BiOE3

जैवप्रौद्योगिकी विभाग
DEPARTMENT OF
BIOTECHNOLOGY
सत्यमेव जयते

बाइरैक
इग्नाइट इनोवेट इन्क्यूबेट
birac
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BIOMANUFACTURING FOR CARBON CAPTURE AND ITS UTILIZATION

CONTENT

Executive Summary

The Department of Biotechnology (DBT) and Biotechnology Industry Research Assistance Council (BIRAC), under the BioE3 Policy—Biotechnology for Economy, Environment and Employment—have launched the Biomanufacturing Initiative to foster High-Performance Biomanufacturing in India. Approved by the Union Cabinet in August 2024, the initiative envisions transforming the nation's manufacturing paradigm towards a regenerative, sustainable, and circular bioeconomy, thereby driving "Green Growth" and contributing to Viksit Bharat @2047.

Within this framework, Carbon Capture and its Utilization (CCU) has been identified as a key thematic area. The initiative seeks to harness the power of biotechnology to convert carbon dioxide—an abundant greenhouse gas—into value-added fuels, chemicals, biomaterials, and other high-value products. By leveraging microbial, algal, and enzymatic systems, and integrating tools from synthetic biology, electro-biorefinery, and biophotonics, this program aims to build scalable, energy-efficient, and economically viable CCU technologies for industrial deployment.

Impact on Bharat's Economic Growth

The Biomanufacturing Initiative aligns with India's commitment to achieving Net Zero by 2070 and strengthening the national Bioeconomy, which is projected to surpass USD 300 billion by 2030. By transforming carbon waste streams into renewable bio-based products, this initiative not only mitigates environmental impact but also stimulates new green industries, enhances employment opportunities, and fosters self-reliance in sustainable manufacturing sectors.

Challenges

Despite its promise, large-scale CCU adoption faces challenges related to process efficiency, cost-effectiveness, technology scalability, and regulatory readiness, especially for the deployment of genetically modified organisms and biocatalytic systems in industrial environments. Addressing these will require deep scientific collaboration, techno-economic optimization, and supportive policy frameworks.

Categories under the Call

To ensure comprehensive innovation and translation, proposals were invited under two distinct categories:

1. **Discovery & Application-oriented Integrated Network Research (TRL 3–5):**

   Focused on proof-of-concept studies, strain development, and laboratory-scale demonstrations of novel CCU biotechnologies. This category emphasizes microbial platform improvement, enzyme enhancement, and early-stage design of transformative pathways.

2. Bridging the Gaps for Industrial Scale-up (TRL 5–7):

Targeted at technologies ready for pilot demonstration and industrial translation. It supports scaling up bio-based CCU processes, demonstrating algal photobioreactors, microbial electrobiorefineries, and deployable biocatalytic devices for point-source emissions such as automobile and industrial exhausts.

The initiative focused on energy-efficient CO_2 capture and biological conversion from industrial point sources and direct air emissions into fuels, chemicals, and high-value biomaterials. The thematic priorities include:

- Engineering microbial and algal platforms for carbon capture and utilization;
- Enabling disruptive, cross-disciplinary CCU innovations;
- Demonstrating bio-based CCU processes within integrated CO_2 biorefineries; and
- Developing deployable biocatalytic systems for emission mitigation at source.

Projects Overview: Industry

Collectively, these PPP-led projects demonstrate science-driven industrial translation, delivering pilot-scale validation (TRL 6–8), novel carbon valorization pathways, and bio-based circular solutions with measurable techno-economic impact. By coupling frontier biotechnology with industrial scalability, the CCU initiative marks a strategic leap in India's leadership in biological carbon valorization, industrial decarbonization, and sustainable biomanufacturing, propelling the nation's $BioE^3$ vision of a carbon-resilient and regenerative bioeconomy.

Projects Overview: Academia

The proposals focus on Engineered Carbonic Anhydrase-Enhanced CO_2 Sequestration, Pilot-scale CO_2 Biorefinery Systems, Biochar, engineered microbes, and products to enhance soil carbon, Bioelectrochemical CO_2 Valorization Platforms, CO_2-based Bioproducts, Functional Carbon Composites, and AI-Optimized Smart Microalgal Biorefinery with CCU integration. The projects are focused on providing biological engineering solutions to transform the carbon capture capacity of the improved algae, microbial strains, and to demonstrate the CCUS process at scale from 100 to 500 litre photo bioreactors/reactors at the interface of biotechnology and process engineering

Way Forward

The DBT–BIRAC Biomanufacturing Initiative marks a strategic step toward positioning Bharat as a global leader in sustainable biomanufacturing. By nurturing academia–industry collaborations, accelerating technology readiness, and integrating CCU into industrial ecosystems, the initiative paves the way for carbon-neutral growth, climate resilience, and a bio-based circular economy that strengthens the nation's innovation and economic landscape.

Lab-Scale Development

Advancing High-Performance CO_2 sequestration via Thermostable Carbonic Anhydrase from Gujarat Hot Springs

Atmiya University, Rajkot, Gujrat, with Mr. Biologist, LLP, Pune, Maharashtra

Objectives :

- Isolation and optimization of thermostable CA enzymes
- CO_2 capture and biomineralization demonstration
- Evaluation of scalability and economic feasibility

USP of proposed innovation :

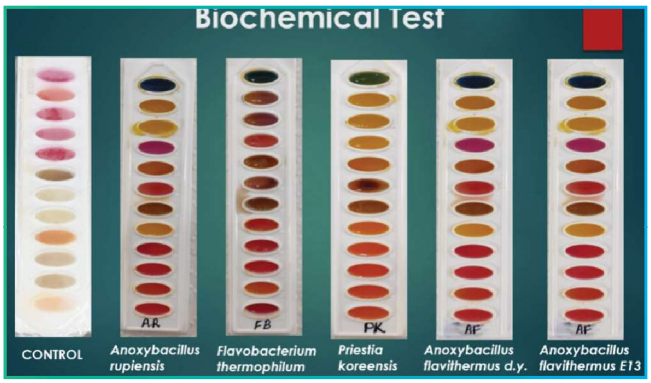
Use of thermostable carbonic anhydrase (CA) from Indian hot springs for CO_2 capture and conversion into valuable $CaCO_3$

Expected Deliverables :

Bench-scale reactor validation (10 L) for CO_2 sequestration using thermostable CA under simulated flue gas conditions

Impact:

Advances India's 2070 Net-Zero goals by efficiently capturing CO_2 and converting it into stable, high-value calcium carbonate thereby reducing industrial carbon emissions.



Cyanobacteria based Low-Cost Dairy Effluent Treatment: An opportunity for Carbon Capture and Biofuel Production for a Green Bio-Economy

IIT Bombay and College of Dairy Science, Kamdhenu University, Gujarat

Objectives :

- Evaluation of cyanobacterial isolates (available at CDS, Amreli & IIT Bombay) for efficiency of dairy effluent treatment
- Study of carbon capture and utilization by cyanobacteria and biofuel extraction from generated biomass
- Engineer metabolic pathways in cyanobacteria for improving biofuel yield and carbon capturing using metabolomics guided approach

USP of proposed innovation :

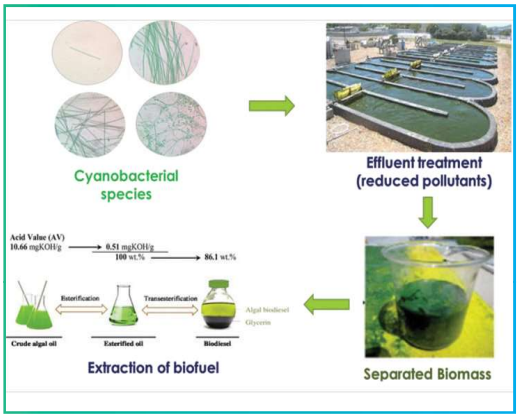
Carbon capturing, both atmospheric and organic CO_2 (~0.5 g/L, equivalent to ~1.84 g CO_2) into cyanobacterial biomass though dairy effluent treatment, which is then converted into biofuel by using natural/wild type cyanobacterial isolates as well as engineered cyanobacterial strains, modified for enhanced biofuel & carbon capturing

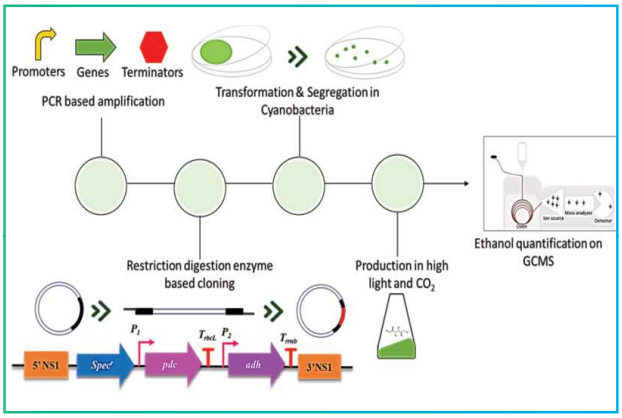
Expected Deliverables :

50–60% pollutant load reduction with carbon sequestration ~0.5 g/L, biomass (~1.84 g CO_2/L) at 1000 L . Scalable for dairy cooperatives

Impact:

Cyanobacteria for the dairy effluent treatment and biofuel production from generated cyanobacterial biomass as well as genetic improvement for biofuel yield and carbon capturing.





Harnessing Microalgae for Carbon Capture and Hard Carbon Synthesis in the Development of Sodium-Ion Battery Technology

Symbiosis International (Deemed University), Pune, Chandigarh University, Mohali, Thapar Institute of Engineering & Technology, Patiala and Jaypee Institute of Information Technology (JIIT), Noida

Objectives :

- Optimization of microalgal cultivation on municipal/domestic wastewater
- Assessment of carbon sequestration potential and biomass generation efficiency
- Evaluate the wastewater treatment efficiency of selected microalgal strains
- Develop an environmentally sustainable, scalable method to derive hard carbon
- Development of high-performance hard carbon-derived batteries from microalgal 100–150 Wh/kg energy density and >80% capacity retention after 1,000 cycles

USP of proposed innovation :

Harnessing the Potential of Microalgae for Carbon Capture, Wastewater Bioremediation, and Sustainable Hard Carbon Synthesis in Sodium-Ion Batteries

Expected Deliverables :

- Optimized Microalgal cultivation with 20% improved biomass yield with higher carbon capture. 1.8-2.2 kg of CO_2 capture/kg of Biomass yield)
- Reducing 1.0–2.5 kg CO_2 per kg hard carbon compared to commercial hard carbon
- Saving 200–500 g CO_2 per kWh compared to conventional electricity sources

Impact:

Algal Biomass derived hard carbon saves 1.0-2.5 kg of CO_2/kg hard carbon reduces as compared to commercially produced hard carbon from petroleum/polymer/other biomass




Carbon Capture in Microbial Electrosynthesis Cell for Sustainable Caproate Production: Addressing Scale-Up Challenges

IIT Hyderabad

Objectives :

- Develop and optimize microbial electrosynthesis (MES) systems for efficient carbon dioxide capture from flue gas.
- Enhance carbon chain elongation through microbial culture optimization and tailored feeding strategies.
- Design and implement cost-effective, corrosion-resistant catalysts for long-term MES Operation.
- Scale up MES systems to 5 L for carbon capture using flue gas.

USP of proposed innovation :

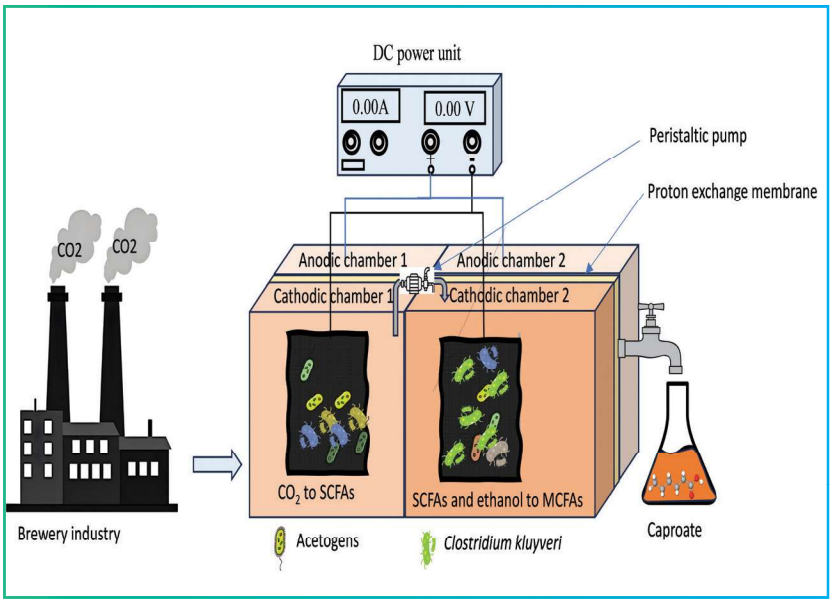
Development of two stage microbial electrosynthesis configuration for improved MCFAs production rates

Expected Deliverables :

- Design of a modular two-stage MES for higher selectivity 90%, carbon conversion efficiency >75%
- Implementation of a 10 L continuous MES with wastewater
- Low-cost CO_2 valorization circular economy

Impact:

Low-cost, low-energy MES enabling CO_2 valorization



Microalgae-Powered Biomanufacturing: A Carbon Capture Approach for Scalable Nutraceutical Aquafeed Production

Central University of Rajasthan

Objectives :

- Exploring the potential of high CO_2 -fixing indigenous microalgal strains *Tetraselmis indica* and *Picochlorum* sp. to develop a carbon capture system and produce omega-3 and carotenoid-rich biomass
- Integration of a photomodulation system in the indigenous microalgal consortium for overexpression of rbcL, rbcS, and CA genes to enhance CO_2 capture efficiency.
- Optimization of cultivation and process parameters for maximizing CO_2 fixation efficiency and biomass productivity.
- To establish a laboratory-scale CCU framework integrating next-generation aquafeed development, and evaluate sustainability through life cycle assessment and techno-economic analysis.

