Transition Town Vincent

My Healthy Soils Project

An Introduction to Biochar for Urban Soil, Water and Vegetation Management

Website

https://transitionaustralia.net/projects/my-healthy-soils/

Originally compiled by Christopher J Watts & Ian Kininmonth,
August 2024. Modified April 2025.

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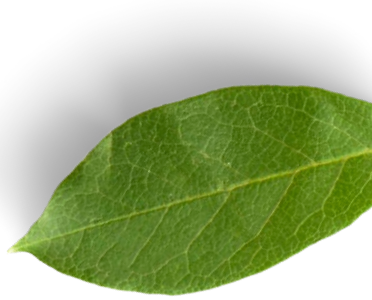

Table Of Contents

Transition Town Vincent

Introduction

Soil and terrestrial vegetation are carbon sinks with around two thirds of the terrestrial carbon pool sequestered in soil (ASOE, 2021). Charcoal a.k.a. biochar is a form of resistant carbon which naturally makes up around 10% of soil organic matter with humus e.g. compost making up 50% and particulate e.g. soil organisms making up about 2-25% (DPIRD, 2022).

Clearing, development and management of land for intensive land uses such as agriculture and urban have resulted in the loss of significant amounts of terrestrial carbon. In Perth, it is estimated that built up urban areas have <1-2% organic carbon while bush areas e.g. Kings Park, have >3% carbon (National Map, 2024).

Significant efforts are being made particularly in the agricultural sector to restore terrestrial carbon, however, in the urban environment this is largely ignored. The My Healthy Soils project aims to empower local residents and others to increase soil health and soil organic carbon (SOC) while providing other benefits including recovering resources from organic waste, reducing water use and improving plant health and associated vegetation and canopy cover.

Vision

Residents are empowered to transform their urban yards into carbon sinks while creating a cool, healthy and more sustainable living environment.

02

Why this workshop?

Biochar and FOGO compost was first used by the Transition Town Vincent (TTV) in their community food forest to enhance water use efficiency and promote healthy trees. Water use is a particular issue for the site due to its sandy, carbon depleted soil, exposed aspect and reliance on hand watering by volunteers.

The results after the first year were very good with only 2 out of 30 plants dying and all other plants growing at an overall average of over 25%. No plants died in the second year despite enduring the hottest and driest summer on record.

Partly because of this and the other benefits of biochar, the TTV have initiated the My Healthy Soils project which aims to provide residents with the knowledge, skills and resources to create healthy soils and transform their gardens into carbon sinks.

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03

What is biochar?

Biochar is a type of charcoal usually* made from plant materials (biomass) and used as a soil amendment plus a multitude of other uses (e.g. water filtration, odour mitigation, detoxifier, chemical spill kit, road base, permeable paving etc). It is usually produced through a process called pyrolysis, where biomass is heated in a reduced oxygen environment. Because oxygen cannot react with the carbon to form carbon monoxide (CO) or dioxide (CO^2) the result is mainly carbon.

This process not only produces biochar but also releases gases and oils that can be used as energy sources and a smoke condensate (wood vinegar) which also has a wide range of uses. Biochar is a form of resistant carbon which can persist in the soil from 100's to 1,000's of years.

*Biochar is made from a wide variety of sources containing carbon including grasses, **sewage and animal manure**

04

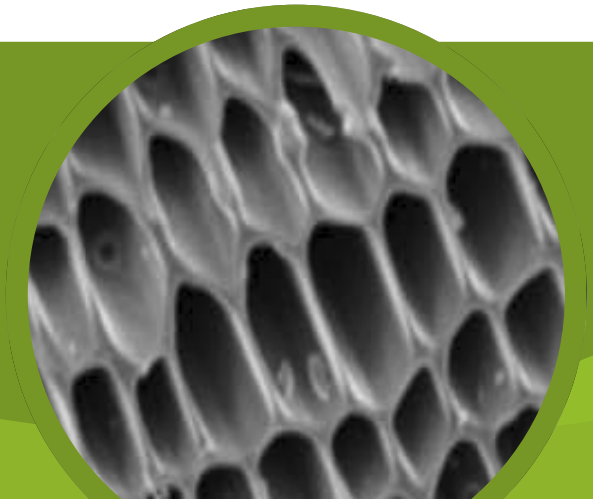
Why biochar?

