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Unveiling The Potential of Biochar in Sustainable Soil Management

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Biochar:

Biochar is a charcoal-like substance produced from agriculture and forest wastes. It has high active carbon surface area that is produced through anaerobic heating of biomass. Composition-wise, it contains 70% carbon and the remaining elements are hydrogen, oxygen and nitrogen. Biochar is used as soil enhancer to increase fertility, prevent soil degradation and to sequester carbon in the soil. It improves soil fertility by retaining water and nutrients in soil, encouraging beneficial soil organisms and thereby reducing the need for additional use of fertilizers. Biochar can store carbon in the soil for as many as hundreds to thousands of years. Biochar technology is different from the conventional charcoal production because it is highly efficient in the conversion of carbon and harmful pollutants are not released upon combustion (Lee *et al.*, 2023). Hence, it is a cleaner and more efficient technology. If this technology is used sustainably, the by-products in the form of oil and gas can substitute for a cleaner and renewable fuel option.

One of the simplest ways of making biochar is through the thermal decomposition of the biomass (waste from agriculture and forest). It can be done in three different ways, namely, Pyrolysis, Gasification and Hydrothermal carbonization. In all these processes, biomass is heated at a high temperature in the absence of air. This releases the volatile gases leaving behind carbon rich biochar. During pyrolysis, a high proportion of carbon remains within the biochar giving it a very high recalcitrant nature. This increases the soil water and nutrient holding capacity (Forbes *et al.*, 2006). Biochar can be produced at small and large scales. Small scale production can be through pyrolysis using modified stoves and kilns which are low cost and relatively simple technologies. For large scale production, larger pyrolysis plants and adequate feed stocks are required which is more capital cost intensive (Pratt & Moran, 2010).

The intensity of pyrolysis determines the product and by-product obtained from the process. For example, more bio-oil and syngas are obtained when fast pyrolysis is done at high temperature, while slow pyrolysis yields more biochar than by-products. Figure 1 demonstrates the biochar production through the pyrolysis process. This not only produces bio-char but also produces clean energy like syngas and bio-oil which can be used for producing heat, power or combined heat and power. Biochar producing cook-stoves are more popular in developing countries. The pyrolysis temperature of 450-500ºC might be difficult to attain in gasification stoves to make biochar. However, most of the stoves can produce 25-30% of biochar (by weight) from the initial feedstock. This is the maximum weight of biochar that can be obtained from the slow pyrolysis process.