USP of proposed innovation :

Development of a complete indigenous microalgal consortium to establish a robust CCU system

Expected Deliverables :

- Expect to capture ~650 mg CO_2/L/d
- Photomodulation system expected to enhancing CO_2 fixation by ~25–30%.
- Microalgal-derived aquafeed will promote 10-20% fish growth and meat quality

Impact:

Improving CO_2 fixation efficiency by 25–30% via photomodulation setup overexpressing genes

Bioengineering of *Rhodopseudomonas* for sustainable CO_2 capture and improved soil fertility to enhance crop productivity and Climate-smart agriculture

RCB Faridabad, NABI and University of Agricultural Sciences, Raichur

Objectives :

- Developing bioengineered strains of photosynthetic *Rhodopsuedomonas* for effective CO_2 sequestration and scalable methods
- Assessing the efficiency of the improved strains of Rhodopseudomonas palustris
- Assessing the improved strains for their CO_2 capturing and N_2 *fixation ability* in direct seeded rice cultivation system.

USP of proposed innovation :

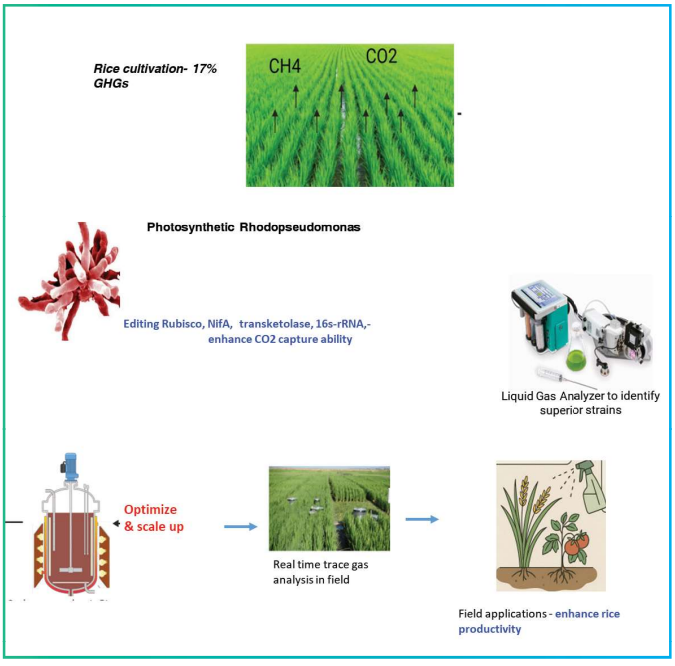
Can capture >1,00,000 tones of CO_2 and reduce methane production and N_2 application, improve soil fertility and enhance rice yields

Expected Deliverables :

- Editing RUBISCO biogenesis-related genes, ribosomal RNA genes, transketolase and transporters of acetate to create variants of *Rhodopseudomonas palustris* to improve CO_2 fixation.
- Assessing the efficiency of methane reduction in rice field.
- Developing a bacterial consortium of *Rhodopseudomonas palustris* and assessing the efficiency of methane reduction, N_2 fixation and improved rice production by using it as a biofertilizer.

Impact:

CO_2 sequestration coupled with methane reduction, N_2 fixation and improved rice production



Development of novel thermophilic chemoautotrophic bacterial workhorses for valorization of CO_2 into fatty acids

IIT Kharagpur

Objectives :

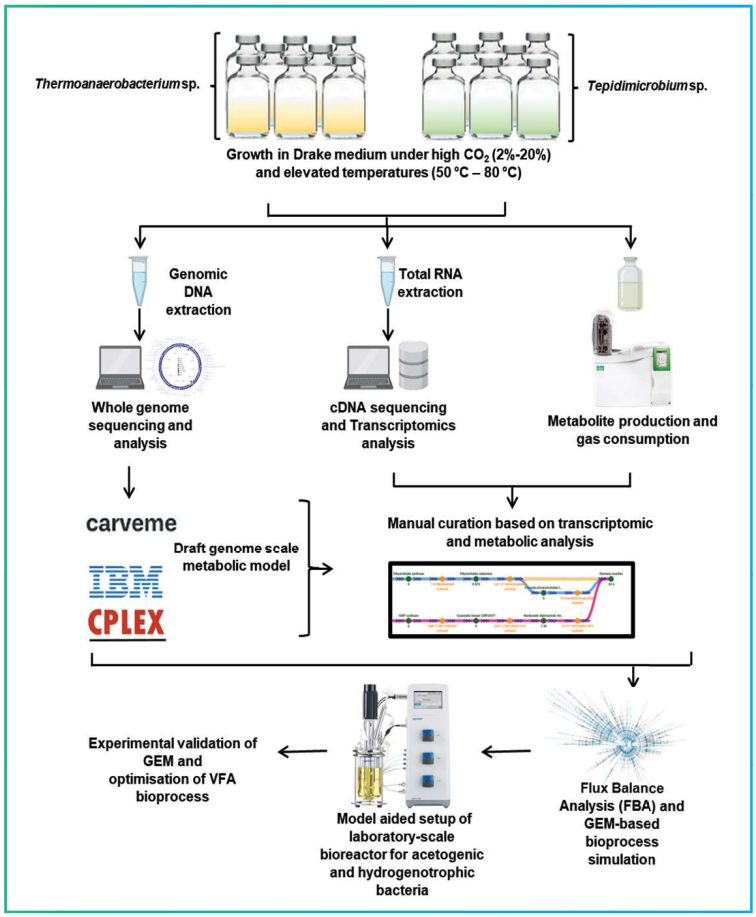
- Genomic and transcriptomic characterisation of novel thermophilic chemoautotrophic bacterial workhorses
- Genome-scale model reconstruction and validation, model aided lab-scale VFA bioprocess optimisation

USP of proposed innovation :

Robust CO_2 -fixing thermophilic bacterial workhorses through multiomics approach and genome scale metabolic model based bioprocess design

Expected Deliverables :

- Indigenous capacity building for hot C1 gas valorisation
- Flux Balance Analysis (FBA) and GEM-based bioprocess design, and lab-scale bioprocess optimisation
- Development of novel bacterial workhorses and their genome-scale modelling for bioprocess design and synthetic biology (attaining TRL-4)



Impact:

Robust microbial chassis organisms for use in hot CO_2 fed bioprocess

Biomanufacturing Feasibility of Underutilized Microbial CO_2 Fixation Pathways and Non-model Strains: Metabolic Profiling, Bioprocess Optimization, and Industrial Viability Assessment

IISER Mohali

Objectives :

- Metabolic Profiling of different microbial strains possessing alternate CO_2 -fixing pathways for the identification of promising target bioproducts
- Multi-parameter process optimization for the production of the select promising products using Design of Experiments (DoE)
- Process demonstration at a liter-scale bioreactor for the select target product and its techno-economic assessment

USP of proposed innovation :

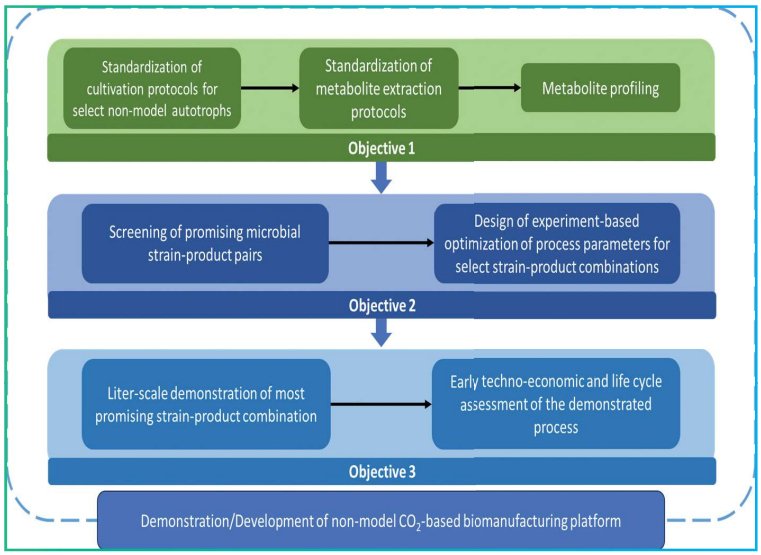
Exploring alternative CO_2 fixation pathways i.e. rTCA, 3-HP bi-cycle, and reductive glycine pathway, is crucial to expand the range of CO_2 -based bioproducts and biomanufacturing

Expected Deliverables :

- Expanding CO_2 -based biomanufacturing product profile with underutilized CO_2 fixation pathways
- Foundation for non-model CO_2 -fixing microbial chassis
- Discovery of native high-value products from CO_2

Impact:

Foundational platform for developing next-generation microbial CO_2 fixation technologies



Exploring Carbon Capture and Utilization in Millet-Based Agroforestry Systems: Enhancing Biomass and Soil Carbon through Microbial Activity

Central Agricultural University, Imphal

Objectives :

- Assess Carbon Sequestration Potential in Millet-Based Agroforestry Systems
- Isolate, identify, and Mass Multiply the biomass-degrading microbes
- Study Soil Organic Carbon (SOC) Dynamics and Soil Fertility Enhancement

USP of proposed innovation :

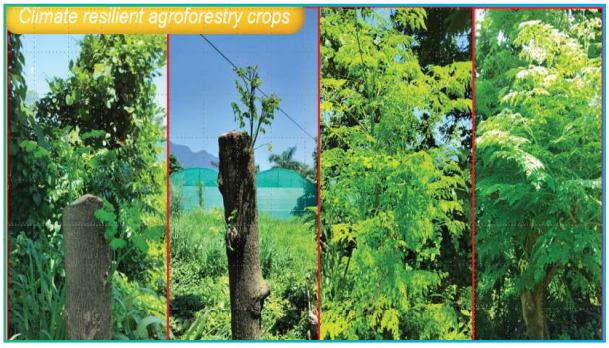
Evaluation of potential of millet-based agroforestry systems to promote sustainable agricultural practices in Arunachal Pradesh

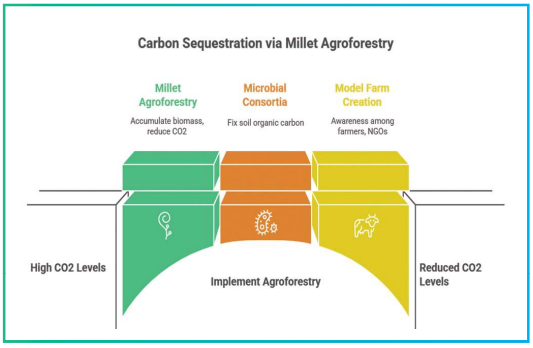
Expected Deliverables :

- Total system CO_2 sequestration: ~3.5–5.2 t C/ha/year
- Organic matter decomposition rate improved by approximate 30–40% compared to untreated soil
- Climate-resilient millets (e.g., Pearl millet, Sorghum): 25–30% increase over control
- SOC increase by ~15–25% over 2 years at 2.5 t/ha application rate

Impact:

Demonstrated carbon sequestration model suitable for community-based mitigation strategies under agroforestry in the North East India





Improved cyanobacterial strain to enhance photoautotrophic CO_2 capture and conversion to fine biochemicals

CSIR- NEERI, Nagpur

Objectives :

- Recombinant expression of CO_2 reducing enzyme, such as formate dehydrogenase (FDH) or CO dehydrogenase (CODH), in cyanobacterial strain, such as *Synechococcus* or *Synechocystis*.
- Determining the feasibility of CO_2 fixation by the recombinant algal strain.
- Optimization of parameters and engineering to maximize CO_2 capture.
- Design of anoxic photobioreactor and demonstration of the process up to 50 L reactor.

USP of proposed innovation :

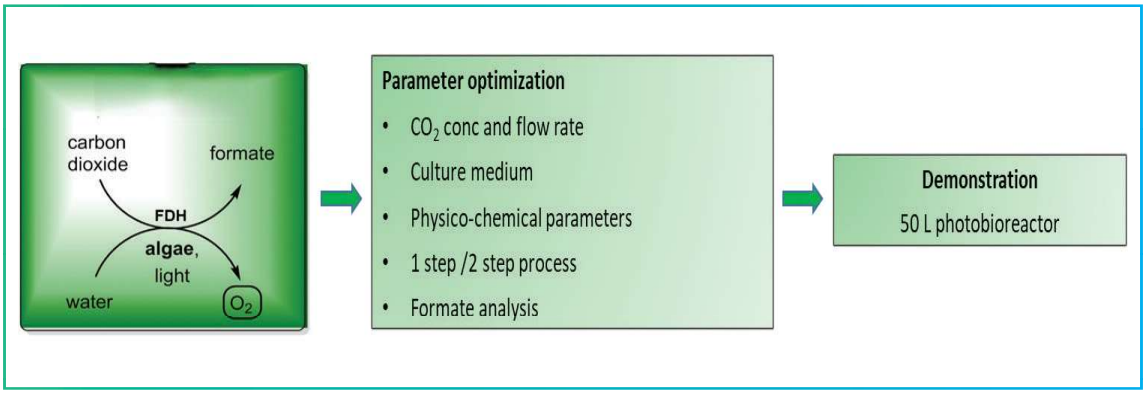
Engineering of algae to use direct CO_2 -reducing enzymes, like formate dehydrogenase, for CO_2 capture independent of the acceptor supply.

Expected Deliverables :

- Light energy-driven system for direct conversion of CO_2 into valuable biochemical formic acid without the need of any acceptor.
- Demonstration up to 50 L scale to assess scalability and industrial employability.