Biochar can be made from a wide range of biomass waste resources but is particularly suited to vegetation based biomass e.g. tree thinning's which are easily accessible. By creating biochar from these resources, the carbon is ‘locked in’ and the emission of greenhouses gases which would otherwise occur through decomposition or incineration is avoided.

Biochar has a range of co-benefits which it can provide especially in improving soil and related water and vegetation management outcomes at all scales.

Biochar is also recognised as a carbon dioxide reduction (CDR) technology, practice or method by the International Panel of Climate Change (IPCC). Other related IPCC CDR’s include:

- **Afforestation, reforestation and improved forest management**.
- **Soil carbon** e.g. composting, retention of crop/turf residue
- **Bioenergy with carbon capture and storage (BECCS)** e.g. pyrolysis



05

Features & Benefits

Biochar has a range of physical, chemical and biological qualities which makes it so useful, particularly as a soil amendment. Some of its features and benefits are summarised below.

01. Improved soil structure	Helps to improve soil structure by increasing aeration and water retention. This leads to better root growth and healthier plants.
02. Increased water retention	Because of its porous structure and large surface area, biochar can hold large amounts of water making it available to plants during dry periods.
03. Enhanced soil fertility	Increases the nutrient-holding capacity of soil, making nutrients more available to plants and reducing the need for chemical fertilizers.
04. Reduction of contaminants	Can bind harmful substances, e.g. heavy metals, pesticides, nutrients reducing their availability in the soil and minimizing their uptake by plants.
05. Improves soil microbes	Biochar can increase the diversity and abundance of both fungi and bacteria resulting in many beneficial effects.
06. Carbon sequestration	It is a resistant form of carbon that can persist in the soil for hundreds to thousands of years. It can also assist in regenerating other forms of carbon in the soil, increasing total carbon.

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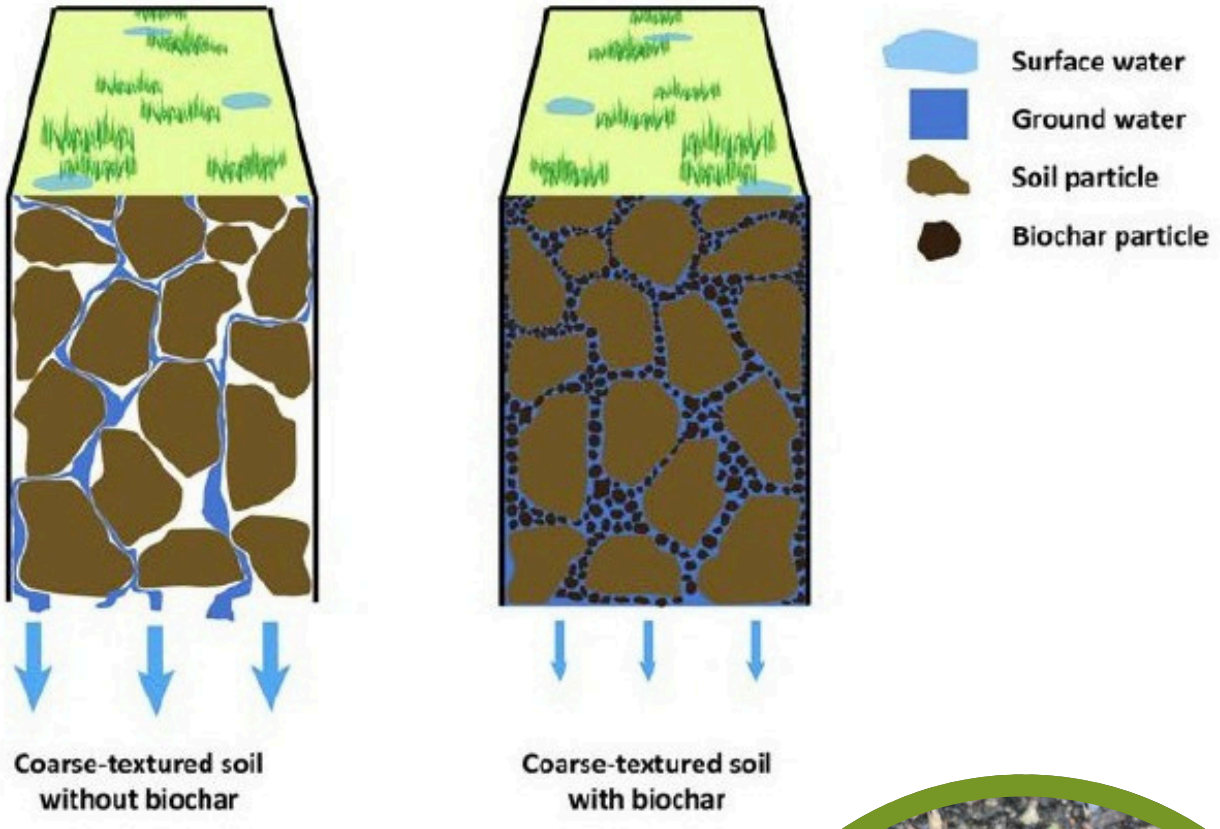
Soil Structure

