Biochar explained

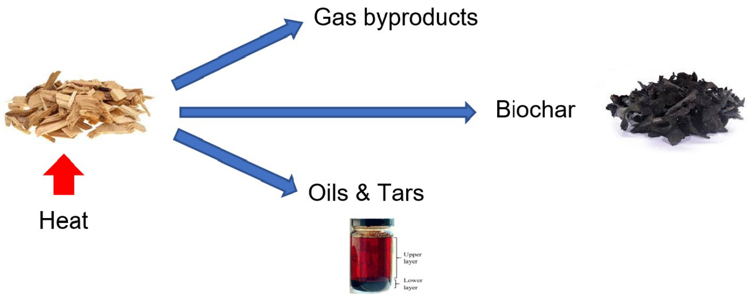
What is the difference between charcoal, biocarbon and biochar?

Biocarbon and biochar are both solid, carbon-rich materials obtained from the pyrolysis of biomass. Both are similar to charcoal but vary in their ultimate fate (energy or carbon storage). The familiar barbeque 'charcoal' is a form of biocarbon.

- Biocarbon production via pyrolysis holds considerable promise for co-production of industrial heating, electricity generation, and as solid, liquid and gaseous feedstocks for many industries:
  - biocarbon as a reductant where fossil fuel carbon such as coal is currently used
  - biocarbon as a coal replacement for industries requiring high carbon and energy content feedstocks
  - bio-coal production by optimising for energy density at lower temperatures (torrefaction)
  - as activated carbon (after steam or chemical treatment).
- Biochar can be produced in the same industrial pyrolysis equipment as biocarbon with the same co-products. The key difference is in the fate of the solid carbon component of the process. Biocarbons are generally short-lived forms of carbon, returning to CO2 via combustion and reduction processes. The carbon in biochar can be utilised for many purposes, all of which intentionally retain the carbon in its solid form for as long as possible.
- Biochar can be produced from a wide range of carbon rich feedstocks, including biomass residues and process wastes. Biocarbon production usually targets high carbon / low ash and high value biomass.
- Biochar can also be produced as a co-product of gasification technologies or a byproduct of industrial combustion boilers (incomplete combustion of biomass).

How is biochar produced?

Biochar (charcoal and biocarbon) is produced by heating biomass in an oxygen-free or air-limited environment.

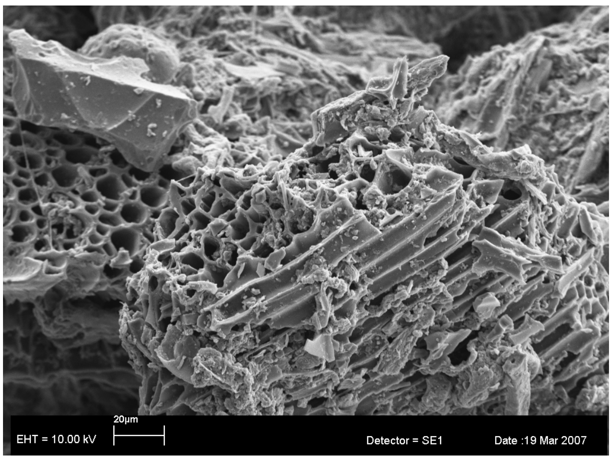


Biochar can be produced in many ways (old and new), many scales and under a wide range of process variables (temperature, heating rate, biomass form):

- Pyrogenic carbon can be found in many soils due to naturally occurring fire cycles. This carbon component of soils can be replicated and augmented with the application of biochar.
- Traditional charcoal production methods, such as smouldering in earth mounds or beehive kilns, are typically slow, polluting, and inefficient. Because of the lower temperatures in these processes, the charcoal produced has a high level of hydrocarbons remaining and is less suitable for many of the applications appropriate to biochar. It is also less long-lived and will degrade or decompose in soil.
- New small-scale technologies or methodologies are being developed for household or farm-scale biochar production: TLUD cookstoves; TLUD drums; ‘flame-cap’ vessels, pits or trenches; top-lit burn piles with artisan fire management; simple ‘retort’ containers.
- Small- to medium-scale commercial technologies include gasifiers for the production of syngas, industrial heat/power and some biochar; pyrolysis systems for the production of biochar, industrial heat, and potentially a range of condensates (pyroligneous acids, oils and tars).
- Large industrial-scale gasification and pyrolysis technologies have historically been dedicated to waste management or metal reductant processes. Opportunities may arise to repurpose large industrial equipment toward biochar production, as and when the application economics are demonstrated.
- Specialised equipment and processes are in existence and being developed for particular industries and feedstocks: fast/flash pyrolysis; microwave assisted pyrolysis; hydrothermal carbonisation, biofuels technologies.

What are biochar’s key attributes?