Impact:

Carbon sequestration with production of value added biochemicals



Synthetic Metabolons for Enhancing Carbon Utilization in Cyanobacteria for Improved Isoprene Production

Institute of Bioinformatics and Applied Biotechnology, Bangalore

Objectives :

- Develop metabolon for enhancing carbon fixation
- Develop metabolon for improving carbon utilization
- Develop metabolon for MEP pathway
- Evaluation of strains with synthetic metabolons
- Combinatorial assembly of metabolons for strain improvement and isoprene production

USP of proposed innovation :

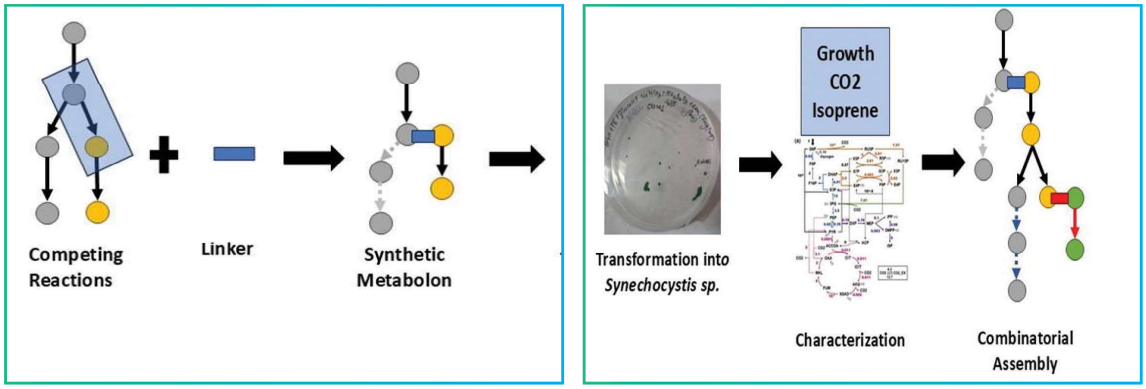
Metabolons as a Synthetic Biology tool for Directing Carbon Flux Application in Chassis development

Expected Deliverables :

- Flask Cultivation (20-500ml)
- CO2 fixation: ~225 mg /gDW/h
- Isoprene Yield: ~520 µg /gDW/h

Impact:

Scalable synthetic biology platform for carbon capture and production of biochemicals



Reengineering Highly Efficient and Ultra-stable Carbonic Anhydrase for CO_2 Reduction

CCMB, Hyderabad

Objectives :

- Rational design of minimally structured carbonic anhydrase with enhanced catalytic efficiency and stability using AI/ML protein design tools
- Cloning, expression, and purification of the candidate carbonic anhydrases. Structural and catalytic activity validation
- Catalytic activity of candidate carbonic anhydrases. Optimization of pilot-scale bioprocess

USP of proposed innovation :

Reengineering Carbonic Anhydrase (SazCA) for high efficiency & ultra-stability and carbon capture

Expected Deliverables :

- Computational enzyme design (AI/ML)
- Cloning & purification
- Stability & kinetics evaluation
- Enhanced CO_2 capture

Impact:

Enzyme engineering for cost effective carbon sequestration

Sustainable Biomanufacturing of Methanol and Platform Chemicals from C1 Gas Mixture via Hybrid Multi- Phase Fermentation with Integrated Business Models for Industry 4.0

Dr B R Ambedkar NIT Jalandhar

Objectives :

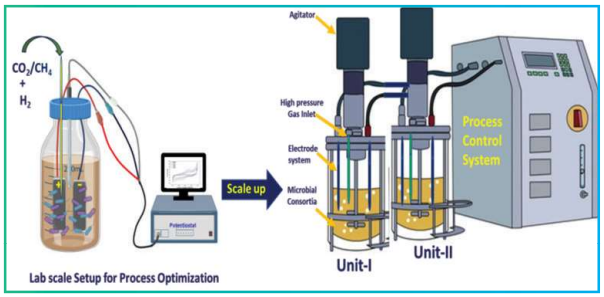
- Identify and optimise suitable SynComs for enhanced C1 (CO_2 and CH_4) gases conversion.
- Develop 20 L hybrid (gas-electro) fermentation for methanol and platform chemicals using non genetic approach.
- Develop optimised microbial metabolic process and pathways for CO_2 and CH_4 sequestration using AI/ML-based models.
- Evaluate sustainability and techno-economic assessment for the biomanufacturing framework.
- Establish biomanufacturing business models and policy roadmap for industry-level scale-up.

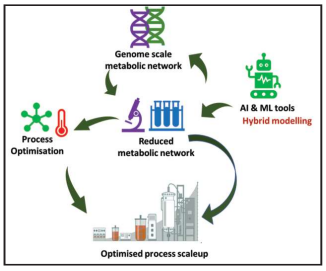
USP of proposed innovation :

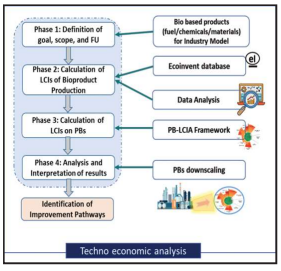
Integrated solution, combining advanced microbial biomanufacturing with bioelectrochemical fermentation and AI-driven process optimization, to transform C1 gases into sustainable bio-based products

Expected Deliverables :

- Novel non-genetic metabolic regulation of selective Syncoms using hybrid C1 gas–bio–electro fermentation for higher yields.
- AI/ML-powered multi-scale process optimization and metabolic modelling through validated microbial metabolic routes.
- Comprehensive systems sustainability and economic assessment for policy and business models.







Impact:

CCUS-driven CO_2 valorization, and high-value bioproduct generation, creating new industrial value chains in sustainable chemicals and fuels.

Production of Tissue-cultured *Bambusa tulda* for Carbon Sequestration through Afforestation and Reforestation

Bioresource Development Centre, Meghalaya

Objectives :

- To develop a tissue culture-based propagation protocol for *Bambusa tulda* for enhanced carbon sequestration and upscaling for Quality Planting Material (QPM) production.
- To maximize carbon sequestration potential of bamboo plantations at different elevation zones using the QPM
- To assess carbon sequestration potential of native bamboos of Meghalaya
- To Establish scalable afforestation models using *Bambusa tulda*
- To link appropriate biomanufacturing industries for value added products

USP of proposed innovation :

Scalable tissue culture-based propagation protocol for *Bambusa tulda* to support afforestation and reforestation programs for enhanced carbon sequestration

Expected Deliverables :

- Total carbon sequestered: 333.48 MgC/ha/yr
- Expected income from carbon credit-$ 60026.40 @$180/ton Carbon
- Total improved plants generated : 15,000
- Total area plantlet: 12 ha

Impact:

Sustainable practices for carbon-neutral biomanufacturing

Development of rotating packed bed reactor for carbon capture using a novel enzyme based solvent

NIT Calicut

Objectives :

- Develop an immobilized carbonic anhydrase enzyme with amine solvent (MDEA);
- Testing of CO_2 capture using a novel solvent in an existing lab-scale RPB absorber;
- Set up and demonstrate a pilot-scale CO_2 capture of RPB absorber and regenerator from 1 tons per day of flue gas;
- Develop CFD models for CO_2 absorption in a RPB and validate the model;
- Evaluate the techno-economic performance of the intensified process and compare with the conventional capture process.

USP of proposed innovation :

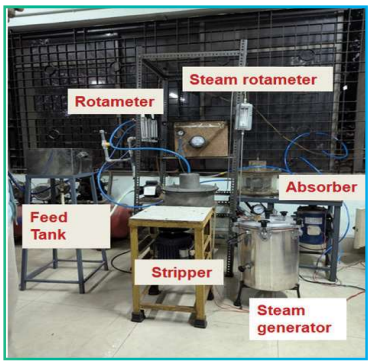
Intensified carbon capture of rotating packed bed (RPB) using immobilised carbonic anhydrase (CA) enzyme with amine solvent

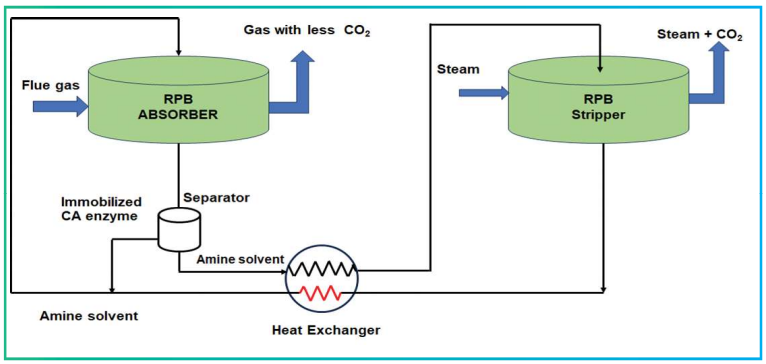
Expected Deliverables :

- Establishment of the pilot-scale facility for CO_2 capture unit achieving at TRL 5
- CO_2 capture efficiency: 90%
- Development of scalable technology of RPB based CO_2 capture
- Simulation-based tools for the techno-economic model for CO_2 capture
- Test CO_2 capture from steel mill flue gas at Peekay Steel industry, Calicut

Impact:

Cost efficient CO_2 capture with reduction of energy required for regeneration cost using a novel solvent





Integrated Biotechnological and Geochemical Approach for Carbon Capture, Utilization, and Storage (CCUS) and Valorization of Wasted Drill Cuttings using ACT and MICP

Dibrugarh University and IIT Guwahati

Objectives :

- Analyzing industrial flue/CO_2 gases, drill cuttings waste, and alkaline materials (cement kiln dust, fly ash).
- Isolation and characterization of indigenous urease-producing bacteria (UPBs) from oilfield sources in Assam.
- Optimizing MICP-ACT process parameters to maximize CO_2 capture and calcite precipitation.
- Evaluating MICP-ACT synergistic effects
- Assessing efficacy of the integrated MICP-ACT process in capturing CO_2 and repurposing drill cuttings into marketable construction materials.
- Assessing the economic feasibility, environmental benefits, and scalability of the integrated MICP-ACT process for industrial adoption.

USP of proposed innovation :

Integrated Bio-Geochemical Solution for Carbon Capture and Waste Valorization

Expected Deliverables :

- Scaling up to process approx. 100 kg (drill cuttings + CKD/FA).
- Producing 50 bio-bricks; capturing approx. 10 kg of CO_2.

Impact:

Carbon capture and waste valorization for generation of value added products

Restructuring CO_2 Bio mitigation for Valuable Eco-friendly Resources

CSIR- IMTECH, Chandigarh

Objectives :

- Development of High-Performance Photosynthetic Microbial Platforms for CO_2 Capture and Sustainable Biomanufacturing
- Metabolic and Genetic Engineering-Driven CO_2 Valorization for Circular Bioeconomy
- Comparative Evaluation and Scale-up of Engineered Microbial Systems for CO_2 -Derived Biopolymers in Biomanufacturing

USP of proposed innovation :

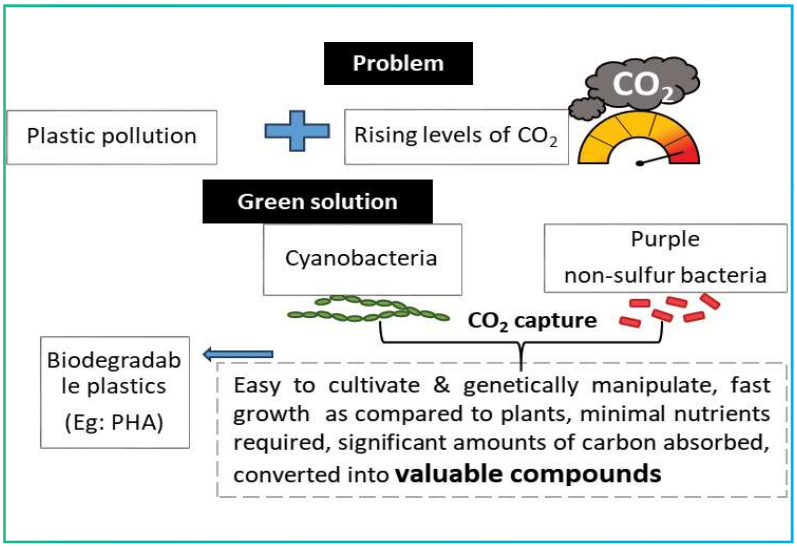
Combinatorial approach of culturomics optimization and genetic engineering of bacteria to improve the efficiency of carbon capture and production of value added product (PHA)

Expected Deliverables :

- Improved CO_2 sequestration and heightened PHA production
- Development of genetically modified strains exhibiting enhanced capabilities for CO_2 capture (exceeding 2.0 g CO_2 per g of biomass per day) and PHA production (surpassing 400 mg/L) for more efficient bioconversion process.
- Potential genetically edited/modified photosynthetic bacterial strains with expected capabilities will be patented.

Impact:

Strategy to enhance CO_2 sequestration and it's conversion into Polyhydroxyalkanoates



Development of Engineered Biocatalyst for Bioelectrochemical Conversion of CO_2 to Formic Acid

NIT Warangal

Objectives :

- Development of an Engineered *Escherichia coli Whole* Cell-Mediated Electro-Biocatalysis with >60% selectivity towards CO_2 Reduction to Formic Acid
- Performance evaluation of biocatalyst by enhancing Enzyme Activity and Electron Transfer Mechanisms in BERC system
- Elimination of intermediate reaction products for improving long-term stability with > 90 % performance retention per 100 h
- Validation of the experimental results with simulation

USP of proposed innovation :

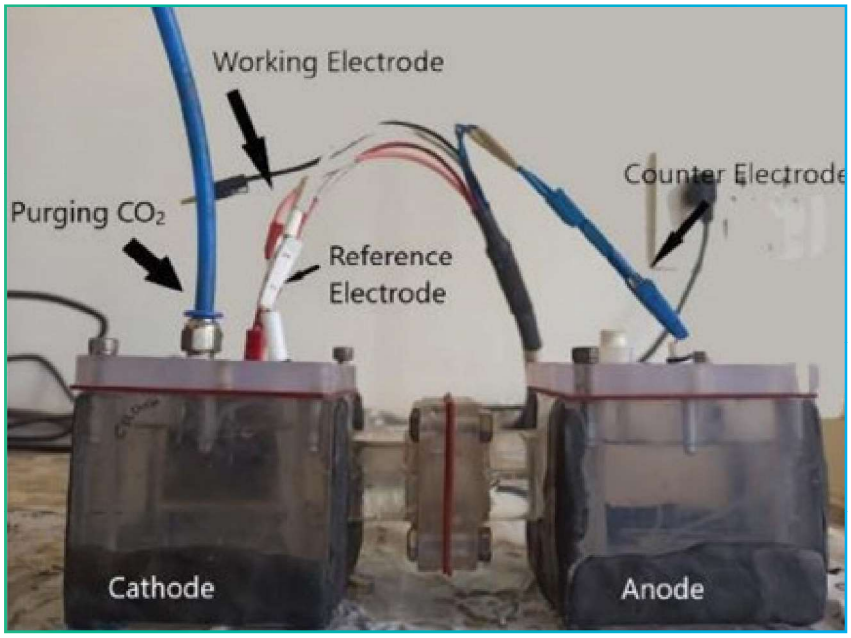
Turning CO_2 into Value: Engineered Biocatalysts for Sustainable Formic Acid Production

Expected Deliverables :

- Carbon conversion efficiency 12%
- 5% improved Faradaic Efficiency
- 15 % higher Formic acid production rate

Impact:

Development of scalable bioelectrochemical platforms for industrial CO_2 valorization with direct applications in green chemical manufacturing, energy storage, and pharmaceuticals.



