

SAMQUEST-Journal of Emerging Innovations

E-ISSN 3108-1207

Vol.1, Issue 2, pp.161-165, July- Dec 25

Available online at : <https://www.samglobaluniversity.ac.in/archives/>

Review

Exploring the possibility of integration of biological carbon sequestering with point source ambient air polluting industry

Deeksha Vijayvargiya^{1*} Malika Pal²

Department of Botany1, School of Sciences, SAM Global University, Raisen 464551, M.P. India

Department of Botany2, School of Sciences, SAM Global University, Raisen 464551, M.P. India

Corresponding E-mail: vijayvargiyadeeksha@gmail.com

Received:10/July/2025; **Accepted:**15/July/2025 ;**Published:**7/Feb/2026.

Abstract

Adoption of various measures to reduce CO₂ is showing positive results. Now increase in CO₂ emission in fiscal year 2023 was lesser than increase in GDP. Use of solar, wind and electric energy is replacing fossil fuel based systems. Thermal power plants and other waste to energy plants still generate considerable amount of carbon foot print. Channelizing this carbon, considering it to be a misplaced resource to produce biomass in an integrated system is a feasible option to be explored.

Key words- **Biological Carbon Sequestering,** microalgae, biomass, photoreactors

Introduction

The issue of emission of GHG continues to be on center stage in world environmental forums. Accumulation carbon dioxide in ambient air is a very strong environmental issue which demands immediate attention. According to IEA report 2023¹ the total energy related CO₂ emission increased by

1.1% in year 2023, i.e., 37.4 Gt in 2023. In India the emission increased by around 190mt. But the silver-lining is that the increase in CO₂ is much slower than the increase in GDP. Thus although the communities are prospering, the increase in CO₂ emission is slowing down. The credit goes to the adoption of clean energy options like wind & solar energy and advancement in EV sector. So generation of electricity still remains a major concern. Hydropower is comparatively less polluting (gaseous emissions) than thermal power but as the recent reports⁹ shows it is effected by rate and duration of precipitation and India saw a decline in hydropower generation may be as a consequence² of combined in effect of El Nino & the positive phase of the India Ocean Dipoler resulting in a weaker monsoon in year 2023. Electricity production by thermal power resulted in emission of 922.2 million metric ton of CO₂ in fiscal year 17-18 in India³. Thermal power plant and waste to fuel plants^{4,5} generate enormous amount smoke, reducing ambient air quality and visibility⁶.

The eventual target of net zero emissions by 2050 calls for an integrated effort on CO₂ sequestration by various methods and depositing it to the natural sinks via biological fixation or chemical absorptive techniques. Improvising on the existing technologies without compromising on economic growth is essential. Another approach is to convert the carbon into a useful resource like bio-fuel, green manure by CO₂ valorization.

Biological Carbon Sequestering.

On one hand elevated levels of CO₂ is a matter of global concern and on the other it is a precious nutrient and often a limiting factor for the growth of microalgae. If the spent gas is subjected to biological carbon capturing and sequestration (R. Gayathri 2021⁷, Bhola et al 2014⁸) involving microalgae, it could be a cost effective way of converting a potent GHG into a biomass. The efficiency of capture and sequestration of CO₂ by microalgae ranges from 40% and 93% (M. Raisolsadati et al 2019⁹). But its potential at large scale is yet to be harnessed at large scale.

Algae refer to a very large group of predominantly aquatic/Marine photosynthetic organisms. These eukaryotic organisms are generally divided into multicellular macroalgae and unicellular microalgae. Algae are adapted to almost all the environmental niches on earth and are represented by about 40000 species. Although the requirements for nutrients for algae are similar to that of higher plants, it does not compete with them. Thanks to its unique ecological niche it rather compensates to lack of higher plants in vast

expanses of oceans, estuaries, lentic & lotic habitats as primary producers (Wehr 2015¹⁰). Water rich in nutrients like nitrogen, magnesium, iron, phosphorus etc., is well suited for its growth. Some algae (cyanobacteria) grow well in nitrogen free environment and fix atmospheric nitrogen. So they grow freely in waste water streams if proper aeration is available. Aeration is an important factor. It grows well when it receives CO₂ at elevated concentrations and low oxygen levels in the growth environment. For photosynthesis solar radiation of 4.0kWh/m²/day (approximately 14MJ/m²) is considered enough for algal growth (Milbrandt 2010¹¹).

