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A Brief Review of the Role of Microalgae Communities in Reducing Climate Change

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Abstract

Over the past few decades, there has been a global focus on the threat posed by pollution and climate change brought on by diverse human activities. Although carbon capture and storage (CCS) techniques were originally seen to be a potential technological solution to lessen this concerning situation, they are now regarded as economically Stressful, and it is yet unknown how they would affect the environment in the long run. An alternative method for recycling the surplus CO_2 (produced by power stations, cars, volcanic explosions, and the breakdown of organic matter) is the biological capture of CO_2 using microalgae. Algae offer a promising method for sequestration carbon as global CO_2 emissions rise. They effectively collect CO_2 from the atmosphere through photosynthesis, turning it into biomass at rates that are noticeably higher than those of ordinary plant systems. Microalgae are considered as a feasible substitute for reducing climate change due to this natural process. This essay examines the ecological significance of algae in absorbing CO_2 and converting CO_2 into biomass by microalgae, like *Chlorella* sp. and its conversion into bioenergy goods, such as biohydrogen.

key words: Algal biomass, Climate Change, CO2 Emissions, greenhouse gas.

مراجعة مختصرة لدور مجتمع الطحالب في تقليل التغييرات المناخية

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الخلاصة:

على مدى العقود الماضية، كان هناك تركيز عالمي على التهديد الذي يشكله التلوث وتغير المناخ الناجم عن الأنشطة البشرية المتنوعة، وعلى الرغم من أن تقنيات احتجاز الكربون وتخزينه (CCS) كانت تُعدُّ في الأصل حلاً تكنولوجيًا محتملاً للحدّ من هذا الوضع المقلق، إلا أنها فضلا عن ذلك تُعدُّ الآن عبئًا اقتصاديًا، ولا يزال مجهولا تاثيره على البيئة على المدى الطويل. تتمثل إحدى الطرق البديلة لإعادة تدوير فائض ثاني أكسيد الكربون الناتج عن محطات الطاقة والسيارات والانفجارات البركانية وتحلل المواد العضوية في الاحتجاز البيولوجي لثاني أكسيد الكربون باستخدام الطحالب الدقيقة. توفر الطحالب طريقة واعدة لعزل الكربون مع ارتفاع انبعاثات ثاني أكسيد الكربون العالمية. فهي تجمع ثاني أكسيد الكربون بفعالية من الغلاف الجوي من خلال عملية التمثيل الضوئي، وتحوله إلى كتلة حيوية بمعدلات أعلى بشكل ملحوظ من فعالية النباتات التقليدية. وتعدُّ الطحالب الدقيقة بديلاً عمليًا للحد من تغير المناخ بفضل هذه العملية الطبيعية. تبحث هذه المقالة في الأهمية البيئية للطحالب في امتصاص ثاني أكسيد الكربون وتحويله إلى كتلة حيوية بواسطة الطحالب الدقيقة، مثل *Chlorella* sp. وتحويلها إلى طاقة حيوية، مثل الهيدروجين الحيوي.

الكلمات المفتاحية: الكتلة الطحلبية، التغييرات المناخية ، انبعاثات CO_2، الغازات الدفيئة.

1. Introduction:

NASA defines climate change as the ongoing alteration of the earth's climate brought on by human activities (industrialization, the burning of, deforestation, fossil fuels etc.), which produce greenhouse gases (GHGs) and ultimately lead to global warming. The rise in greenhouse gases, primarily CO2 (418 ppm at the moment), is blamed for climate change. This trend is increasing and contributes to an increase in our planet's surface temperature of roughly 33.81°F [1]. In addition, this phenomenon causes the oceans to warm by more than 0.4°F since the early 1970s, Antarctica's ice mass to rapidly diminish (by roughly 147 gigatons annually), the sea level to rise (by 3.4 mm annually), and ultimately, various natural disasters such as drought, heavy precipitation, or ocean acidification [2]. There are global efforts made to reduce the negative consequences of climate change and lower greenhouse gas emissions like CO_2. Certain microorganisms, like microalgae and photosynthetic bacteria, have the ability to absorb CO_2 and use it as a

source of carbon for growth. Microalgae are excellent options for lowering atmospheric CO_2 in cities due to their exceptional CO_2 bio-capture or CO_2 capacity [3].