Carbonic Anhydrase Promoted Electrocatalytic Conversion of CO_2 to Valuable Chemicals

IISER Bhopal and NIT Rourkela

Objectives :

- Simultaneous capture and conversion of CO_2 by bio-electro-chemical process
- By integrating electro-catalytic process with CA enzyme based bio-chemical process, reactant availability in the electrolyte can be increased
- Development of process for the immobilization of CA enzyme on the gas diffusion electrode using binding agent

USP of proposed innovation :

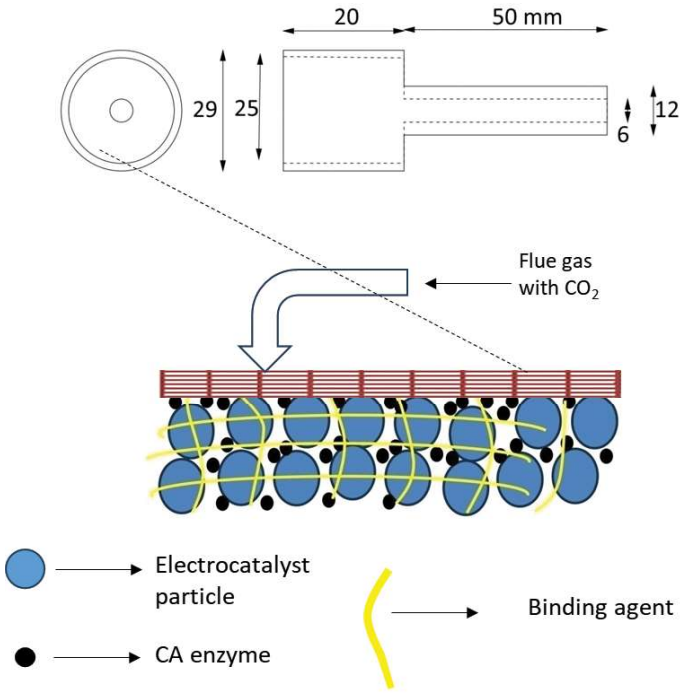
Integration of electro-chemical process (CO_2 reduction) with bio-chemical process (CO_2 hydration by carbonic anhydrase (CA) enzyme) for efficient conversion of carbon dioxide to valuable chemicals

Expected Deliverables :

- CO_2 electrolyser system with CA enzyme immobilization on gas diffusion electrode
- Faradaic efficiency ≈ 80 %
- Reactor scale ≈ 1 litre

Impact:

Development of scalable bioelectrochemical platforms for industrial CO_2 valorization with direct applications in green chemical manufacturing, energy storage, and pharmaceuticals.



Schematic of gas diffusion electrode with CA enzyme and binding agent

3D Printed Bioenriched Electrodes for Bioconversion of Industrial CO_2 to Biofuels through Microbial Catalyzed Systems

VIT University, Vellore

Objectives :

- Engineer the 3D printed biofilm-coated electrode using the enriched culture for CO_2 conversion to ethanol and butanol.
- Evaluate the performance of 3D bioprinted electrode in the microbial catalysed electrochemical system.
- Evaluate the poised 3D bioprinted electrodes in the Gas fermentation processes.
- Demonstrate the large scale fermenters using industrial waste gas as substrate by using the poised 3D electrodes
- Perform techno-economic analysis for both gas fermentation and bioelectrochemical systems

USP of proposed innovation :

Sequester CO_2 into, multiple value-added biofuel like Ethanol and Butanol using Microbial catalysed electrochemical system (MCES) and Gas Fermentation (GF).

Expected Deliverables :

- Enrichment of the bacterial culture towards CO_2 uptake
- Develop 3D printed graphite electrode
- Run the semi –pilot scale rector with a capacity of 5L using industrial CO_2 gas sequestration
- Optimization studies for enhanced yield

Impact:

The outcome of the study towards CO_2 reduction and product formation ethanol and butanol will help to install the integrated processes in the Industrial sectors.

Integrated Enzyme and Nanozyme systems for pilot scale: CO_2 Capture and Conversion via Cascade Catalysis

CSIR-IICT Hyderabad and GITAM deemed to be university, Vishakhapatnam

Objectives :

- Synthesis, characterization, and activity evaluation of the metal-organic framework as a carbonic anhydrase mimic.
- Cloning, expression, and purification of the enzymes (formate dehydrogenase (FateDH), formaldehyde dehydrogenase (FaldDH)) and alcohol dehydrogenase (ADH).
- Synthesis and characterization of enzyme-nanozyme containing hybrid microreactors and evaluation of the microreactors' catalytic efficiency for converting CO_2 to methanol.
- Large-scale production of enzymes and nanozymes for CO_2 capture and reduction reactions.

USP of proposed innovation :

Protein engineering and encapsulation strategies are explored independently or in isolation.

Expected Deliverables :

- Cost-effective, stable, and sustainable catalytic process for large-scale CO_2 capture/fixation (environmental remediation) and conversion

Impact:

Synergy between protein engineering and encapsulation strategies offers a powerful and multidisciplinary approach to develop robust, efficient, and economically viable systems for capturing and utilizing CO_2.

Photosynthetic Plasmonic Bio-Semiconductor Nanohybrids with Single Atom Nainozymes: An Innovative Technology for Selective CO_2 to fuel conversion.

Vignan University, Guntur

Objectives :

- Synthesis of Advanced Plasmonic Nanohybrids
- Fabrication of Plasmonic Photosynthetic Bio-Nanohybrid Catalysts
- Investigation of Plasmonic Photosynthetic Nanohybrids for CO_2 Reduction
- Scale-Up for Commercial CO_2-to-Acetate Conversion

USP of proposed innovation :

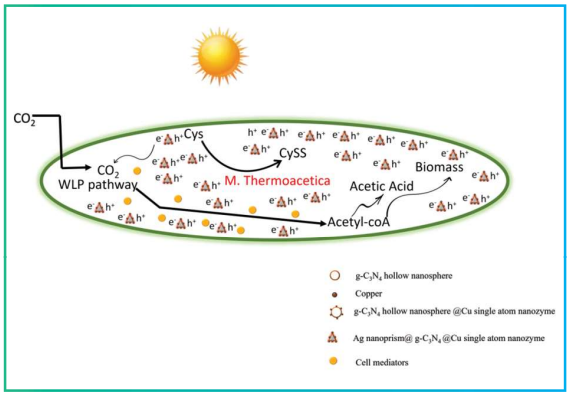
Plasmonic photosensitizers, bio-compatible semiconductors, and single-atom nanozymes (SAZs) to drive solar-to-chemical CO_2 conversion

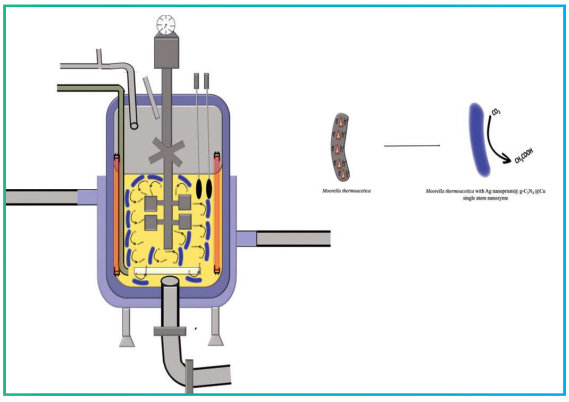
Expected Deliverables :

- Optimize and scale up the plasmonic bio-nanohybrid catalytic system for commercial production of acetate from CO_2, ensuring high conversion efficiency, economic viability, and industrial applicability.

Impact:

Carbon capture for commercial generation of value added products





Fabrication of Portable Biocatalyst Immobilized in Nanohydrogel for Capturing of Carbon Dioxide Evolving from Industries

Vinayaka Missions University, Tamil Nadu

Objectives :

- Preparation and characterization of Nano-hydrogel for analyzing CO_2 capturing capacity.
- Extraction, purification and characterization of CO_2 capturing enzymes from various biological sources.
- Immobilization of CO_2 capturing enzymes in Nanohydrogel and analyzing its efficiency of CO_2 capturing
- Fabrication of Model for Industrial application of CO_2 Capturing enzyme immobilized Nanohydrogel

USP of proposed innovation :

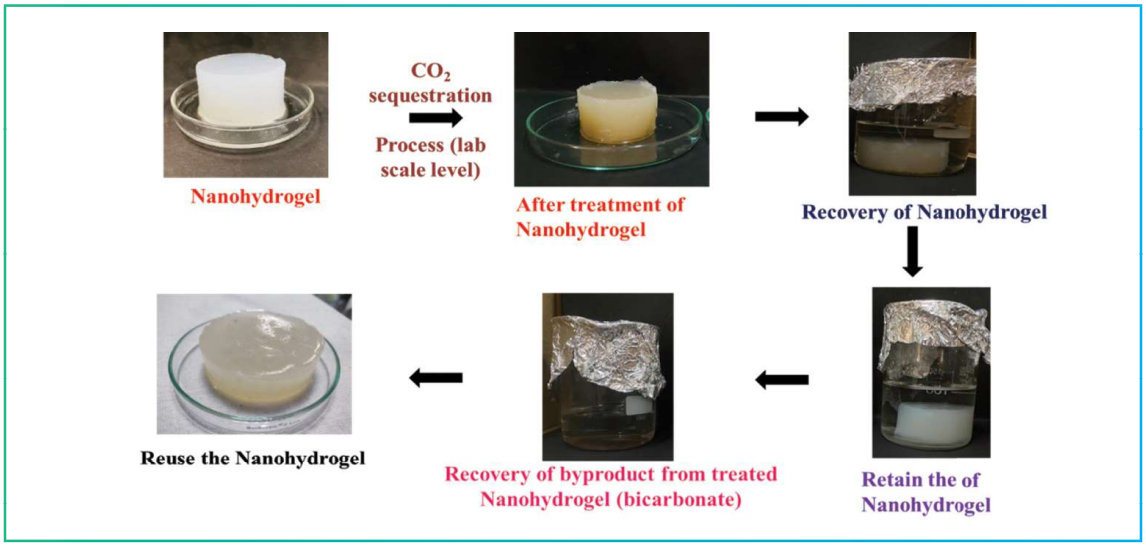
Scalable biocatalyst development for CO_2 capture and agricultural waste conversion

Expected Deliverables :

- A scalable, reusable biocatalyst technology achieving 80-90% CO_2 capture efficiency while converting agricultural waste into valuable environmental solution

Impact:

Enzyme engineering for cost effective carbon sequestration



Silk Fibre Derived Amino Acid For CO_2 Capture Applications

CSIR-NEERI, Nagpur

Objectives :

- Utilization of cocoon waste and/or textile silk waste
- Simple process for the dissolution of silk protein.
- Separation of amino acids from silk salt solution.
- CO_2 capture with silk-based amino acids singly as well as in combination.
- Comparison with conventional alkanol amine-based CO_2 capture process

USP of proposed innovation :

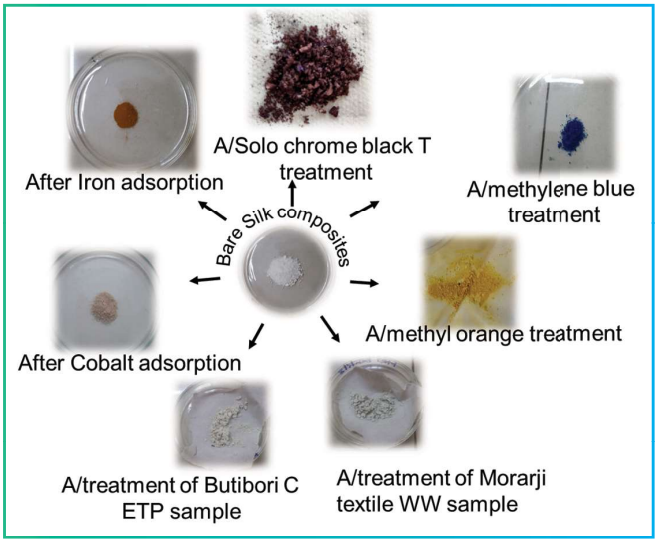
First of its kind proposal that offers Silk-derived amino acid for CO_2 capture

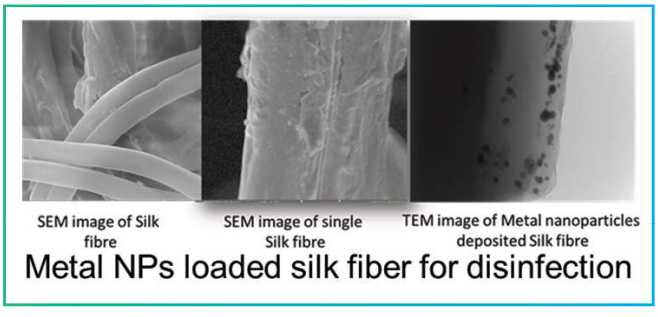
Expected Deliverables :

- Silk-derived Amino acid-based technique for CO_2 capture by considering several factors as an alternative to conventional alkanolamine-based technology.
- 0.3 to 0.5 mol CO_2/mol amino acid
- Reduced energy penalty (50%)
- Scale up for kilo-scale testing

Impact:

Alternative and environment-benign silk-waste derived amino acids, in particular glycine, alanine and serine, for CO_2 capture





Advancing Circular Economy with Microbial Carbon Capture by Transforming Gas and Waste Water into Resources

Caliche Private Limited, Guwahati, Assam

Objectives :

- Deploy purple non-sulphur bacteria (PNSB)-based Microbial CO_2 Capture at Smelter Site
- Convert Biomass into Value-Added Products
- Techno-Economic & Environmental Assessment

USP of proposed innovation :

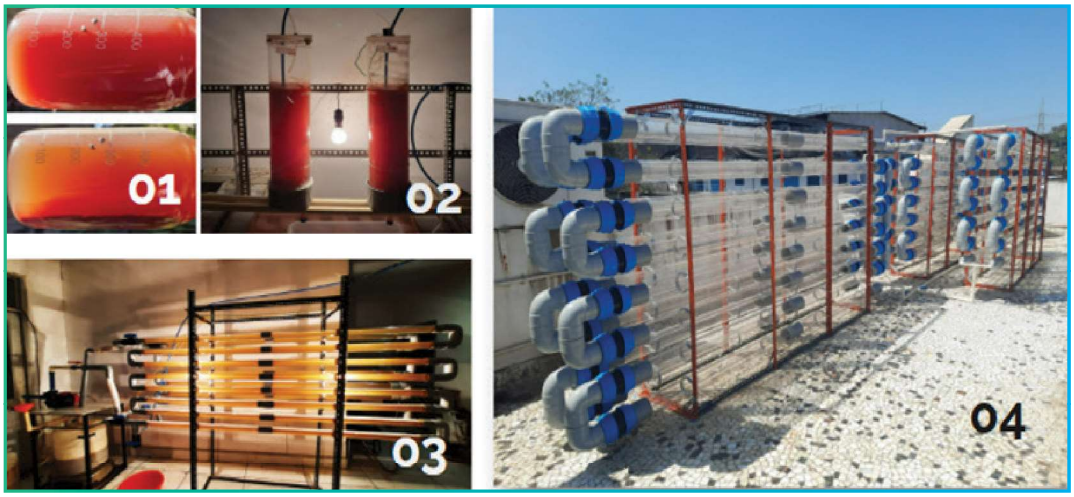
Microbial CO_2 capture for producing polyhydroxybutyrate (PHB), Sustainable Aviation Fuel (SAF), biofertilizer, and animal feed.

