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Policy Article

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Opportunities and Challenges of Carbon Sequestration in Indian Condition

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Abstract

This study highlights the pressing issue of climate change, emphasizing global warming as a consequence of escalating CO2 concentrations attributed to human activities. It explores carbon sequestration as a pivotal strategy to mitigate atmospheric CO2 levels, encompassing geological, oceanic, and terrestrial methods. The significance of carbon sequestration is underscored by its potential to enhance soil structure, water management, erosion control, biodiversity, and overall ecological health. However, various challenges impede successful soil carbon sequestration, including deforestation, residue burning, conventional tillage, imbalanced fertilizer use, and reduced organic matter. Despite the acknowledged benefits, carbon sequestration encounters drawbacks such as costliness, potential hazards, and technical limitations. The abstract also elucidates opportunities for soil carbon sequestration through crop management, conservation tillage, nutrient management, and agroforestry. Emphasizing the intricate relationship between agricultural practices and carbon sequestration, the abstract underscores the need for sustainable solutions to address climate change while fostering agricultural productivity.

Introduction

Climate change is an important environmental issue that has captured the world's attention during the recent past. Global climate change commonly referred to as global warming, is a serious environmental issue affecting human life and planet earth. The continue increase in CO_2 concentration in the atmosphere is believed to be accelerated by human activities such as burning of fossil fuels and deforestation. One of the approaches to reducing CO_2 concentration in the atmosphere is carbon sequestration.

Carbon Sequestration

- Carbon Sequestration/ CO_2 storage is the placement of CO_2 into a depository in such a way that it remains safely stored and not released back to the atmosphere.
- Carbon sequestration (CS) refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground or the oceans, so that the buildup of CO_2 concentration in atmosphere will reduce or slow down (Lal, 1995).

Sources of Carbon dioxide emission

Man made Sources	**Natural sources**
Industries	Volcano
Land Use Change	Wild fires
Soil cultivation	Respiration
Transportation	Decomposition
Biomass Burning	

Ways that carbon can be sequestrated

Geological sequestration

Geologic carbon sequestration is a method of securing carbon dioxide in deep geologic formations to prevent its release to the atmosphere and contribution to global warming as greenhouse gas.

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.
- At the present time, approximately one third of human generated emissions are estimated to be entering the ocean.
- Geological and ocean carbon sequestration is not yet viable at a commercial level.

- Small scale projects demonstrated but carbon sequestration is still a developing technology due to high price of installing these carbon capture system.

Terrestrial sequestration

- The process through which CO_2 from the atmosphere is absorbed naturally through photosynthesis and stored as carbon in biomass and soils.

Importance of carbon sequestration

- Improved soil structure
- Better water use and storage
- Less erosion
- Increased soil fertility
- Improved biodiversity
- Healthier ecology
- Improved agricultural performance

Challenges in soil carbon sequestration

1. Deforestation

- Forests are the most effective system of carbon sequestration in Nature.
- Deforestation causes loss of a valuable resources of carbon sequestration along with additional increase of CO_2 in atmosphere.
- Deforestation accounts for an annual release of carbon between 90-250 Mt., about one third of which comes from oxidation of soil carbon in the tropics.

2. Residue burning

- This method is used to clear the land cheaply in short duration.
- It leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P and S.
- Heat generated from the burning of crop residues elevates soil temperature causing death of active beneficial microbial population.

3. Conventional Tillage

- Conventional agricultural practices such as ploughing, removal of crop residues, soil fertility mining and accelerated soil erosion are mainly responsible for low SOC in cultivated soils.
- Conventional tillage breaks soil aggregates
- It exposes organic C to microbial attack and weathering
- It causes more CO_2 emission.

4. Imbalance use of fertilizers

- Chemical and physical properties of soil are degraded which reduces the ability of soil to support plant and microbial growth.
- This results in reduced efficiency of soil and plants to sequester the carbon from atmosphere.