Many people agree that one of the important concerns confronting the world today is climate change, which has broad implications like increasing sea levels, biodiversity loss, increased atmospheric GHG concentrations, and longer heat waves that occur more frequently [4,5]. Unfortunately, human health has also suffered as a result of these resulting changes in natural phenomena, these detrimental effects are constantly made worse by the ozone layer's thinning and also the rise in temperature, which raises the number of illnesses and fatalities related to heat [6,7,8].

The ability of algae to fix CO_2 higher than terrestrial plant up to 50 times, one of the primary advantages of employing them to reduce CO_2 [9] and store solar energy as chemical fuels through the photosynthetic process [10] **Figure 1** [11].

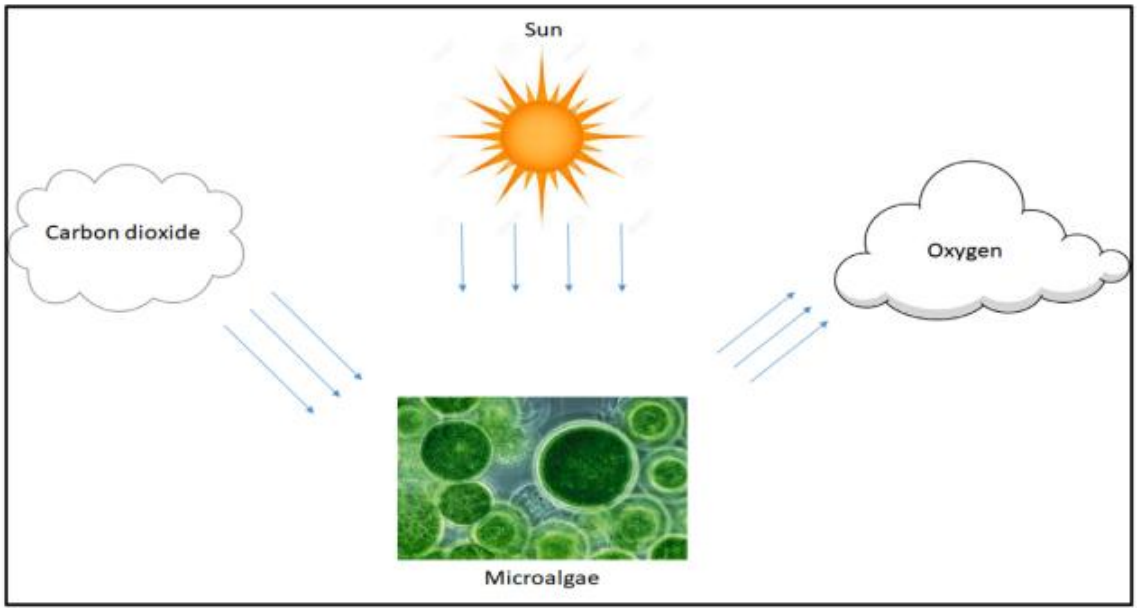


Figure 1: Minimizing carbon footprint via microalgae as a biological capture [11].

According to the mechanism of photosynthesis, microalgal species may thrive at high levels of CO_2 (40%). It is proven to facilitate in reducing greenhouse gas emissions, which eventually benefits the Blue Economy [12] **Figure 2** [13]. To estimate, half of the biomass of microalgae is made up of carbon (w/w), and they can convert inorganic air carbon into organic carbon biomass [14]. Algae biomass can transform into different biofuels (like bioethanol, biodiesel, and biogas). By producing liquid fuels, biogas, these procedures help remedy environmental worries related to fossil fuels [15].

