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# An Introduction to Biochar and Its Potential as Soil Amendment

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## What is Biochar?

Biochar is the carbon-rich charred organic matter, resulting from the heating of biomass in an oxygen-limited environment.
In a physico-chemical (physical appearance and chemical properties) sense, biochar and charcoal are essentially the same material; but there are differences between biochar and normal charcoal, based on their production method and intended use. Charcoal is the solid product of natural fire and produced for fuel by traditional biomass conversion from high value feedstock (raw materials used for biochar production), whereas biochar is the charcoal material which has a non-fuel use and is produced to promote beneficial effect for the sustainability of our environment. It helps capturing atmospheric carbon (C) and therefore when used as soil amendment improves soil's capacity to sequester C. Biochar is generally made from a lower value feedstock and usually contains higher levels of nutrients and mineral ash which can be favourable soil additives. In addition, biochar could provide an effective long-term store of C in soil than normal charcoal, and thus provide an abatement option for anthropogenic C emissions. However, properties of biochar vary immensely depending on production type, heating and residence time, level of activation, and most certainly feedstock characteristics. Therefore, in brief, as a material, biochar is defined as: "charcoal specifically made for application to soil".

Chemical characteristics of biochar and charcoal

| Component | Weight by % (Biochar) | Weight by % (Charcoal) |
|---|---|---|
| Carbon | 98.58 | 92.04 |
| Hydrogen | 0.4 | 2.45 |
| Oxygen | 0 | 2.96 |
| Nitrogen | 1 | 0.53 |
| Sulphur | 0.02 | 1.00 |

## Uses of Biochar

The principal reasons of applying biochar to soil are -
1. High affinity to nutrients (adsorption)
2. High persistence (stability)

Biochar is considered 'carbon negative' as it removes carbon dioxide ($CO_2$) from the atmosphere, reduces the soil's need for water, helps to increase the growth rate in plants, increases soil fertility, and most importantly, it can be applied to most types of soils. Other environmental benefits of biochar application are to rehabilitate contaminated wetlands and to assist in managing the aquatic ecosystems through adsorption of nutrients. Because of its large surface area, biochar provides a secure habitat for the microbes and help to reduce the bioavailability of organic compounds. Biochar application is increasingly promoted world-wide for restoration of infertile soils and also to increase soil's C sequestration potential.

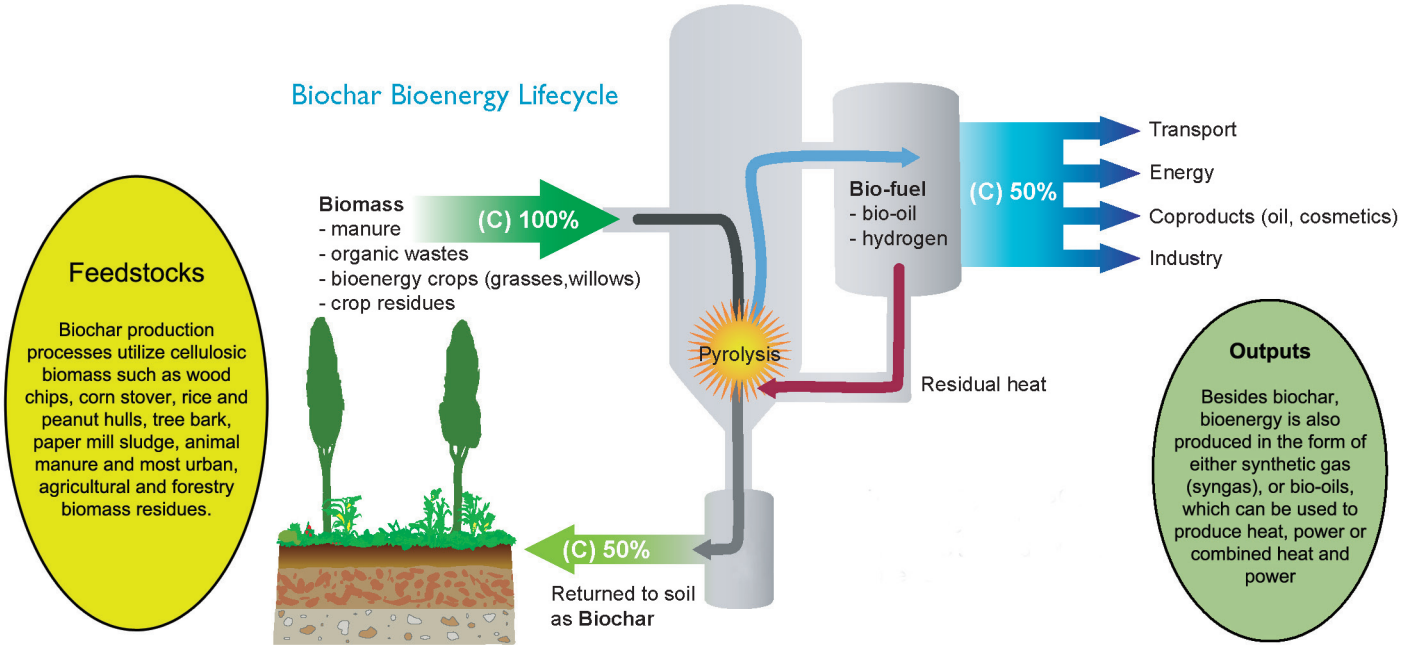
The estimated residence time of biochar- C is hundreds to thousands of years and therefore has the potential to act as an effective C sink in soil; consequently, would help to mitigate greenhouse gas emission by sequestering atmospheric $CO_2$. The growing cost of waste disposal is likely to make the production and application of biochar for electricity and waste management economically viable.

