Microalga: a sustainable CO_2 biofixation towards the circular economy

International Conference on Green Technologies for Climate Action and Resilience
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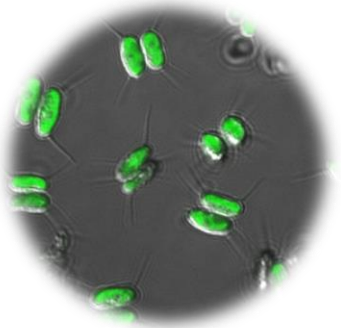

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Overview of Presentation

CO_2 fixation Current scenario and initiative

- Global warming
- Current trends and the need for CO_2 Emission control
- Present scenario of CO_2 fixation
- Government initiatives and policy
- Different methods/concepts
- Alga: Sustainable Green Alternative
- Efficiency of microalga over plants
- Overall merits of microalgae

Alga the Green future

- Mechanism of CO_2 fixation
- Biomass valorization
- Circular economy

A climate-resilient alternative to ensure the
Food
Energy
Environment

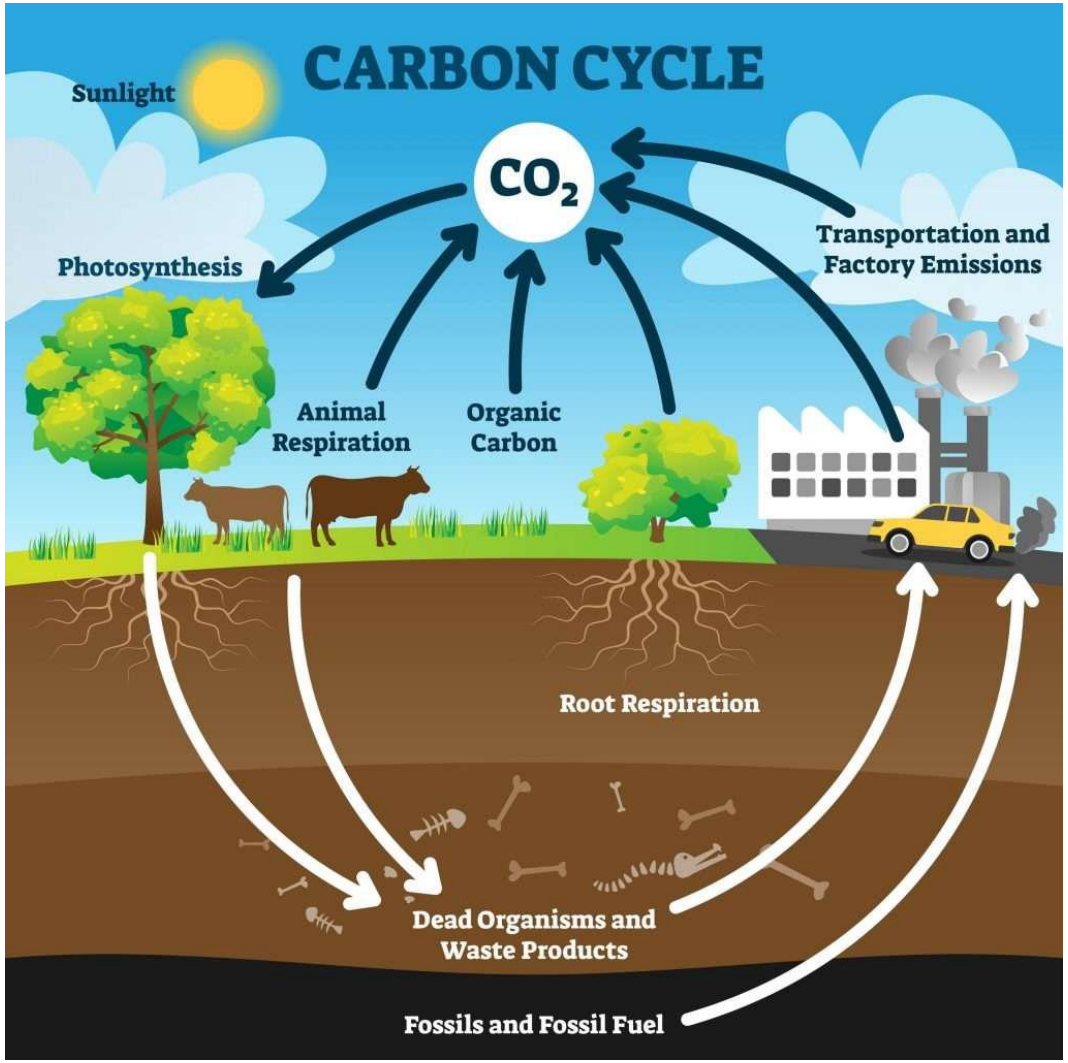
Global Warming: Causes and impact

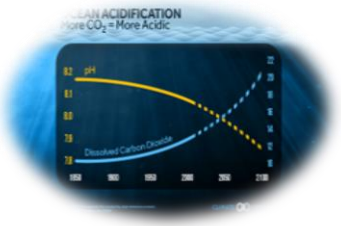
Global warming is the gradual increase in Earth's average surface temperature due to human activities, particularly the emission of greenhouse gases.