Expected Deliverables :

- Pilot Carbon Capture for 0.5–1.2 tonnes CO_2/day from industrial flue gas.
- Production of 12–18 kg/day PHB using PNSB microbial biomass.
- Conversion of 4.5–6 liters/day of CO_2 to SAF via thermal/ catalytic process
- Residual biomass for animal feed and Aqueous phase as organic biofertilizer

Impact:

Reduces industrial CO_2 emissions, supports circular economy by generating sustainable biofuels, biodegradable plastics, and bio-based chemicals



Carbon Dioxide Biorefinery for Integrated Biofuel-Biopolymer-Biofloc Shrimp Production using Water-Energy-Food Nexus approach

Pondicherry University with Amazing Biotech Pvt. Ltd

Objectives :

- Bioconversion of CO_2 to microalgal Biomass
- Bioconversion of CO_2 to PNSB Biomass and PHAs
- Process Integration to the Food-Energy-Water nexus

USP of proposed innovation :

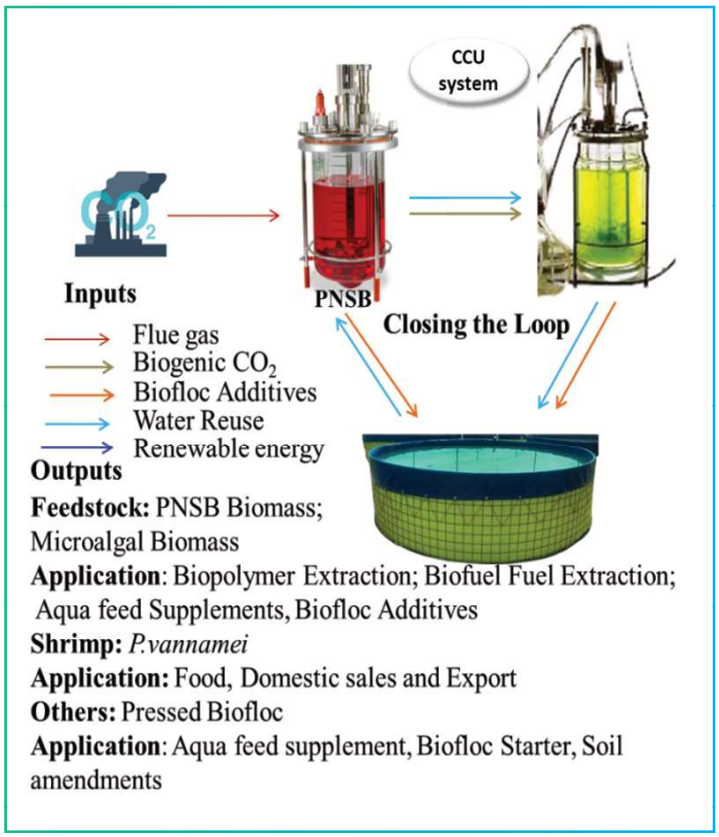
Integrated biological CCU platform combining smart aquaculture, photobioreactors, and circular resource efficiency for sustainable urban food and energy production with minimal carbon footprint.

Expected Deliverables :

Prototype photobioreactor with optimized algal–PNSB processes, validated for scalable CO_2 capture, high-value biomass, and sustainable bio-based applications.

Impact:

A scalable, cost-effective, and sustainable CO_2 biorefinery prototype advancing biomass valorization and circular resource use



Developing and demonstrating microalgae-based CO_2 capture and biomass valorization towards high performance biomanufacturing of sustainable aviation fuel and biopesticide

IIT Guwahati and MNIT Jaipur

Objectives :

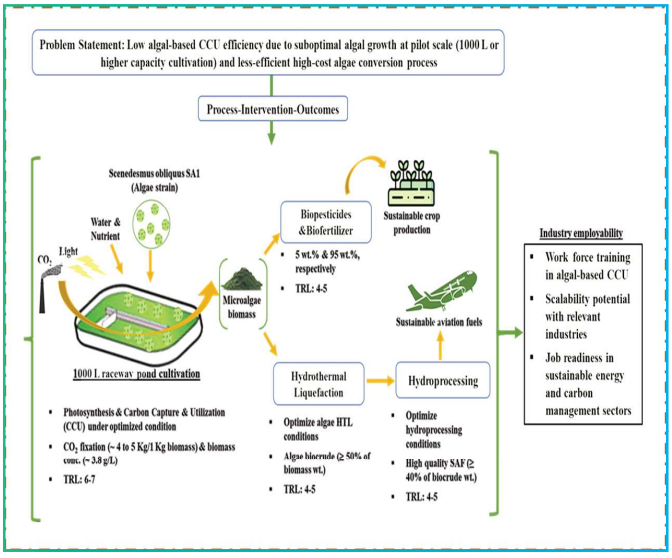
- To maximize photosynthetic efficiency and optimize resource use through advanced photobioreactor and raceway pond technology.
- To develop cost-effective catalytic systems for algae to sustainable aviation fuels (SAFs) conversion.
- To develop sustainable microalgae based biopesticides and biofertilizer.
- To develop a life-cycle assessment of the proposed algae-based carbon capture and utilization technology.

USP of proposed innovation :

CO_2 valorization for SAF and biopesticides

Expected Deliverables :

- Design of 100 L PBR and 1000 L raceway pond
- Optimize operational variables for enhanced CO_2 uptake (>80%) and algae biomass conc. (3.8 g/L).
- Optimize HTL conditions for improved biocrude yield (≥ 50%).
- Efficient hydrochar catalysts and optimized hydroprocessing of biocrude to SAFs.
- Develop biopesticides and biofertilizer production process (self-life enhancement study, nutritional value testing and its effect on the plant growth, etc.)



Impact:

Capturing CO_2 and converting it into SAF and aiding sustainable crop production

Sustainable Carbon Capture and its Utilization using Biocatalysts

Quantumzyme LLP, Bengaluru, Karnataka with Amrita Vishwa Vidyapeetham, Mysuru, Karnataka

Objectives :

- Engineering and Screening of Carbonic Anhydrase Variants.
- Development of Aqueous-Phase Reactor for CO_2 Capture
- Pilot-Scale Demonstration

USP of proposed innovation :

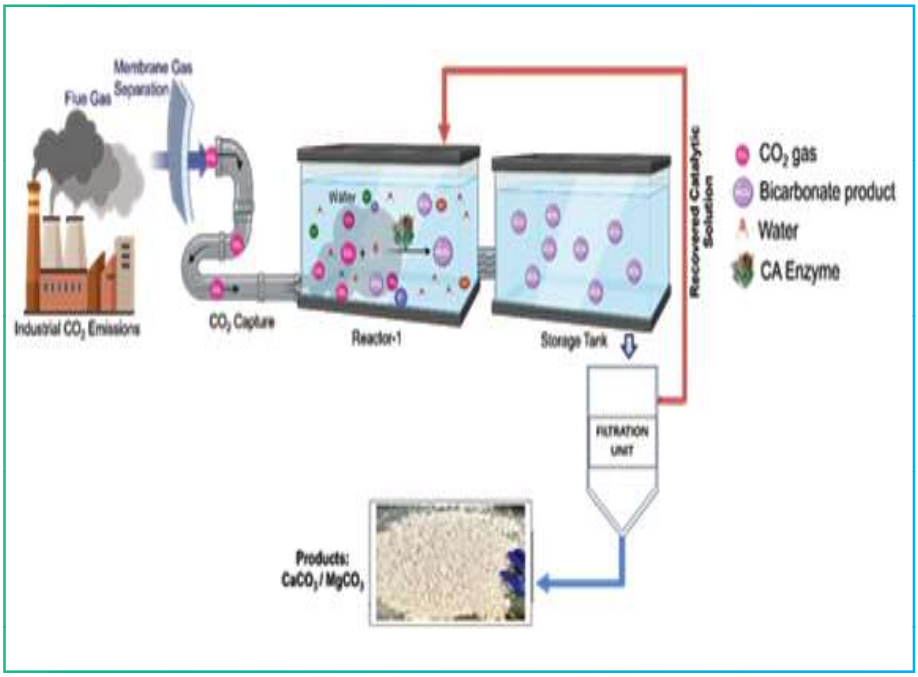
An efficient, eco-friendly CO_2 capture system using engineered biocatalysts with enhanced thermal and pH stability, for converting CO_2 into useful bicarbonates

Expected Deliverables :

Scale-up and validation of 50L and 100L pilot reactors achieving ≥80% CO_2 conversion efficiency.

Impact:

Leads to reduction in industrial carbon emissions by ~50%



Bioelectrochemical system (BES) assisted enhanced carbon capture by methano/ methylotrophic bacteria and their role in PGP activity

CSIR- NEERI, Nagpur

Objectives :

- Evaluation of different microbial approaches for carbon capture potential
- Integration of the selected approaches for enhanced carbon capture
- Assess the impact of selected microbes on carbon flux in different plant-soil systems and assess carbon sequestration rates

USP of proposed innovation :

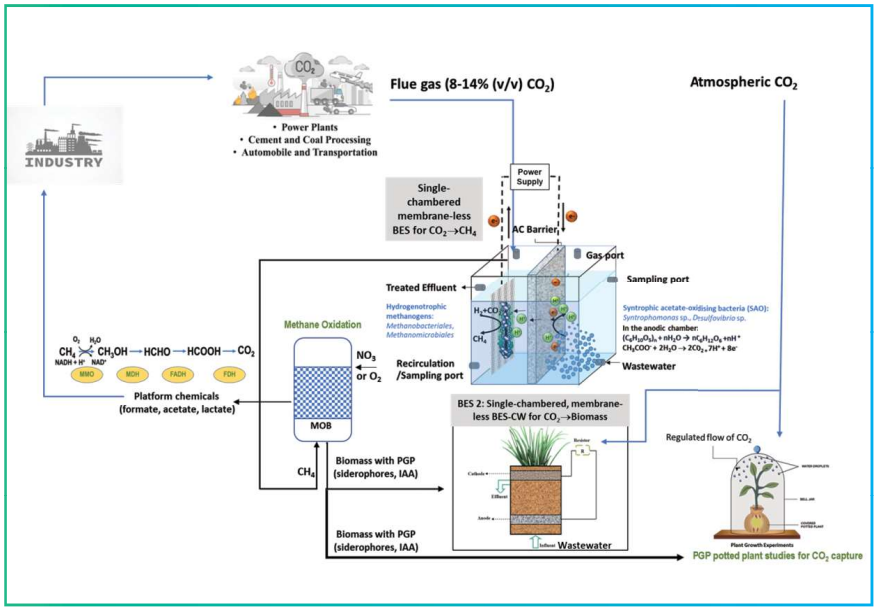
Multiphasic CCU intervention strategy

Expected Deliverables :

- CO_2 capture efficiency in BES: up to 70-80%
- CO_2 capture from PGP bacterial species aided plants ~ 1-2 tons CO_2 per annum
- Pilot scale BES 0.1 - 0.5 KLD

Impact:

Carbon capture with generation of PGP bacteria & platform chemicals



AI-driven Microalgal CO_2 Capture and Peptide-Based Nutraceuticals

CSIR-IICT, Hyderabad with CSIR-NEERI, Nagpur and Core CarbonX Sols Pvt Ltd, Hyderabad

Objectives :

- AI-driven process optimization for CO_2 sequestration and productivity enhancement for the short-listed Microalgal Strains
- AI-Augmented Protein Extraction and Peptide Bioactivity Optimization at 50 L capacity
- Circular Valorisation of residual biomass and Sustainability Assessment of CO_2-to-Biomass Bioprocess

USP of proposed innovation :

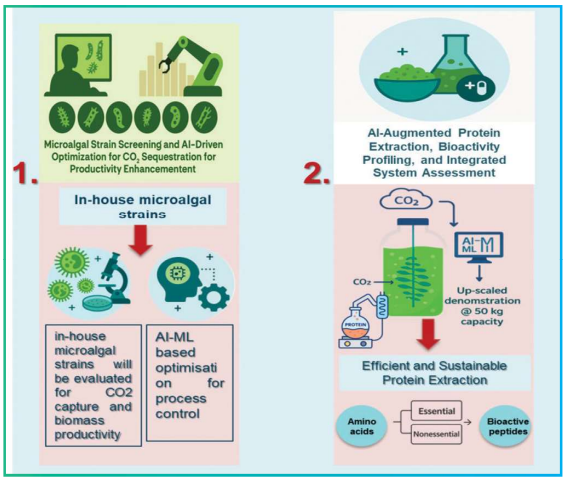
A platform that integrates microalgae, green extraction (DES & SC-CO_2), and AI/ML-driven digital twins to convert industrial CO_2 into multiple high-value products—proteins, peptides, fish feed, and biochar

