ECM 2025 Conference
The 3rd International Electronic Conference on Microbiology
01–03 April 2025 | Online
MDPI

# Photobioreactors for Atmospheric Carbon Dioxide Fixation (Liquid trees): A Conceptual Approach Using *Chlorella vulgaris* Cultivation

Juliana Puello-Mendez[a], Jorgelina C. Pasqualino[b], Ildefonso Baldiris-Navarro[c], Miguel Cuesta-Peña[d], Shirley Osorio-Herrera[d], Martha Torres-Virviescas[e], Henry A. Lambis-Miranda[f*]

[a]GICI Research Group, Chemical Engineering Department, Universidad de San Buenaventura Cartagena, Diag. 32 # 30- 966, Cartagena, Colombia. ORCID: 0000-0003-0185-1053 jpuello@usbctg.edu.co

[b]GISAH Research Group, Environmental Engineering Program, Universidad Tecnológica de Bolívar, Campus Tecnológico, km 1 vía Turbaco Cartagena, Cartagena, Colombia. ORCID: 0000-0002-8731-762X. jpasqualino@utb.edu.co

[c]Universidad de Cartagena, Departamento de Ing. Química. Campus Piedra de Bolívar, Cartagena. ORCID: 0000-0001-9189-3710 ibaldiris@gmail.com

[d]Processes and Systems program, Fundación Universitaria Tecnológico Comfenalco, Cartagena, Colombia. mcuesta@tecnologicocomfenalco.edu.co ORCID: 0000-0003-0485-8293. sosorioh@tecnocomfenalco.edu.co

[e]Magíster en Ciencias del Mar, Universidad del Sinú. Cartagena, Colombia. ORCID:0000-0003-1914-0583 biologiamarina@unisinucartagena.edu.co

[f*]Processes and Systems program, CIPTEC Research Group, Fundación Universitaria Tecnológico Comfenalco, Cartagena, Colombia. ORCID: 0000-0002-6261-4062 hlambis@tecnocomfenalco.edu.co

## INTRODUCTION & AIM

Photobioreactors, colloquially termed 'liquid trees,' cultivating microalgae, particularly *Chlorella vulgaris*, present a significant biotechnological avenue for environmental remediation. These systems capitalize on the inherent photosynthetic efficiency of microalgae, enabling the sequestration of atmospheric carbon dioxide ($CO_2$) through the Calvin-Benson-Bassham cycle. Specifically, *Chlorella vulgaris* exhibits a high $CO_2$ fixation rate, directly proportional to light intensity and nutrient availability, thereby contributing to the mitigation of anthropogenic climate change effects. The process involves the conversion of inorganic carbon into organic compounds, primarily carbohydrates, via enzymatic reactions within the algal chloroplasts.

## METHOD

The construction of a self-sufficient liquid tree involves the integration of several key components:

1. **Reactor:** The core of the system is a reactor, typically a transparent glass or plastic vessel, which provides a controlled environment for microalgae cultivation. The reactor design must allow for adequate illumination, mixing, and aeration of the culture (see Fig 1).
2. **Light Source:** A solar panel serves as the primary energy source for the system. During daylight hours, the solar panel provides the necessary energy for microalgae photosynthesis. Additionally, a battery can store excess energy generated during the day to power the system at night, ensuring continuous microalgae growth.
3. **Aeration System:** A compressor, powered by the solar panel, supplies $CO_2$-enriched air to the reactor. $CO_2$ is essential for the photosynthetic process and enables efficient microalgae growth.
4. **Control System:** A control system, which can be electronic or mechanical, monitors and regulates culture parameters, such as temperature, pH, nutrient concentration, and light intensity. This ensures that the cultivation conditions are optimal for microalgae growth.
5. **Recirculation Pump:** A recirculation pump ensures a homogeneous distribution of nutrients and oxygen within the culture, preventing the formation of stagnant zones and promoting uniform microalgae growth.

