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BIOCHAR AS CARBON SEQUESTRATION POTENTIAL

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Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass, such as wood, manure or leaves have been subjected to thermo-chemical conversion process (pyrolysis) at a temperature between 350 to 600 °C in an environment with little or no oxygen. While much of this carbon ultimately returns to the atmosphere as soil microbes decompose carbon-based plant biomass and release carbon dioxide, soil carbon stores can increase if the rate of carbon inputs exceeds the rate of microbial decomposition. Carbon sequestration refers to this process of storing carbon in soil organic matter and thus removing carbon dioxide from the atmosphere.

Introduction

Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass, such as wood, manure or leaves have been subjected to thermo-chemical conversion process (pyrolysis) at a temperature between 350 to 600 °C in an environment with little or no oxygen (Amonette and Joseph, 2009). Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions. Slow pyrolysis temperature ≤500 °C and hydrothermal carbonization are two efficient methods to produce biochar in high amount (Malghani *et al*., 2013). Biochar is commonly considered to be highly aromatic and containing random stacks of graphitic layer.

Soil's store three times more carbon than exists in the atmosphere. Plants absorb atmospheric carbon during photosynthesis, so the return of plant residues into the soil contributing to soil carbon. While much of this carbon ultimately returns to the atmosphere as soil microbes decompose carbon-based plant biomass and release carbon dioxide, soil carbon stores can increase if the rate of carbon inputs exceeds the rate of microbial decomposition. Carbon sequestration refers to this process of storing carbon in soil organic matter and thus removing carbon dioxide from the atmosphere.

Persistence of Biochar Carbon in Soil

While biochar does contain high levels of carbon, there remains uncertainty as to how long that carbon will persist in the soil following application. The inherent characteristics of the biochar--as dictated by feedstock and pyrolysis conditions--interact with climatic conditions such a precipitation and temperature to influence how long biochar carbon remains stored in the soil. Recent studies suggest that shorter pyrolysis times and higher pyrolysis temperatures make for more recalcitrant biochar (i.e., it persists for longer periods in the soil). However, there are trade-offs involved as these pyrolysis conditions produce less biochar per unit feedstock. As is so often the case, soil texture plays a key role in determining the persistence of biochar carbon. Biochar becomes stabilized in the soil by interacting with soil particles.

Clay particles have more surface area for biochar to interact with and are therefore more effective at stabilizing biochar. Biochar is carbon negative and thus resulting in long-term removal of carbon from the atmosphere. Mitigation of carbon emissions is obtained not only from biochar soil application, but also from substitution of fossil fuel by the produced bio-oil. The mechanisms of biochar stability is mainly due to the composition changes through a complete destruction of cellulose and lignin, thus changes the appearance of aromatic structures Biochar has been preferentially found in fractions of SOM that reside in aggregates rather than as free organic matter.