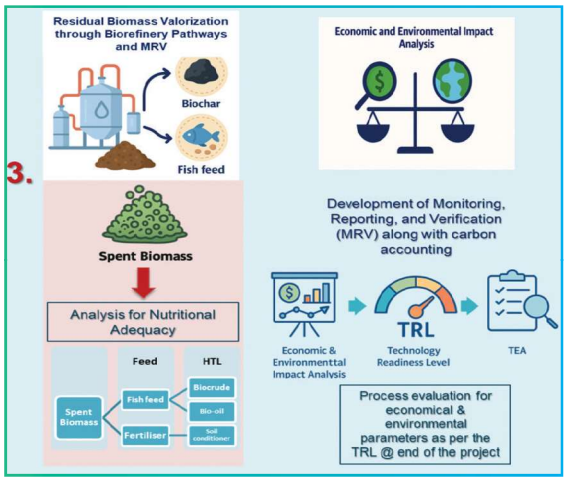
Expected Deliverables :

An AI-enabled, data-driven circular biorefinery framework validated at 50 L scale, delivering optimized CO_2 fixation, high-value algal biomass, and carbon-market aligned LCA/TEA/MRV protocols

Impact:

A scalable circular biorefinery model that transforms industrial CO_2 into high-value products while generating verifiable carbon credits for climate and economic impact will be established





Pilot-Scale Demonstration

Enhanced Microalgal CO_2 Sequestration via Engineered Carbonic Anhydrase

Aatral Green Renewable Energy Private Limited, Chennai, with Indian Institute of Technology, Madras (IITM), Chennai

Objectives :

- Engineer and characterize recombinant CA for improved CO_2 capture
- Integrate CA into microalgal systems to enhance CO_2 fixation
- Scale-up CA-assisted sequestration in bioreactors and assess

USP of proposed innovation :

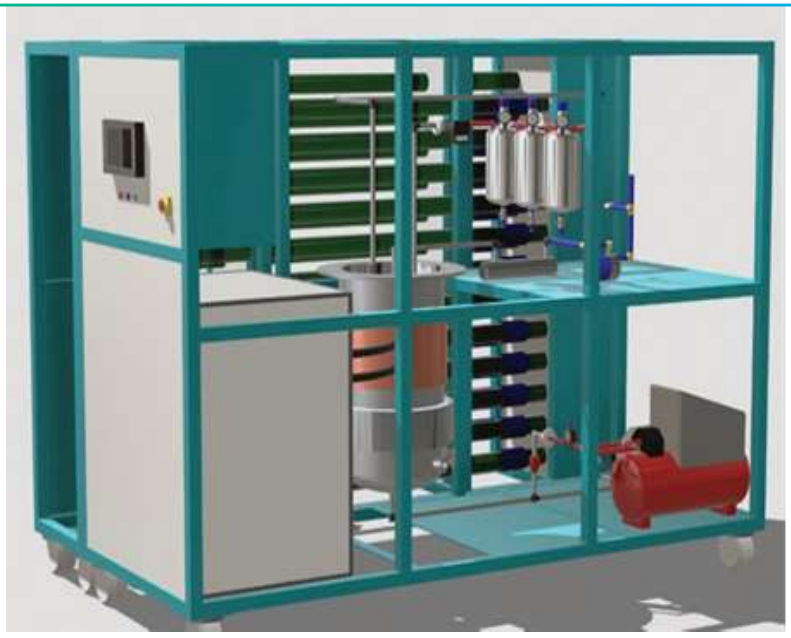
Recombinant carbonic anhydrase (CA) in algal system to boost CO_2 capture efficiency

Expected Deliverables:

Lab to pilot-scale validation (up to 200L photobioreactor) under simulated flue gas conditions.

Impact:

Projected to result in significant cost savings (70–75%), boost in CO_2 sequestration, high-value sustainable biomass generation, supporting low- footprint and industrial-scale carbon utilization



CARBON CAPTURE TO COMMERCE: Diatom Driven Carbon Sequestration and Sustainable Biomanufacturing of Value-Added Compounds

Institute of Chemical Technology, Mumbai

Objectives :

- Engineer *Phaeodactylum tricornutum* to enhance CO_2 hydration
- Design and construct PBRs with efficient CO_2 diffusion
- Develop biorefinery workflow for extracting value added products
- Quantify CO_2 capture efficiency

USP of proposed innovation :

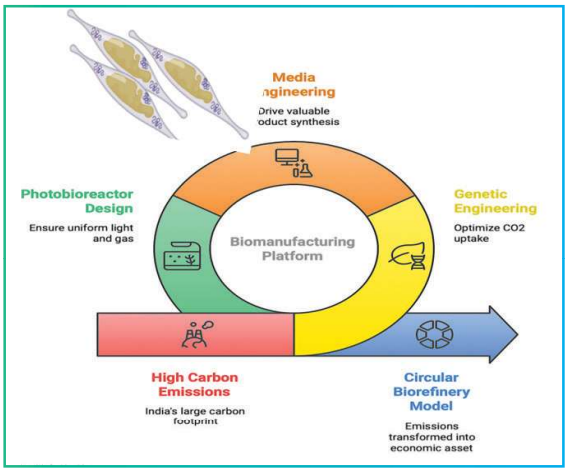
World-first combination of enzyme-engineered diatoms and PBR technology, delivering unmatched CO_2 removal and bioproduct yield.

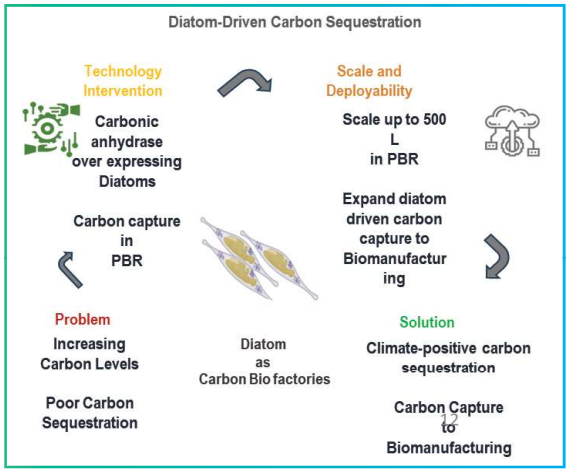
Expected Deliverables :

- Carbonic anhydrase over expressing Diatoms
- Scale up to 500 L in PBR
- CO_2 sequestration: ~100 metric tons/year/hectare
- High-value product potential: >$100,000/ha/year

Impact:

Transforms waste CO_2 into valuable resources, catalyzing the clean-tech revolution and driving the net-zero economy





Collaborative development of indigenous marine cyanobacteria for Carbon capture – valorization of biomass and spent media

ICGEB, Bharatidasan University, IIT Bombay and SASTRA University

Objectives :

- Integrated low-cost systems for bioconversion of CO_2 into high-value products.
- Introducing EPS as sturdy biomaterial to Capture CO_2 from untreated flue gas.
- Pilot-scale EPS production under simulated flue gas as a bridging the gap technology.

USP of proposed innovation :

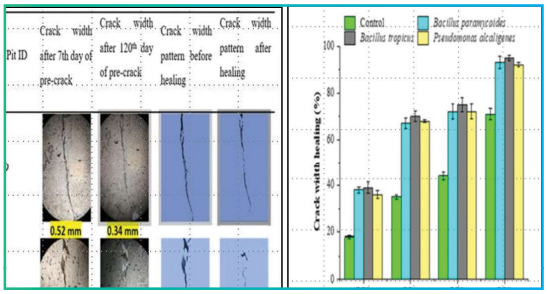
Development of 3D translucent algal panels as carbon negative building materials

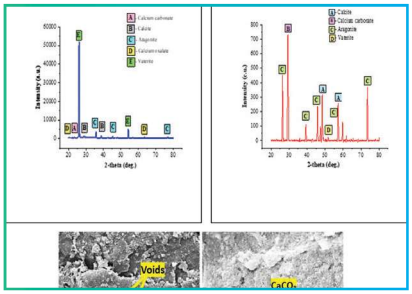
Expected Deliverables :

- Screening of high EPS producing Cyanobacteria and Microalgae
- CO_2 Sequestration in biphasic mode
- Biomass+ EPS production under simulated flue gas in 10 L PBR (continuous process)
- EPS mediated flue gas refinement and adsorption for heavy metals and biosurfactant
- Development of 3D translucent panels with algal consortium for atmospheric CO_2 capture

Impact:

Reduces CO_2 emissions, supports circular economy by generating sustainable biomaterials





Carbon capture over biocoal for lipase production using acetate generated from CO_2 via microbial electrosynthesis

BRIC NABI, Mohali and IISER Mohali

Objectives :

- Process system development for CO_2 capture using biocoal
- Bio-electrochemical conversion of CO_2 into acetate using biocoal-based electrode
- 100-Litre volumetric processing of acetic acid-fed yeast for lipase production

USP of proposed innovation :

Rice straw-derived biocoal (torrefied solid) as an adsorbent and electrode material for CO_2 conversion

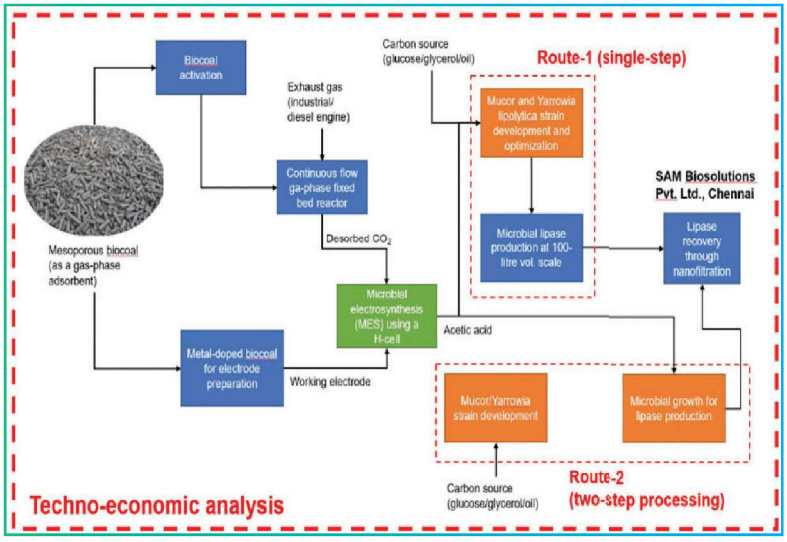
Bio-electrochemical conversion of CO_2 into acetate to produce lipase enzyme

Expected Deliverables :

- A viable technology for carbon capture to reduce environmental carbon at TRL 5-7
- An alternative applied process of utilizing biocoal for electro-catalytic applications at TRL 3-4
- An effective lipase enzyme for biodiesel applications at TRL 3-5
- Effective bio-electrocatalysis methodology with a low-cost cathode made from biocoal to produce acetic acid (a versatile molecule for chemicals/products) for industrial applications at TRL 3-5

Impact:

Utilization of Atmospheric Carbon for Lipase Production



Hybrid Absorption Membrane - Assisted CO_2 capture and Microalgal Solvent Regeneration: An integrated Pilot-Scale Platform for Bio-Regenerative CO_2 Sequestration and lycopene Pigment Production from *Dunaliella salina*

NIT Durgapur, IIT Madras and St. Joseph's College of Engineering, Chennai

Objectives :

- To develop an integrated hybrid absorption–membrane photobioreactor platform for scalable CCS technology , while simultaneously optimizing *Dunaliella salina* cultivation for enhanced lycopene production and biomass valorization under controlled CO_2 regimes, supported by techno-economic and life cycle analyses

USP of proposed innovation :

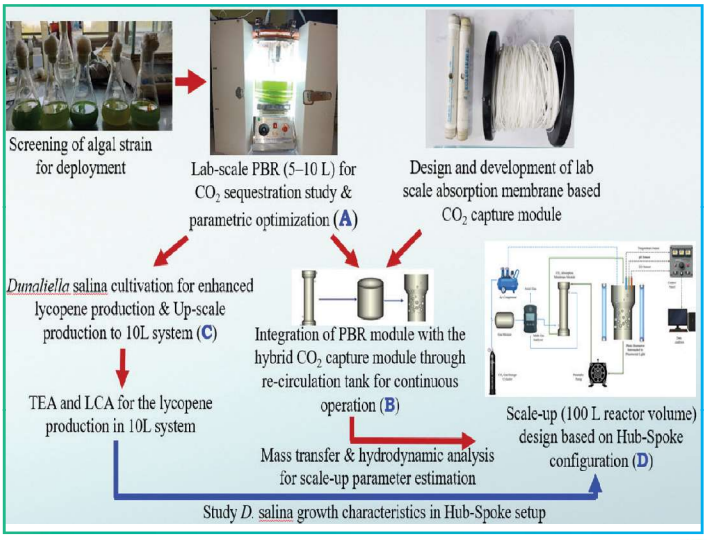
Development of a Hybrid absorption-membrane integrated PBR for efficient CCS System.