The addition of biochar can fill the pores of coarse textured soils e.g. sand, trapping much more water (Adapted from Edeh et al. See Joseph and Taylor (2024). This can extend water availability, reduce flooding and reduce irrigation need.



Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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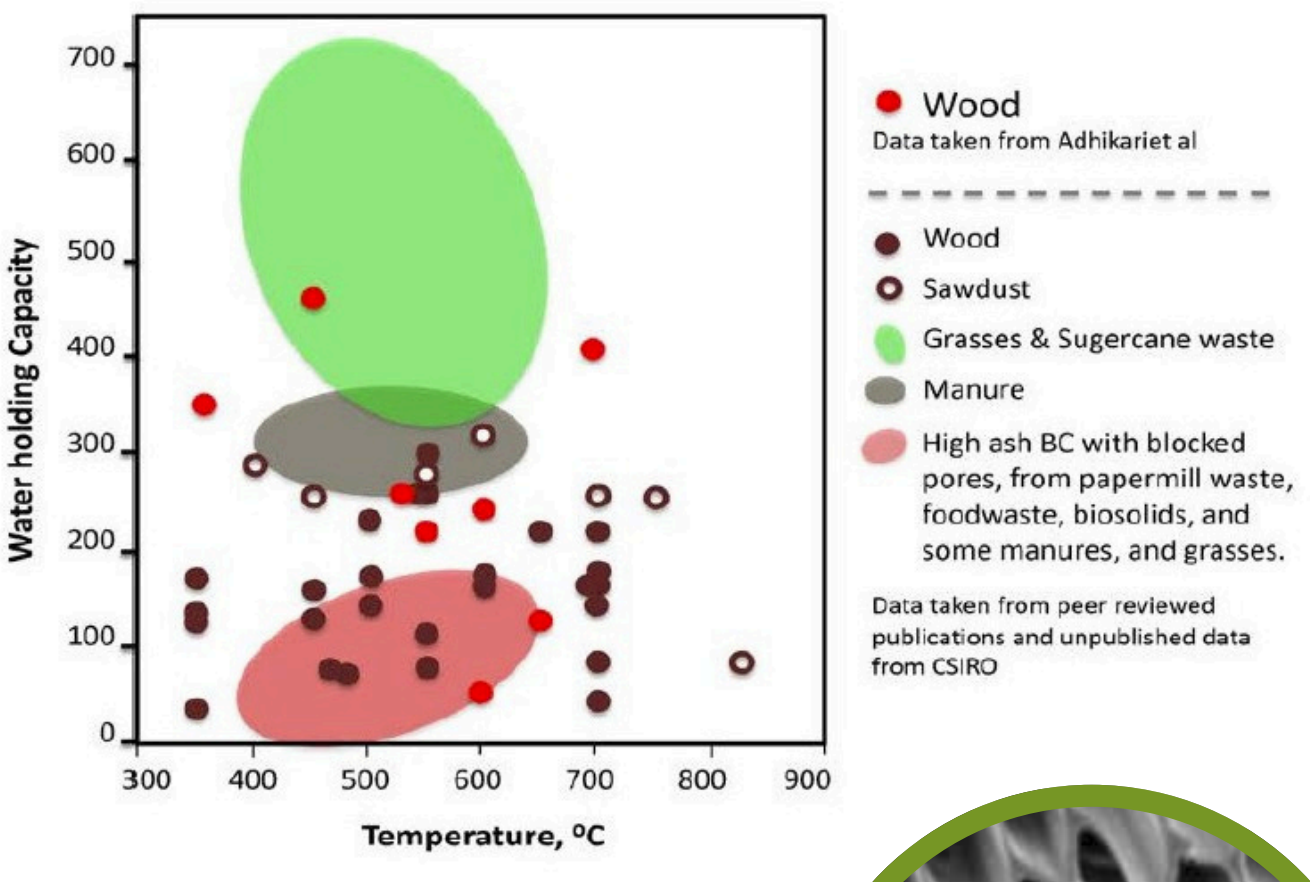
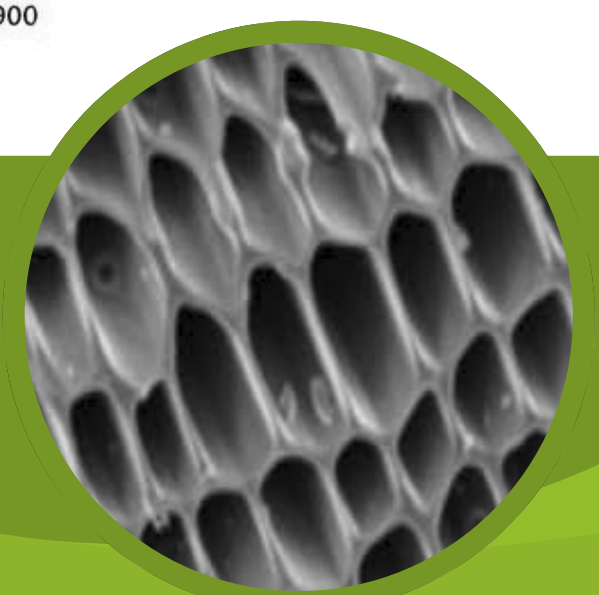
Water holding capacity

Biochar has a very porous structure and large surface area. A teaspoon of biochar can cover a football field. This gives it a very large water holding capacity. Depending on various factors such as the biomass used and pyrolysis temperature, biochar can hold up to 700% its mass in water. This quality aids soil water retention, plant growth and minimises water consumption.





Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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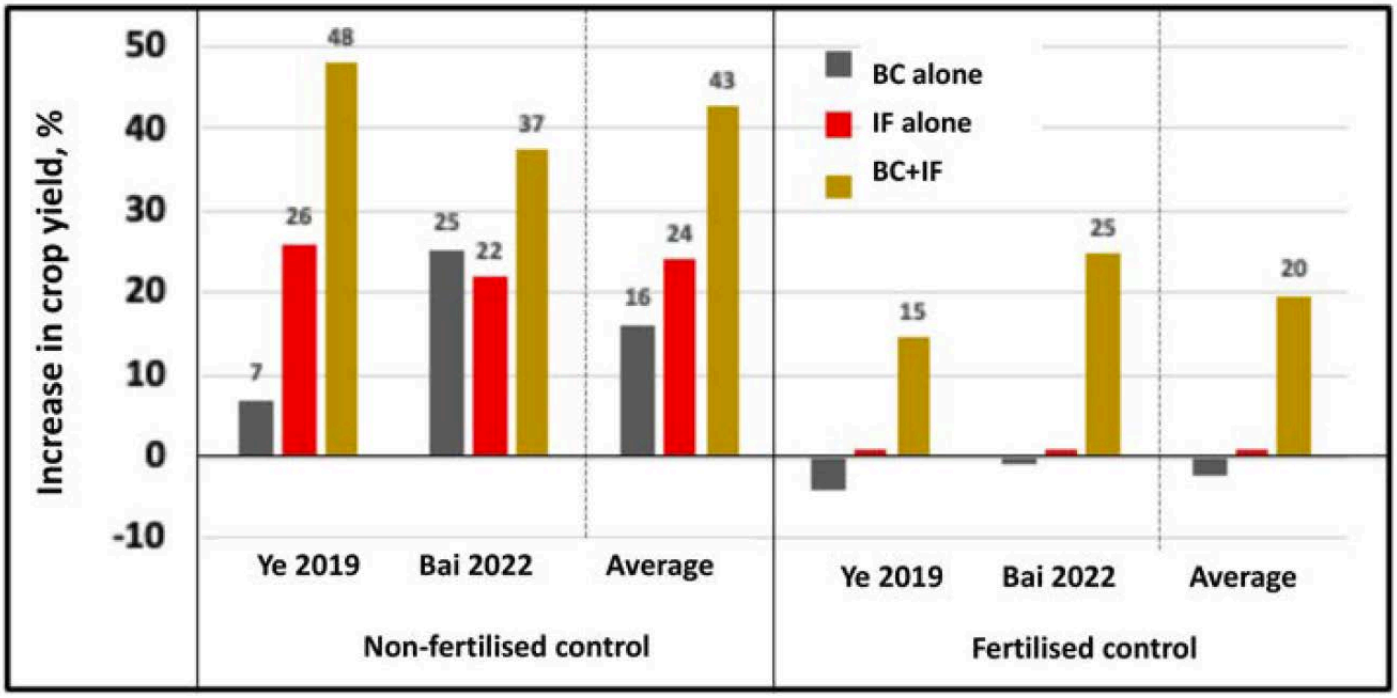
Soil fertility

Biochar can significantly improve plant growth and crop yield. It also binds nutrients acting like a slow release fertiliser. Combining biochar with inorganic or organic fertilisers can also accentuate its impact. In the case below, biochar + inorganic fertiliser improved yeilds by an average of 43% compared to the non-fertilsed control.



Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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Contaminants

Biochar can reduce contaminants in soil, water and air. Some examples include nutrients removed from ponds, use in grey water systems, use in wastewater treatment, use in composting to mitigate odour, use to remove heavy metals and pesticides from soil.

Figure 7.8 Left: Biochar-filled bags in a nutrient-loaded pond. **Right:** Biochar-filled bags have adsorbed nutrients from the pond water, resulting in a clean-water pond.[19]

Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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Soil microbes

The porosity of biochar, along with other characteristics can increase the number and diversity of soil bacteria and fungi which in turn improves things like soil aggregation and structure, chlorophyll and plant biomass, carbon sequestration, and reduces contaminants.