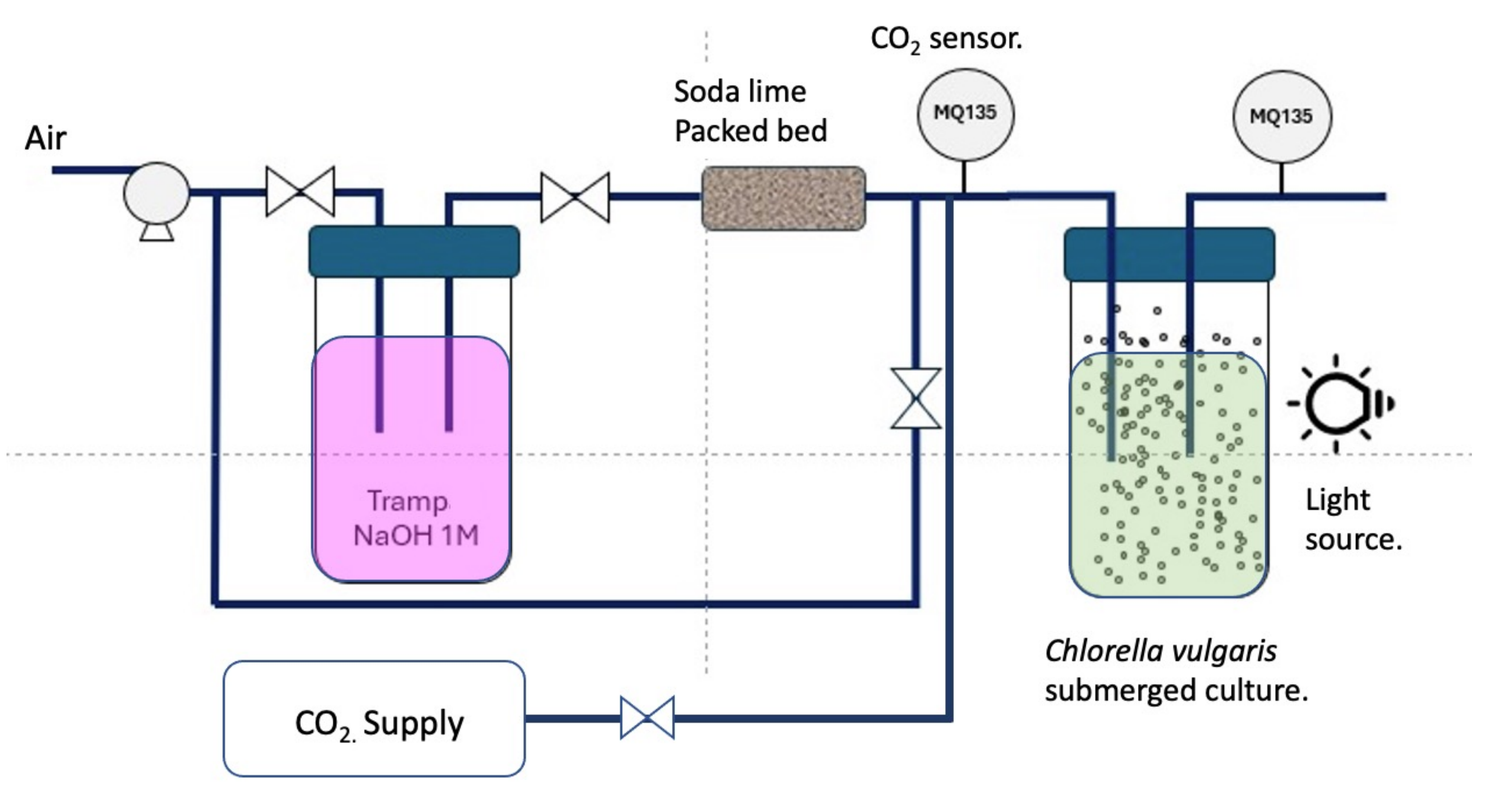


*Figure 1.* Conceptual design for "Liquid tree".

## RESULTS & DISCUSSION

**•Fix Large Amounts of $CO_2$:** Microalgae, due to their high growth rate and photosynthetic efficiency, can capture significant amounts of atmospheric $CO_2$.
**•Produce Algal Biomass:** The produced algal biomass can be used for various applications, such as the production of biofuels, animal feed, fertilizers, and chemical products.
**•Improve Air Quality:** By removing $CO_2$ from the atmosphere, liquid trees improve air quality.
**•Be Energy Self-Sufficient:** Through the use of solar panels, liquid trees can operate autonomously, without requiring connection to the electricity grid.
**Moderate $CO_2$ concentrations**: The photosynthetic rate improves significantly. *Chlorella vulgaris* can process more carbon, resulting in faster growth and greater biomass production. These concentrations also favor the production of lipids and carbohydrates in the cell.

*Figure 2.* Submerged cultures of *C.vulgaris.*

## CONCLUSION

Liquid trees have a wide range of potential applications, including:

- **Climate Change Mitigation:** By capturing atmospheric $CO_2$, liquid trees contribute to mitigating the effects of climate change.
- **Biofuel Production:** The produced algal biomass can be converted into liquid biofuels, such as biodiesel, thereby reducing dependence on fossil fuels.
- **Wastewater Treatment:** Microalgae can be used to treat wastewater, removing pollutants and producing biomass.
- **Food and Nutritional Supplement Production:** Algal biomass is rich in proteins, vitamins, and minerals, and can serve as feed for animals or food for humans.
- **Sustainable Urbanization:** Liquid trees can be integrated into urban environments to improve air quality and create sustainable green spaces.

## FUTURE WORK / REFERENCES

- Wang, R. L., & Li, M. J. (2024). The study of novelty nutrients supplementary scheme and methodology on advanced carbon sequestration of microalgae. *Results in Engineering*, *22*, 102178. https://doi.org/10.1016/j.rineng.2024.102178
- Ighalo, J. O., Dulta, K., Kurniawan, S. B., Omoarukhe, F. O., Ewuzie, U., Eshiemogie, S. O., ... & Abdullah, S. R. S. (2022). Progress in microalgae application for $CO_2$ sequestration. *Cleaner Chemical Engineering*, *3*, 100044. https://doi.org/10.1016/j.clce.2022.100044
- Gupta, S., Raghuvanshi, S., & Verma, S. K. (2021). Bio-Mitigation of Carbon Dioxide Using *Desmodesmus* sp. in the Custom-Designed Pilot-Scale Loop Photobioreactor. **https://doi.org/10.3390/su13179882**

Fundación Universitaria Tecnológico Comfenalco
Universidad de San Buenaventura
Universidad del Sinú Elías Bechara Zainúm Seccional Cartagena
Universidad de Cartagena Fundada en 1827
Universidad Tecnológica de Bolívar