

# BIO-SEQUESTARTION OF CO<sub>2</sub> USING MICROALGAE

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## Abstract

The threatening crisis of climate change and pollution resulting from various anthropogenic interventions has attracted worldwide attention over the last few decades. However, Carbon Capture and Storage (CCS) methods are still unclear. To overcome this global issue, biological Microalgae can be used for capturing of CO<sub>2</sub>. This study involving the utilization of various sensors and boards, such as the MG811 CO<sub>2</sub> sensor, Arduino UNO, and DHT11 for monitoring temperature, humidity, and CO<sub>2</sub> levels. The results and discussions highlighted the impact of factors like temperature and air supply on algal growth and its CO<sub>2</sub> capture efficiency. Mixed culture microalgae showed maximum CO<sub>2</sub> removal efficiency of 23.36% with a low air flow rate at indoor conditions, for a run time of 180 minutes. At the end of the lab scale experimental study 3 gram of biomass from mixed culture was generated as result of CO<sub>2</sub> sequestration. The study emphasized the importance of microalgae and sensors in sustainable way to capture CO<sub>2</sub> from the ambient air. Algae can be extensively used to capture CO<sub>2</sub> from various point sources. Besides giving environmental and economic benefit. Overall, the project delved into the potential of mixed algal cultures for bio-sequestration of CO<sub>2</sub>, showcasing promising results for environmental sustainability.

**Key Words:** Climate change, carbon capture and storage (CCS), Microalgae, MG811, DHT11, mixed culture, spirulina, sustainability

## 1. INTRODUCTION

Excessive release of greenhouse gases (GHG's) and increase in the concentration of anthropogenic carbon dioxide (CO<sub>2</sub>) in recent time have aroused the attention of everyone due to the serious threat they represent to the environment and human health. According to the World Health Organization (WHO), it is estimated that seven million deaths a year are the product of environmental pollution arising from GHGs and it is predicted that these deaths may amount to up to nine million in 2060 if the growing trend in CO<sub>2</sub> and GHG emissions continues (Qin. 2022). In this regard, it is necessary to capture CO<sub>2</sub> through an environmentally

sustainable process to reduce the damage on the environment. Among the different technologies for capturing CO<sub>2</sub>, the use of microalgae, which are photosynthetic microorganisms that can naturally fix CO<sub>2</sub> from 10 to 50 times that of terrestrial plants to produce O<sub>2</sub> (Cheng et al., 2022). Bio-sequestration emerges as a promising solution to tackle the harsh effects of climate change on our environment, offering a natural and eco-friendly approach. It involves utilizing microalgae, tiny organisms found in water, to capture and store CO<sub>2</sub>. Carbon sinks are these amazing natural systems that take in and soak up a whole bunch of carbon dioxide from the air. they're like the Earth's super cleaners. They come from places like forests, oceans, soil, wetlands, and grasslands

### 1.1 Carbon sequestration

Sequestration is generally of three types - physical, chemical and biological methods. Most of the technologies are used to reduce carbon dioxide emissions in the atmosphere, widely sequestration methods are used to capture carbon. Direct air capture, oxy-combustion, precombustion, post combustion is some of the carbon sequestration methods (Narinder Singh et al. 2023). By trim and fill analysis, it is estimated that carbon capture cost comprises of over 80% of total Carbon capture and storage (CCS) cost (Gal Hochman and Vijay Appasamy, 2024).

### 1.2 Role of microalgae in bio-sequestration

The role of microalgae in bio sequestration is pivotal for mitigating climate change, as these microscopic organisms efficiently capture and store carbon dioxide from the atmosphere. Through photosynthesis, microalgae convert CO<sub>2</sub> into biomass, which can be harvested and processed to sequester carbon for extended periods. Their rapid growth rates and high biomass productivity make them effective carbon sinks, while their versatility allows for various applications, including bioenergy production and bioremediation. Harnessing the potential of microalgae in carbon capture offers a sustainable solution to combatting rising CO<sub>2</sub> levels and mitigating the impacts of climate change.

