Review Article

Modern Agro Techniques for Carbon Sequestration to Mitigate Climate Change

Abstract

The crucial topic of global warming has recently been discussed throughout the world. In conclusion, it was found that the main contributor to global warming is greenhouse gases, of which CO_2 makes about 31%. Including methane and nitrogen dioxide, also play a significant role. Thus, lowering or managing CO_2 emissions into the atmosphere is our primary objective. Thus, the solution of carbon sequestration is reduced. In an attempt to reduce the net rate of rise in atmospheric CO_2, carbon sequestration entails transporting or storing CO_2 into various long-lived global reservoirs, such as biotic, geological, pedologic, and marine layers. Technologies are being developed to reduce the rate at which land-use change, energy, process industries, and the process of cultivating soil is raising the atmospheric concentration of carbon dioxide. This book discusses both abiotic and biotic technologies and describes the mechanics involved in sequestering carbon dioxide (CO_2), of the three possibilities: sequestering emissions and producing low- or no-carbon gasoline. Along with these techniques, there are other ways to lower CO_2emissions into the atmosphere. Certain more contemporary methods such as liquid plants, are useful for storing carbon within them.

Keywords: Climate Change, Greenhouse Impact, Soil Management, Geological, Oceanic, forest, Agriculture and Mineral Sequestration.

Introduction

From controlling the earth's temperature to producing the food that keeps us alive and powering the global economy, carbon has both advantages and disadvantages. It is the main contributor to ozone depletion, global warming, ocean acidification, climate change, and other health hazards. One of the most significant elements in the universe, carbon is derived from a variety of sources. Soil organic matter contains more microorganisms, including microflora such as bacteria, fungus, and actinomycetes. It is a multifaceted composition that is mostly enhanced with carbon. The fundamental element of all organic materials is carbon. Every aspect of existence depends on it, according to (Winowiecki, 2016).

The planet's largest carbon store outside of solid organic carbon (SOC) is rocks, which provide all of the carbon in the atmosphere, plants, and seas. The carbon cycle includes the transfer of carbon from one terrestrial deposit to another. A few years in the atmosphere, decades in plants, hundreds to thousands of years in soils and seas, and millions of years in rocks are its usual residence times. These organic evidences show that minerals store carbon in the most stable way. According to Lal (2009), since the industrial revolution, agricultural practices have changed natural ecosystems, causing 50–100 GT of carbon from soil to be released into the atmosphere. This has resulted in a decline in SOC levels. But carbon in soil can also have more advantageous effects, like increasing soil productivity through carbon storage Kragt *et al.*(2017). whereas if it enters the atmosphere, it poses a serious threat.

Carbon sequestration is the process of removing carbon dioxide from the atmosphere by biological or geological mechanisms (plants and trees, for example). The method of keeping carbon in a stable, solid state is known as sequestration. It is caused by atmospheric CO_2 fixation, both directly and indirectly. Because they directly impact the energy balance of the planet, greenhouse gases (GHG) have a significant impact on climate. Gases such as methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), and water vapor are categorized as greenhouse gases by Hansen *et al*, (2005). Direct soil carbon sequestration occurs when CO_2 is transformed into inorganic carbon molecules that are found in soil, such as calcium and magnesium carbonates. Plants directly sequester carbon during photosynthetic processes.

Carbon capture and storage (CCS) Technologies

It's a technique for slowing down global warming that depends on sequestering carbon dioxide (CO_2) as opposed to allowing large point sources, such as fossil fuel power plants, to spew it into the sky. CCS can cut CO_2 emissions to the atmosphere in modern conventional power plants by 80–90% when added to a plant without it. CO_2 capture and compression (CCS), an energy-intensive process, would raise a coal-fired plant's fuel requirements by 25% to 40%. The process of capturing atmospheric carbon (C) that would otherwise be released into or remain in the atmosphere and safely storing it in biotic and pedologic carbon banks is known as terrestrial carbon sequestration (Lal, 2007). Plants, soil, and other terrestrial organisms all sequester or retain carbon.

Geological Storage

Using this method, industrial CO2 is transported, liquefied, and injected into deep geological layers. (Baines and Worden,2004)CO_2 can be used to treat coal seams, stable rock layers, aged oil wells (to boost yield), and sealed aquifers. This process, called geo-sequestration, usually involves injecting supercritical carbon dioxide straight into underground geological formations.

