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Contribution and impact of plants to achieving carbon neutrality under global climate change

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Abstract. The sustainability of life on Earth is facing an escalating threat from climate change. The greenhouse effect, which is one of the primary causes of this perilous change, has resulted in detrimental consequences such as ocean acidification, biodiversity loss, climate disasters, and adverse economic and social impacts. As climate change continues to progress, its effects are expected to broaden and intensify. Consequently, countries and the international community are collaborating to mitigate climate change and promote measures for carbon neutrality and sustainable development. By achieving carbon neutrality, the world can decelerate the rate of climate change and biodiversity, foster sustainable development, and establish a healthier and more sustainable environment.Among the various methods employed to attain carbon neutrality, plant carbon sequestration stands out as a primary approach. Studying the impact and potential of plants in achieving carbon neutrality holds immense significance. In this review, I provide a comprehensive overview of the current state of plant carbon sequestration from diverse perspectives, explore the role of different plants in accomplishing carbon neutrality, and analyze the future potential of plants in mitigating the greenhouse effect and addressing climate change. Simultaneously, this review delves into the feasibility and relevant measures of integrating plants with other fields to collectively combat the greenhouse effect and promote carbon neutrality.

Keywords: Carbon neutrality, Greenhouse effect, Carbon sink, Plant monitoring

1. Introduction

The goal of carbon neutrality is to achieve net zero carbon emissions or negative carbon emissions by removing or reducing carbon dioxide from the atmosphere in order to offset or reduce carbon dioxide emissions from human activities [1-5]. It is a strategy to combat climate change and global warming, and aims to mitigate and mitigate the effects of climate change [6]. In the process of carbon neutrality, we need to minimize the emission of carbon dioxide in the atmosphere and increase or enhance the absorption and fixation of carbon dioxide through various methods to achieve climate neutrality. This means that the carbon dioxide emissions from human activities do not exceed the amount of carbon dioxide absorbed and fixed by the Earth's systems, resulting in net zero or negative carbon emissions [7].

Achieving carbon neutrality requires a global effort involving actions in different areas, such as promoting renewable energy, improving energy efficiency, establishing and facilitating carbon trading and markets, and improving energy efficiency [7]. At present, plants are the main means of controlling

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carbon neutrality [8], plants absorb carbon dioxide in the atmosphere through photosynthesis [9], convert it into organic matter, and convert the absorbed carbon into biomass [10], such as trees, leaves, roots, etc., and store a lot of carbon in the plant body. For example, forest carbon sequestration [11], through forest restoration and afforestation projects, has increased a large amount of forest [12] and vegetation cover globally and improved the carbon sequestration capacity of plants [13]. In addition to forests, other types of vegetation, such as grasslands, wetlands, and farmland, release organic matter through their roots as they grow, which can improve the texture and structure of the soil, promote more carbon storage, and reduce the concentration of carbon dioxide in the atmosphere.

In addition to storing carbon, plants have many other related roles in the process of carbon neutrality [14]. For example, plant transpiration helps regulate the water cycle by taking water from the soil and releasing it into the atmosphere through leaf transpiration [15]; In order to protect and improve the soil environment, the roots of plants can protect the soil from wind and water erosion and prevent the deterioration of soil quality. At the same time, plant leaves and residues can be gradually degraded into organic matter, improve soil structure and fertility, increase soil organic carbon content, and help to achieve carbon neutrality.

As shown in Figure 1, in this review, I provide the process by which plants absorb and convert carbon dioxide, an overview of the role of plants in achieving carbon neutrality and how plants in different regions can help address the greenhouse effect [10] and achieve carbon neutrality [9]. Firstly, the carbon dioxide monitoring function of plants is briefly introduced [8], and how people use plants to measure carbon dioxide content is introduced. It then Outlines how Marine and continental plants can reduce greenhouse pollution. In addition, other ways to control the greenhouse effect of plants in conjunction with other fields such as physical chemistry are discussed to achieve the goals of climate change mitigation and carbon neutrality. Finally, it presents current insights on the use of plants to monitor and control carbon pollution to achieve carbon neutrality, and assesses future trends in plant control of the greenhouse effect and the challenges of reversing global warming and the greenhouse effect.

