; Carbon fixation; Genetic engineering; Microalgae; Scenedesmus obliquus

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FABRICATION OF MAGNETIC ALGINATE-BASED BIOHYBRID JANUS PARTICLES INCORPORATING MICROALGAE FOR WASTEWATER REMEDIATION

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ABSTRACT

Rising wastewater generation, driven by modern lifestyles, has intensified the search for sustainable, eco-friendly remediation methods. Janus particles have emerged as a promising option in this space. Our project incorporates microalgae, photosynthetic organisms that accumulate pollutants and use them as nutrients for growth, enabling nutrient recycling alongside the removal of pharmaceutical residues and biopesticides.Sodium alginate serves as the matrix for holding the algal biomass. Its permeability and strong immobilizing capacity complement the physicochemical properties of microalgae, making it a sustainable base for particle fabrication.The Janus design separates two functions into distinct hemispheres. One half, enriched with magnetic chitosan, provides structural stability, pollutant capture, and magnetic recoverability. The other half, loaded with microalgal biomass, drives active biological remediation. By pairing abiotic and biotic processes, the particles offer improved selectivity, rapid removal kinetics, and environmentally friendly operation.Overall, integrating microalgae and alginate into magnetic Janus particles offers a novel, green, and multifunctional strategy for advancing bioremediationand sustainable environmental management.

Keywords: Janus particles, microalgae, sodium alginate, magnetic chitosan, bioremediation, wastewater treatment

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P700 & Chlorophyll Fluorescence System Model DUAL-PAM-100



P700, PC, Fd & Chlorophyll Fluorescence System Model DUAL-KLAS-NIR



Chlorophyll Fluorometer Model MINI-PAM-II



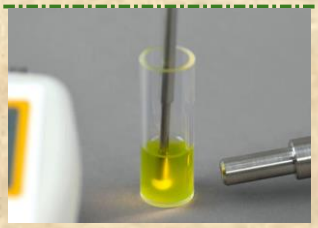
Algal CO2 Analysis Package Model FL-23



Underwater Fluorometer Model DIVING-PAM-II



Dissolved Oxygen & pH Meter Model FireSting O2



Underwater PAR/Quantum Sensor & Meter



Leaf State Analyser Model LSA-2050
(Multi-pigment, + Fv/Fm)



Multi Sensor Monitor Model SM-500
(For: Air Temp.& RH, PAR, VPD, CO_2)



Chlorophyll Concentration Meter Model MC-100



Ultraportable Green House Gas Analyser



Sap Flow Meter Model SFM-1 (with/without IoT
(Corn/ Cotton to large Tree)

Other Instruments:

Portable Spectroradiometer, Multi-spectral Camera, PAR/Quantum Meter, Research Grade Temp. Sensor, NDVI Sensor, Weather Station, Soil Tensiometer, Dissolved Oxygen Sensor, Soil/Air Oxygen Meter, Portable N_2O & CO_2 Analyser, Dendrometer, Methane Analyser, Automatic Infiltrometer, Ecotron (Climate controlled Lysimeter), Nitrogen Fixation Analyser, NIR Analyser etc.

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