Microalgae cultivation can contribute to bioremediation efforts by removing pollutants from waste water, indirectly aiding in reducing environmental factors contributing to climate change. Their adaptability to different aquatic environments ensures suitability for various geographical regions and climates. Implementing microalgae bio-sequestration techniques in urban region not only reduces carbon footprint but helps in enhancing its green belt.

## 2. MATERIALS AND METHODOLOGY

The main objective of this report is to analyze environmental factors influencing algal growth through a project that integrates environmental engineering principles with sensor technology and biotechnology. The project involves a comprehensive literature survey on various methodologies for CO<sub>2</sub> capture and the installation of sensors to monitor CO<sub>2</sub> levels. The experimental setup, designed to study both indoor and outdoor environments, uses materials and methods to evaluate the efficiency of a bioreactor in capturing carbon dioxide, focusing on spirulina and mixed culture microalgae. This project highlights bio-sequestration using microalgae as a sustainable solution to mitigate climate change impacts.

The experimental setup integrates two main components: electrical components and laboratory equipment. Electrical Components such as Sensors (MG811) to Monitor temperature, humidity, and CO<sub>2</sub> concentrations, Arduino UNO Board which serves as the microcontroller, Connecting Wires, Air Pump, Flow Regulator, LCD Display, Adapters were used to Facilitate the overall functioning and real-time monitoring of the system. Laboratory Equipment's required are Closed Culture Media for cultivating microalgae, polymer Pipes to Transfer gases in and out of the culture media. Function and features of MG811 CO<sub>2</sub> Sensor: Senses carbon dioxide concentration by monitoring the infrared radiation absorbed by CO<sub>2</sub> in ppm. High sensitivity, stability, wide detection range, simple circuit, digital and analogue outputs, compatibility with Arduino UNO. Figure 2.1 shows the pictorial representation of MG811-CO<sub>2</sub> sensor. Specification of CO<sub>2</sub> sensor is represented in table 1.

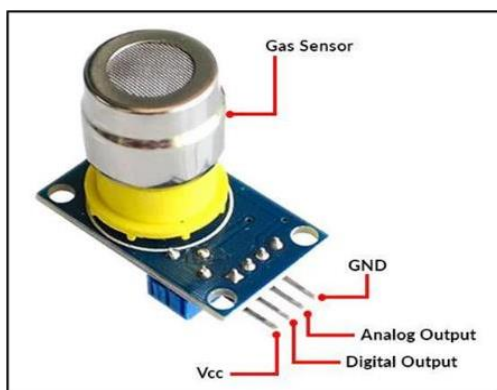


Figure 1: Pictorial representation of MG811-CO<sub>2</sub> Sensor

Figure 2.1 shows the pictorial representation of MG811-CO<sub>2</sub> sensor. Specification of CO<sub>2</sub> sensor is represented in table 1.

Table 1: Specifications of MG811-CO<sub>2</sub> Sensor

Sensor Type	Gas Sensor
Chip	MG811
Gas Sensitivity	Carbon Dioxide
Operating Voltage	6 Volt
Dimensions	3.2 X 2.2 X 2.9 cm
Weight	10 g

### 2.1 EXPERIMENTAL METHOD

The methodology implemented in the study is in two phases, i.e., Primary phase and Secondary phase. The primary phase comprised of selection of algal strains followed by algae cultivation and observation. On the other hand, design of experimental setup was in progress.

Following the completion of primary phase, the secondary phase of the project was initiated. As shown in figure 2, the phase consisted of selection of algal strains conducting the experiment, monitoring and collecting data and analyzing the results.

