BIOCHAR IN CARBON SEQUESTRATION: A SOLUTION FOR CLIMATE CHANGE

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There has been a significant increase in the CO_2 emission in the last few years, resulting in rise in global temperature triggering the need for effective ways to sequester carbon. Out of the numerous options explored, terrestrial carbon sequestration especially in soils has emerged as a universally important method in combating CO_2 emissions from human activities. This method not only supports global cycle of carbon while at the same time reducing the volume of CO_2 released into the atmosphere. India and other tropical countries face the challenge of managing soils that have low organic matter as a result of extensive farming and high temperatures resulting to significant CO_2 loss. The farming practices employed in these regions leads to the loss of soil organic carbon which poses the problem of long-term carbon storage in soils. This calls for utilization of biochar which protects organic matter in soils through the formation of stable organo-mineral complex to mitigate climate change by sequestering carbon in soil (Lehmann et al. 2021).

WHAT IS BIOCHAR AND HOW IT APPEARS?

Biochar is a porous material like fine charcoal which is produced under high temperature and lack of oxygen by a method known as pyrolysis. The pyrolysis process converts organic materials like biomass into a stable type of carbon (recalcitrant in nature) that is resistant to decay (Skjemstad et al. 2002). This stability of biochar renders it as a good source for carbon sequestration techniques. Biochar can be derived from an array of organic materials, for instance, agricultural wastes, wood chips and even waste materials from the urban centres. The process of pyrolysis not only locks carbon in a solid form but also makes a product that is beneficial to agriculture in several ways. Biochar has a porous structure which allows better soil aeration and increased water retention in soil and provides a niche for useful microorganisms.

CONTRIBUTION OF BIOCHAR TOWARDS SOIL FERTILITY AND AGRICULTURE

There is one aspect of biochar that remained interesting, i.e. the use of biochar in boosting soil fertility. In the Brazilian Amazon region, it was discovered that soil with biochar, referred to as “Terra Preta” or “Black Earth”, is more fertile than normal soils. It was found that this kind of soil was very fertile because of the ability of biochar to reduce nutrient and water leaching from the soil thereby making the nutrients more readily available to plants (Glaser et al. 2000; Lehmann et al. 2021).

Besides enhancing the fertility of the soil, biochar also aids in combating against climate change as it helps in the long-term storage of organic materials in the soil (Lehmann et al. 2021). The highly condensed structure of carbon in biochar ensures that carbon is prevented from rapid decomposition into CO_2. By incorporating biochar into soil, farmers are able to boost the production of crops while also achieving global efforts to sequester carbon.

THE ROLE OF BIOCHAR ON SOIL ORGANIC CARBON DYNAMICS

Interrelation with preexisting soil organic carbon (SOC) largely credits the biochar's potential to sequester carbon. Upon application, biochar changes the native soil organic matter's decomposition and this interrelation is often termed as the "priming effect". The soil's organic thermal decomposition can either be suppressed through negative priming or stimulated through positive priming (Coumar et al., 2024). In cases of positive priming, biochar may enhance microbial activity by providing essential nutrients like nitrogen, phosphorus, and micronutrients. This, in turn, can accelerate the breakdown of native soil carbon, potentially offsetting the carbon sequestration benefits of biochar. On the other hand, negative priming occurs when biochar stabilizes organic matter through adsorption or the formation of organo-mineral complexes, leading to a reduction in carbon mineralization.

IMPACT OF BIOCHAR TYPES ON ORGANIC CARBON DYNAMICS IN SOIL

Different types of biochar can have varied effects on soil carbon dynamics. For instance, biochar made from pigeon peas and biochar made from hardwood differ in their carbon stability and nutrient content. As a result, their interaction with soil organic carbon dynamics also varies. Hard wood (*Prosopis sp.*) biochar is relatively dense with more polyaromatic hydrocarbon (PAH) as compared to soft wood biochar (Pigeon pea). This makes the hard wood biochar resistant to microbial decomposition, leading to greater stability of carbon in soil which provides a viable alternative for the long-term carbon sequestration (Coumar et al., 2024).

The Pigeon pea biochar, obtained from the pigeon pea plant which is a legume, has been shown to have a different chemical composition which makes it more likely to be partly mineralized in the soil. Furthermore, pigeon pea biochar could also improve microbial population and nutrient cycling. It is important to note these differences as they influence the choice of biochar to use for soil management and carbon sequestration.

CHALLENGES IN THE USE OF BIOCHAR IN AGRICULTURE

Biochar has a potential to enhance carbon sequestration while also improving the soil structure; nonetheless there are concerns that need to be addressed before the technology is adopted at a wider scale. One such barrier is the differences in properties of biochar which are a result of the type of biomass being used for biochar production and other factors like the conditions under which it is produced. The temperature, duration, and method of pyrolysis all affect the chemical and physical characteristics of the resulting biochar, making it essential to tailor biochar production to the specific needs of different soils. In addition, cost effective and farmers friendly biochar production technologies needs to be explored for large scale adoption of biochar use in agriculture at farm levels.

BENEFITS OF BIOCHAR BEYOND CARBON SEQUESTRATION

Biochar has several important environmental advantages in addition to its function in carbon sequestration. Because it enhances soil nutrient retention, its use in agriculture may help lessen the demand for chemical fertilizers. As a result, runoff of phosphorus and nitrogen, two main causes of water pollution in agricultural areas, may decrease. Additionally, it has been demonstrated that biochar lowers soil emissions of nitrous oxide (N_2O) and methane (CH_4). Both CH_4 and N_2O are strong greenhouse gases that have a far higher potential to cause global warming than CO_2. Beyond its capacity to retain carbon, biochar can contribute to combat against climate change by reducing these emissions.

FUTURE RESEARCH: EXPLORING THE FULL POTENTIAL OF BIOCHAR

Even while our knowledge of biochar's function in carbon sequestration has advanced significantly, there is still more to learn. The long-term impacts of biochar on agricultural yield, carbon storage, and soil health are being investigated by the researchers. Furthermore, biochar's ability to clean up contaminated soils (Coumar et al.,2016) and absorb pollutants like heavy metals is gaining attention, making it a useful instrument for environmental restoration. More studies are also needed to understand how biochar interacts with various soil types and climates. Further studies are needed in the area of the priming effect in particular, to find out how biochar may be utilized most successfully for carbon sequestration without compromising the stability of existing soil organic matter.

CONCLUSION

A promising tool for tackling some of the most important issues, such as soil erosion, climate change, and agricultural sustainability, is biochar. Biochar helps to lessen the effects of rising CO_2 levels in the environment by storing carbon in the soil. It is also a useful tool for farmers looking to increase crop yields in a sustainable manner because of its capacity to improve soil fertility and water retention. It is becoming more and more evident that biochar has enormous potential for the future of agricultural and environmental management as studies continue to find new uses and advantages for this age-old substance. By adding biochar to soil management techniques, we may make significant progress toward creating a future that is more sustainable and resilient.

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