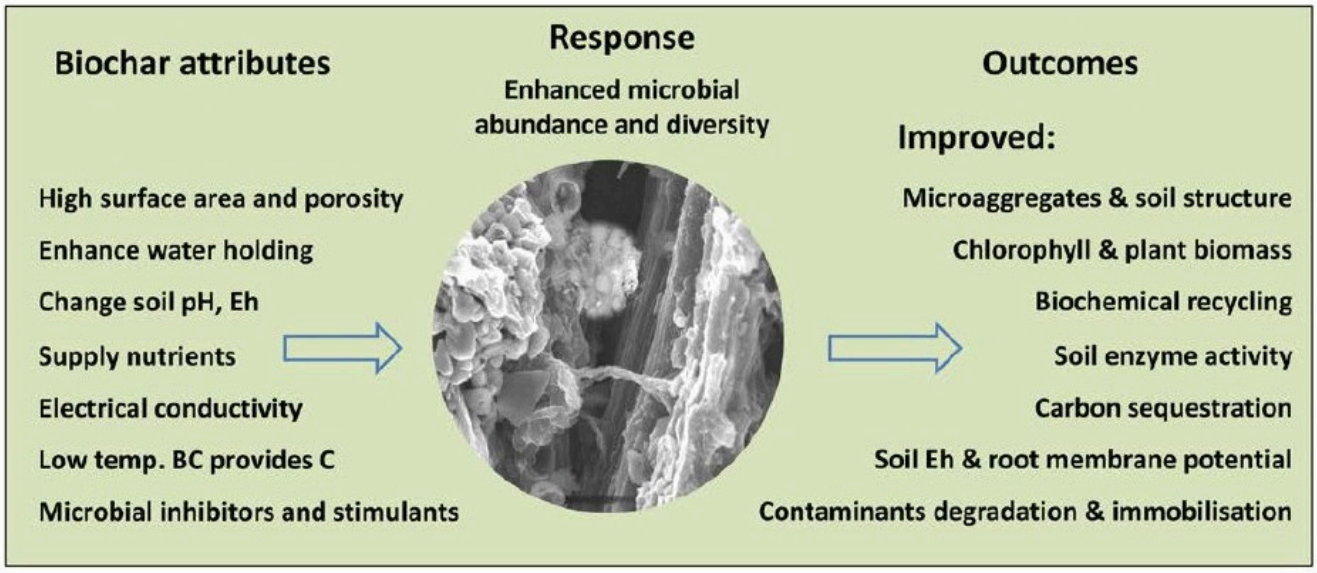

Figure 6.17 Schematic showing the microbial response and outcomes following biochar application. **Centre:** Electron microscope image of fungi and bacteria on surfaces of biochar. BC = Biochar, Eh = redox potential. (Modified from Palansooriya et al.[36])

Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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Carbon sequestration

Biochar is recognised by the IPCC carbon dioxide reduction (CDR) technology and can be applied to soil where it can persist for hundreds to thousands of years continuing to provide the benefits outlined previously. At the same time it can stimulate microbial, soil and plant processes that accumulate more C from the atmosphere.