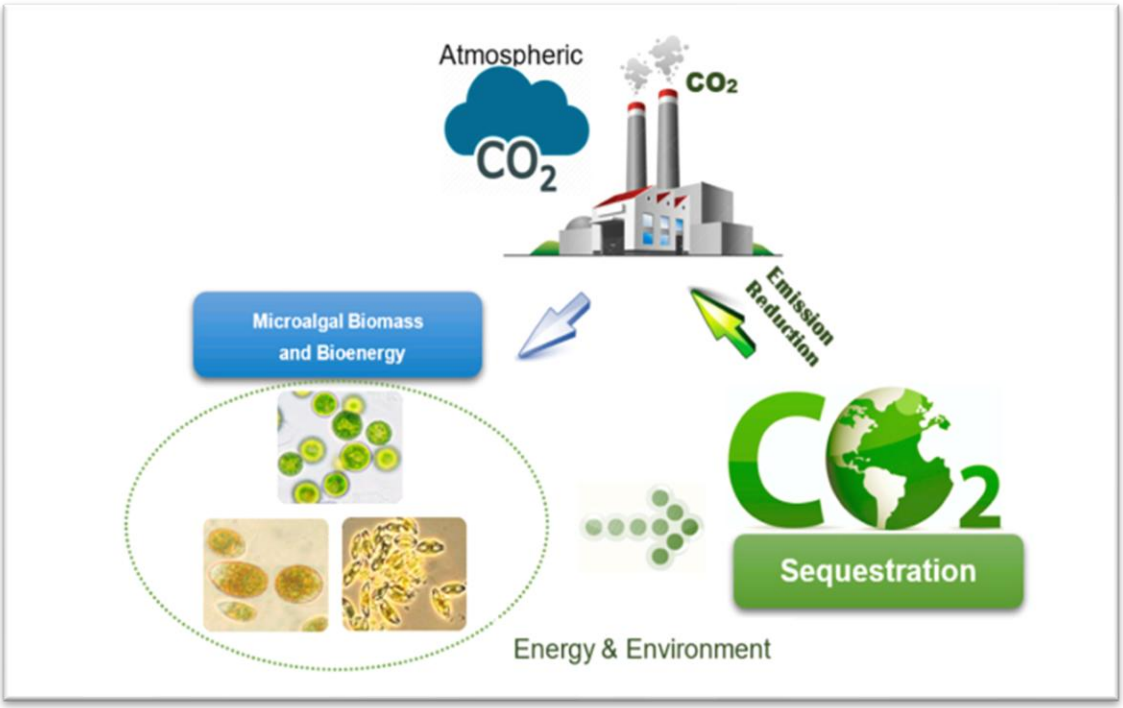


Figure 2: Macro assessment of microalgae-based CO_2sequestration: Environmental and energy effects **[13].**

The microscopic, free-drifting microalgae, also known as phytoplankton, are the most abundant plant life found in the waters.

Photosynthesis is how these single-celled organisms like Chlorella use solar energy to stay alive, and algae stay suspended in water bodies [16]. Phytoplankton contribute over 50% of the world's primary production and oxygen, as well as other supporting services. Furthermore, phytoplankton significantly influences nutrient recycling and biogeochemical cycles in both terrestrial and aquatic environments. So, it makes a substantial contribution to climate regulation [17]. In contrast to numerous other species, algae are characteristically very adjustable and lack the need for arable land for cultivation, making them a suitable biomass alternative [18].

The role of CO_2 in algal growth and biocomponent-1.2

production

CO_2 is a basic substrate for photosynthetic processes undertaken by algae, acting as the main source of carbon for the production of biomass and bioproducts. During photosynthesis, microalgae use CO_2 to transform sunlight and inorganic carbon for

organic compounds, including proteins, lipids, carbohydrates, and other useful biochemicals. CO_2 is a basic substrate for photosynthetic processes undertaken by algae, acting as the main source of carbon for the production of biomass and bioproducts. During photosynthesis, microalgae use CO_2 to transform sunlight and inorganic carbon for organic compounds, including proteins, lipids, carbohydrates, and other useful biochemical according to studies, adding CO_2 to cultures often increases biomass yield and microalgal development while also the synthesis of important biochemical components, including pigments, lipids, and fatty acids [١٩]. Increased synthesis of these chemicals results from improved carbon flow through metabolic pathways brought about by elevated CO2 levels. Lipid production is a crucial component in biofuel applications, so this result is very significant. While some species may tolerate concentrations as high as 30%, the ideal CO_2 concentrations for different species usually fall between 0.1% and 15%. For instance, when CO_2 concentration is raised from ambient levels (~0.04%) to roughly 15%, Chlorella vulgaris shows improved growth and higher lipid accumulation[20].