## Production of Biochar

The process used for biochar production is known as 'pyrolysis', which is the thermal conversion of biomass feedstock by slow heating at temperatures between 450 – 650°C in the absence of oxygen. The output of this pyrolysis are biochar (35%), bio-oil (30%) and syngas (35%) in approximately equal proportions.

The raw materials used as feedstock may include a wide variety of biomass, such as wood chips, animal manure and most of the urban, agricultural and forestry biomass residues. The efficiency of pyrolysis plants may vary because of the type, quality and composition of the biomass feedstock being used. The raw material and the temperature at which pyrolysis takes place can affect the physical properties of biochar and thereby affecting it's impact on soil. A commercial pyrolysis plant can operate feedstock at 50-100 ton/day.

Production of Biochar - Pyrolysis Process (CSIRO, 2010)




Source: International Biochar Initiative *(http://www.biochar-international.org/biochar/soils)*

## Application of Biochar

Before application, characterization of biochar material is important as it will vary depending upon the feedstock material it is made from. Because of its relatively low density, there is risk of erosion by wind and water, therefore the application strategies have to be devised accordingly to minimize loss due to wind and water erosion. One of the best management practices is the proper incorporation of biochar into the soil and add water immediately after the application to avoid its loss due to erosion. Application rate of biochar varies according to soil type and should be based on extensive research trials. Experiments conducted by CUGE Research revealed that application of local charcoal at 50% by volume significantly improves the chemical properties of sand based growing media used for turfgrass and urban tree plantation. Due to its long-term stability, single application of biochar can provide beneficial effects for several

years. There is also interest in blending it with other materials such as synthetic fertilizers, compost and manures to enhance its value as a soil amendment.

## Research on Biochar

A number of studies world-wide showed the advantage of applying biochar for mitigating global warming and as an active strategy to manage soil health and productivity. The objective of the biochar concept is to abate the enhanced greenhouse effect by sequestering C in soils, while concurrently improving soil quality. International Biochar Initiative (IBI) specifies the need for application of the material to soil for agricultural and environmental gain. However, to date, most of the research on biochar has concentrated on the agricultural soils and no studies have examined biochar's impacts on urban soil quality. Urban soils are often deficient in C, available nutrients, and biological activity; because biochar has high affinity for nutrients and long persistence, it can be a superior organic amendment for urban soil restoration.

Addition of biochar as a soil amendment is not widely used in Singapore because of unavailability of the material in this part of the world. CUGE Research has conducted an incubation experiment in a controlled environment using commercial char product ('hort carbon'), collected locally (coarse and fine) and four different types of soil-based root zone mixes typically used for turf grass and rooftop application such as clay loam soil, Approved Soil Mix (ASM, 3 soil:2 compost:1 sand), 50/50 (sand/soil) and 75/25 (sand/soil). The char material was mixed thoroughly at three different rates (25, 50 and 75% by volume) with the soil mixes. Results showed that application of char (both coarse and fine) significantly increased the organic matter content and nutrient status (total N, extractable P, K, Ca and Mg) of the soils.

Following the above results, CUGE will conduct further research on efficacy of biochar for restoring soil quality for the growth of urban trees. These studies will determine whether biochar can replace sand in the growing media such as ASM. These studies will help to identify appropriate application rates and procedures for urban tree management with biochar. In these studies, we will also consider the economic aspect of biochar as an urban soil amendment compared to other current materials.

## Suggested reading


- *http://www.css.cornell.edu/faculty/lehma nn/research/biochar/biocharmain.html*
  Biochar and soil management in Cornell University, USA.
- *www.biochar-international.org*
  The International Biochar Initiative provides a platform for the international exchange of information and activities in support of biochar research, development, demonstration and commercialization.
- *www.biochar.org*
  University of Georgia maintains a website with a variety of information about biochar.
- *www.biochar-europe.org*
  Bio-Char Europe aims to promote the development of a large-scale bio-char industry within Europe.
- *www.biochar.bioenergylists.org*
  Information on the intentional use of biochar to improve soils.
- *http://www.anzbiochar.org/biocharbasics.html*
  Australia and New Zealand Biochar Research Network