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MORALITY BEFORE KNOWLEDGE

Utlize microalgae in order to lowering green house emission by using carbon capture

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ABSTRACT

Background: The greenhouse effect cause the temperature in earth, one of the main contributor in GHG g emission is carbon dioxide (CO^2). In order to reducing GHGs empathize in mitigation can be one of the way. By implementing Carbon capture using Algae, where it considered as the main resource of renewable biofuel in the future and possibly play important role in the mitigation of the greenhouse effect. By utilize the photosynthesis process from algae, it can be used for CO2 sequestration as a great potential to reduce GHS gas. The objectives of this research is to understanding and know the process and benefit on using microalgae as the carbon dioxide capture to mitigate climate change (reducing Green House Gas emission). **Method and results:** The method use in this literature review, method that firstly discussed is the general description with pro cons of carbon capture technology method also with the background in order to reducing the highest contributor of Green House gas Emission (GHGs) which is Carbon Dioxide (CO_2), from this utilizing the natural process method from photosynthesis of microalgae whose need a lot source of CO_2 being the most beneficial method, and the end of product create a biomass and that will be helping to reducing the use of fossil fuel. Discussing the photosynthesis system it can be far from light dependent and light independent reaction since both of it is a recycled system. Therefore, implementing carbon dioxide capture using microalgae is very useful. Though there still need improvement in this sector. **Conclusion:** Carbon capture using Microalgae CO2 sequestration is one of the promising way to mitigate climate change and control environmental pollution is by fixing CO2 in the atmosphere and recovering organics from wastewater.

KEYWORDS: CO2; climate change; greenhouse gas; microalgae; Photosynthesis

1. Introduction

Through decade climate change has always been the main issue toward environmental problem. Raise on the temperature create the negative impact and until know earth emerging into much higher level of the temperature (Global Warming). Based on Intergovernmental Panel on Climate Change (IPPC) in 2018, reporting that temperature already reach 1 degree Celsius, and will be higher in 2040 reach about 1.5 degree Celsius and in 2065 around 2 degree Celsius [1]. It will likely happen if there's no action plan for this. No doubt, climate change is a threat to human kind since it indicate to the changing of temperature, ocean acidification, extreme weather, sea level rise, precipitation which is the most concerned from the report of United Nation Climate Change Secretariat (UNCCS) because various natural hazard become more easy to encountered [2]. Therefore, what we need to do is tackle the main player on climate change which is greenhouse gas (GHG)

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emission. GHGs consist of a lot of substance gas but the most gases create and trap in the atmosphere is Carbon Dioxide and may be produce from nature and human activity but human activity is the reasons why the temperature level increase rapidly (Fawzy et al., 2020).

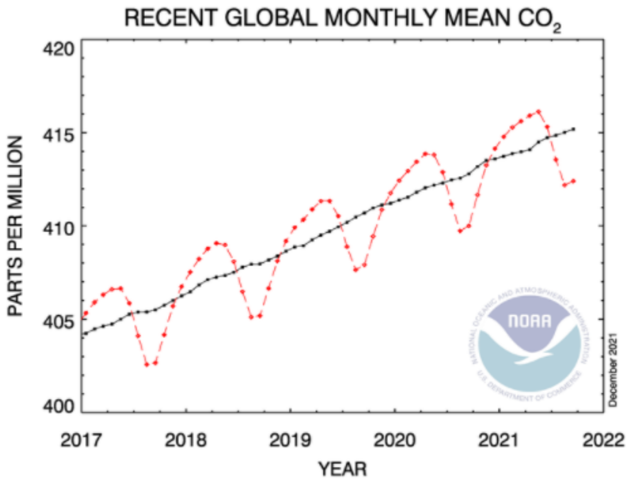

Figure 1. Recent global monthly mean CO_2 (Source:NOAA *[4]*)