Potential storage locations have been proposed for oil resources, gas deposits, saline formations, unmineable coal seams, and saline-filled basalt formations. Ajayi *et al.* (2019) state that carbon capture and storage, which immobilizes CO_2 permanently in underground geological storage formations, provides an appropriate means of removing it from the atmosphere. These geological formations' sedimentary rocks are widely recognized for having limited porosity and being impermeable.

Oceans as Carbon Sequestrators

About 40% of these CO_2 emissions that are the product of human activity have been able to remain in the atmosphere, however. The remaining 60% of anthropogenic carbon has been rather evenly absorbed by the terrestrial and oceanic carbon stocks, according to Le quere*et al.* (2017).Direct CO_2 injection into deep oceans, some of which are isolated from the atmosphere for hundreds of millions of years, may speed up this natural process (Devries and Primeau, 2011). The concept of "direct injection" describes the deliberate acceleration of atmospheric CO_2 uptake by the oceans (Marchetti, 1977). Therefore, injecting direct CO_2 into the deep ocean would postpone the final, almost certain, change in climate and stop CO_2 emissions from humans from influencing it anytime soon.

Mineral Storage

One of the many types of mineral entrapment is when CO_2 combines with organic materials and minerals in geologic formations to form part of the solid matrix (Chang *et al.*, 2007). Mineral phases that contain carbonate, like siderite, calcite, magnesite, and dawsonite, precipitate and retain CO_2(Burruss *etal.*, 2009). The process of mineral dissolution and precipitation, known as mineralization, traps CO_2(Flett *et al.*, 2007). CO_2 is trapped when metal cations and dissolved carbonate anions precipitate as solids (Saadatpoor*etal.*, 2010). The idea of mineralizing anthropogenic CO_2 by means of this organic mineral carbonation process was first proposed in the 1990s (Lackner *et al.*, 1995). This technique creates stable carbonates by reacting easily available metal oxides with carbon dioxide exothermically. Much of the surface-visible limestone is produced by this process, which takes place naturally over several years. Although these methods can use more energy, they can speed up the rate of reaction by pre-treating the minerals or reacting at higher temperatures and/or pressures. Because divalent metal cations are abundant in silicates and basaltic and ultramafic rocks are highly reactive, they are best suited for natural mineral carbonation (Wolff-Boenisch *et al.* 2006). According to Rogers *et al.* (2006), carbon mineralization may result from the easy transportation of CO_2-bearing fluids, even in severely altered basalts.

Forest as Carbon Sequestrators

The greatest carbon store and an essential component of terrestrial ecosystems is the forest .Forest resources are employed, particularly in developing nations to combat poverty despite carbon sequestration (Voituriez*et al.*, 2017) .Through biological development, which can increase forest stocks, deforestation, which can increase carbon emissions, or the storage or emission of carbon, a significant greenhouse gas, and forests can have a significant impact on climate change. Forest soils not only hold onto biomass from the trees but also store carbon.

Liquid tree using microalgae

When biomass is produced and used using environmentally friendly methods, the method of storing carbon dioxide is very beneficial since it may guarantee the net elimination of excess carbon dioxide. Because algae have a bigger surface area, develop more quickly than trees, and are easier to manage in bioreactors, they absorb more carbon dioxide than trees. Carbon dioxide recycling can help minimize a number of environmental issues by providing food for algae. Photobioreactors serve to facilitate the process of growing algae. The algae employ the carbon dioxide they take in to create the skeletons of proteins, lipids, carbohydrates, and colors (Sydney *et al.* 2010).

Reusing CO_2

One potentially useful tactic could be to transform CO_2 from industrial sources into hydrocarbons, which can then be stored, repurposed as fuel, or used to make polymers. The reliable process of producing methanol is one way to produce a hydrocarbon. CO_2 and H_2 can be readily converted to methanol. According to Hussein and Aroua (2019), carbon dioxide is transformed into beneficial compounds including 2, 3 furandiol and methylglyoxal, which are utilized as raw materials for medicines, adhesives, and plastics. We are getting closer to a low-carbon, sustainable economy thanks to this latest revelation.