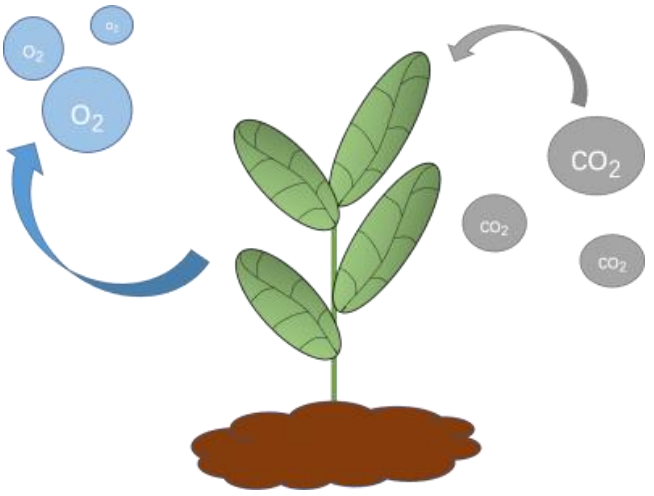

Figure 1. The theory of how the plant purified air

2. Plants can monitor carbon dioxide

2.1. Direct monitoring plant

For carbon dioxide, some plants can be used as indicator plants to indirectly reflect the content or concentration of carbon dioxide in the environment because of their physiological characteristics or reaction mechanisms [13]. These plants usually exhibit special physiological or morphological changes in high carbon dioxide concentrations. Table 1 shows the different indicator plants, their indicative sites and the year in which the relevant literature was published.

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Table 1. Plants which can direct monitoring of carbon dioxide

Type	Part	year
Dalbergia sissoo Roxb	Total carbohydrate	2013
Microalgae	Hydrogen production	2016
Microalgae	Carbon streaming	2017
Aalae	Photosynthesis	2022
Eukaryotic marine phytoplankton	Carbon concentrating mechanisms	2011
Marine diatoms	Carbon dioxide concentration mechanisms	2021
Mangrove forests	Carbon stocks	2014
Echinocereus	Transpiration	1974
Saguaro cactus	Seasonal controls on ecosystem-scale CO_2	2018
Coral reef	Community calcification	2018
Moss	Air purification	2023

2.2. Indirect monitoring plant

Some plants can not directly show the concentration of carbon dioxide in the air or other carbon content through external performance, can not be used as carbon dioxide indicator plants, but these plants can absorb carbon dioxide through the process of photosynthesis and convert it into organic matter [12], so as to fix carbon in their own bodies, with the potential to fix carbon dioxide. Recent studies [10] have shown that plant diversity increases soil organic carbon (SOC) stocks by increasing carbon input from underground biomass and promoting microbial contributions to organic carbon storage. Affected by terrain, climate and vegetation types, different types of plants, plants in different regions and plants under different climatic conditions have different potential to fix carbon dioxide. A series of methods should be adopted according to the actual situation to increase the fixed carbon dioxide content of plants and improve the ability and efficiency of plants to purify air. Local CO_2 levels are indirectly monitored by measuring the CO_2 fixation potential of different plants in different regions. At the same time, by comparing and discussing the potential of vegetation to fix carbon dioxide in different regions, it can also provide ideas for improving the development of plant air purification technology. Table 2 shows the types of plants with high fixed carbon in different geographical Settings.