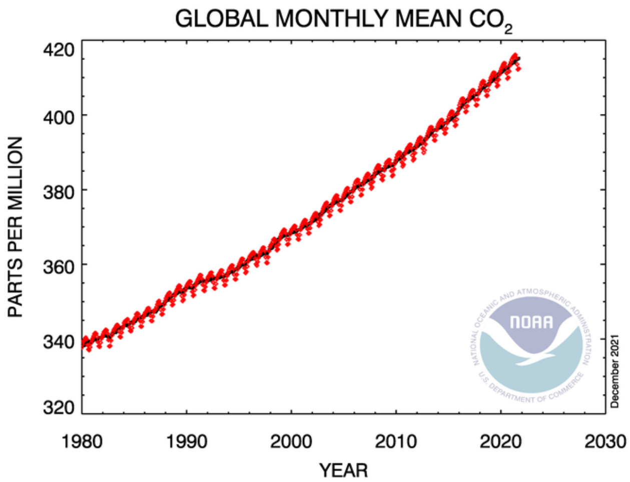

Figure 2. Global monthly mean CO_2 (Sorce: NOAA *[4]*)

From the data reported by National Oceanic and Atmospheric Administration, comparing data from September 2020 the concentration of $CO_{2\ in}$ global is 410 ppm and increase about 412.40 ppm in 2021. This data proving that the concentration of CO_2 keep increase. In order to manage and control CO_2 concentration, we need to empathize the mitigation to reduce GHG emission (Fig. 1&2) (Dietz et al., 2020). Advancing technology is one of the way to reducing gas emission (Ahmed, 2020), where we also live in 21th and innovative technology growing rapidly. There are few option worth to try from using renewable energy, in this paper it will focus on carbon sequestration by using microalgae as the CO_2 capture (Singh & Dhar, 2019). Development in industrialization and urbanization create rapid increase in waste production such as CO2 emission and etc. By algae technology one of the promising way to mitigate climate change and control environmental pollution by reduce CO_2 in atmosphere [8]. The process of carbon sequestration is utilizing the natural process from the photosynthesis required the energy from the light, carbon dioxide and nutrient. Same with algae using the photosynthesis process for metabolism and algae is the fastest plant growing in earth.

2. Methods

2.1 Carbon capture method reducing most influential GHG emission (Carbon Dioxide)

Massive production of carbon dioxide (CO_2) from human activity from individual, transportation until large industry, influence human to think a way on how to reducing CO_2 emission out of the atmosphere. Therefore, carbon capture technology is create. This technology is proven have the ability to reduce carbon emissions [9]. There are many method or application of carbon capture Carbon capture technologies can be evaluated as a whole, from capture to utilization, or individually. The strategies are classified as, physical adsorption, concentration, chemical absorption, cryogenic distillation, mineralization, and membrane separation [7], [10]. Detailed process of carbon capture is start in place where there are high concentration of CO_2 Starting from here the CO2 is taken and compressed, through pipeline, the CO2 is transferred, this is the process were the carbon capture happen, then it's stored in particular place designed place for CO2 capture, such as injection CO2 to geological sequestration or oceanic injection [7] .

The function in carbon capture development is to capture, transferring and storage until it being use for more profitable things, the general process in every approach consist of pre combustion (all the CO_2 in is being separate and store in pre combustion), post combustion (process to removing CO_2), Oxy fuel combustion (where coal is burned with oxygen to producing a concentrated stream of CO_2) [9]. One of the approach mostly applicate and explore in carbon capture technology is post-combustion, but because of the gas produce in mass transfer and power plant create the results obtained are not comparable to the source so it does not give a big change. That's why to use this technology there's a few considered parameter before occurs to prevent negative impact in the future. Therefore, natural process using biological substance from various green plants can be explored more to have more understanding regarding biological capture. The most promising green plant to be functioning in carbon capture is algae because it has efficient photosynthesis process [11].