This warming trend results in climate changes, including rising sea levels and more extreme weather events, with significant implications for ecosystems and human societies.

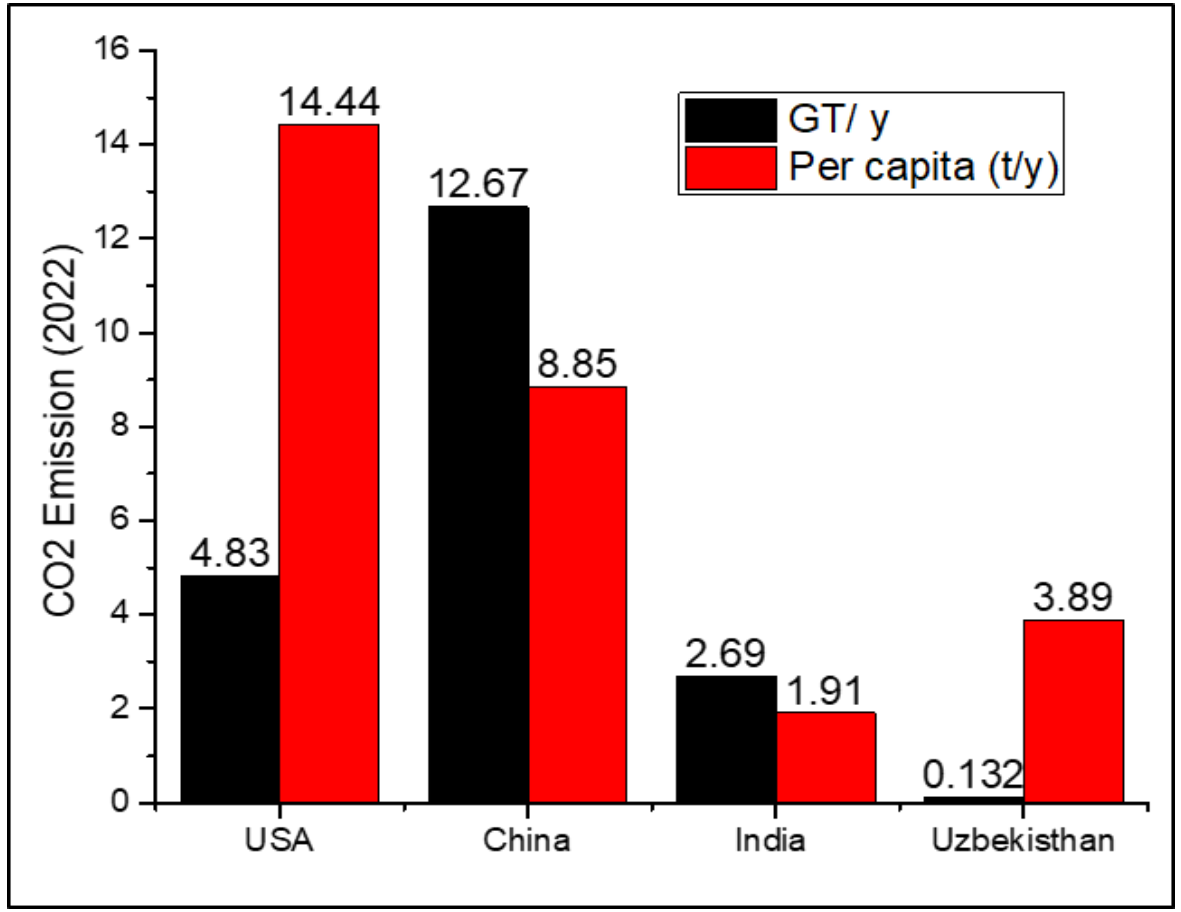
It is a critical aspect of climate change, driven by human-induced alterations to the planet's natural balance.