Table 2. Carbon fixation potential of plants in different regions

Place	Species	Year
Agricultural landscapes	Hedgerows	2022
Latin American tropics	Second-growth forest	2016
Malaysian	Native microalgae species	2020
Burkina Faso	Smallholder agroforestry parklands	2016
Brazilian Amazon	Secondary forests	2021
Norway	Forest	2020
lower Gangetic plain	Young species	2011
Global	Croplands	2022
China	Forestry bioenergy	2022
Global	Grassland	2022

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3. Plants absorb, fix, and transform carbon dioxide

Most plants can absorb carbon dioxide through photosynthesis, trapping large amounts of it in their bodies and converting it back to organic carbon through the chemobiotic cycle. For example,Plants, algae and phytoplankton in the ocean take up carbon dioxide through photosynthesis and convert it into organic carbon, thus participating in the ocean carbon cycle. There are also carbon sinks in the ocean, such as Marine wetlands, coral reefs and seagrass beds, which can absorb and fix large amounts of carbon. Marine carbon neutral governance aims to protect Marine ecosystems, promote Marine carbon uptake and storage, and reduce climate change impacts such as ocean acidification and sea level rise.

In continental areas, forests can greatly increase carbon storage in continental areas;Water areas such as lakes and rivers can increase aquatic plant cover to enhance the carbon fixation capacity of water bodies; In desert areas, some drought-tolerant plants, such as cactus and desert willow, are adapted to dry environments and can grow in poorer soils [13]. These plants are able to fix carbon under extreme conditions and can be used to prevent soil erosion and increase carbon storage by growing adaptable plants.

4. Plants can be combined with other fields to control the greenhouse effect

Plants can not only rely on their own conditions to improve the greenhouse effect, but also cooperate with many other technical fields to jointly control environmental pollution and achieve the goal of carbon neutrality. In terms of biotechnology, synthetic biology can be used to intervene in the process of photosynthesis, so as to improve the efficiency of photosynthesis. In terms of physical technology, a series of related devices can be designed to help plants grow, improve the ecological environment, and indirectly promote plants to fix carbon dioxide; In terms of chemical technology, through the application of beneficial elements, nitrogen, phosphorus and potassium fertilizer, etc., to help plants grow vigorously, eliminate the interference of pests and diseases to promote the improvement of the greenhouse effect. Through scientific cooperation, climate change can be effectively and accurately mitigated, carbon neutral and sustainable development measures can be promoted, and a clean, green living environment can be created. Table 3 shows the different technologies of combining with plants to control environmental pollution.

Table 3. Technology of combining with plants to control environmental pollution

Technology	Effect	Year
Multi-Media	Mercury Emission	2023
Maneuvering System	Air Pollution	2015
Physics And Ecology	Mining Carbon Dioxide	2019
Remote Sensing	Plants' Faint Glow	2014
Microbial Protein Production	Carbon-Neutral Food Systems	2022
Universal Model	Carbon Dioxide Uptake By Plants	2017

5. Conclusion

Currently, plants have demonstrated significant progress in various aspects of carbon neutrality, and the utilization of plants as instruments and methods to control carbon pollution is relatively advanced. However, there are still shortcomings in using plants to achieve carbon neutrality, including time and scale limitations, conflicts in land demand and use, vulnerability of ecosystems, unstable carbon storage, and concerns regarding cost and economic feasibility. Nevertheless, there remains a vast potential and untapped space for the exploration and utilization of plants that have not yet been fully utilized, such as lignaceous aquatic plants, high carbon sequestration potential tropical tree species, desert plants, and artificial plant species. Additionally, expanding the utilization of plants with the capacity to monitor CO_2 but are currently underutilized, such as grasslands, native plants, aquatic plants, and wild tree species, is necessary.

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To overcome the challenges associated with using plants for carbon neutrality, it is crucial to develop the integration of plants with other technological aspects, break through technical barriers, enhance governance efficiency, and innovate cutting-edge governance methods. Examples of such advancements include the improvement of carbon capture and storage technology, biochar preparation, plant and climate modeling, and technologies for tracking the carbon cycle. There are still numerous obstacles to overcome on the path to achieving carbon neutrality through plant utilization, and it is expected that future research will focus on relevant scientific directions to achieve carbon neutrality through sustainable approaches.

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