Table 1. Comparison of Carbon Capture and Storage method with Biological Method (Source : J. Singh and D. W. Dhar, "Overview of Carbon Capture Technology: Microalgal Biorefinery Concept and State-of-the-Art," Frontiers in Marine Science, vol. 6, no. 29, 2019 *[7]*)

Technology	Mechanisms	Advantages	Limitations
CCS methods			
Absorption	CO_2 is dissolved/captured using chemical solvents, such as monoethanolamine, amine, and potassium hydroxide	• High dissolution capacity	• High solvent loss due to evaporation • Solvent degeneration by reaction with other flue gas components, such as SO_x • Corrosion of the equipment
Adsorption	CO_2 is captured using a solid adsorbent, such as activated carbon, zeolite, Na_2CO_3, CaO, etc.	• High surface area available for CO_2 adsorption results in high capture efficiencies	• Low energetic efficiency • Flue gas requires a pretreatment due to its high moisture content and presence of contaminants (e.g., SO_x and NO_x)
Membrane technology	CO_2 is separated from the main stream by passing through a polymeric membrane that acts as a filter with selective permeability	• High separation efficiency • Small installation requirements	• Energy demanding because flue gas needs to be cooled • High moisture content of the flue gas affects membrane performance • High membrane costs • Clogging and fouling of the membrane
Cryogenic separation	CO_2 is separated through consecutive refrigeration and condensation of gas mixture at different condensation temperatures	• High capture efficiency (up to 99.9%)	• Energy demanding because of refrigeration • Moisture content of the flue gas should be removed before cooling to avoid plugging by ice formation • CO_2 solidifies in the heat-exchanger surfaces and needs to be removed

Continue

Table 1. Comparison of Carbon Capture and Storage method with Biological Method (Source : J. Singh and D. W. Dhar, "Overview of Carbon Capture Technology: Microalgal Biorefinery Concept and State-of-the-Art," Frontiers in Marine Science, vol. 6, no. 29, 2019 [7])

Technology	Mechanisms	Advantages	Limitations
Biological methods			
Microalgal-based CO_2 capture	CO_2 capture during microalgal biomass production in autotrophic conditions	• Effective for a wide range of CO_2 concentrations • Higher growth and uptake rates than terrestrial crops • Arable land is not required • Coproduction of food, feed, biofuels, fertilizers, and high added-value products	• Low CO_2 diffusivity in the liquid medium • Biomass production costs are high • Cultures may be sensitive to other flue gas components (e.g., SO_x and NO_x) and susceptible to contamination and extreme cultivation conditions (pH, temperature, salinity, etc.)

2.2 Carbon Dioxide (CO_2) capture using Microalgae

Same with another green plants, microalgae have chloroplast as the system of their photosynthesis. Microscopic organism like algae can be found in seawater and freshwater, categorize as eukaryotic microorganism and prokaryotic cyanobacteria, it have the ability to adaptable in any quality of water from growing in heterotrophy, mixotrophy, and autotrophy [9], [12]. Valuable product create in CO_2 Bio-sequestration as emerge a viable technique in turning CO_2 becoming biomass by photosynthesis utilizing recycle gas emission into bioenergy and beneficial substance [7].

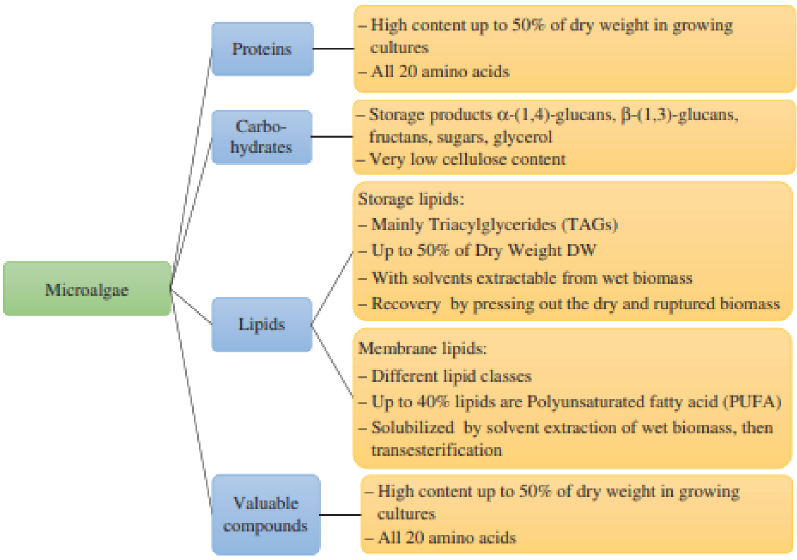

Figure 3. Microalage nutrient (Soruce : *[13]*)