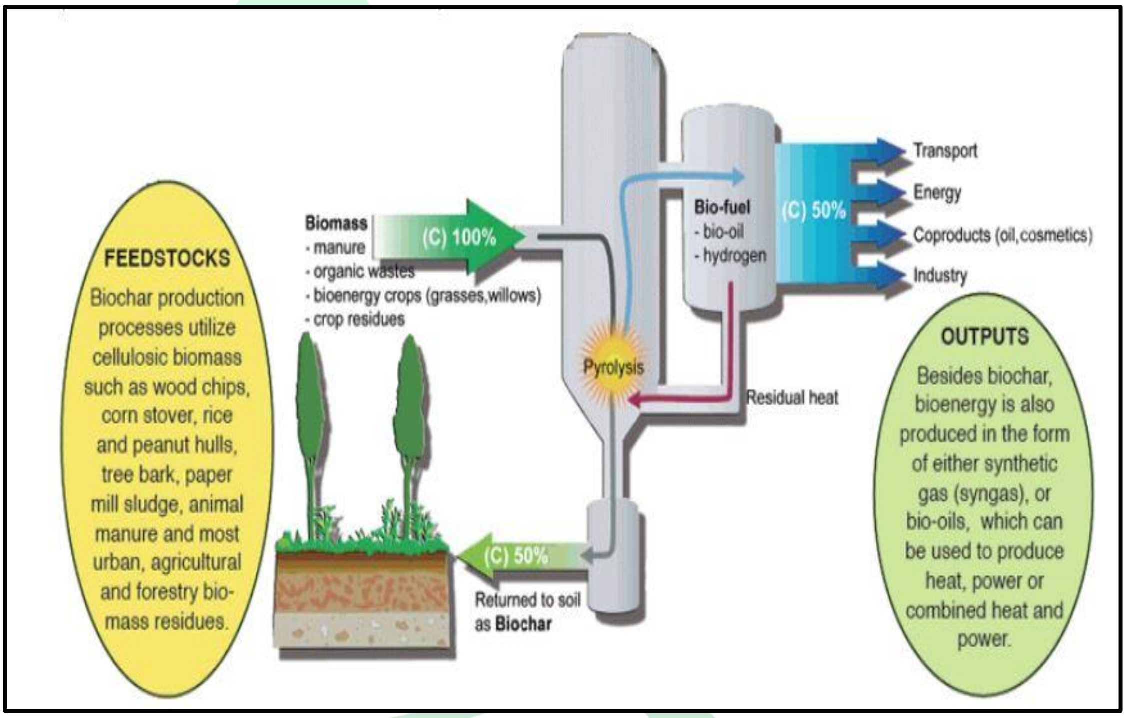

Figure 1: Production process of Biochar

Uses of Biochar

In agriculture, biochar can be used as growth promoter, soil conditioner and soil amendment. A soil conditioner is a product which is added to soil to improve the soil's physical qualities, usually its fertility (ability to provide nutrition for plants) and sometimes its mechanics. Soil conditioners can be used to improve poor soils, or to rebuild soils which have been damaged by improper soil management. Biochar can make poor soils more usable, and can be used to maintain soils in good fertile and productive condition.

Effects of Biochar on Soil Health

1. Physical properties

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- Biochar reduces soil bulk density
- Biochar increases soil aeration
- Biochar lessens the hardening of soils
- Biochar helps to reclaim degraded soils
- Increases Cation Exchange Capacity

2. Chemical properties

Significant changes in soil quality, including pH increase, organic carbon and exchangeable cations were observed at higher rates of biochar application.

- Biochar reduces soil acidity by increasing pH (also called the liming effect).
- Biochar helps in retention of soil nutrients and fertilizers
- Biochar increases C, N, and P availability to plants, because biochar adsorbs and slowly releases the adsorbed nutrients.
- Biochar increases the soil levels of available Ca, Mg, P, and K.
- Biochar adsorbs herbicides and pesticides in soil, thus reducing their toxic effects.

3. Nutrient use efficiency

Long term benefits of biochar application on nutrient availability is mainly due to a greater stabilization of organic matter, concurrent slower nutrient release from added organic matter and better retention of all cations due to a greater cation exchange capacity.

4. Soil microbial activity

Biochar provides a suitable habitat for a large and diverse group of soil microorganisms. Symbiosis between effective microbes and plant root through the medium of charcoal, that promotes the growth of plants.

5. Effect of Biochar on Soil Water availability

Biochar addition to soils had mixed results with regard to modifying soil hydraulic conductivity. Some experiments have reported improvements in hydraulic conductivity after biochar additions to a silt and sandy loam textured soil, respectively. In contrast no significant change has been reported in hydraulic conductivity for biochar applied to loam and clay textured soils, respectively.

Disadvantages of Biochar

- Biochar applications sometimes disturb the physical and chemical balances of nutrients in the rhizosphere.

- Biochar generally helps the growth of undesirable weeds.
- Biochar manufacturing is relatively expensive.

Method of Application

Like any other organic amendments, biochar can be applied to soil by different methods including broadcasting, band application, spot placement, deep banding etc. However, the method of biochar application in soil depends on the farming system, available machinery and labour. Application of biochar by hand is well known, but is not viable on largescale because of labour intensity and human health concerns due to prolonged contact with airborne biochar particulates. In developed countries, several large scale biochar trials have been conducted using a tractor propelled lime spreader. Similarly, deep banding of biochar has been successfully implemented in several wheat fields in Western Australia. Mixing of biochar with composts and manures may reduce odours, and improve nutrient performance over time due to slower leaching rates.

Rate of Biochar Application

Rate of application of biochar depends on many factors including the type of biomass used, the degree of metal contamination in the biomass, the types and proportions of various nutrients (N, P, etc.), and also on edaphic, climatic and topographic factors of the land. Experiments have found that rates between 5-50 t/ha (0.5-5 kg/m^2) have often been successful. Application of higher amounts of biochar may increase the carbon credit benefit; but, in nitrogen-limiting soils it could fail to assist crop productivity as a high C/N ratio leads to low N availability (Lee *et al.*, 2023)**.** Crop productivity benefits of higher biochar application rates can be maximized only if the soil is rich in nitrogen, or if the crops are nitrogen-fixing legumes. Therefore, application of biochar to soils in a legume-based (e.g. peanut and maize) rotational cropping system, clovers and lucerne are more beneficial.

References

Forbes, M. S., Raison, R. J., & Skjemstad, J. O. (2006). Formation, transformation and transport of black carbon (charcoal) in terrestrial and aquatic ecosystems. *Science of the total environment*, *370*(1), 190-206.

Lee, J., Lee, S., & Park, Y. K. (2023). Reduction of odor-causing compounds in wastewater using biochar: A review. *Bioresource Technology*, 129419.

Pratt, K., & Moran, D. (2010). Evaluating the cost-effectiveness of global biochar mitigation potential. *Biomass and bioenergy*, *34*(8), 1149-1158.