Expected Deliverables :

- CO_2 fixation: ≥ 1.7 g/L/day (5L gas lift bioreactor setup).
- CO_2 fixation: 2.2 – 2.4 g/L/day (10L hybrid reactor setup)
- Scale Up (10L system): CO_2 fixation: 2.0 - 2.3 g CO_2/L/day
- Scale Up (100L system): CO_2 fixation: 3.0 – 3.2 g of CO_2 /L /day (0.11 – 0.12 tonnes of CO2 fixed per year)

Impact:

Carbon sequestration and microalgae production with generation of value added materials



Physiological and chemical characterization of potential climate resilient bioenergy grasses (*Arundo donax* and *Coix lacryma-jobi*) and exploration of their root associated cyanobacterial population to capture atmospheric CO_2

Presidency University, Kolkata

Objectives :

- Assessment of elevated CO_2, drought and temperature level on photosynthetic efficiency and biomass accumulation of *Arundo donax* and *Coix lacryma-jobi*
- Metagenome guided isolation of grass root associated cyanobacteria and exploration of their ability to capture CO_2 in grass-microbe protocooperation
- Green conversion of captured carbon into bioethanol by microbial consortia mediated pretreatment and saccharification of grass biomasses

USP of proposed innovation :

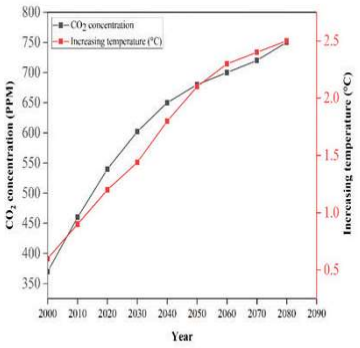
Use of bioenergy grasses for carbon sequestration and biofuel production

Expected Deliverables :

- Assimilation of atmospheric CO_2 by grasses- resilient to major environmental stressors
- Enhanced carbon capturing by synthetic cyanobacterial consortium (SynCom) and grass-cyanobacteria protocooperation
- Scale: 2 Ltr (Lab scale) to 100 Ltr (pilot scale in collaboration with MASOJA TECHNO SOLUTION PRIVATE LIMITED)

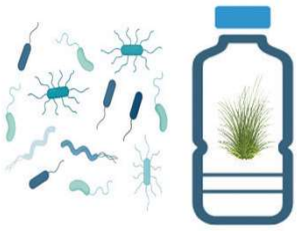
Impact:

Reduction in GHG emission with nature based solutions



Projected CO2 and temperature elevation

Metagenome-guided isolation of root-associated cyanobacterial strains



Development of SynCom

Environmentally Sustainable Quantum Containers (QCs) Assisted Microalgae Growth for Faster CO2 Capture And Utilization With the Potential Recovery of the Biomass for Value-added Products

MNNIT, Prayagraj and BHU, Varanasi

Objectives :

- Synthesis, Characterization of QCs and their Cytotoxicity assay in microalgae culture.
- Optimization of microalgae-QCs cultivation for efficient CO_2 uptake and improved yield of biomass.
- Demonstration of the technology in 100 L tubular CO_2 bubbling photobioreactor.
- Extraction of lipids and carotenoids and their characterization as value- added bioproducts.

USP of proposed innovation :

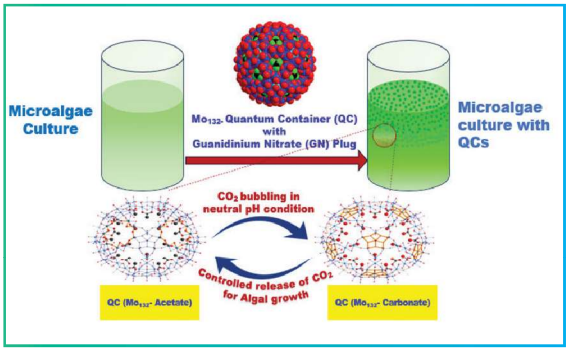
The Mo132-Guanidinium nitrate QCs enhances the local CO_2 concentration in the microalgae culture medium resulting in the increased cellular growth and yield of value-added products (lipids and carotenoids), associated with sustainable biorefinery.

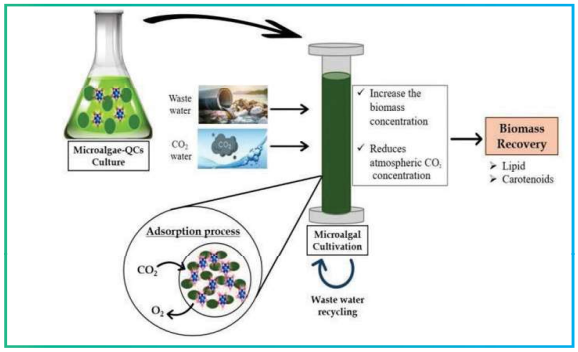
Expected Deliverables :

- The Microalgae-QC technology enables decentralized carbon utilization—ideal for industries with moderate CO_2 emissions, allowing localized biofixation and on-site biomass valorization.
- Deployment in 100 L modular tubular photobioreactors confirms operational feasibility, with potential for scale-up to vertical or rooftop systems in urban and peri-urban environments.
- Microalgal Lipids and Carotenoids bioproducts in an enhanced quantities making the technology profitable under the biorefinery concept.

Impact:

Decentralized carbon utilization, ideal for industries with moderate CO_2 emissions, allowing localized biofixation and on-site biomass valorization.





Development of Genetically Engineered Microalgae, Membrane-Based Photobioreactors and Microalgal-Derived Acid-Base Bifunctional Activated Biochar for Enhanced CO_2 Capture and Biofuel Generation: A Life Cycle Assessment

NIT Silchar and CGCRI Kolkata

Objectives :

- Development of genetically engineered microalgae for enhanced CO_2 capture and its cultivation in a membrane-based photobioreactor pilot prototype (100 L)
- Synthesis of acid-base bifunctional activated biochar from algal biomass and evaluation of CO_2 capture performance under simulated flue gas conditions
- Development of zeolite composite membrane-based pervaporation process (50 L) for superior grade bioethanol (~98%) production from microalgal biomass
- Demonstration of a membrane-based integrated prototype at a selective industry, energy foot print and life cycle analysis of total process

USP of proposed innovation :

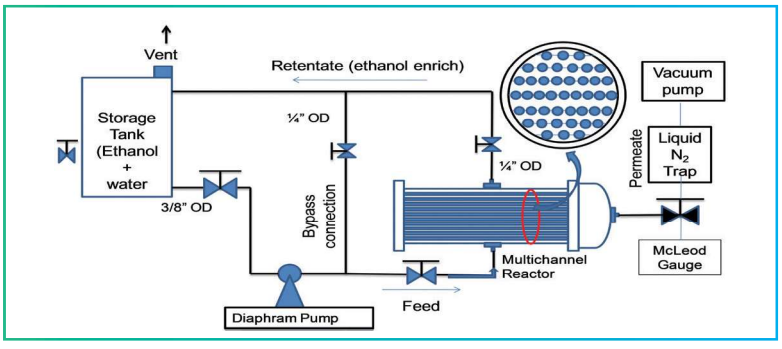
Design of membrane-based process of high efficiency owing to the unique advantages of the tailor-made indigenous membranes

Expected Deliverables :

- Pilot scale membrane PBR (100 L) with superhydrophobic membrane modules
- Membrane based harvesting prototype (100 L) for dewatering algal biomass, mitigating biofouling
- Prototype validation of a bifunctional activated biochar for CO_2 capture in simulated flue gas

Impact:

Carbon capture and bioproducts development with indigenously developed membrane bioreactor



BioCO2nnect-Algae: Harnessing Non-Model Strains for Carbon Capture and High-Value Bioproducts

ICGEB, New Delhi

Objectives :

- Enhance CO_2 capture efficiency of algal strains using an ALE processes
- Develop essential synthetic biology tools, genome models for such non- model industrial agricultural strains.
- Deliver improved strains for sustainable and scalable biomanufacturing

USP of proposed innovation :

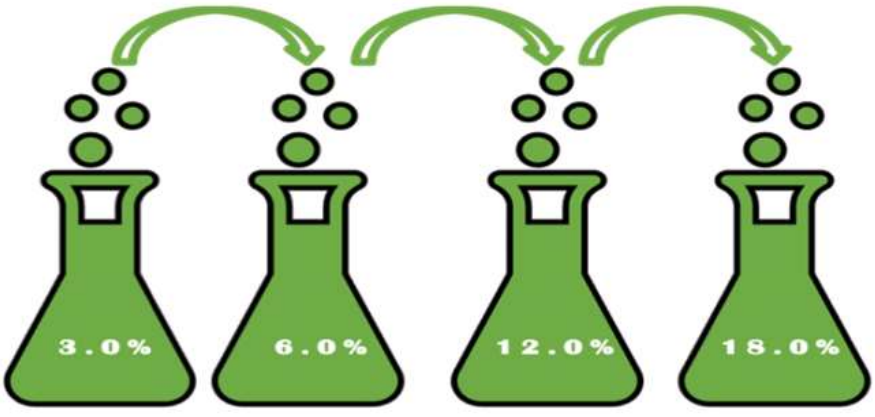
An unique algal-based biomanufacturing process using Adaptive Laboratory Evolution (ALE) that efficiently captures CO_2

Expected Deliverables :

- CO_2 Capture Efficiency: Up to 18% (equivalent to flue gas concentrations).
- Biomass Productivity: 1.0 - 2.0 g/L/D at a 100.0 L pilot-scale.
- Bioproducts Yield: Carotenoids such as Lutein, Zeaxanthin etc.

Impact:

Sustainable and efficient way to mitigate CO_2 via biological routes.



This figure demonstrates the process of adaptive laboratory evolution (ALE) of algae for enhanced carbon fixation via (X) generations of CO2 adaptation

Rumen-Inspired Consolidated Bioprocessing for Methane Production from Industrial Carbon Emissions

GreenShift Energy Pvt. Ltd.

Objectives :

- Development of starter culture for CO_2 to CH_4 Conversion.
- Flask-level validation of starter culture performance and design of lab-scale reactor (capacity: 5 kg CO_2/day).
- Optimization of rumen inspired bioprocess at lab-scale reactor and fabrication of pilot scale reactor of 50 kg CO_2/day conversion capacity.
- Performance evaluation of pilot-scale bioreactor of 50 kg CO_2/day conversion capacity.

USP of proposed innovation :

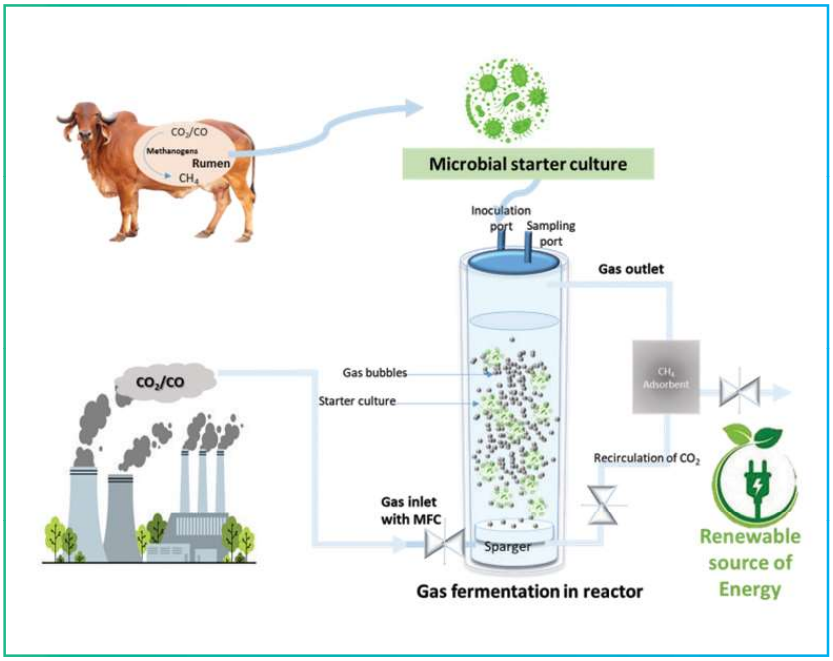
Leveraging rumen-derived starter cultures for stable, high-efficiency methane production under ambient, low-cost conditions

Expected Deliverables :

A functional pilot-scale plant with a demonstrated capacity to utilize 50 kg of CO_2 per day

Impact:

Provides a solution for converting industrial emissions into a valuable, renewable energy source



Sustainable microalgae-yeast biorefinery for enhanced lutein and lipid production utilizing coal-fired flue gas CO_2 through a waste-to-wealth strategy

Amity University, Noida

Objectives :

- Develop and optimize a microalgae-yeast biorefinery for producing lutein- and lipid-rich biomass using coal-fired flue gas CO_2 and wastewater
- Establish an efficient, simultaneous extraction technique for lutein and lipids from both wet and dry microalgal biomass
- Demonstrate a 100-200L pilot-scale open raceway pond (ORP) system for enhanced CO_2 capture and biomass production using treated and untreated wastewater

USP of proposed innovation :

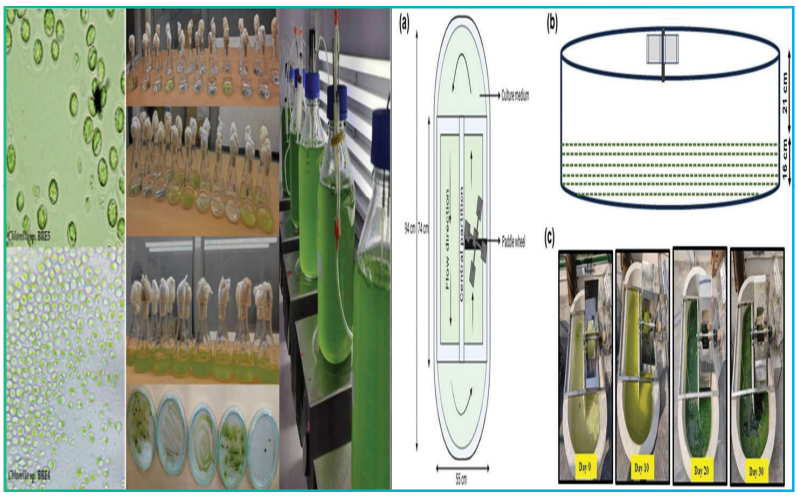
Sustainable microalgae-yeast biorefinery that valorizes coal-fired flue gas CO_2 and wastewater into high-value lutein and lipids via waste-to-wealth integration.

