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Regenerating Agricultural Soils through Organic Carbon Enrichment

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Introduction:

Soil is the world's second-largest active carbon sink, after oceans, storing 1,500 billion tons of carbon in their organic matter worldwide. The world's most intricate and diverse ecosystem is found in soils. Their ability to store carbon and water is crucial for soil fertility because it releases nutrients for plant growth and maintains the biological and structural integrity of the soil. Of all the possible natural climate solutions, 25% come from soil organic carbon. However, the industrial agricultural revolution of the last century has mainly ignored soil health and biodiversity below ground. In addition to increasing greenhouse gas emissions, unsustainable land management methods that deteriorate soils also lower soils' capacity to store carbon and maintain agricultural output. Over 3.2 billion people are adversely impacted by the 20-40% of the world's geographical area that is degraded or decaying to varied degrees. Thus, improving soil health is essential for increasing food landscape productivity and can greatly impact mitigating climate change. The term "soil health" describes the soil's capacity to maintain terrestrial ecosystems' productivity, variety, and environmental services. Healthy soil ensures high productivity and environmental health (site-specifically), which improves ecosystem services. Building soil organic carbon and reducing greenhouse gas emissions are linked to soil health, which sustains the entire ecosystem. The soil's physical, chemical, and biological characteristics- all of which are interrelated- determine the health of the soil. A healthy soil is a requirement for long-term crop production. Gaining knowledge of and making improvements to these characteristics will increase crop yield and quality as well as the soil's potential for productivity. As a result, preserving the fertility and health of the soil can enhance food security and nutritional results. A more productive and sustainable agriculture can be achieved by implementing sustainable techniques such as cover cropping, less tillage, and the addition of organic matter. These activities can considerably enhance soil organic carbon.

Keywords: Soil health, organic matter, organic carbon, soil management, organic content

What is soil organic carbon?

The component of organic remains in soil at different stages of decomposition is known as soil organic matter, or SOM. SOM enhances soil health considerably even though it makes up a minor portion of the soil matrix. Large volumes of water and nutrients are retained by SOM because of its physical and chemical characteristics, which enhance soil biodiversity, lower erosion and leaching, and improve water and nutrient availability. Carbon, sometimes called soil organic carbon (SOC), is the primary ingredient in SOM. Because soils are essential to the carbon cycle of our planet, this carbon makes up the biggest terrestrial carbon reservoir. Globally, more carbon is found in the top 30 centimeters of the soil than in the atmosphere and vegetative cover put together. According to the Intergovernmental Technical Panel on Soils (ITPS), "the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems" is the definition of soil health. Since SOC is a necessary component for soils to offer various services, it is a crucial sign of the health of the soil.

Importance of soil organic carbon:

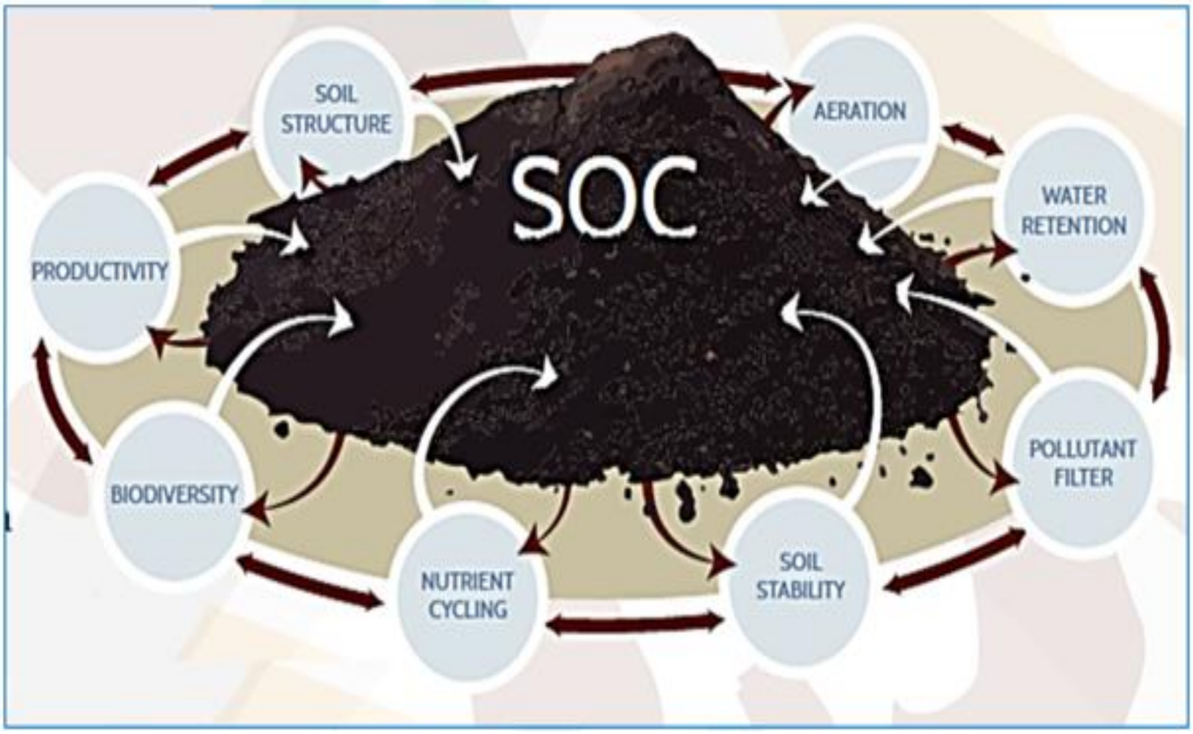
- **Foundation of soil health:** SOC is a crucial measure of soil health since it affects microbial activity, water retention, and nutrient availability. By helping to create soil aggregates, SOC enhances the structure of the soil. Better plant development and increased agricultural yields result from this increased root penetration, water infiltration, and soil aeration.
- **Climate regulation:** SOC absorbs carbon dioxide from the atmosphere and functions as a carbon sink, which helps to mitigate climate change. A healthy SOC can play a critical role in controlling the global carbon cycle by regulating the release and absorption of greenhouse gases.

