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Carbon sequestration to mitigate climate change: A review

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Abstract
Carbon sequestration is the process involved in carbon capture and the long – term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. Potential adverse impacts include sea-level rise; increased frequency and intensity of wildfires, floods, droughts, and tropical storms; changes in the amount, timing, and distribution of rain, snow, and runoff; and disturbance of coastal marine and other ecosystems. Rising atmospheric CO_2 is also increasing the absorption of CO_2 by seawater, causing the ocean to become more acidic, with potentially disruptive effects on marine plankton and coral reefs. Technically and economically feasible strategies are needed to mitigate the consequences of increased atmospheric CO_2.

Keywords: carbon sequestration, green house gas, carbon dioxide, biomass, ecosystem, ocean

Introduction
Rising levels of CO_2 leading to global warming has triggered a search for methods to control and bring down the levels of atmospheric carbon. Carbon sequestration in biomass and soil has been proposed to be a key strategy to reduce atmospheric CO_2 these sequestration strategies are likely to play a major role in the next 20-30 years, until new technologies, particularly in the energy sector, are developed and implemented to bring down emission levels. Soil C sequestration is expected to account for about 90% of the total global mitigation potential available in agriculture. While there has been considerable interest in carbon sequestration through iron fertilization in the oceans, forest and agricultural lands may also play a key role in the overall strategy for slowing the atmospheric accumulation of carbon. Further, ocean fertilization to sequester CO_2 by phytoplankton can be ecologically disruptive and is unlikely to be effective for climate mitigation. Though land-based carbon capture and storage has been proposed the high cost involved is often used as an argument against it.

Why carbon sequestration is important?
- Carbon sequestration is one of the important mitigation strategy to cope with the impact of climate change by reducing the atmospheric concentration of carbon dioxide emission.
- Carbon sequestration is necessity to restore degraded soils and ecosystem, improve water quality, enhance biodiversity and increase agronomic productivity to achieve food security.
- Soil is the third largest terrestrial sink for carbon on the planet.
- The potential of soil organic sequestration through restoration of degraded and decertified soils in India is about 10-14 Tg C per year.
- The present attempt is made to estimate carbon (both SOC and SIC) in Indian soils and there application to focus issue and priorities on carbon sequestration in soil.

Table 1: Indicators for Climate Change

1.	Global Green House Gas emission	11.	Change in precipitation pattern
2.	Atmospheric concentration of greenhouse gases	12.	Tropical Cyclonic activities
3.	Change in Sea level	13.	Increase in the occurrence of extreme events
4.	Change in Ocean heat	14.	Change in Arctic Sea ice
5.	Change in sea surface temperature	15.	Glaciers melting
6.	Change in Ocean Acidity	16.	Change in length of seasons
7.	Submergence of land into sea	17.	Length of growing season

8.	Climate forcing	18.	Bird wintering ranges
9.	Change in Snow fall pattern	19	Heat related deaths
10.	Change in Temperature pattern		

What is carbon sequestration and their type

The term "carbon sequestration" is used to describe both natural and deliberate processes by which CO_2 is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils and sediments) and geologic formations.

Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. Carbon dioxide is naturally captured from the atmosphere through biological, chemical or physical processes. Carbon dioxide may be captured as a pure by-product in processes related to petroleum refining or from flue gases from power generation. Terrestrial sequestration, Geological sequestration and Ocean sequestration are the type of the carbon sequestration.

