Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 02 (MAR-APR, 2022)
Available online at http://www.agriarticles.com

Soil Carbon Sequestration: A Way to Improve Soil Health under Changing Climatic Conditions

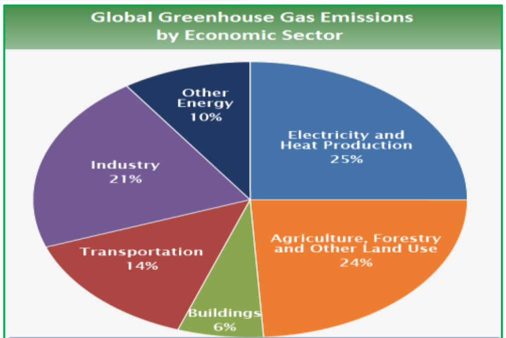
(*Mehak Nagora[1] Sharad Nagora[1] Sumit Bhardwaj[1] and Shital Kumar[2])
[1]College of Agriculture, CCS Haryana Agricultural University, Hisar, Haryana
[2]ICAR-Indian Agricultural Research Institute, New Delhi, India
* mehaknagora4@gmail.com

Since the industrial revolution, greenhouse gas emissions have increased tremendously, notably from the mid- to late-twentieth century onwards. There are many greenhouse gases which causes greenhouse effect *i.e.* carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Chlorofluorocarbons (CFCs). All these gases have different life time (years) and global warming potential (100 years) which decides their contribution to changing climatic conditions (Table 1). The major anthropogenic cause for the emission of these gases is burning of fossil fuels to generate electricity. There are many other sectors which causes emissions of these greenhouse gases as represented in Fig. 1.

Table 1: Life time (years) and Global Warming potential (100 years) of different Greenhouse gases (Source: IPCC Climate Change report, 2014)

Greenhouse gas	Life time (years)	Global Warming potential (100 years)
Carbon dioxide (CO_2)	50-200	1
Methane (CH_4)	12	25
Nitrous oxide (N_2O)	114	298
	Chlorofluorocarbons (CFCs)	
Hydrofluorocarbons (HFCs)	Upto 270	14800
Perfluorocarbons (PFCs)	2600-50000	12200
Nitogen trifluoride (NF_3)	740	17200
Sulphur hexafluoride (SF_6)	3200	22800

Deforestation, biomass burning, conversion of natural to agricultural ecosystems, wetlands draining, and soil cultivation all contribute to land use change-related greenhouse gas (GHG) emissions. Additionally, higher carbon emissions are caused by soil carbon depletion due to land exploitation, increased dependency on agrochemicals, and soil degradation. Increases in atmospheric CO_2 and global temperatures may have a range of consequences on soil carbon inputs, including an effect on photosynthetic rates and



Worldwide emission contribution by different sectors, 2019 Report carbon losses through respiration and organic matter breakdown. Increased CO_2 concentrations cause plants to fix more carbon via photosynthesis, resulting in increased biomass. Carbon loss, on the other hand, may rise as a consequence of higher plant respiration as a result of increased root biomass or as a result of increased microbial activity. Similarly, rising temperatures may have an effect on the carbon balance by restricting the availability of water and so lowering photosynthetic rates. On the other side, when water is plentiful, rising temperatures may boost plant productivity, affecting the carbon balance as well. Increased temperatures may also result in increased rates of SOM decomposition, leading in increased CO_2 generation and positive feedback effects on climate change.

The transfer of natural ecosystems to agricultural use has led in the decrease of SOC levels since the industrial revolution. This is a result of decreased plant roots and residues returning to the soil, increased decomposition caused by soil tillage, and increased soil erosion. The depletion of SOC stores has created a soil carbon deficit, presenting an opportunity to store carbon in soil through a variety of land management strategies. As a result, the carbon content of soil must be increased. Climate change, particularly growing levels of carbon dioxide (CO_2), gives a good opportunity for soil carbon sequestration.

What is soil carbon sequestration?

Soil carbon sequestration, often known as "carbon farming" or "regenerative agriculture," is a technique that involves extracting CO_2 from the atmosphere and storing it in the soil carbon pool. This is mostly accomplished by plants through photosynthesis, with carbon stored as SOC.

Factors affecting carbon Sequestration capacity

The carbon sequestration capacity of the soil may be influenced by local controls on ecosystem processes:

Regions: The forest region stored the most carbon (15990 kg C ha^{-1} yr^{-1}), probably due to the ecosystem's greater aptitude for physical and chemical interaction as compared to other locations.

Rainfall infiltration: Carbon sequestration occurred at a faster pace in wet areas due to increased precipitation than in dry ones. Differences in precipitation patterns can have a significant influence on community composition, as well as on the structure and function of the ecosystem. Annual grasslands' carbon cycle will be less susceptible to variations in rainfall amount and more impacted by changes in seasonal rainfall timing, with a longer or later wet season resulting in considerable carbon losses from annual grasslands.