Global Warming: Imbalance in the carbon cycle

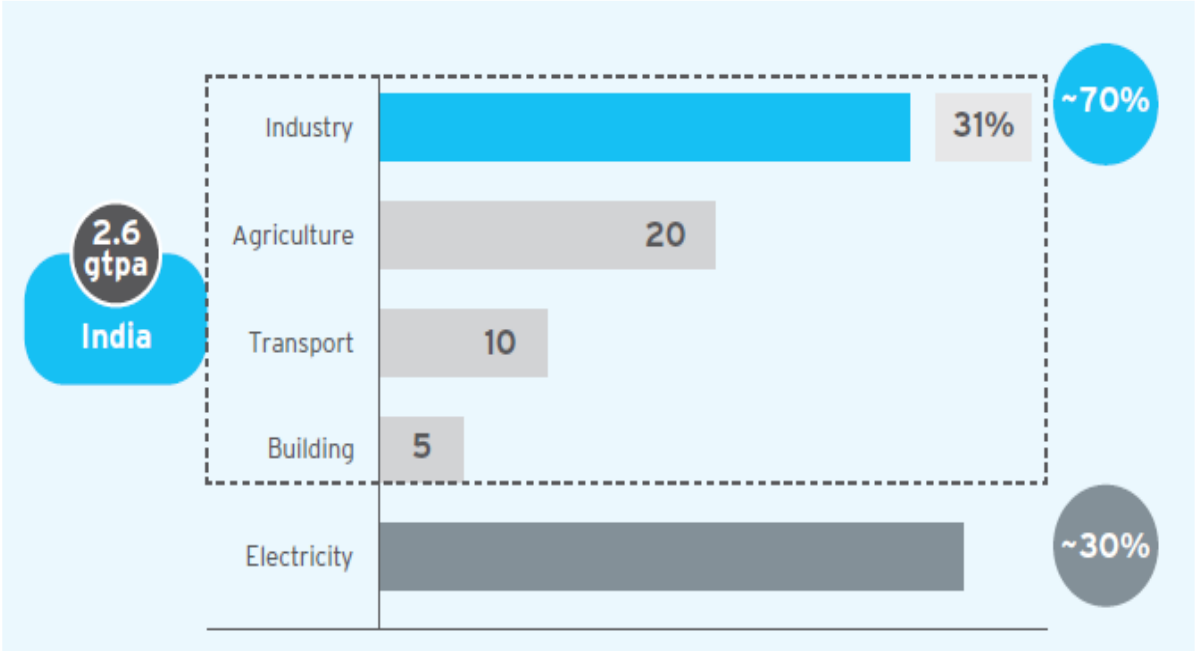




Carbon emission: current scenario

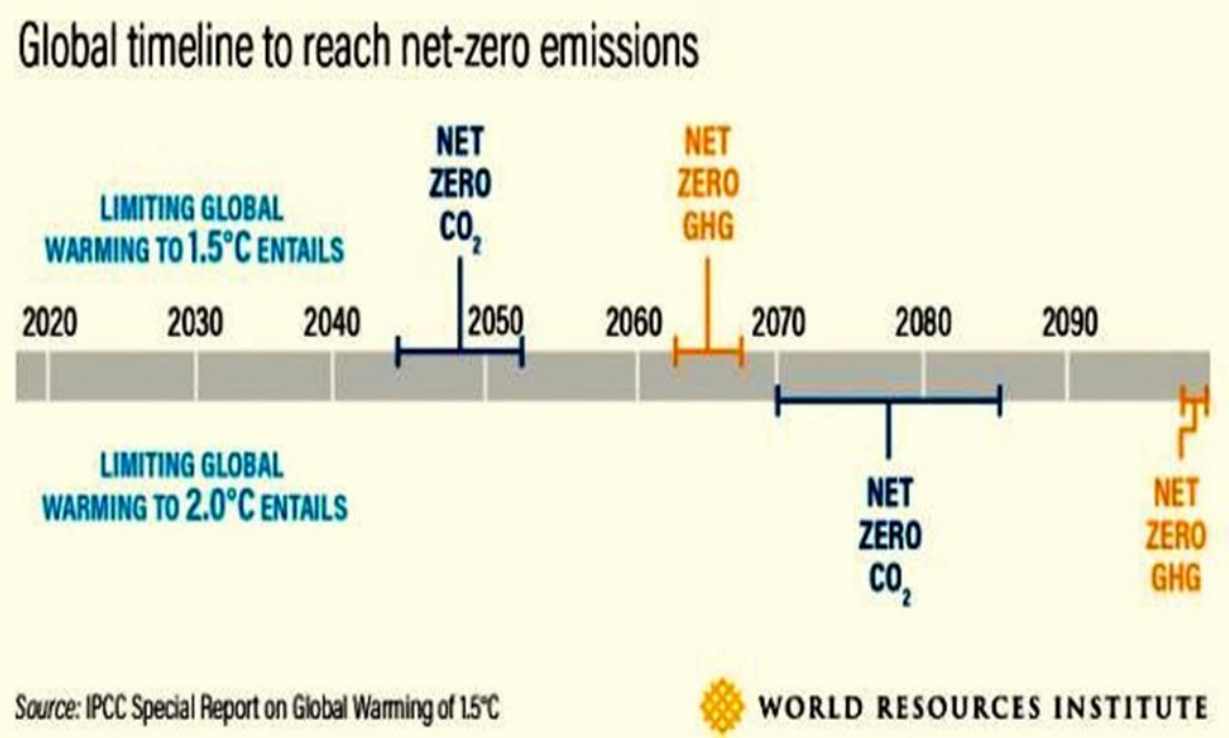


Emission Database for Global Atmospheric Research, EC



Source: NITI Aayog, GoI, 2022

Global Carbon-Neutral Initiative and Strategy



Strategy to achieve

1. Increased use of non-fossil-fuel-based energy consumption.
2. Meeting 50 % of current energy requirement from renewable, low carbon intense feedstock by 2030
3. Reduce carbon emissions by 1 billion tons by 2030
4. Net-Zero Carbon Emission by 2070