5. Reduced use of organic matter

- Organic matter is a key component of soil that affects its physical, chemical and biological properties, contributing greatly to its proper functioning on which human societies depends.
- Soil organic matter is made of organic compounds that are highly enriched in carbon.
- Soil organic carbon levels directly related to amount of organic matter contained in soil and SOC is often how organic matter is measured in soils.

Disadvantages of carbon sequestration

- It is a costly method and implementing it in power plants requires 40% more coal.
- If the injected gas leaks out because of structural faults in the geological formation, it can be fatal.
- The process of trapping and liquefying CO_2 from power plant emissions requires significant electric power.
- High amount of CO_2 injected into ocean will turn it acidic which endangering aquatic life.
- There may not be enough geological reservoirs available for sequestering carbon.
- Decomposing of mature tree plant after their death released CO_2 gas.

Opportunities to soil carbon sequestration

1. Crop management

Crop rotaion: It enhance C inputs

Fallow management: It reduce C losses

- To increase soil carbon levels through crop rotations that reduce fallow period.
- Especially crop rotation with fallow periods during the summer when temperatures result in maximum soil respiration rates

2. Conservation Tillage and Residue management

- Soil surface management, soil water conservation and management, and soil fertility regulation are all important aspects carbon sequestration in soil.

- Conservation tillage, a generic term implying all tillage methods that reduce runoff and soil erosion in comparison with plow based tillage, is known to increase SOC content of the surface layer.
- Principal mechanisms of carbon sequestration with conservation tillage are increase in micro-aggregation and deep placement of SOC in the sub soil horizons.

Crop residue Management

- Cost effective
- Economically beneficial to many producers and more importantly to society.
- Alternative for nutrient requirement
- Improve soil properties
- Improve species diversity of soil biota quality

3. Nutrient management

- Agricultural soils in India can be a **sink for rising atmospheric CO_2 concentrations** through the formation of soil organic matter (SOM) or humus.
- Humification is limited by the availability of nutrients such as nitrogen (N).
- Recommended management practices (RMPs) that optimize N availability **foster humus formation.**
- Nutrient management practices that contribute to maximizing N availability for optimizing sequestration of atmospheric **CO_2 into soil humus.**
- Farming practices that enhance nutrient use, reduce or eliminate tillage, and increase crop intensity, together, affect nutrient availability and, therefore, C sequestration.
- Nutrient additions, from especially, livestock manure and leguminous cover crops are necessary for **increasing grain and biomass yields** and returning crop residues to the soil thereby increasing soil organic carbon (SOC) concentration.
- Different cropping systems including, **cropping intensity and/or crop rotations** produce higher quantity and quality of residues, increase availability of N, and therefore foster increase in C sequestration.
- The benefit of C sequestration from N additions may be negated by CO_2 and N_2O emissions associated with production and application of N fertilizers.
- More studies need to be conducted to ascertain the benefits of **adding N via manuring** versus N fertilizer additions. Furthermore, site specific adaptive research is needed to identify RMPs that optimize soil nutrient use efficiency while improving crop yield and C sequestration thereby curbing greenhouse gas (GHG) emissions.

4. Agroforestry

- Forestry has been recognized as means to reduce CO_2 emissions as well as enhancing carbon sinks. Forests are large sink of carbon and their role in carbon cycles is well recognized.
- Agroforestry is the land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound and sustainable land use system.
- Agroforestry provides a unique opportunity to creating synergies between both adaptation and mitigation actions.

Conclusion

Soil carbon sequestration provide vast opportunity to sequester carbon in soil. A diversity of agricultural management practices can be employed to sequester more carbon in plants and soil like crop management, Nutrient management, conservation tillage and residue management and Agroforestry. Soil carbon reduce greenhouse gases by sequestrated carbon, increase in soil carbon which leads to increasing soil fertility, water retention and increasing crop yield.

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