Soil type: Oxisols trapped the most carbon (2205 kg C ha^{-1} yr^{-1}). The soil carbon pool is composed of two components: the soil organic carbon (SOC) pool and the soil inorganic carbon (SIC) pool. The SIC pool is particularly essential in desert soils. SOC concentrations range from very low in desert soils to quite high in temperate soils and extremely high in peat soils.

Soil temperature: Carbon sequestration occurs at a rate that varies with mean yearly temperature. Carbon sequestered rose from less than 150°C to 250°C, at which point it decreased. Additionally, the SOC pool varies significantly between ecoregions, being greater in cold and wet regions than in warm and dry parts. The key rate determinant of microbial activities is soil temperature. As a result, increasing soil temperature accelerates mineralization, resulting in a drop in the SOC pool.

Slope: Slope location has an effect on soil moisture and nutrient levels, which has an effect on plant root development and may have an effect on soil carbon.

The combined impacts of variations in carbon inputs and losses from land use, as well as the effects of land management on carbon input and loss rates, result in heterogeneity in the capacity of landscapes to sequester carbon.

Ways to soil carbon sequestration

Carbon sequestration in soil is performed in a variety of methods, including the following:

1. Reducing soil disturbance through the use of no-till or low-till practises or the cultivation of perennial crops.
2. Changing planting dates or rotations, for example, by planting cover crops in place of fallow lands.
3. Avoid cattle overgrazing.
4. Frequent application of compost or agricultural leftovers to fields.

Co-Benefits

1. Improved soil health
2. Increased climate resilience
3. Decreased fertiliser usage

Concerns

1. Measurement difficulty: measuring and validating carbon removal by soil carbon sequestration is complex and expensive.
2. Saturation: soils have a restricted capacity to store carbon.
3. Reversibility.

Conclusion

SOC storage occurs as a result of dynamic biological processes such as photosynthesis, breakdown, and soil respiration interacting. Human activities have disrupted these processes over the last 150 years, leading in the depletion of SOC and amplification of global climate change. However, these human activities now provide a mechanism for soil carbon sequestration. Future warming and increasing CO_2, as well as previous land use patterns and management practises, together with the physical variety of landscapes, are anticipated to result in complex patterns of SOC capacity in soil. Thus, the significance of land management techniques in carbon sequestration is being evaluated as a component of acceptable mitigation strategies in order to promote sound land management as a means of accomplishing agricultural and environmental goals.

References

1. Chou, W.W., Silver, W.L., Jackson, R.D., Thompson, A.W. and ALLEN-DIAZ, B.A.R.B. A.R.A. (2008). The sensitivity of annual grassland carbon cycling to the quantity and timing of rainfall. *Global Change Biology*. 14(6): 1382-1394.
2. Drake, B.G., Gonzàlez-Meler, M.A., and Long, S.P. (1997). More efficient plants: a consequence of rising atmospheric CO_2. *Annual review of plant biology*. 48(1): 609-639.
3. Ehrenfeld, J.G., Kaldor, E. and Parmelee, R.W. (1992). Vertical distribution of roots along a soil top sequence in the New Jersey Pinelands. *Canadian Journal of Forest Research*. 22(12): 1929-1936.
4. FAO (2014). Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks. *Climate, Energy and Tenure Division. FAO*. 89.
5. Hungate, B.A., Holland, E.A., Jackson, R.B., Chapin, F.S., Mooney, H.A. and Field, C.B. (1997). The fate of carbon in grasslands under carbon dioxide enrichment. *Nature*. 388(6642): 576-579.

6. IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. 151.
7. Knapp, A. K., Fay, P. A., Blair, J. M., Collins, S. L., Smith, M. D., Carlisle, J. D., ... & McCarron, J. K. (2002). Rainfall variability, carbon cycling, and plant species diversity in a mesic grassland. *Science*. 298(5601): 2202-2205.
8. Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science*. 304(5677): 1623-1627.
9. Lal, R. (2009). Sequestering atmospheric carbon dioxide. *Critical Reviews in Plant Science*. 28(3): 90-96.
10. Lemus, R. and Lal, R. (2005). Bioenergy crops and carbon sequestration. *Critical Reviews in Plant Sciences*. 24(1): 1-21.
11. Maracchi, G., Sirotenko, O., and Bindi, M. (2005). Impacts of present and future climate variability on agriculture and forestry in the temperate regions: Europe. *Climatic change*. 70(1): 117-135.
12. Ontl, T.A. and Schulte, L.A. (2012). Soil Carbon Storage. *Nature Education Knowledge*. 3(10):35.
13. Pataki, D. E., Ellsworth, D.S., Evans, R.D., Gonzalez-Meler, M., King, J., Leavitt, S.W., and Ehleringer, J.R. (2003). Tracing changes in ecosystem function under elevated carbon dioxide conditions. *Bioscience*. 53(9): 805-818.
14. Zak, D.R., Pregitzer, K.S., King, J.S. and Holmes, W.E. (2000). Elevated atmospheric CO2, fine roots and the response of soil microorganisms: a review and hypothesis. *The New Phytologist*. 147(1): 201-222.