Excessively elevated amounts may be harmful. Elevated CO_2 lowers pH, which can inhibit photosynthetic efficiency and interfere with the activity of enzymes like carbonic anhydrase. Also, by competing for the activity of Rubisco and producing oxidative stress, the buildup of dissolved oxygen during photosynthesis can prevent CO_2 fixation [21].

Microalgae are crucial to the carbon cycle because they are thought to absorb about 50 gigatons of CO_2 a year, which is more than half of all photosynthetic activity worldwide. In addition to reducing human-caused CO_2 emissions, using microalgae for CO_2 bio-fixation offers prospective avenues for carbon capture and use carbon capture and utilization for the production of renewable biofuels and bioproducts. The economic viability and environmental advantages of scaling up CO_2-enriched cultivation of algae in conjunction with treatment of wastewater and industrial sources of carbon dioxide could be enhanced [22].

1.3-Sources of CO2 Emissions

The Earth heats as a result of greenhouse gases catching heat. Nearly every increase in greenhouse gases during the past 150 years in the atmosphere is attributable to human activity, also Fossil fuel combustion for electricity, transportation, and heating is the major cause of greenhouse gas emissions linked to human activities [23] **Figure 3**[24]. Carbon

dioxide occurs as part of the Earth's carbon cycle in the atmosphere, which is the natural flow of the element carbon between the atmosphere, seas, soil, animals, and plants. Anthropogenic activity is changing the carbon cycle by raising the atmospheric concentration of CO_2 and influencing the ability of natural ecology, like soils and forests, to absorb and hold onto CO_2. Human activity is the main driver of the rise in the atmosphere through the industrial upheaval, despite the fact that there are other natural sources of CO2 emissions [25].

Approximately 45 percent of Iraq's domestic product is derived from industrial production. Recognizing that energy significantly increases carbon emissions is essential. The International Energy Agency estimates that the energy industry in Iraq is responsible for 90% of the country's carbon emissions. Carbon emissions, produced by industry, are detrimental to the environment, public health, economic sustainability [26]. Since many industrial processes require electricity, the generation of electricity indirectly increases CO_2 emissions [24].

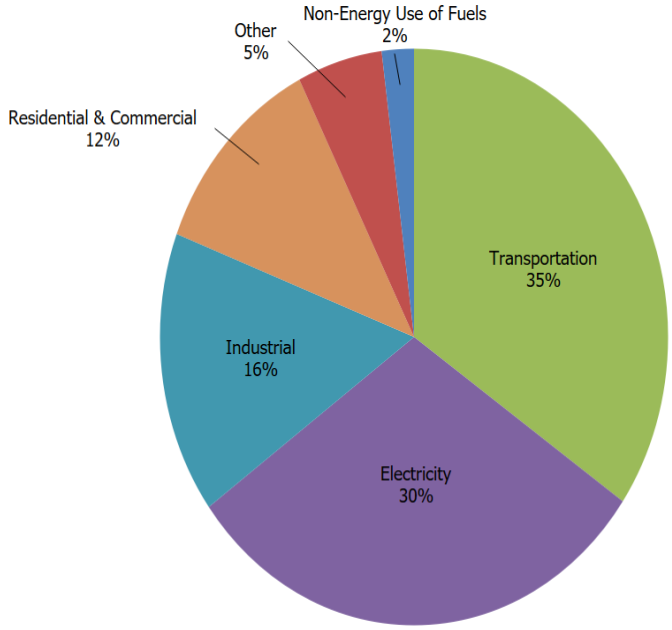


Figure 3: United States Environmental Protection Agency (EPA). Carbon Dioxide Emissions [24]