Uses of the biomass generated

Microalgae are known to accumulate various bio-molecules like starch, proteins, and lipids depending upon the species. So these have found wide acceptance as bio-fertilizers, single cell proteins, bio-stimulants, feed for poultry, fish feeds and bio fuels¹³. Some species *Chlamydomonas* are known to accumulate lipids in the form of triacylglycerols (TAGs) X Deng 2013¹². Triacylglycerols are produced outside any cellular organelle in case of nitrogen stress and has been accepted as bio-fuel¹². This oil can reach 20%–60% of the dry cell weight and is typically synthesized in response to conditions of stress, such as lack of nitrogen, and is a promising bio-fuel. The technical feasibility of algal biofuels has been demonstrated. The challenge comes in making the system cost-competitive with other fuel sources. While government incentives and monetization of externalities (e.g., environmental benefits) can help to

give this nascent technology a boost, becoming directly competitive with the cost of petroleum-derived fuels is the best way to ensure growth of an algal biofuels industry

Cultivation of Microalgae in India

In both industrialized and developing countries, closed photoreactors and conventional open ponds are typically used for the commercial growth of microalgae. According to (M. Raisolsadati, et al. 2019)⁹, the authors discussed the traditional open sun ponds used for microalgae culture. The scientists also noted that three crucial processes—photo restriction, photoinhibition, and photosaturation—may have an impact on the growth of concentrated microalgae cultures, especially when they are cultivated outdoors in the sun.

In most parts of India, clear sunny weather is experienced 250 to 300 days per year with the sunshine hours ranging between 2,300 and 3,200 per year depending upon the location (Muneer, Asif, and Munawwar 2004)¹³

It is considered that 4.0 kWh/m²/day (approximately 14MJ/m²) of solar energy is sufficient for algae production. Therefore, almost the entire country (except Arunachal Pradesh region) is suitable for algae production in terms of receiving sufficient solar radiation every year. Solar radiation values are lower in the central, northeastern and western coastal areas during monsoon and in the northern province during postmonsoon/early winter. Algal productivity in these regions will be low during this month. Therefore, almost the entire country (except Arunachal Pradesh region) is suitable for algae production in terms of

receiving sufficient solar radiation every year. Solar radiation values are lower in the central, northeastern and western coastal areas during the monsoon season and in the northern states during the post-monsoon/early winter. Algal productivity in these regions will be low during this month Milbrandt 2010¹¹. **Conclusion**

Integration of gas emitted from thermal power plants and micro algal growth system

Algae can be grown using industrial CO₂ streams, such as flue gas from electricity generation stations (typically 10%–15% CO₂). Thus, there is the potential to provide the algae's key nutrient (CO₂) while capturing and recycling the primary gas responsible for global warming. Given the right resources, micro-algal oil productivities can be quite high. India's national policy on biofuels targets to increase the blending of biofuel by 20% by year 2025-26.

Microalgae can be cultivated in any system that provides the right environment for growth, including sufficient light, gas exchange (CO₂ delivery and O₂ removal), temperature control, and mixing. By optimizing all of these parameters and maintaining ideal growth environment with minimal system cost, micro algae cultivation systems have to be developed which cater to the needs of the specific industry and are less complex than photo bioreactors and more controllable than open ponds.

PBRs suffer from the complexities of gas exchange (CO₂ introduction and O₂ removal), mixing, temperature control, and

prevention of fouling (biofilm formation). But even more critical is the capital costs of such systems because of their complexity and the expensive materials used for construction (e.g., steel, glass, and plastic). Some authors have predicted that the increased performance of PBRs will never compensate for the added economic and life cycle costs of such systems (Benemann 2013¹⁴).