- **Biodiversity support:** For the proper cycling of nutrients and the health of plants, a diversified and active soil microbial population is fostered by healthy SOC levels. Ecosystem functions like pollination, disease, and pest management, and pollution detoxification are supported by healthy levels of SOC.
- **Resilience to environmental stress:** SOC increases soil's capacity to control surplus water during floods and retain water during droughts, strengthening agricultural systems' resistance to extreme weather. Long-term agricultural productivity is ensured by soils with high organic carbon content because they are better able to tolerate and respond to the effects of climate change.
- **Economic benefits:** SOC makes the soil more fertile and structurally sound, which lessens the need for chemical pesticides and fertilizers and promotes more economical and environmentally friendly farming methods. Higher crop yields and improved food security are typically the results of more productive soils with a high SOC content.

Practices enhance soil organic carbons:

- **Cover cropping:** In addition to reducing nutrient leaching and preventing soil erosion, planting cover crops like legumes, grasses, or brassicas between main crop cycles also enriches the soil with organic matter as the cover crops break down. Leguminous cover crops can fix nitrogen from the atmosphere, improving soil quality and encouraging SOC buildup.
- **Conservation tillage:** Minimizing soil disturbance through techniques like no-till or reduced-till farming helps to conserve soil structure, lower erosion, and sustain SOC levels. Crop leftovers that are left on the field as opposed to being removed or burned contribute to the soil's organic matter content, which raises SOC.
- **Organic amendments:** Applying compost derived from food waste, manure, or plant leftovers raises the soil's organic matter content and raises SOC levels. By adding stable organic carbon sources, such as well-decomposed manure or biochar (a type of carbon-rich charcoal), soil fertility is increased and SOC is raised.
- **Agroforestry:** By increasing organic matter inputs from leaf litter, root biomass, and pruning, adding trees and shrubs to agricultural systems (such as alley cropping and silvopasture) improves soil organic carbon (SOC). Trees play a major role in the accumulation of SOC by storing carbon above and below ground.

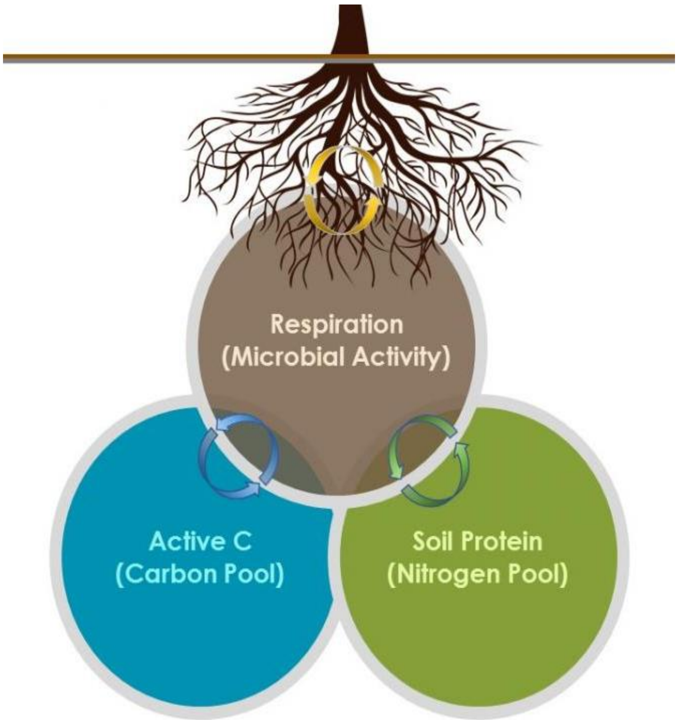
- **Grazing management:** Shifting cattle across pasture areas reduces overgrazing, which promotes root growth and manure deposition, both of which contribute to SOC and help preserve vegetation cover. In degraded grazing pastures, SOC can be increased by adding organic amendments, reseeding with legumes or grasses, and enhancing pasture management.
- **Mulching:** When organic mulch (such as straw, leaves, or wood chips) is applied to the soil's surface, it inhibits weed growth, retains moisture, contributes organic matter, and increases soil organic carbon (SOC) as the mulch breaks down. Mulching aids in controlling soil temperature, which fosters microbial activity and the breakdown of organic materials, both of which advance SOC.