1.4- The mechanism of CO2 phyco-capture

The technique known as "phyco-capture" allows microalgae to fixate CO2 through photosynthesis, which is the mechanism used by most kinds of carbon capture. In this mechanism, photoautotrophs transform light energy and inorganic molecules into organic matter [27]. Energy is produced by microalgae through both light-dependent and light-independent processes. Both reactions take place inside the chloroplasts, the first in the stroma and the second in the thylakoid membranes Figure 4[3]. During photosystems 1 and 2 (light-reliant processes), which are composed of protein and pigment complexes that absorb light and carry out the reactions to produce NADPH and ATP, electrons are transported from water out of non-cyclic photophosphorylation. Following energy collection, the Calvin cycle (including light-non-reliant processes) uses it to create glucose (C6H12O6) and other carbohydrates [28,29].

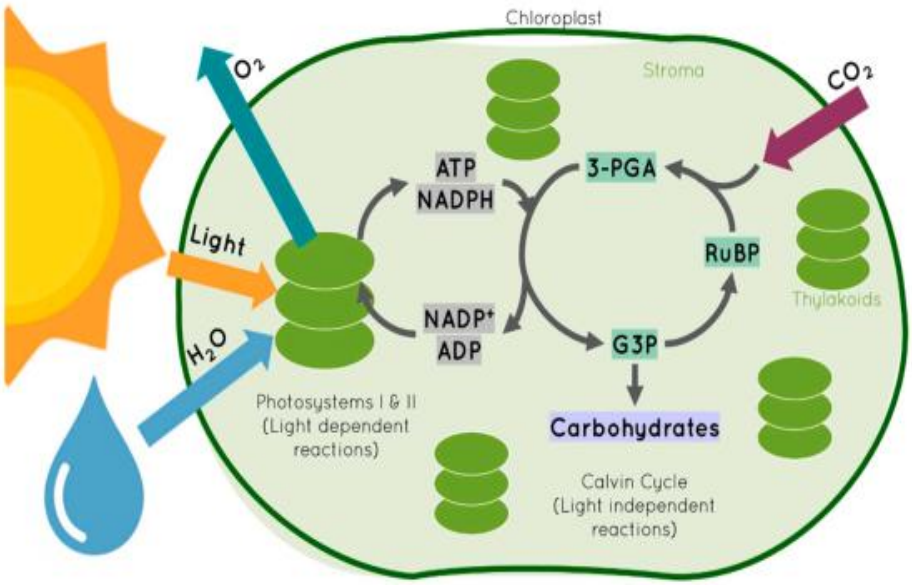


Figure 4: Phycocapture of CO2 as an option to reduce greenhouse gases in cities: Carbon sinks in urban spaces [3]

Due to its effects, climate change has become The main topic on international agendas. Finding ways to trap greenhouse gases is crucial for both the environment and our way of life. One promising option for global implementation is the biocapture of CO2 by microalgae. These systems can operate on a large scale similarly to the carbon credits currently in place in forest zones, In the broadcast area, they capture CO2 comparable to emissions from human activities that are not exactly carried out. Because the algae system

can take in more than 15 times as much data as a typical tree, this form of capture can ensure a higher capture rate than that utilized with taller plants [20].

2. Conclusions

Biological CO_2 capture using rapidly growing microalgae during photosynthesis is one of the key elements that can eventually aid in decarbonization and turn it into biomass. Microalgae biomass can be converted into renewable biofuels, providing sustainable energy alternatives that lower reliance on fossil fuels and decrease carbon emissions, thus reducing global warming. Additionally, by taking the place of feed and chemical fertilizers, microalgae provide a multifaceted strategy to mitigate climate change and improve sustainable agriculture. Microalgae also support ecosystem health by lowering nutrient pollution and treating wastewater. Although several studies on the bio-capture of carbon dioxide by algae have been published, additional study is demanded to decrease the greenhouse effect.

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