What interesting from microalgae, it doesn't require specific place or room to grow since it can adapt easily and high rate of photosynthesis process. Thus, because of this factor microalgae able to collect lipid to be extracted became chemical energy which alternative energy source of unrenewable energy which is fossil fuel. Other than this since microalgae live from adsorbing nutrient like phosphorus and nitrogen microalgae can be utilize to removing these nutrient [9]. This is indicate the algae by using it as CO_2 sequestration it can tackle the issue of Harmful Algal Blooms (HAB) so it will not harmful the water source by spreading toxins [7]. Utilize this system by put the power plant in industrial from the perspective of economical is very profitable and environmental friendly since it reducing the transportation cost [10], wastewater treatment, and reducing the release of GHS emission [12], [14]. However the efficiency process is what the main concern in this carbon capture technology from screening, cultivation, the system reactor so that it can create high productivity and low cost, also which alga type will be use. In the research from Kong et al, Chlorella sp., Scenedesums sp., and Spirulina are the most common use to treating the wastewater and fixing CO2 because of the efficiency [15].

2.3 Photosynthesis system

Carbon capture using microalgae is using the natural process from photosynthesis system and from this process is also beneficial in producing biomass product [16] since it is high in lipid, carbohydrates, and proteins where other than biomass, it is potential to use as animal feed, feedstock for antibiotic [17]. Photosynthesis divide into two reaction, there are light dependent and light independent where it take place in chloroplast [16].

2.3.1 Light dependent reaction

In this process solar energy (the light captured) in the form of photon convert it to become nicotinamide adenine dinucleotide phosphate (NADPH) and adenosine triphosphate (ATP) occurs in thylakoid membranes. For NADPH creating glucose from CO_2 and ATP use as the source of energy for process metabolism from phosphorylate ADP to ATP [9]. Producing hydrogen molecule and oxygen [18]

$$2H_2O + 2NADP^+ + 3ADP + 3P + light \rightarrow 2NADPH + 2H^+ + 3ATP + O_2 \quad (1)$$

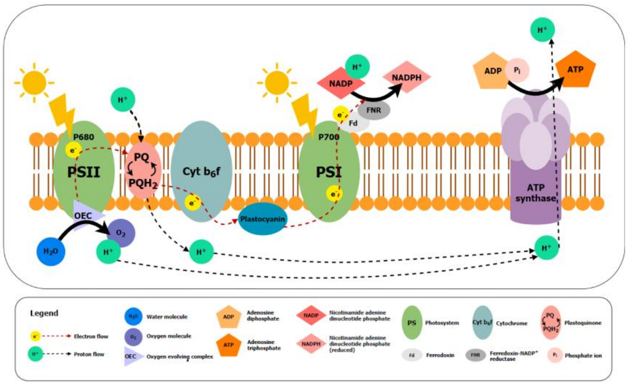

Figure 4. Fundamental molecular pathways of oxygenic photosynthesis (Source : *[16]*)

2.3.2 Light independent reaction

In this reaction is forming Calvin cycle and the synthesis organic microalgae of ATP and NADPH is create from photoreaction. Therefore, the existence of CO_2 is important since it's relate to the light dependent reaction [15].

$$3CO_2 + 9ATP + 6NADPH + 6H^+ \rightarrow C_3H_6O_3 - phosphate + 9ADP + 8P + 6NADP^+ + 3H_2O \quad (2)$$