1. **Terrestrial sequestration:** Terrestrial carbon sequestration is the process through which carbon dioxide (CO_2) from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils. The term "sinks" is also used to refer to forests, croplands, and grazing lands, and their ability to sequester carbon. Agriculture and forestry activities can also release CO_2 to the atmosphere.
2. **Geologic sequestration:** Geologic sequestration begins with capturing CO_2 from the exhaust of fossil-fuel power plants and other major sources. The captured CO_2 is piped 1 to 4 kilometers below the land surface and injected into porous rock formations. Compared to the rates of terrestrial carbon uptake shown in figures 1 and 2, geo-logic sequestration is currently used to store only small amounts of carbon per year. Much larger rates of sequestration are envisioned to take advantage of the potential permanence and capacity of geologic storage. The permanence of geologic sequestration depends on the effectiveness of several CO_2 trapping mechanisms. After CO_2 is injected underground, it will rise buoyantly until it is trapped beneath an impermeable barrier, or seal. In principle, this physical trapping mechanism, which is identical to the natural geologic trap-ping of oil and gas, can retain CO_2 for thousands to millions of years. Some of the injected CO_2 will eventually dissolve in ground water, and some may be trapped in the form of carbonate minerals formed by chemical reactions with the surrounding rock. All of these processes are susceptible to change over time following CO_2 injection. Scientists are studying the permanence of these trapping mechanisms and developing methods to determine the potential for geologically sequestered CO_2 to leak back to the atmosphere.
3. **Ocean sequestration:** Carbon is naturally stored in the ocean via two pumps, solubility and biological, and there are analogous man-made methods, direct injection and ocean fertilization, respectively.

Carbon sequestration in fruit crops

Trees are carbon reservoir on earth. In nature, forest ecosystem act as a reservoir of carbon. They store huge quantities of carbon and regulate the carbon cycle by exchange of CO_2 from the atmosphere. Forest ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. It uptakes the carbon dioxide by the process of photosynthesis and stores the carbon in the plant tissues, forest litter and soils. Thus, fruit trees play important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere. Carbon sequestration is a mechanism for the removal of carbon from the atmosphere by storing it in the biosphere.

Estimation method of carbon sequestration

There are two methods of carbon estimation in tree species, destructive method and non-destructive method approved by many researches.

1) Destructive method

In destructive method need of harvest entire biomass with sacrifice the tree.

2) Nondestructive method

In this method no needs of harvest entire biomass with sacrifice the tree.

Allometric equation for calculating carbon sequestration

The height and diameter at breast height (DBH) are two main biophysical measurements which measured for each tree sample.

Estimation of Aboveground biomass

Above ground Biomass (AGB) are estimated by multiplying the bio-volume to the green wood density of tree species.

AGB (t/ha^{-1})	Total biomass (t/ha^{-1}) x woody density
Total biomass	Diameter (m) X Height (m)
Diameter	Girth breast height (GBH)/π
Height	Height of tree
Woody density	Wood density is used from Global wood density The standard averagedensity of 0.6 gm/ cm is applied wherever the density value is not available for tree species.

Estimation of belowground biomass

The Below Ground Biomass (BGB) includes all biomass of live roots excluding fine roots having <2mm diameter. Biomass estimation equations for tree roots are relatively uncommon in the literature. The belowground biomass (BGB) has been calculated by multiplying above-ground biomass taking 0.26 as the root to shoot.

$$BGB = AGB\ (t/ha^{-1}) \times 0.26$$

Estimation of Total Biomass

Total biomass is the sum of the above and below ground biomass.

Total Biomass (TB) = Above Ground Biomass + Below Ground biomass

Carbon Estimation

Generally, for any plant species 50% of its biomass is considered as carbon.

Carbon Storage = Biomass x 50% or Biomass/2

Benefits of Carbon Sequestration

- Improved soil structure.
- Better water use and storage.
- Increased soil fertility.
- Improved biodiversity.
- Healthier ecology.
- Importantly plant and soil carbon represents the only available buffer against the impacts of climate change already being experienced.

Conclusion

Carbon sequestration by green plants is a suitable way to reduce atmospheric CO_2. plant C sequestration is essential to improving the soil quality to increase agriculture productivity and achieve global food security and mitigate climate change by reducing emission of CO_2 Important management practices that enhance plant C sequestration include afforestation, adoption of conservation tillage with residue mulching and use of integrated nutrient management to achieve positive nutrient balance. Trading C credit is an option to enhance income of small land holders and poor farmers.

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