Source: NITI Aayog, GoI, 2022

Carbon capture methods and utilization

- Pre-Combustion Capture
- Post-Combustion Capture
- Oxy-Fuel Combustion

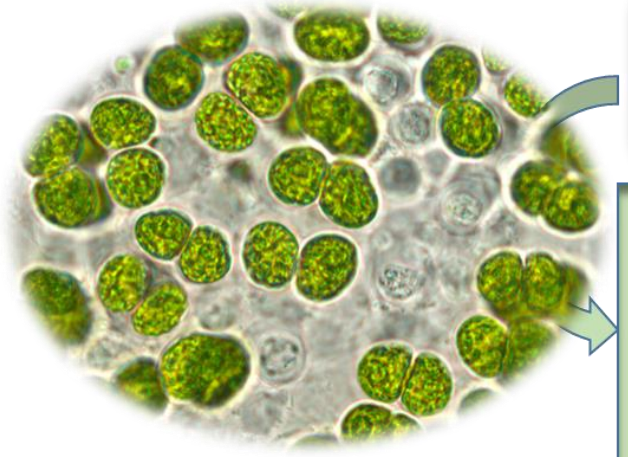
- Adsorption
- Absorption
- Membrane separation
- Cryogenic separation
- Hydride based separation

- **Carbon Capture and Storage (CCS)**
  - -Ocean or Geological separation
- **Carbon Capture and Storage & Utilization (CCSU)**
  - -Used for petroleum oil recovery
  - -Used as a precursor for VAPs

Conventional Strategies

Carbon Capture Methods

Processing pathway of Captured CO2

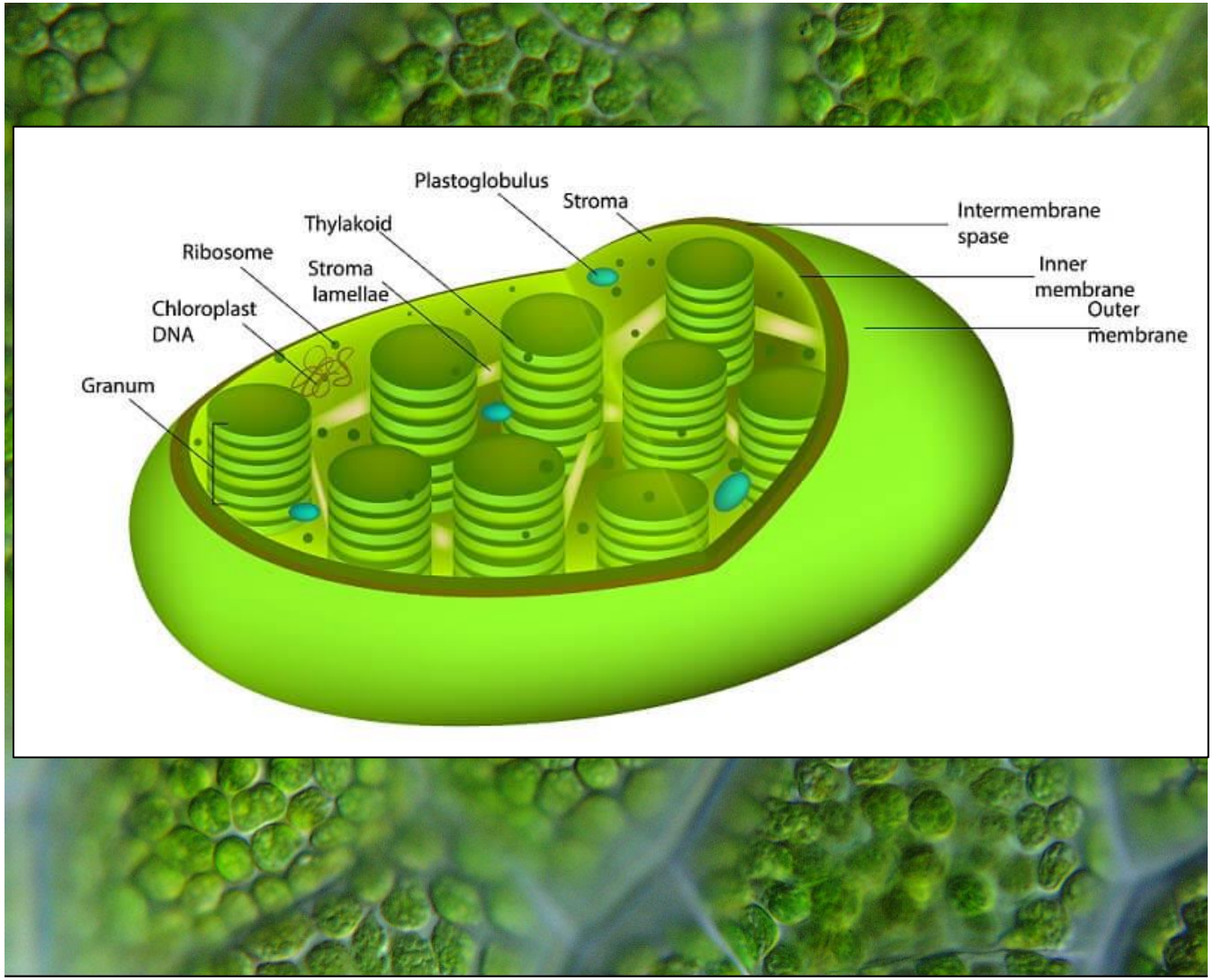


Microalga – CO_2 Biofixation

Organic biomolecules
- Carbohydrates
- Proteins and peptides
- Lipids and Fatty acids
- Pigments

