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# Biochar basics

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## What is Biochar?

Biochar is an extremely complex stable form of carbon produced by the controlled heating of plant and/or animal material (biomass feedstock) at high temperatures (350 – 600$^{o}$C) in a low oxygen environment. The technique of heating in a low oxygen environment is called pyrolysis.

Biochar's complex chemical structure is defined by the feedstock it is made from and the temperature conditions used in its manufacture.

Biochar is a form of charcoal but is different in that biochar is produced in controlled conditions so that most of the carbon is converted to usable products. Charcoal usually has a total carbon content of over 75% whilst biochar often has much less total carbon (often 40-75%) but it has a higher mineral content, containing minerals such as Calcium(Ca), Potassium (K), Phosphorus (P) and Nitrogen (N).

## Are all biochars the same?

No two biochars are the same. The characteristic of any biochar is a function of the material from which it is made and the temperature conditions used to make it. The range of biochars available could be considerable, representing the wide range of feedstock, temperature, residence times and heating rates used in their creation.

Biochar made from material such as animal manure or broiler litter will have a greater nutrient content than a biochar made from carbon rich materials such as municipal green waste or tree prunings.

Biochars produced at high temperatures such as 600°C have greater porosity and higher adsorptive qualities compared to biochar produced at 400°C. However, while most of the carbon from a feedstock pyrolysed at high temperatures is converted to energy, more carbon is recovered in lower temperature pyrolysis

As the characteristics of biochar vary widely it is difficult to state categorically what benefits biochar can provide beyond the addition of carbon to the soil and alternative waste management. The creation of biochar may generate energy and mitigate climate change while some biochars may

*Biochar made from papermill residues.*

*Biochar made from green waste.*

be useful as soil nutrient amendments.

*Table 1 Basic chemical characteristics of three biochars produced at 450$^{o}$C*

| Feedstock | Poultry litter | Green waste | Papermill |
|---|---|---|---|
| **N (%)** | 2.2 | 0.25 | 0.44 |
| **P (%)** | 2.4 | 0.049 | 0.11 |
| **K (%)** | 2.1 | 0.0072 | 0.047 |
| **Lime equivalency (CaCO3 (%))** | 14 | 0.90 | 7.50 |
| **Total C (%)** | 35 | 66 | 37 |

## What are the benefits to agriculture?

Many of the benefits attributed to the application of biochar to the soil are related directly to the resulting increase in carbon.

Biochar applications have been shown to increase crop (biomass) production and applications to soil have been shown to:

- improve nutrient storage, CEC
- increase soil carbon content
- increase Water Holding Capacity
- increase soil pH
- decrease Aluminium toxicity
- decrease tensile strength
- change microbiology of the soil
- decrease greenhouse gases emissions from the soil ($N_2O$ and $CH_4$ )
- improve soil conditions for earthworm populations
- improve fertiliser use efficiency.

However in other research it has been found to have no influence on the above aspects, the results being highly dependent on the type of biochar as well as crop, soil type and climatic conditions. It appears that where positive effects occur the biggest impacts are on highly degraded sites that are nutrient poor and/or acidic.

To maximise the benefit of an addition of biochar to the soil it is important to know why it is being added. As seen previously, biochar made from animal wastes can have nutrient values that enable it to be used as a nutrient source for plants as well as a carbon source. Biochar made from carbon rich materials is primarily useful for increasing soil carbon levels but supplies little in the way of plant available nutrients.

However it is important to remember that use of this technology is new to modern agriculture and experts state that there is “no rapid screening technique currently available that provides the means for biochar products to be compared or matched to a particular use.” (anzbiochar.org/index.html)

## Biochar and climate change

The benefits of biochar in mitigating climate change may be substantial but more research and appropriate legislation are needed to accompany its use.

| Predicted benefits | Implications |
|---|---|
| **Increased biomass production** | ▪ Greater atmospheric C uptake,<br>▪ Carbon sequestration through greater biomass production,<br>▪ Potentially reduced soil emissions of non- $CO_2$ Green house gases,<br>▪ Reduced requirement for N fertilisers. |
| **Increased soil C** | ▪ C sequestration |
| **Waste reuse** | ▪ Reduced methane production from landfill |
| **Renewable energy production** | ▪ Offset of fossil fuels, |

The production of biochar can provide a net storage of carbon providing the process is well engineered. In this situation the storage of carbon (or carbon dioxide equivalents ($CO_2e$) is greater than the production of $CO_2e$ for a full life cycle assessment. In contrast, carbon from crop and plant residues is generally released back into the atmosphere within 2 to 5 years.

During pyrolysis, stable carbon structures are formed, which are extremely resistant to microbial attack preventing carbon release back into the atmosphere. The stability of biochar depends on the type of biomass used, temperature and length of heating, surface to volume ratio of the particles, soil and climatic conditions.

Generation of renewable energy by pyrolysis also requires a well engineered facility. The high energy gases such as hydrogen ($H_2$) methane ($CH_4$) and carbon monoxide (CO) released can be either converted into thermal energy or electricity. The amount of energy released during the pyrolysis process is again highly dependant upon the biomass feedstock as well as the pyrolysis conditions.

## Can I make my own biochar?

Biochar has been made in the shifting cultivation regions of South American and in Japan for centuries. However, to make a high quality uniform product and prevent the formation of toxic substances some time and investment in constructing a pyrolysis kiln/stove is required. The kiln must be designed so that the high energy gases (syngas, pyrolysis gas) and particulates which are produced during pyrolysis are disposed of safely. This gas may be used as an energy source but must be managed with care for human health and greenhouse gas emission reasons.

In the simplest kilns high energy gases are captured and burned (flared). This converts the methane back into $CO_2$ which is a far less damaging greenhouse gas. Low-tech “stoves” are used in many developing countries for cooking purposes, enabling the effective recycling of agricultural wastes such as rice husk into energy and biochar, which is then returned to the paddock.

*Large scale biochar production plant at Somersby.*

**Further reading:**

anzbiochar.org/index.html

www.biochar-international.org/workgroups

www.bodgershovel.com/index.htm

http://www.dpi.nsw.gov.au/research/topics/biochar

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