Long-term sustainability:

1. One of the main sources of important nutrients, including sulphur, phosphorus, and nitrogen, is SOC. These nutrients are released as organic matter breaks down over time, guaranteeing a steady supply that promotes crop growth without diminishing soil reserves. Soils can naturally give nutrients by keeping a healthy SOC level, which lessens the demand for synthetic fertilizers. This minimizes the negative effects of chemical use on the environment while also saving farmers money.

2. SOC improves the soil's water-retention capacity, strengthening its resistance to dry spells. This is especially crucial in drought-prone regions where crop development is constrained by the availability of water. High SOC soils are better able to adapt to changing rainfall patterns in the face of climate change, lowering the chance of crop failure and guaranteeing steady agricultural productivity.



3. Soil microbes, which are vital for functions including organic matter breakdown, nutrition cycling, and disease prevention, mostly obtain their energy from SOC. Soil fertility and resilience are guaranteed for the long run by a robust, diversified microbial community. Soil microbes, which are vital for functions including organic matter breakdown, nutrition cycling, and disease prevention, mostly obtain their energy from SOC. Soil fertility and resilience are guaranteed for the long run by a robust, diversified microbial community.
4. By storing carbon that would otherwise contribute to greenhouse gas emissions, SOC functions as a long-term carbon sink. The long-term storage of carbon in the soil through SOC management is a critical component in the mitigation of climate change. Carbon is prevented from returning to the atmosphere over time by practices that increase soil organic carbon (SOC). This aids in the worldwide endeavour to lower CO_2 levels in the atmosphere.
5. Long-term crop production stability and the prevention of food insecurity are made possible by soils with high SOC levels, which also promote sustainable agricultural livelihoods. Reducing the need for outside inputs, cutting production costs, and improving the financial sustainability of farming operations are all achieved through sustainable SOC management. Long-term agricultural sustainability is aided by this.

Conclusion:

For sustainable agriculture and environmental resilience, soil health must be restored through Soil Organic Carbon (SOC) management. Improved soil fertility, water retention, and carbon sequestration result from raising SOC levels, and healthier, more fruitful soils are the end result. Sustaining long-term agricultural sustainability and preventing climate change are two important goals of effective SOC management, which will guarantee a sustainable future for the earth and our food systems.

References:

Bhaduri, D., Sihi, D., Bhowmik, A., Verma, B. C., Munda, S., & Dari, B. (2022). A review on effective soil health bio-indicators for ecosystem restoration and sustainability. *Frontiers in Microbiology*, *13*, 938481.

Meena, R. S., Das, A., Yadav, G. S., & Lal, R. (Eds.). (2018). Legumes for soil health and sustainable management.

Ngong, F. C. (2024). Sustainable soil revival with successional agroforestry.

Rao, D. L. N. (2013). Soil biological health and its management. *Soil health management: productivity-sustainability-resource management. FDCO, New Delhi*, 55-83.

Vamshi, M., Jagadeesan, R., Lamani, H. D., Rout, S., VijayKumar, R., Jagadesh, M., & Sachan, K. (2024). The Revolutionary Impact of Regenerative Agriculture on Ecosystem Restoration and Land Vitality: A Review. *Journal of Geography, Environment and Earth Science International*, *28*(4), 1-14.

Wanjari, R. H., & Singh, M. (2019). Soil Sustainability and Quality Assessment from Long Term Fertilizer Experiments: A Step Forward to Improve and Revive Crop Productivity and Soil Health. *SS Narkhede, AD Rane, GD Shirke, VG More and MC Kasture*, *43*, 9.