Bio-Carbon Capture and Storage & Utilization (CCSU)
- -Biofuels and Bioenergy products
- -Food and feed
- -Health supplements and medicines
- -Plant growth-promoting substances

Microalga – Biological cell factory



Photosynthesis

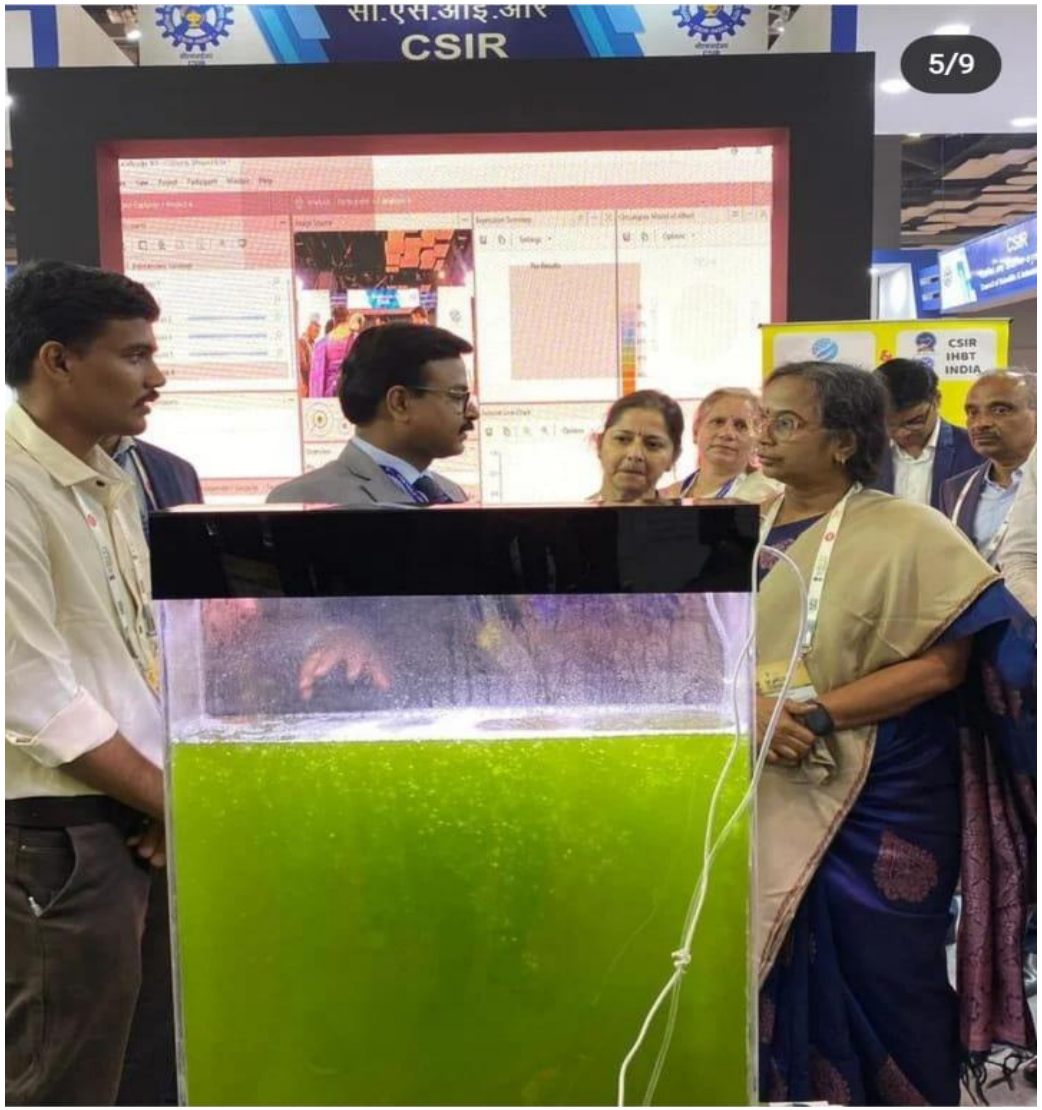
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Microalga: a sustainable alternative

- Every 1 ton of microalga biomass bio-fixes about 1.83 Tons of carbon.
- Equivalent to 3.66 tones of CO_2 sequestration
- 1.33 tones of O_2 liberated per ton (75 % Oxygen)

Microalga – A sustainable alternative

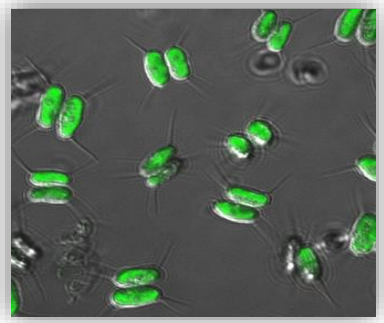
- A climate-resilient Alternative
- High CO_2 sequestration efficiency
- Biological, Renewable, and sustainable
- Minimal Environmental Impact
- Co-generation of Bioactives
- Waste water utilization
- Uses solar energy = Reduced reliance on Chemicals
- Viable Circular Economy
- Global Carbon offset