Hybrid systems specific to the industry has to be developed. Co-located facilities are those operating in concurrence with spent gas treatment where algae are produced as a byproduct of the spent gas treatment process. The biomass produced will also fetch some carbon credits to industry, It could be directly used as biodiesel, fish & poultry feed, bio-fertilizer, green manure after basic harvesting process or can be purified or subjected to extraction purification process to extract more specific products like pigments, pharmaceuticals, antiviral components, food additives, food supplements. (Poonam Sharma, Nivedita Sharma 2017¹⁵). Using the wastewater effluent as water source also provides a cost-effective solution to water, land, and nutrients considerations of growing micro algae. This could be a step closer to a true **circular carbon economy**.

References

1. IEA report on CO₂ emissions in 2023. www.iea.org.
2. Syam Sankar, Vijaykumar P., Abhilash S., K. Mohanakumar. 2021. Influence of the strongest positive Indian Ocean Dipole and an El Niño Modoki event on the 2019 Indian summer monsoon. *Dynamics of Atmospheres and Oceans*. Volume 95, September 2021, 101235
3. Government of India Ministry of Power Central Electricity Authority 2018. CO₂ Baseline Database for the Indian Power Sector. User Guide version 14.0 pp14. December 2018
4. <https://www.newindianexpress.com/cities/delhi/2024/Dec/07/dpcc-to-begin-another-waste-to-energy-plant-in-bawana-amid-locals-opposition-over-air-pollution>
5. [CPCB inspection report of the WTEs in Delhi](https://www.cpcb.gov.in/inspection-report-of-the-wtes-in-delhi) chrome-extension://mhjfbmdgcfjbbpaeojofohoefgijai/index.html
6. <https://www.newindianexpress.com/cities/chennai/2021/Jan/28/iit-madras-research-explains-poor-visibility-in-delhi-2255938.html#:~:text=CHENNAI%3A%20A%20study%20led%20by,in%>
7. R. Gayathri., et al J. K. Saud (2021) A review on biological carbon sequestration: a sustainable solution for a cleaner air environment, less pollution and lower health risks. *Journal of King Saud University. Science : Elektronski vir*. [Online ed.]. 2021, vol. 33, art. 101282, str. 1-9, ilustr. ISSN 2213-686X
8. V Bholá, F Swalaha, R Ranjith Kumar, M Singh, F Bux 2014 [Overview of the potential of microalgae for CO₂ sequestration](#) - *International Journal of environmental science & technology* .09755462.

9. [M. Raisolsadati, D.R. Moheimani, MD. Parlevliet](#) 2019. [Luminescent solar concentrator panels for increasing the efficiency of mass microalgal production. Journal of Renewable and Sustainable Energy Reviews, 101 \(May\) \(2019\), pp. 47-59, 10.1016/j.rser.2018.10.029](#)

of Advances in Plant Biology - 1(1):01-25.
<https://doi.org/10.14302/issn.2638-4469.japb-17-1534>

10. Habitats of Freshwater Algae June 2015
DOI:[10.1016/B978-0-12-385876-4.00002-5](https://doi.org/10.1016/B978-0-12-385876-4.00002-5)
In book: Freshwater Algae of North America (pp.13-74) Edition: 2nd Chapter: 2 Publisher: Academic Press Editors: Wehr, Sheath, Kociolek

11. Anelia Milbrandt and Eric Jarvis 2010. Resource Evaluation and Site Selection for Microalgae Production in India .*Technical Report* NREL/TP-6A2-48380 **September 2010**

12. X Deng, J Cai, X Fei 2013 [Effect of the expression and knockdown of citrate synthase gene on carbon flux during triacylglycerol biosynthesis by green algae *Chlamydomonas reinhardtii*](#). - **BMC biochemistry, Springer.1471-2091**

13. Muneer, T.; Asif, M.; Munawwar, S. (2004). "Sustainable Production of Solar electricity with Particular Reference to the Indian economy." *Renewable and Sustainable Energy Reviews*, Volume 9, Issue 5, October 2005, 1879-0690

14. John Benemann 2013 *Microalgae for Biofuels and Animal Feeds* **November 2013**
Energies 6(11):5869-5886
DOI:[10.3390/en6115869](https://doi.org/10.3390/en6115869)

15. Poonam Sharma, Nivedita Sharma (2017) *Industrial and Biotechnological Applications of Algae: A Review. Journal*