Biochar is a stable form of carbon derived from renewable biomass. Biological processes can not easily break the chemical carbon bonds. This leads to a number of important attributes and opportunities for agriculture and environmental services.



Biochar SEM image Co/ Dr Robert Hill, Bio-Protection NZ

- **porosity & surface area**: biochar production from the pyrolysis retains the vascular structure of the biomass. This is similar to biomass-based activated carbon and provides many moisture management and aeration functions that benefit soils and plants.
- **chemistry**: most of the carbon in biochar is tightly bound (aromatic) but at surface boundaries there are many opportunities for chemical (& electrical) interaction with minerals, molecules and biology. Many of the minerals in the original biomass are also retained in the biochar and can provide pH and nutrient benefits.
- **Stability**: a key chemistry attribute but worthy of separate attention due to the focus on climate change and the growth of carbon markets. Each tonne of carbon bound as biochar is theoretically equivalent to 3.66 TCO2e (44/12) but the stability and *carbon cost* of production must be factored. Biochar standards are discussed in more detail later.

What is biochar being used for?

The international focus on using biochar in agriculture applications began about 15 years ago but it has re-emerged from ancient origins. Scientific interest, research and commercial applications have proliferated. The brief listing in this technical note groups these applications as follows:

- **Agriculture applications:** soil enhancement (water holding, aeration and structure improvement, pH buffering, nutrient management); animal feed supplements; animal bedding; carrier substrate (prebiotics, probiotics, beneficial bacteria & fungi)
- **Environmental services:** stormwater swales; rain garden media; green roofs
- **construction and engineering:** aggregate for concrete and plasters; bitumen supplement; anaerobic digestion (AD) supplement;
- **specialist applications:** energy storage (capacitors & batteries); low cost AC; filtration and adsorption media (similar to activated carbon)
- **cascading uses:** examples - farm (biomass management > feed supplement > dung beetles > soil enhancement > environmental services); urban (woody greenwaste management > energy + biochar > stormwater swales > environmental service); (Municipal sludge > energy + biochar > AD + water polishing > environmental service)
- **climate change:** C sequestration**;** ruminant methane reduction; NoX reduction from soils & agriculture; ammonia reduction in poultry and animal bedding.

Considerations in producing biochar for the market

Various applications require biochar with specific properties to meet agricultural, environmental, engineering, or process requirements. The raw biomass type, moisture, density and composition as well as pyrolysis conditions (slow vs fast pyrolysis) and temperature greatly influence properties. The original biomass carbon content will have some effect but pyrolysis conditions play a more significant role in the final product. With an increase of pyrolysis temperature or residence time, the carbon content, energy content, grindability, porosity and surface area are higher with a lower bulk density.

Standards and C sequestration eligibility

One of the primary drivers for economic production of biochar is likely to be the price of carbon credits, either through a government-operated cap and trade system like the NZ Emissions Trading Scheme, or via a voluntary market such as Puro.earth. In order for this value to be properly attributed, quantification of the carbon stored in biochar needs to be robust and verifiable, and must take into account the complete lifecycle analysis (LCA) of production and application, along with reliable models of its longevity in the environment.

Traditional mound or kiln production of charcoal without the combustion of pyrolytic gases is unsatisfactory not only for its carbon inefficiency and its overall environmental footprint, but also as a result of the low quality and longevity of the product. Accordingly, those methods are unsuitable for the production of biochar to be used in agriculture or industry. Modern pyrolysis plants as well as certain types of farm-scale methods such as flame cap pyrolysis systems are now ready to produce biochar from a large variety of different feedstocks in an energy efficient way and without harming the environment. As both biochar properties and the environmental footprint of its production are largely dependent on the pyrolysis parameters and the type of feedstocks to be used, a reputable LCA system for its production and application will be required.

European Biochar Certificate

An example of an existing standards framework is the European Biochar Certificate http://www.european-biochar.org/en/home, which was developed to limit the risks of biochar usage according to the latest scientific knowledge and to help the users and producers of biochar to prevent or at least reduce any hazard for the health and for the environment while producing and using biochar. Currently, the European Biochar Certificate is a voluntary industry standard in Europe. In Switzerland, however, it is obligatory for all biochar sold for use in agriculture.

IBI Standards

The IBI Biochar Certification Program is a voluntary scheme administered by the International Biochar Initiative (IBI) to provide certification of biochar products. The purpose of the program is to provide to biochar manufacturers the opportunity to demonstrate that their biochar(s) meet the minimum criteria established in the most recent version of the IBI Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil (also referred to as the IBI Biochar Standards).

Biochar Network New Zealand

The Biochar Network New Zealand Inc (BNNZ) is your group to promote biochar in New Zealand and represent biochar related interests. BNNZ is an incorporated society of members who are passionate about biochar and the benefits that come from its production and use. Join BNNZ at www.biochar.net.nz