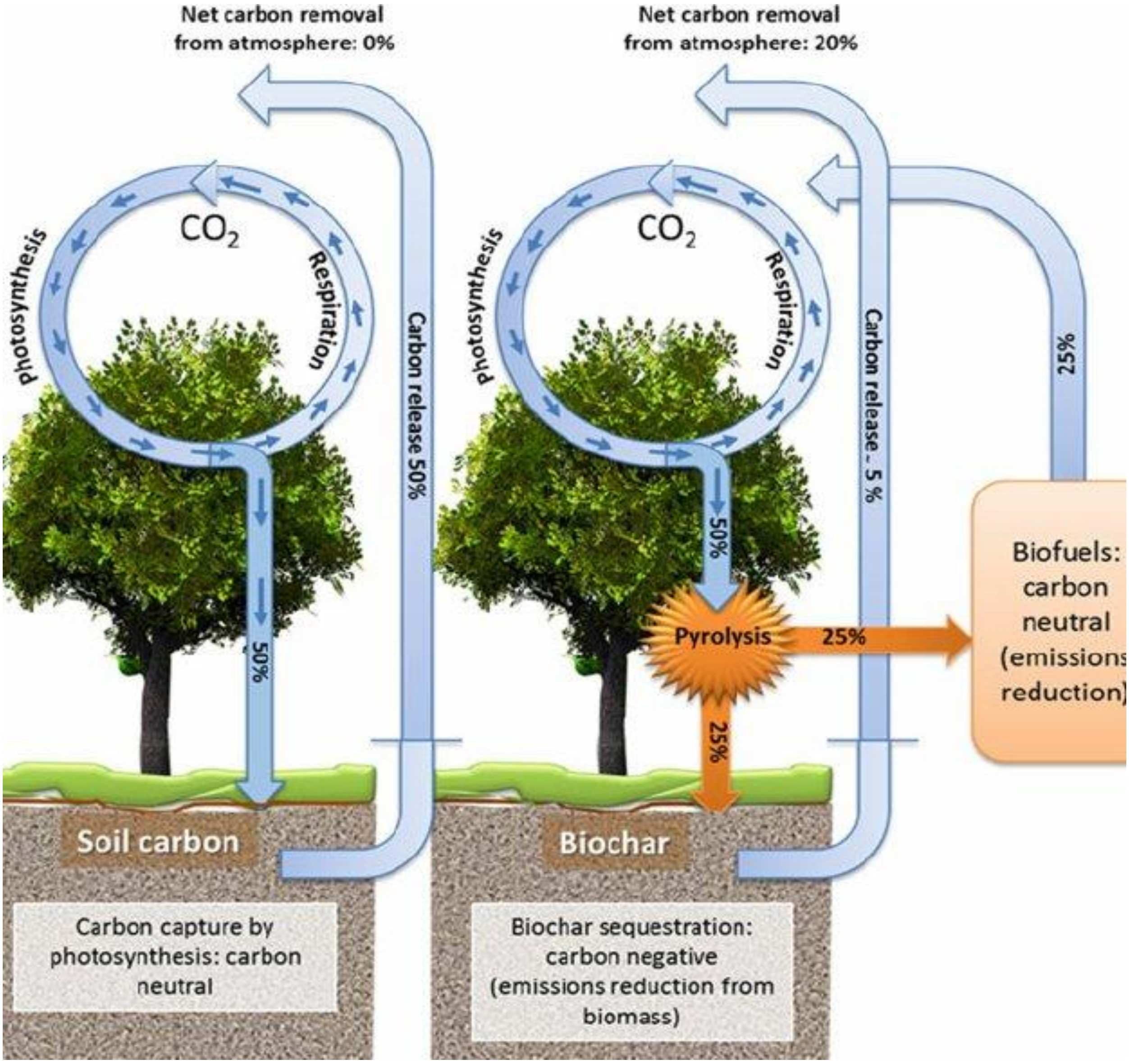

Figure.1. Depicting Principle of Biochar Sequestration.

The Priming Effect

A number of studies have observed an increase in the rate of organic matter decomposition following biochar application. This so-called "priming effect" complicates any efforts to sequester carbon as this increase in microbial activity could result in decomposition rates exceeding carbon input rates (see figure above). While the exact mechanism responsible for this effect has not been conclusively identified, it may result from the stimulation of microbial activity as microbes utilize carbon and nitrogen present in biochar. Biochar remains a hot topic with regards to increasing soil carbon stores and helping fight climate change. However, many questions remain before definitive conclusions about what conditions allow for biochar to positively contribute to soil carbon sequestration.

Conclusion

Biochar has the potential to sequester (rather than simply store) carbon into the biosphere. Sequestration could be at the Gt scale using currently available feedstock, given suitable policy and economic instruments. Pyrolysis offers bio-energy co-products with the potential to exceed the carbon gain (abatement) from combustion. Therefore, biochar application is a promising alternative to sequester more C compared to more traditional agricultural practices involving direct incorporation of biomass, which results in immediate and rapid mineralization, and CO_2 release.

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