Microalga – better alternative to Plants

- Large area requirement
- Urbanization
- Reduced forest cover
- 5-10 years to productive canopy
- Seasonal dependence

- **The danger of forest fire**



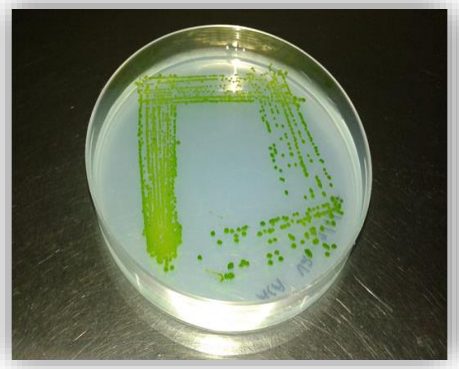
- Fast multiplication (short generation time)
- Require less space
- Grown in wastewater
- Independent of seasonal barrier
- Do not compete with agricultural input
- Upscaling potential
- Co-generation of VAPs
- It can be cultivated on the rooftop

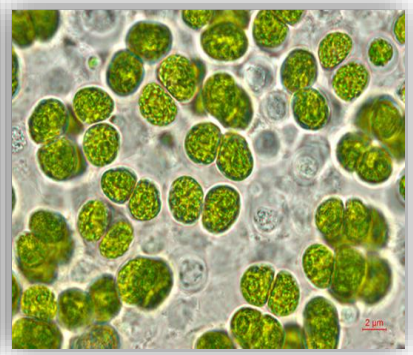
Ability to fix carbon dioxide up to 50 times more than the terrestrial plants

Culturing of Microalga: CSIR-NIIST

Natural habitat

Culturing and purification





Scale-up processes

CSIR-NIIST initiatives on CO_2 capture potential of microalga

CO_2 capture potential of microalga

Microalgae species	Maximum CO_2 tolerated (%v/v)
Cyanidium caldarium	100
Scenedesmus sp.	80
Chlorococcum littorale	60
Synechococcus elongatus	60
Euglena gracilis	45
Chlorella sp.	40
Eudorina sp.	20

Review: Carbon Capture Sci Technol 1: 100007." (2021)

Open raceway pond

- 300 L culture
- Uniform mixing
- Natural sunlight

Details	Average (n= 6)	CO2 Capture potential	Projected (Hectare^{-1})
Areal productivity (g/m^2/day)	9.2	33.672 g/m^2/day	366.72 Kg Ha^{-1} day^{-1}
Volumetric productivity(g/L/day)	0.06	0.2196 g/L/day	2.196 Kg Ha^{-1} day^{-1}

Microalgal Biomass Valorization

1. Essential dietary Omega-3 fatty acid EPA from edible marine microalga

A scalable alternative:

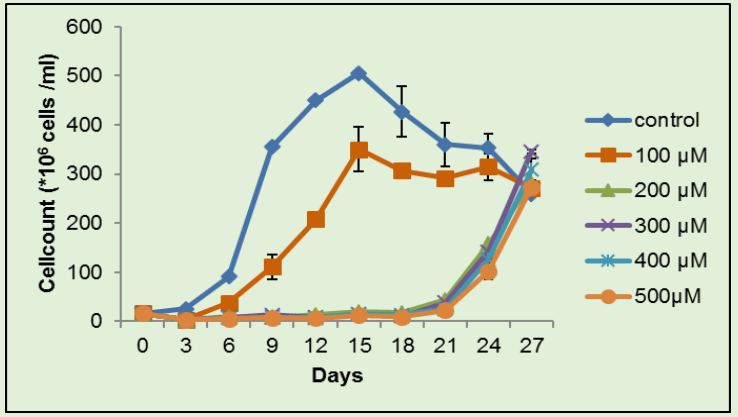
1. Optimized the bioprocess with the EPA (10.76%) by PGR

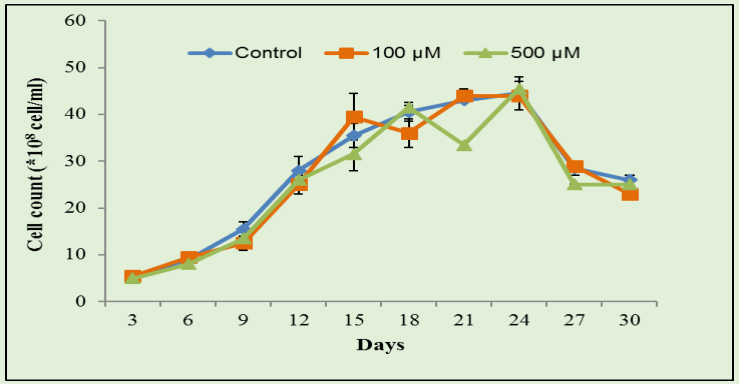
2. **Demonstrated and validated the lab-scale result in 1500 L commercial farm**

2. Selenoproteins as Organic dietary Selenium and its therapeutic applications

Selenoproteins: are a class of proteins with an essential trace element Selenium (Selenocysteine) with a significant role in *human health and relevance to several pathophysiological disease conditions*.

