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Carbon sequestration through phytolith - Oil palm

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Introduction

Climate change mitigation through carbon sequestration in phytoliths involves leveraging the natural process by which certain plants form these silica structures to lock away carbon for extended periods. This method is part of broader carbon management strategies aimed at reducing atmospheric CO_2 levels and thereby mitigating global warming. Phytolith carbon sequestration is a process in which carbon is stored in phytoliths, which are microscopic silica structures formed within the cells of certain plants. These phytoliths, sometimes called "plant stones," can encapsulate small amounts of carbon during their formation. When plants die and decay, phytoliths can remain in the soil for thousands of years, effectively locking away the carbon they contain. Phytolith carbon sequestration is particularly significant in grasslands, forests, and agricultural systems where silica-accumulating plants are prevalent. Understanding and enhancing this natural process could be a valuable tool in global carbon management strategies.

Phytolith carbon sequestration contributes to climate change mitigation:

1. **Long-term Carbon Storage**: Phytoliths encapsulate organic carbon within their silica structures. Due to their durability and resistance to decomposition, the carbon sequestered in phytoliths can remain in the soil for thousands of years, providing a stable and long-term carbon sink.
2. **Resilience to Environmental Changes**: Unlike organic matter that can decompose and release CO2 back into the atmosphere, phytoliths are resilient to environmental changes, making them a reliable means of carbon storage.
3. **Agricultural Practices**: Incorporating crops that produce high amounts of phytoliths, such as grasses (including bamboo and rice), into agricultural practices can enhance carbon sequestration. This approach can be integrated with sustainable farming practices to maximize carbon storage while maintaining soil health and productivity.

Phytolith Occluded carbon

1. **Formation**: Phytoliths form when plants absorb silica from the soil, which precipitates within plant cells, often in the stems, leaves, and roots.

2. **Carbon Encapsulation**: During the formation of phytoliths, organic carbon from the plant can become encapsulated within the silica structure.
3. **Longevity**: Phytoliths are highly resistant to decomposition, allowing the sequestered carbon to remain in the soil for long periods, potentially thousands of years.
4. **Environmental Impact**: This process contributes to long-term carbon storage and can help mitigate atmospheric CO_2 levels, playing a role in combating climate change.

Carbon sequestration in Oil palm

Oil palm carbon sequestration refers to the process by which oil palm plantations absorb and store carbon dioxide (CO_2) from the atmosphere. Oil palms, like other plants, photosynthesize, taking in CO_2 and converting it into biomass through growth. This process contributes to the reduction of atmospheric CO_2, a greenhouse gas, thereby mitigating climate change.

Oil palm plantations can sequester carbon in various ways:

1. Biomass: Carbon is stored in the trunks, leaves, and roots of the oil palm trees.
2. Soil: Carbon can also be sequestered in the soil through organic matter from fallen leaves, fruits, and other plant residues.

The potential for carbon sequestration in oil palm plantations depends on factors such as plantation management practices, the age of the palm trees, and soil health. While oil palm cultivation has been criticized for deforestation and habitat loss, sustainable practices can enhance its role in carbon sequestration and contribute to environmental sustainability.

Carbon storage capacity of oil palm

A study conducted by Lamade and Bouillet, 2005, the oil palm ecosystem in different ecologies have been calculated for the major productive countries in Africa, Asian and American continents. Comparisons with several natural forest types and other planted ecosystems, such as eucalyptus and coconut, were made. Regarding the extremely high rate of carbon sequestration by the oil palm ecosystem between 250 and 940 C m^{-2} yr^{-1} (estimates including harvested bunches) carbon budget components such as NPP, autotrophic and heterotrophic soil respiration, litter, and fine litter contributions were studied.