Expected Deliverables :

- CO_2 sequestration: 1.5-2.5 g/L/d
- Biomass: 1.2-1.8 g/L/d
- Lipids: 25-35% (DCW)
- Lutein: 4-6 mg/g
- Wastewater treatment: >80-90% N & P removal

Impact:

Integrated CO_2 capture and wastewater valorization through microalgae-yeast biorefinery



Field Validation and Demonstration

Carbon Capture through Algae and Sustainable & Resilient Agriculture

Pinnacle Biosciences India Private Limited, Kanyakumari, Tamil Nadu

Objectives :

- Sequesteration of 1 TPD of CO_2 and feed it into the algal culture system.
- Design and operate a novel High-Rate Algae Cultivation System (HRACS) for efficient biomass production.
- Convert microalgae biomass into nitrogen-rich amino acid fertilizer fully bioavailable to crops

USP of proposed innovation :

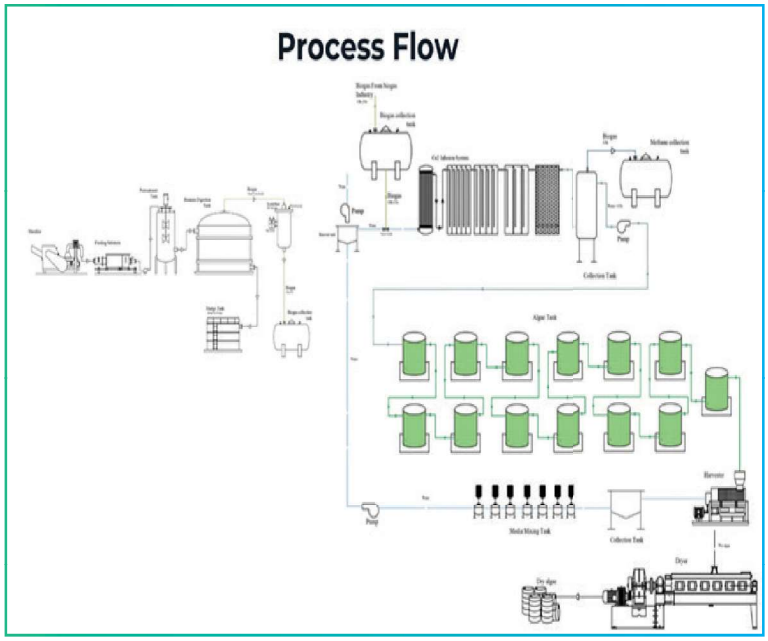
Uses high-rate microalgae-based HRACS units to achieve 85–90% CO_2 absorption, converting emissions into high-value amino acid fertilizers

Expected Deliverables :

- One TPD CO_2 Sequestration
- Production of 0.5 MT/day of Algal Biomass
- Production of 2 MT/day of nitrogen-rich amino acid fertilizer
- 1.3 MT/day oxygen generated; 1 carbon credit per MT CO_2 captured

Impact:

Enables high-efficiency CO_2 capture using microalgae while producing nutrient-rich fertilizers.



Scalable Algal-Methanotrophs Formulations for Carbon Capture and GHGs Mitigation in Coastal Agricultural Systems

NRRI, Cuttack

Objectives :

- Upscaling of the identified high CO_2 capturing microalgal strain.
- Large-scale demonstration and popularization of solid methanotrophs formulation for GHGs emissions mitigation from agriculture through industrial partnerships.
- Economic utilization of algal biomass as a formulating agent for methanotrophs in agriculture for climate change mitigation.
- Development of algal-based biochar for long-term carbon storage in agricultural soils

USP of proposed innovation :

CO_2 valorization for SAF and biopesticides

Expected Deliverables :

- 5.6 t C stored/ha/yr CO_2 capture and storage by *Leptolyngbya sp.*
- 10–14% CH_4 reduction
- Scalable to at least 1000 ha

Impact:

Reduction in GHG emission with improved soil fertility

solid methanotrophs formulation


Patent of the Methanotrophs

Optimization of Usable Calcite Biomanufacturing through Enhanced Microbial CO_2, Sequestration and Phosphogypsum Biotransformation via a Novel Heterotrophic Carbonic Anhydrase- Mediated Microbially Induced Carbonate Precipitation Process

Jadavpur University, Kolkata

Objectives :

- Novel Indigenous Microbial Bioconsortium (IMoBc), consisting of seven heterotrophic bacteria with high carbonic anhydrase activity (450 U/mL), enabling rapid CO_2 sequestration and calcite biosynthesis.
- Application of multi-omics strategies (WGS, RNA-Seq) to reveal genotype-to-phenotype links for CO_2 capture and calcite precipitation pathways

USP of proposed innovation :

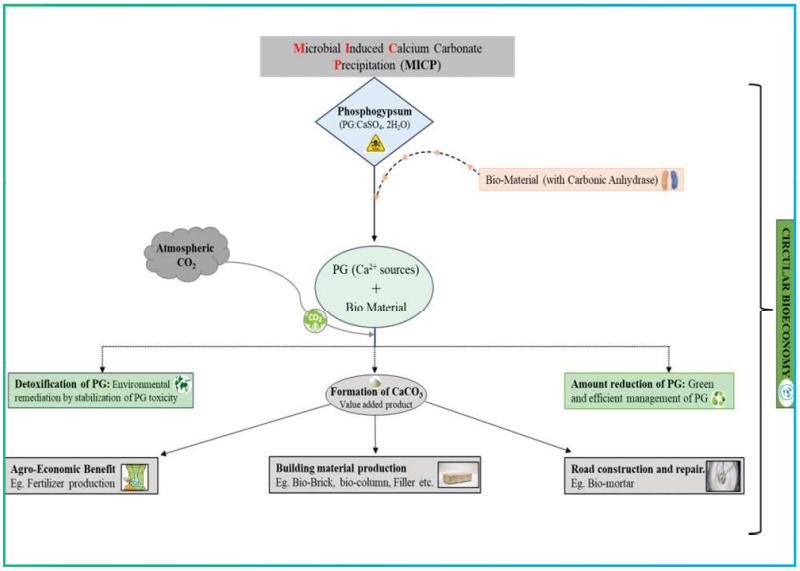
First-ever application of a carbonic anhydrase-mediated non-ureolytic heterotrophic MICP process using phosphogypsum (PG) as a calcium source and atmospheric CO_2 as a carbonate source

Expected Deliverables :

- 100 L pilot bioreactor; with industry-collaboration (**Paradeep Phosphate Ltd.**)
- Bio-cement production: ~500 to 5,000 L batches in **Blue Planet Ltd.**, **BioMason**, and EU climate innovation pilots, etc

Impact:

Contributes to third-generation biorefineries by transforming waste PG into biogenic calcite fertilizer



Utilizing CO_2 (from biogas) for Harnessing Algal Cultivation and photo-catalytic CO_2 conversion to mixed alcohol

Organic Recycling Systems Limited with IIT Bombay and IIT Kharagpur

Objectives :

- To establish the foundational infrastructure for biogas generation, CO_2 separation, and initiate parallel R&D on algal and photocatalytic CO_2 utilisation.
- To integrate all developed systems (biogas, VPSA, algal PBR, photocatalytic reactor) and optimise their real-time performance for CO_2 valorisation.

USP of proposed innovation :

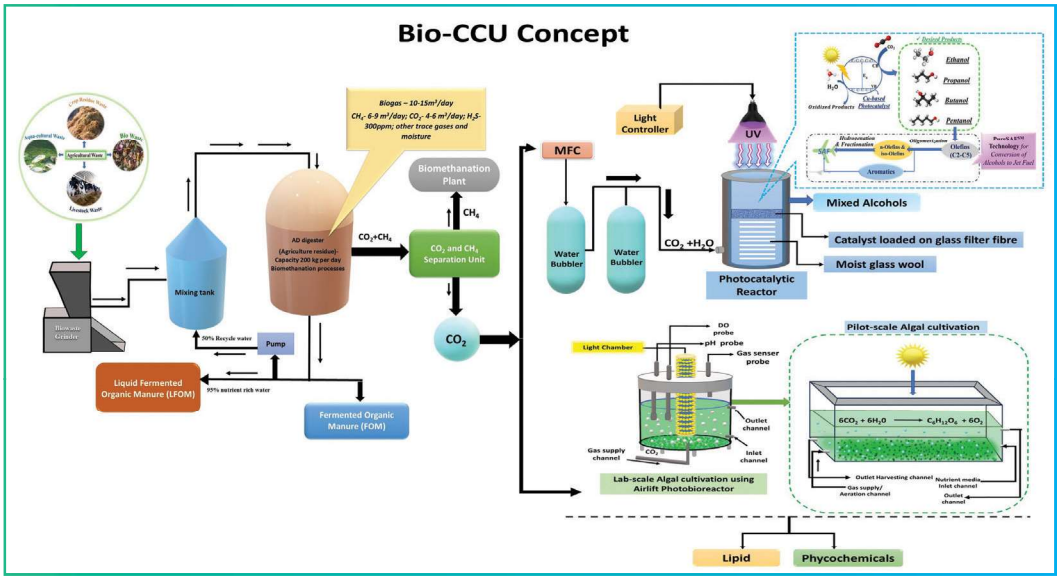
Novel integrated platform combining THERMI-NIBE V.1 microbial consortium, CO_2 -optimized algal strains, and advanced Ti_3C_2MXene/CeO_2 –CuO photocatalysts for efficient bio-methanation and selective mixed alcohol production

Expected Deliverables :

Demonstration of pilot system (1000 L Bio-methanation reactor) with algal and photo-catalytic reactors.

Impact:

Accelerated deployment of sustainable CO_2 utilization technologies through validated pilot demonstrations



Sustainable valorization of low cost substrates into high value porous carbon for carbon capture

IIT Delhi and TERI, New Delhi

Objectives :

- Expression, purification and characterization of enzyme for porous carbon synthesis
- Mutagenesis of the enzyme for developing a stable and improved variant
- Application of the mutant enzyme for porous carbon synthesis from low value asphaltene
- Structural and functional characterization of synthesized porous carbon
- Synthesis of porous carbon from 10 kg asphaltene and determination of CO_2 capture

USP of proposed innovation :

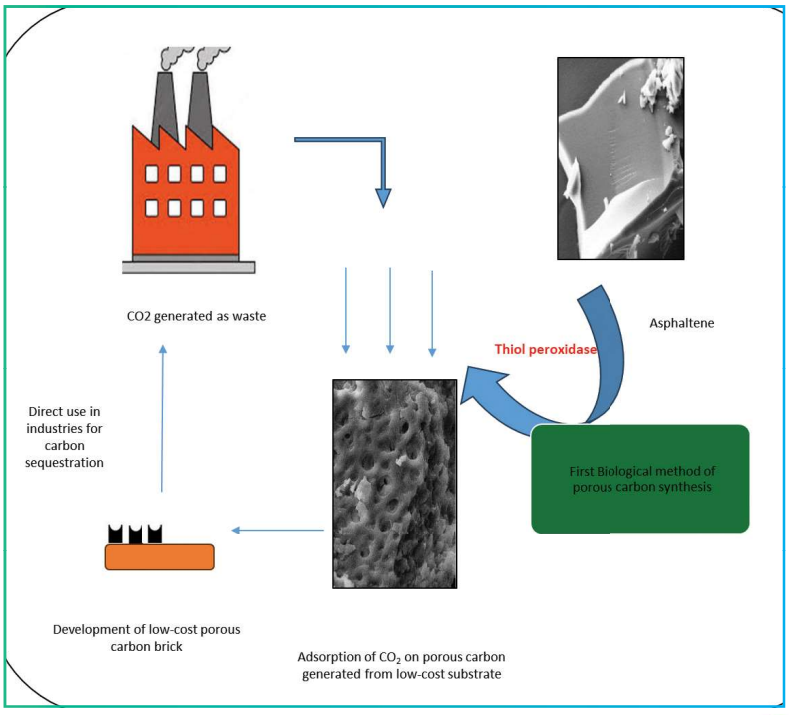
Development of porous carbon brick by valorization of asphaltene for CO_2 capture

Expected Deliverables :

- Selection of Asphaltene/ Groundnut as low cost substrates
- Green synthesis of porous carbon and characterization
- Scale Up to 1000 L bioreactor with synthesis of 22 kg porous carbon

Impact:

Adsorption of CO_2 on porous carbon generated from low-cost substrate



To develop a CO_2-biorefinery by carbon capture from flue gas through medium-large scale micro-algal biomass production as feedstock for biofuels and value-added products

ICGEB, New Delhi, CSIR- CSMCRI, Gujarat and CSIR- NEERI, Nagpur

Objectives :

- Designing smart photobioreactors for efficiently sequestering maximum CO_2 by algae
- Algae-based biorefinery and downstream processing for value-added products

USP of proposed innovation :

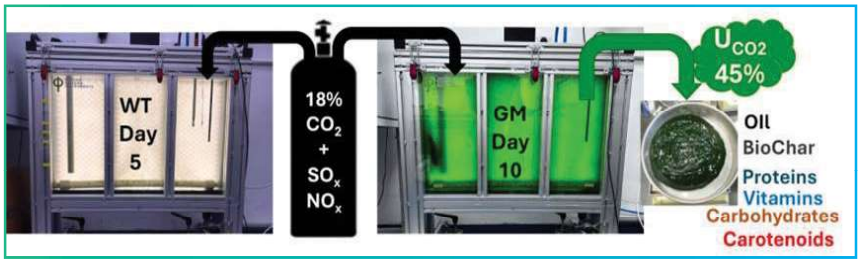
An efficient, algae based biorefinery for efficiently sequestering maximum CO_2 by algae and down streaming for value added products.

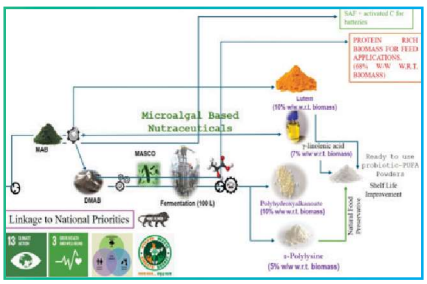
Expected Deliverables:

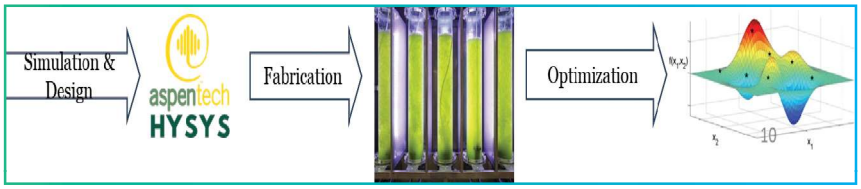
100 KL Tubular Photobioreactor targetting 3kg per day CO_2 capture from flue gases of Cement factory of **Dalmiya Cement** and generating 2kg microalgal biomass per day. The complete pilot set of 100 KL microalgal cultivation will be set up at selected site of Dalmiya Cement.

Impact:

Flue gas CO_2 reduction and development of up to 30kg value added products such as microalgal biomass, SAF, linoleic acid, astaxanthin







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DEPARTMENT OF
BIOTECHNOLOGY

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