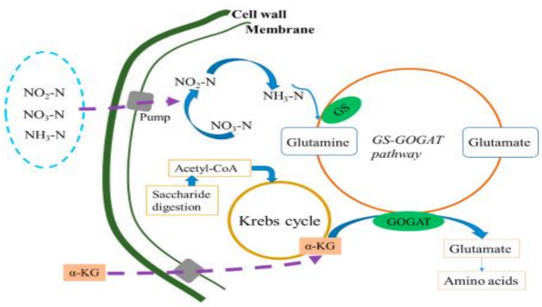

Figure 5. Mechanism of nitrogen assimilation by microalgae
(source: Kong et al, 2021)

3. Result and Discussion

Using technology from carbon capture to reducing Carbon Dioxide is one of the way to reducing Green House Gas emission. There are many method or technique to capture the carbon. In this paper is focusing on carbon capture using Microalgae as CO_2 sequestration overall consider regarding this technology is the output and input on how much efficient this technology really is [19]. The production of biomass by using microalgae as carbon capture is consist of biodiesel, biofuels, bioethanol, bio hydrogen, methane, electricity and other than biomass there are fertilizers and animal feed and bioactive compound. Also from the notice above using microalgae can be use from wastewater treatment from nutrient pollutant removal into heavy metal removal [20]. To make this system became sustainable as possible, the placement of this can be conclude by this parameters.

3.1 Cultivation system of Microalga

3.1.1 Open System

Open system is describe as natural or traditional way using open place like lake and pound. There are two type of this sistem such us circular pond and raceway ponds. The different from these pond;

Table 2. Comparison between Circular Pond and Raceway Pond (Source : [9])

	Circular Pond	**Raceway Pond**
Construction	Only Concrete	Concrete, plastic or fiber glass
Water depth	30 – 70 cm	15 – 30 cm
Average Biomass Productivity	15 g m^{-2} day^{-1}	22 g m^{-2} day^{-1}
Input for mixing	Rotating arm in te center of the pond	Paddlewheel (Circulation rate can be adjusted)

The advantage by using open system are relatively economical, simple, and easy to build and clean than the closed ones, but the disadvantage from using this is the temperature and light cannot be controlled since it is depend on the weather then will be easily contaminated, need larger area, poor productivity if the weather is not preferable, high water loss due to water evaporation etc. [9], [10]. From two type of open pond it is more preferable using the Raceway Pond because of the high rate algal ponds. Therefore, running this system the parameter of light, pH and CO_2 is highly demanded concerned [20].

3.1.2 Closed System

Rather than open system, close system the photo bioreactors system is highly beneficial because the microalgae is more controlled (cost, production, biomass from lipid production) [20]. There are more benefit from using this like control in concentration, non-contamination and evaporation, pH and temperature control, the input for carbon dioxide etc. And the disadvantage is came from construction cost, overheating, scale up already solve, the prevent it happen is using several different type of algae, the reactor allow rapid transfer of CO2 and O2 masses and equal light cultivation etc.

3.2 Parameter to Cultivate Microalgae system

Light is very important in the part of microalgae CO_2 sequestration, because microalgae absorb the energy for photosynthesis from the light. The light can be from sunlight or even an artificial light which mainly used in close system [9]. **Nutrients** algae can fed from wastewater like from agriculture who produce phosphorus and nitrogen. **pH** is important for biomass productivity an dit need be in optimal pH from 7-9. **Temperature** this is also important preferable in between of 20 – 30 degree celcius and if it using photobiorecatore it is very prone to overheat [9].

4. Kesimpulan

Seeing how climate change thorough the year became the center of environmental issue. Thus, we need to find an innovation on how to reducing the Green House Gas emission and one of the promising way is by using carbon capture from Biological process using microalgae CO_2 sequestration. Utilizing the natural process of photosynthesis providing us beneficial product of biomass. If the application of this design with carefully from the parameters of microalgae type, nutrient, light, pH etc. This technology can help reducing the GHG emission.

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