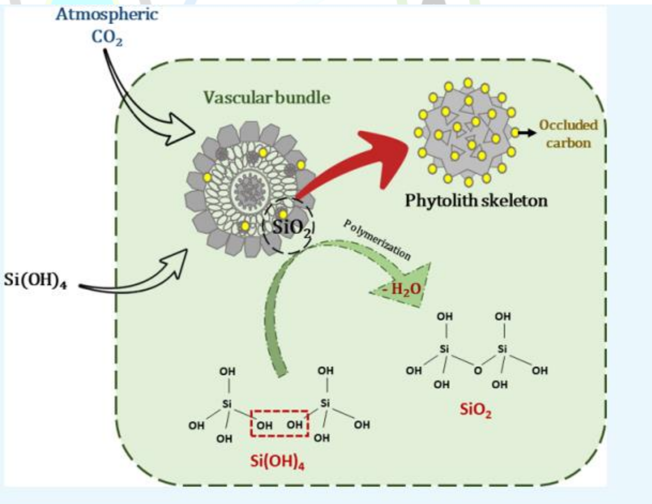

Fig. Phytolith in oil palm

Another study conducted by Borbon *et al.*, 2020, revealed the potential for sequestering carbon from oil palm farms, particularly in two regions of Mindanao, Philippines. Oil palm trunk biomass was determined using an allometric equation. Destructive techniques were also employed to calculate the biomass of the remaining oil palm components (fruits, leaves, and fronds). Measurements were made of the carbon stocks in the soil, litterfall, and understory of the oil palm farms. The average carbon stock in the oil palm farms, according to the results, is 40.33 tC/ha. The oil palm plant contains the majority of the carbon stock (53%), with soil (38%), litterfall (6%), and understory (4%), following closely after. It is projected that oil palm plants sequester 4.55 tC/ha/year on average. In order to prevent "carbon debts," it is suggested that oil palm expansions take place on grasslands and barren areas rather than in forests. Additionally, it is advised that oil palms be planted alongside shrub crop species to improve soil organic carbon and raise aboveground biomass in oil palm plantations.

Recently Davamani *et al.* (2022) proved that, Oil palm (*Elaeis guineensis*), is a species rich in phytolith-occluded carbon (PhytOC), which is essential for functioning as a carbon sink to lower the concentration of carbon dioxide (CO_2) in the atmosphere. They calculated the silicon, phytolith, and PhytOC contents in oil palm plantations that were four (OP4), eight (OP8), and fifteen (OP15) years old. Using a scanning electron microscope (SEM) for qualitative analysis, it was discovered that fronds, empty fruit bunches, and roots had a large number of globular echinate phytoliths with a diameter ranging from 8.484 to 10.18 µm.

Moreover, the amorphous character of silica was highlighted by a broad band (400–490 cm^{-1}) that highlighted a larger relative abundance of Si-OH groups in empty fruit bunches, fronds, and roots. The concentrations of phytolith (phytolith/dry biomass), PhytOC (PhytOC/phytolith), and PhytOC (PhytOC/dry biomass) increase with age, according to quantitative study. There was a noticeable fluctuation in the PhytOC stock, with OP15 > OP8 > OP4. The greatest PhytOC content was found in the belowground biomass of OP4 (16.43 g kg^{-1}) and OP8 (17.13 g kg^{-1}) as compared to the aboveground biomass, with the belowground fraction varying between 20.62 and 20.65%. Oil palm should be grown for improved long-term sequestration as a phytolith accumulator, since the study showed a favorable association between the phytolith and PhytOC contents of the plant.

Conclusion:

Grasslands, savannas, and forests with high densities of phytolith-producing plants contribute significantly to phytolith carbon sequestration. Preserving and restoring these ecosystems can enhance their natural carbon sequestration capabilities. Advances in understanding the role of phytoliths in carbon sequestration can lead to innovative practices and policies aimed at enhancing this natural process. Research into plant species selection, soil management, and the ecological dynamics of phytolith formation can optimize the sequestration potential. By incorporating phytolith carbon sequestration into climate change mitigation strategies, we can enhance the natural processes that remove CO_2 from the atmosphere. This approach, combined with other carbon sequestration methods, renewable energy adoption, and emission reductions, forms a comprehensive strategy to combat climate change.

Reference:

Davamani, Veeraswamy, Ramasamy Sangeetha Piriya, Srirangarayan Subramanian Rakesh, Ettiyagounder Parameswari, Selvaraj Paul Sebastian, Periasamy Kalaiselvi, Muthunalliappan Maheswari, and Rangasamy Santhi. "Phytolith-occluded carbon sequestration potential of oil palm plantation in Tamil Nadu." *ACS omega* 7, no. 3 (2022): 2809-2820.

Borbon, Sheila Mae C., Michael Arieh P. Medina, Jose Hermis P. Patricio, and Angela Grace Toledo-Bruno. "Carbon Sequestration Potential of Oil Palm Plantations in Southern Philippines." *bioRxiv* (2020): 2020-04.

Lamade, Emmanuelle, and Jean-Pierre Bouillet. "Carbon storage and global change: the role of oil palm." (2005).