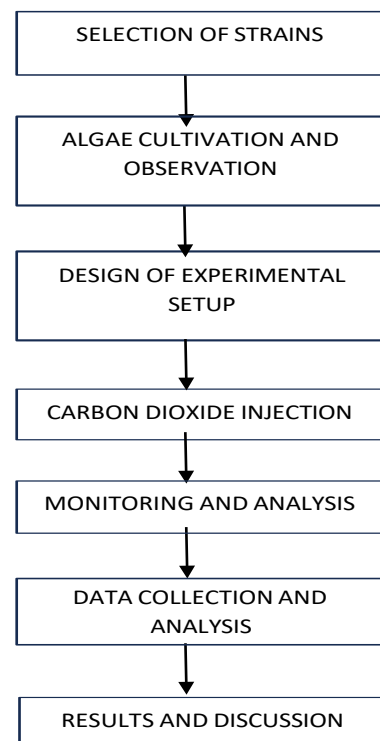


Figure 2: Flowsheet of methodology adopted for the project

## 2.2 Selection of Microalgal Strains

To identify suitable microalgal species for CO<sub>2</sub> bio-sequestration, an extensive literature review was conducted. The primary factors considered included strain availability, growth rate, cultivation conditions, lipid content, and tolerance to flue gas and extreme environmental conditions. Based on these criteria, Spirulina was selected. Additionally, a mixed culture approach was adopted by collecting algal samples from a local water body and cultivating them under laboratory conditions. This mixed culture contained various species of microalgae.

### 2.2.1 Spirulina

Spirulina (fig-3), a blue-green alga of the cyanobacteria class, is characterized by its spiral-shaped, multicellular filaments. Renowned for its high nutritional value, Spirulina contains significant levels of proteins, vitamins, minerals, and fatty acids. It is a photosynthetic organism that converts carbon dioxide and water into organic compounds in the presence of sunlight, and can tolerate temperatures of 35-38 C. Spirulina has a lifespan of approximately eight days and a doubling time of 2-3 hours



Fig: 3 a) Pictorial representation of Spirulina Algae



Fig : 3 b) Spirulina Algae under microscope

### 2.2.2 Mixed Culture

The project also utilized a mixed culture(fig-4) of various algal species, which included both unicellular and multicellular organisms. Cultivated in aquarium conditions at temperatures of 30-40°C, the mixed culture had a lifespan of up to ten days and contained numerous algal species.

Plate 3.2 illustrates the mixed culture used in the project, which included species such as Oscillatoria, Diatoms, Chlorella, Euglena, Eudorina, Cynadommmus quadriquadra, Zygnema, Phacus, Anabaena, and Microcyst. °



Fig 4: Picture of Mixed Culture

## 2.3 Algae Cultivation and Observation

Cultivating algal species requires algal strains, sterilized water, nutrients, and sunlight, as illustrated in Figure 5. The strains used were Spirulina and mixed culture, with urea serving as the nutrient medium. After full growth, continuous aeration was provided to maintain the live culture. Bubbling air through the water, therefore algae get enough oxygen and don't settle at the bottom. The aeration helps to keep the nutrients and light evenly distributed throughout the culture, ensuring that all the algae can continue to thrive.



