



Carbon Sequestration: The Ultimate Weapon against Global Warming

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ABSTRACT

Global warming, driven by the rising concentrations of greenhouse gases like carbon dioxide (CO₂), presents a critical threat to the planet's climate. Carbon sequestration, the process of capturing and storing CO₂, offers a promising solution to mitigate the impacts of climate change. This article explores the two primary forms of carbon sequestration—biological and geological—and discusses their role in reducing atmospheric CO₂ levels. Biological sequestration, through plants and soils, naturally absorbs carbon, while geological sequestration stores CO₂ deep underground in secure formations. Despite challenges such as high costs, public acceptance, and scalability, carbon sequestration remains a key tool in global climate strategies. With continued advancements in technology and international cooperation, it holds significant potential to help achieve net-zero emissions and limit global warming, making it a crucial weapon in the fight against climate change.

INTRODUCTION

Global warming is one of the most pressing challenges faced by humanity today. The Earth's climate

is undergoing rapid changes, largely driven by the increasing concentrations of greenhouse gases (GHGs) in the atmosphere. These gases,

primarily carbon dioxide (CO_2), trap heat, resulting in rising temperatures, extreme weather patterns, and environmental destruction. One promising solution to mitigate global warming is carbon sequestration—a process that captures and stores carbon dioxide, preventing it from entering the atmosphere. In this article, we will explore how carbon sequestration works, its importance, and how it can serve as a powerful tool in the fight against climate change (Baig *et al.*, 2023).

1. What is Carbon Sequestration?

Carbon sequestration refers to the process of capturing and storing atmospheric carbon dioxide (CO_2) to reduce the amount of this greenhouse gas in the atmosphere. The goal is to prevent CO_2 from contributing to the greenhouse effect and thus help mitigate global warming. Carbon sequestration can take two primary ways: **Biological and Geological**.

1.1. Biological Sequestration: This occurs naturally through plants, trees, and soil. Trees and plants absorb CO_2 from the atmosphere during photosynthesis and store it in their roots, stems, and leaves. Forests, wetlands, and grasslands act as carbon sinks, absorbing vast amounts of CO_2 over time. Soils, too, store large amounts of carbon, particularly in agricultural and forested areas.

1.2. Geological Sequestration: This involves capturing CO_2 from industrial sources or directly from the air and injecting it into underground rock formations. These formations, such as depleted oil and gas fields or deep saline aquifers, can securely store CO_2 for thousands of years. This method is particularly promising for industries with high carbon emissions, such as power plants and cement factories.

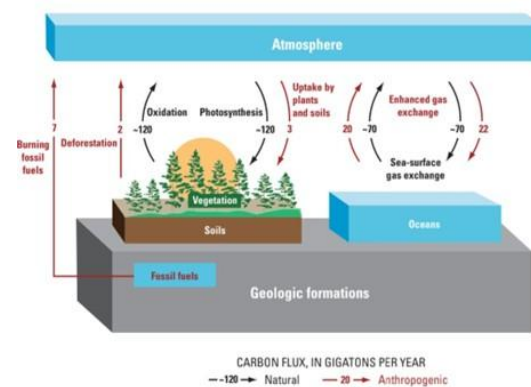


Figure 1. Global Carbon Cycle
Source: USGS science for a changing world

Figure above shows how Carbon naturally moves, or cycles, between the atmosphere, vegetation, soils, and the oceans over time scales ranging from years to millennia and longer. Human activities, primarily the burning of fossil fuels and clearing of forests, have increased the transfer of carbon as CO_2 to the atmosphere. Although some of this anthropogenic CO_2 is removed from the atmosphere by the natural uptake processes (“sinks”) of the carbon cycle, much of it remains in the atmosphere and causes rising CO_2 concentrations. The goal of carbon sequestration is to decrease the net flux of CO_2 to the atmosphere by sequestering carbon in the oceans, vegetation, soils, and porous rock formations. Fluxes shown in the above figure are approximate for the period 2000–05, as documented by the Intergovernmental Panel on Climate Change.

2. The Importance of Carbon Sequestration

As the world continues to burn fossil fuels and deforest large areas for agriculture and urban development, the concentration of CO_2 in the atmosphere has reached unprecedented levels. In 2021, global CO_2 levels were estimated to be 414.72 parts per million (ppm) which increased up to 419.47 ppm and continued to rise approximately up to 414.19 ppm, far above pre-industrial levels of around 280 ppm. This increase in CO_2 has been directly linked to the intensification of climate change.

Carbon sequestration offers a critical opportunity to reduce the impact of these emissions. According to the Intergovernmental Panel on Climate Change (IPCC), achieving global climate targets, such as limiting warming to 1.5°C above pre-industrial levels, will require substantial carbon removal technologies in addition to reducing emissions at their source.

Table 1: Potential Global Carbon Sequestration Capacity by Method (Gigatonnes of CO₂)

Carbon Sequestration Method	Potential Global Capacity (Gigatonnes of CO ₂)
Biological Sequestration (Forests and Soils)	200 - 500
Geological Sequestration (Deep Saline Aquifers)	2,000 - 10,000
Ocean Fertilization	1,000 - 2,000
Direct Air Capture and Storage	0.5 - 5

[Source: IPCC Special Report on Climate Change and Land (2019) (Legg, 2021)]

Table 1. provides an overview of the estimated global capacity for different carbon sequestration methods. Biological sequestration, through forests and soils, has a significant potential, while geological sequestration (such as deep saline aquifers) offers the largest storage capacity. However, the feasibility of each method varies based on technological, environmental, and economic factors.

3. Challenges

Despite its potential, carbon sequestration faces several challenges that need to be addressed for it to be implemented at scale:

3.1. **Cost:** Carbon sequestration technologies, particularly geological sequestration, are expensive. The infrastructure required to capture, transport, and store CO₂ is costly, and it will take significant investment to make these technologies widely

accessible. Governments, businesses, and international organizations must invest in the research and development of cost-effective solutions.

3.2. Public Perception and Acceptance:

Geological sequestration, in particular, can raise concerns among the public about the safety of storing CO₂ underground. There is a need for public education and transparent communication to build trust in these technologies. Strict monitoring and regulatory frameworks will also be necessary to ensure the safety and effectiveness of sequestration projects.

3.3. Scaling Up:

While carbon sequestration has demonstrated promise at a small scale, scaling up these efforts to the level needed to make a significant impact on global CO₂ levels is a major challenge. Expanding sequestration projects will require cooperation across industries, governments, and research institutions.

4. The Future of Carbon Sequestration

The future of carbon sequestration looks promising, but significant research and development are still needed to unlock its full potential. Advances in carbon capture technology, along with improved land management practices, will increase the efficiency and effectiveness of sequestration efforts.

In the coming decades, carbon sequestration could become a cornerstone of global climate strategies. Governments around the world are recognizing the importance of carbon removal technologies and are beginning to implement policies to incentivize their development. The United Nations, through initiatives such as the Paris Agreement, has emphasized the role of carbon sequestration in achieving net-zero emissions by 2050 (Herzog, 2001).



CONCLUSION:

Carbon sequestration is a vital tool in the fight against global warming. By capturing and storing CO₂, it can reduce the concentration of greenhouse gases in the atmosphere, mitigate the effects of climate change, and provide economic and environmental benefits. While challenges remain in terms of cost, public perception, scalability, the future of carbon sequestration looks bright. With continued investment and research, it holds the potential to become a key weapon in the battle against global warming.

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