Table 1. An overview of the CO_2 sequestration techniques (IPCC, 2005)

Storage types	Benefits	Drawbacks	Potential Gt
Mineral carbonation	ecologically secure Thermodynamic processes Plenty of feedstock Continuous Non-monitoring Use of Industrial Waste	Expensive Slow kinetics of reactions Preparing the feedstock High energy content Uncertain future prospects Poor additive chemical recovery Issues with using or disposing of the process product if it is used extensively Feedstock mining causes environmental problems.	>10,000 to 1,000,000

A few technological solutions to reduce the amount of CO_2 **that power plants release into the environment are as follows:**

Reducing the amount of carbon dioxide emissions by using (a) fuels with lower carbon emissions, like natural gas instead of coal (b) utilizing nuclear or renewable energy sources more frequently (c) looking into the possibility of CO_2 storage and capture

Afforestation

One of the practical methods for sequestering carbon in ecosystems on land (Lamb *et al*., 2005). Another viable alternative is to restore damaged tropical forests. Thus, the establishment of productive monoculture Acacia, Eucalyptus, and Pinus plantations can improve the terrestrial C pool in these environments. There is also an opportunity to enhance secondary or regeneration forest management in degraded tropical environments.

Biofuels

It is possible to reduce the use of fossil fuels and produce alternative, sustainable energy sources by converting sugars from biomass into ethanol and oils and fats from plants into bio-diesel (Himmel *et al.* 2007). Transforming atmospheric CO_2 into biomass-based biofuels. Energy plantations can create biofuels that trap carbon in the soil, offset the emissions of fossil fuels, and reduce the increase of atmospheric CO_2 and other greenhouse gases by using specific crops including poplar, willow, switch grass, miscanthus, Karnal grass, and Pennisetum. All of these benefits can be achieved with careful species selection and management. Some contend that despite the advantages, there would be more rivalry for the land and water needed to set up energy plantations.

What can Agricultural Producers do to enhance Carbon Sequestration?

The ramifications of climate change are far-reaching and diverse, impacting not only agricultural and water supplies but also economic stability and health. Moving on to the source of global warming, According to Manna *et al.* (2013), deforestation, changes in land use, and agricultural practices account for roughly 14%, 20%, and 17% of greenhouse gas emissions, respectively. Cias*et al.* (2013) state that carbon is stored in soils and living organisms through biotic and abiotic processes, and that through plant photosynthesis, terrestrial ecosystems absorb CO_2 from the atmosphere.

According to Kukal *et al.* (2009) arable land regeneration of SOC pools is another potential sink for atmospheric CO_2. Several studies have reported notable variations in soil SOC concentration due to tillage practices that differ from conventional tillage (CT) systems in terms of form and technique. By increasing soil temperature and aeration, cultivation significantly reduces soil organic carbon (SOC), particularly from the surface layer. Thus, soil is exposed to microbial breakdown and microbial activity is stimulated .However, research indicates that applying conservation or reduced tillage may be able to stop this depletion and increase the amount of SOC stock, both of which would help lower greenhouse gas emissions .

Wetlands restored for carbon sequestration.

According to Griscom *et al.* (2016), this strategy uses wetlands, grasslands, and forests as natural ecosystems to absorb and store $\mathbf{CO_2}$. Wetlands are of great significance for their potential to store carbon because of their long residency times. Anaerobic circumstances allow vegetation to continue absorbing ambient carbon dioxide ($\mathbf{CO_2}$) while preserving the carbon (C) in the soil.

Remote sensing and sensors

The success of these projects can be greatly dependent on developments in sensor technology and remote monitoring (Glasgow *et al.*, 2004). Furthermore, Asner *et al.* (2011) have identified significant remote sensing applications that can aid in the decision-making process related to carbon sequestration. The ability to estimate geographical variation and temporal change in terrestrial C dynamics has been significantly improved by the use of data sources generated from satellite-based remote sensing. These measures, which are widespread and conducted at a high frequency, are crucial for promoting climate action and policy. Comprehensive mapping of the vegetation and our comprehension of complicated eco-physiological processes across changing environments has substantially increased due to gross primary production (GPP) and its spatiotemporal variation throughout the biosphere .

Economics and Policies

To stop "carbon leakage," which occurs when businesses relocate their operations to nations with lax environmental rules, the pricing systems must be harmonized globally. The implementation of a national carbon inventory-based approach, as opposed to one that rewards project-level gains, may reduce issues related to leakage, baseline definition, and information asymmetries (Andersson and Richards, 2001).

Conclusion

The accumulation of greenhouse gases in the atmosphere is making the problem of climate change increasingly urgent, necessitating swift action to mitigate its adverse effects One potential result of lowering greenhouse gas emissions by carbon capture and sequestration is the removal of carbon dioxide from the environment. The fact that CCS has been used on projects spanning several decades and has demonstrated technological viability is undoubtedly one of its advantages. Its primary shortcoming is that it remains too costly and opaque for the economic actors to be fully engaged. We can regulate CO_2 by enacting strict policies on carbon trading. Choose a plan that benefits the local economy and area. Further study is required.

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