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Exploring the Possibility of Integration of Biological Carbon Sequestration with Point Source Ambient Air Polluting

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***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.**

***Keywords*: Pollution, microalgae, CO2, solar, wind, electric energy.**

1. 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 2023 [1] the total energy related CO_2 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 CO_2 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 reports [9] shows it is affected by rate and duration of precipitation and India saw a decline in hydropower generation may be as a consequence [2] 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 CO_2 in fiscal year 17-18 in India [3]. Thermal power plant and waste to fuel plants [4], [5] generate enormous amount smoke, reducing ambient air quality and visibility [6].

The eventual target of net zero emissions by 2050 calls for an integrated effort on CO_2 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 CO_2 valorization.

2. Biological Carbon Sequestering

On one hand elevated levels of CO_2 is a matter of global concern and on the other it is a precious nutrient an often a limiting factor for the growth of microalgae. If the spent gas is subjected to biological carbon capturing and sequesterisation (R. Gayathri 2021 [7]., Bhola et al 2014 [8]) 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 2019 [9])· 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 multi-cellular 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 2015 [10]). 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 CO_2 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 2010 [11]).

3. 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

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proteins, bio-stimulants, feed for poultry, fish feeds and bio fuels [13]. Some species Chlamydomonas are known accumulate lipids in the form of triacylglycerols (TAGs) X Deng 2013 [12]. Triacylglycerols are produced outside any cellular organelle in case of nitrogen stress and has been accepted as bio-fuel [12]. 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

4. 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 photo saturation, 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 post-monsoon/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. Algae productivity in these regions will be low during this month (Milbrandt 2010 [11]).

5. Conclusion

A. Integration of Gas Emitted from Thermal Power Plants and Micro Algal Growth System

Algae can be grown using industrial CO_2 streams, such as flue gas from electricity generation stations (typically 10%–15% CO_2). Thus, there is the potential to provide the algae's key nutrient (CO_2) 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 (CO_2 delivery and O_2 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 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 (CO_2 introduction and O_2 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 2013 [14]).

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 2017 [15]). 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.

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