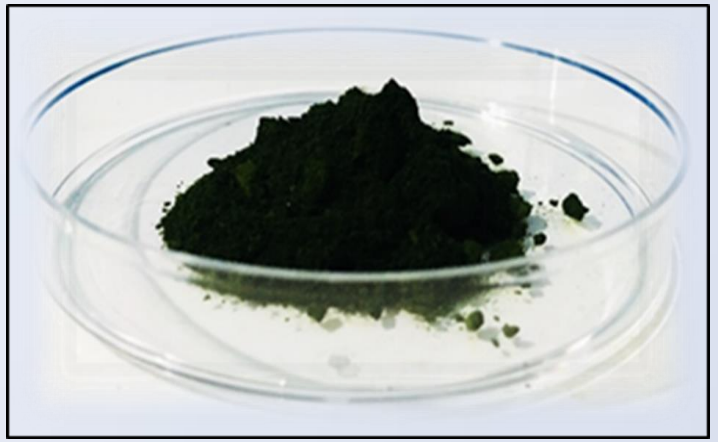
Organic selenium enriched strain

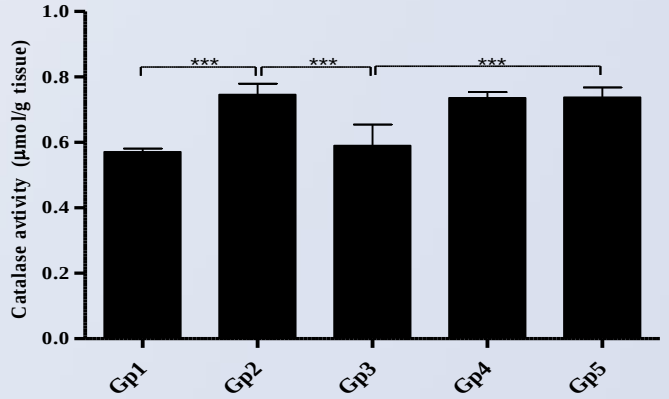




Scale up in 50 L Photobioreactor

Organic Se-enriched *Microalga biomass*

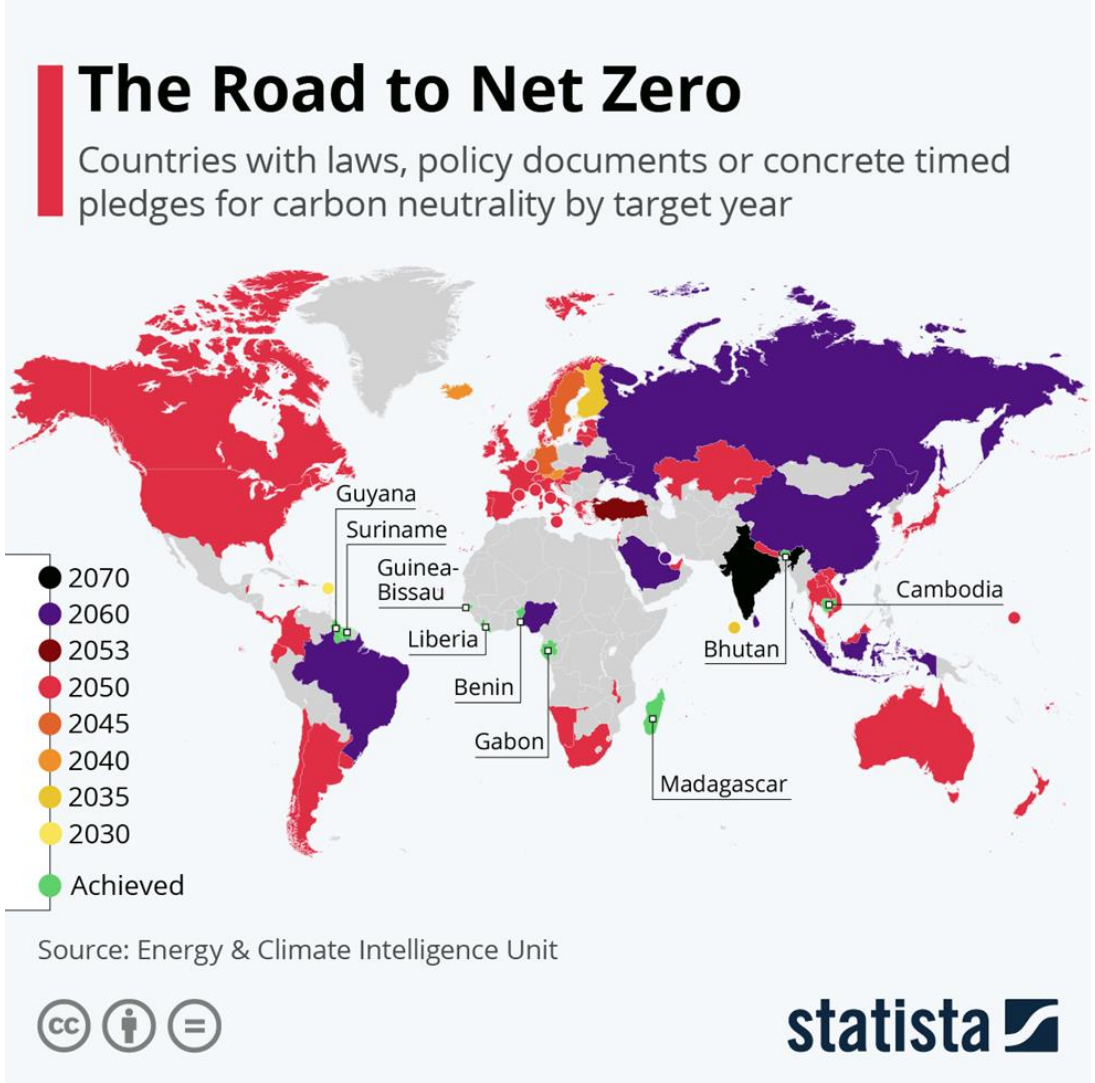




Liver catalase activity of oxidative stress-induced Wistar rats

Patent filled 1; Publications – 3; PhD awarded- 01

Current Scenario of Global Carbon-Neutral Initiative