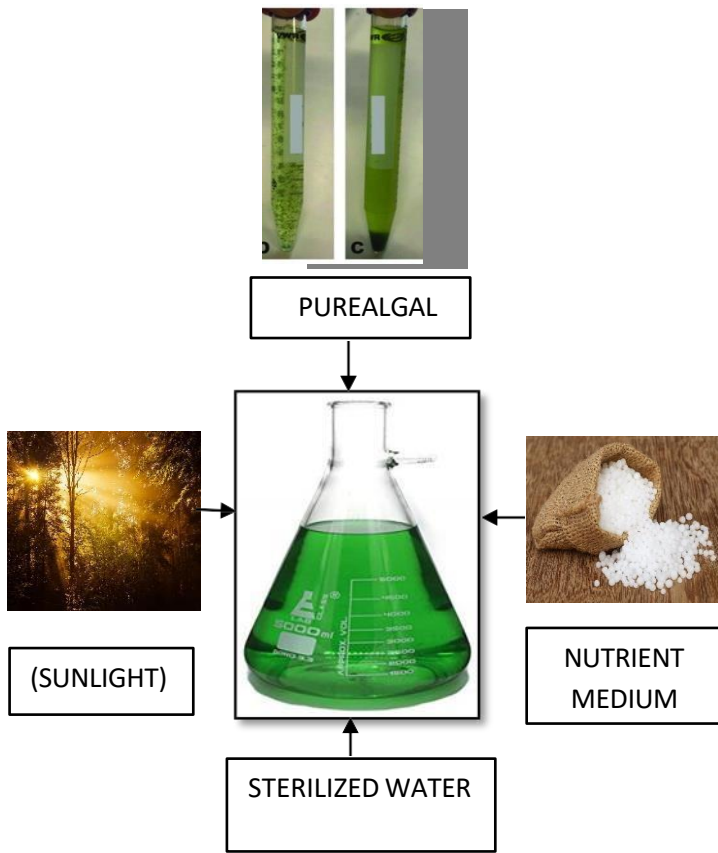


Figure 5: Flowsheet representing requirements for culture of algae

### 2.4 Design of Experimental Setup

The overall design (Fig-8) includes an inlet chamber, an outlet chamber, and the algal culture medium, all of which are placed on an acrylic sheet for stability. The inlet chamber (fig-6 ) is equipped with an air pump, flow regulator, Arduino UNO board, MG811 CO<sub>2</sub> sensor , DHT11 Temperature and Humidity sensor, LCD display, and connecting wires. These components are enclosed with a white sun-board to prevent external environmental interference, The outlet chamber (fig-7) contains an Arduino UNO board, MG811 CO<sub>2</sub> sensor, DHT11 Temperature and Humidity sensor, and LCD display, all enclosed with a sun-board to avoid external contact and the Algal culture medium consists of a 1-liter cylindrical container with a cap that has openings for the inlet and outlet. Tubes connect the inlet and outlet holes to the air pump in the inlet chamber and the air trapping colony in the outlet chamber, respectively.



Fig 6 : The design inlet chamber

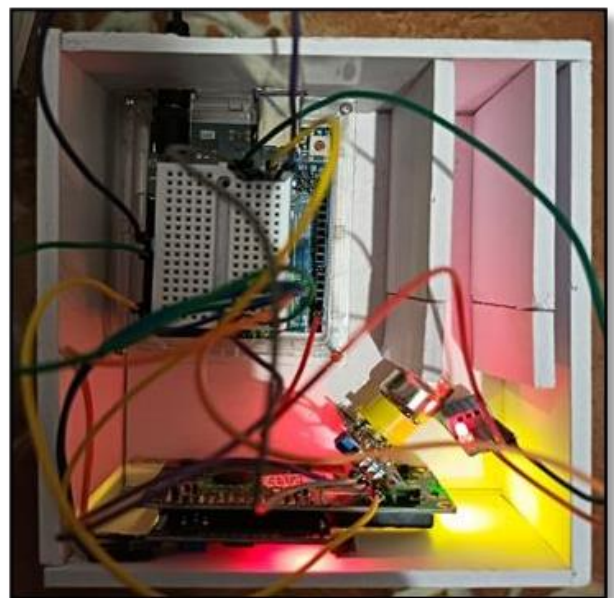


Fig 7 : The design outlet chamber



throughout the 180-minute experimental run. In comparison, the Spirulina algae culture achieved a removal efficiency of 25.61% under outdoor conditions at temperatures around 34°C to 36°C. The optimal temperature range for Spirulina, between 30°C and 35°C, supports high biomass production with significant protein content. It was observed that for higher algae culture, a steady and low air flow rate is recommended for maximum CO<sub>2</sub> capture. Algae can effectively sequester CO<sub>2</sub>, producing biomass that can be converted into biofuel. The energy requirement for carbon sequestration using micro-organisms like algae is minimal, and utilizing solar energy for this process makes it fully eco-friendly. The application of microalgae for CO<sub>2</sub> sequestration not only reduces atmospheric carbon but also contributes to mitigating global warming trends. This method is considered economical and eco-friendly, particularly when implemented at point sources.

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