Achieved through

Percapita CO_2 emission – 0.12 ton per annum

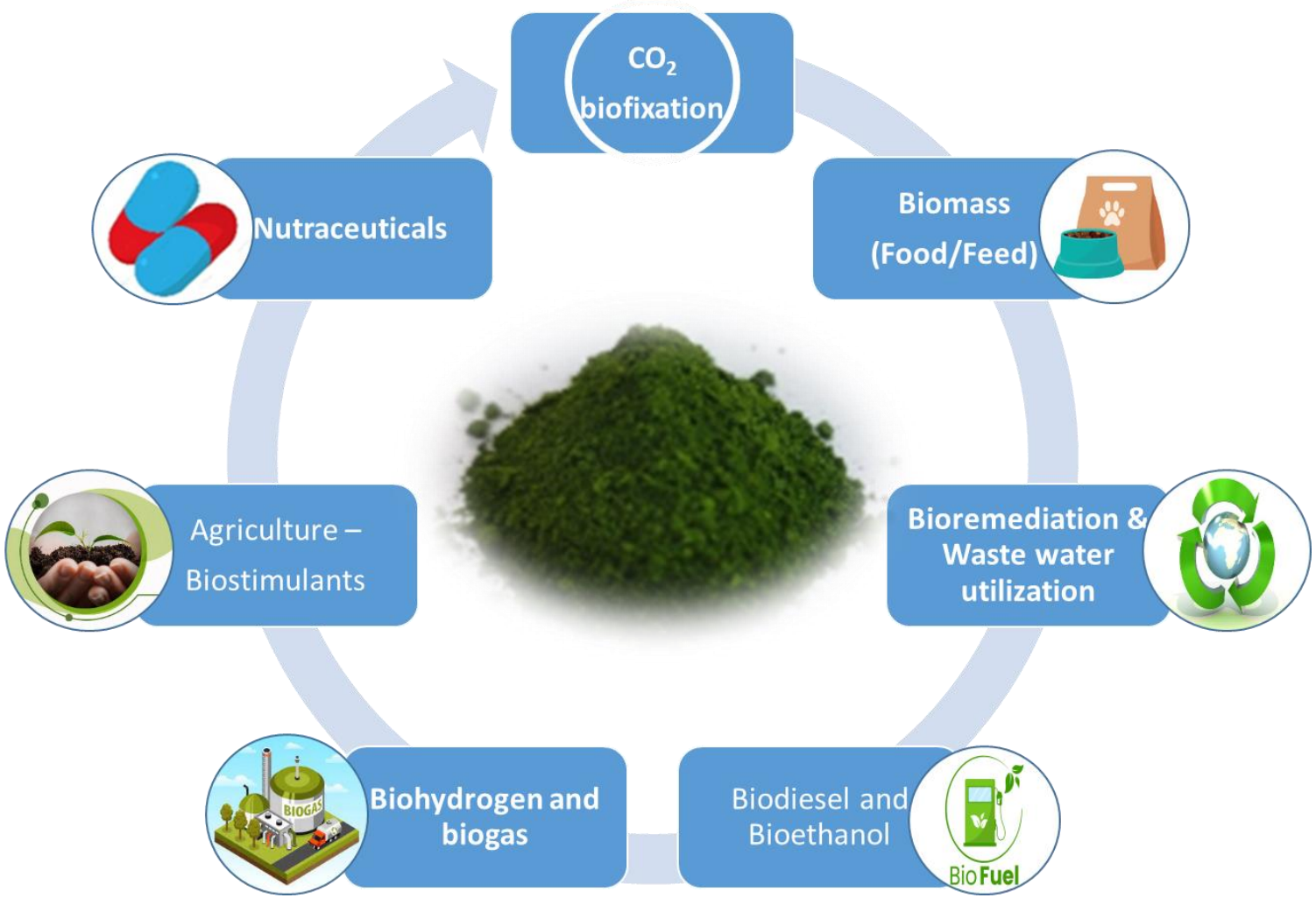
Set to meet 50 % energy requirement by solar

Coal-fired activity is relatively lesser

Forest cover 22 %

Source: Global Carbon Budget (2022)

Eco-friendly Circular Economy



Let's put our hands together to have a carbon-neutral future

International Collaborations

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