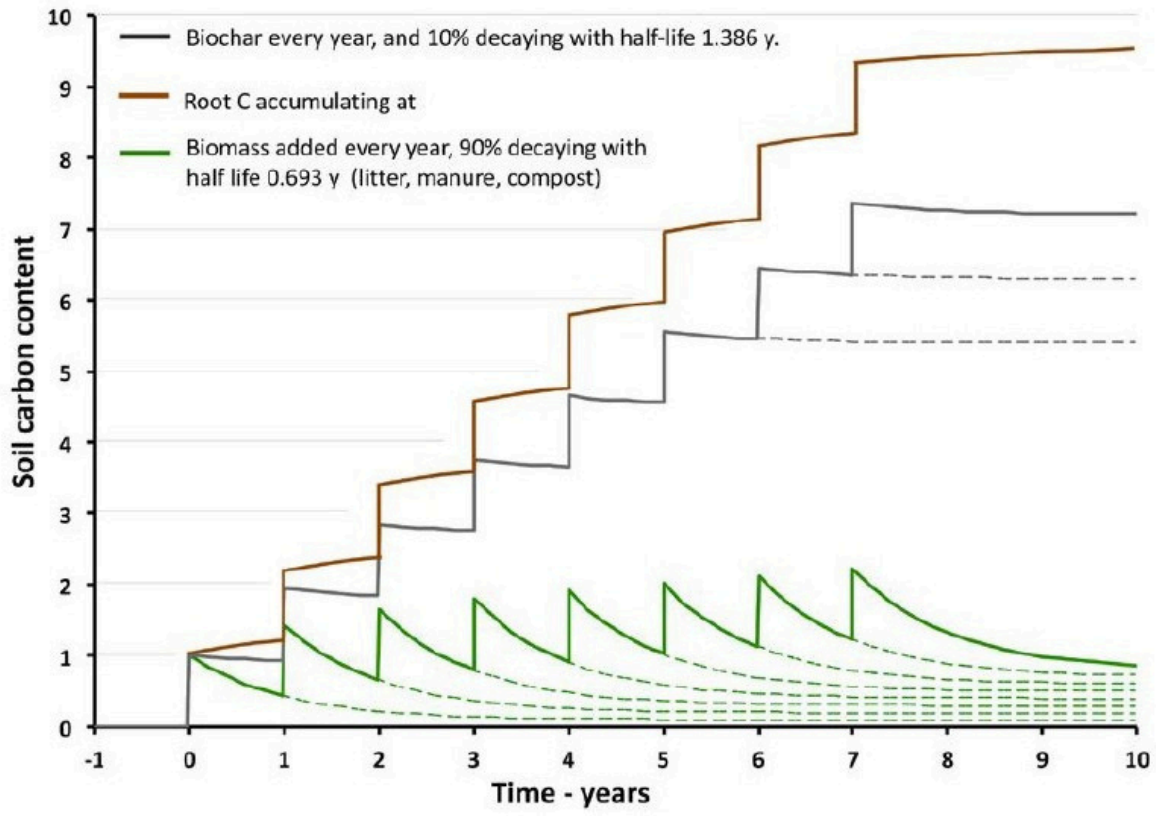

Figure 6.18 Schematic of changes in soil carbon as a function of time, when a unit of biochar or biomass carbon is added every year for eight years. Each increment of biomass or biochar accumulates on the residual of the previous amendment. In this model, all the biomass C (such as in litter, manure, or compost) decays with a half-life of near 0.7 y, whereas only 10% of the biochar C decays with a half-life of 1.4 y. In addition, the biochar has stimulated microbial, soil, and plant processes that accumulate more C from the atmosphere (illustrated here at about ¼ of the biochar increment in C per year). (Adapted from Joseph et al.[40])

Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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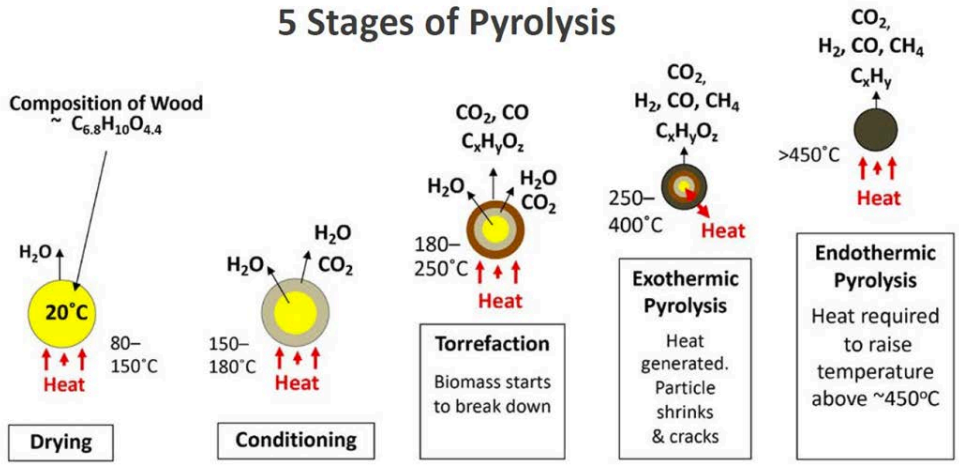
What is pyrolysis

The usual process for making biochar is by a process called pyrolysis where the biomass is heated to high temperatures in a reduced oxygen environment.

As the biomass heats up it releases gases such as methane and nitrous oxide which can be combusted, adding to the heat. Pyrolysis occurs from between 250-800 degrees Celsius. Biomass type and size, temperature and time can be controlled to engineer biochar with particular qualities.



Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

13

How to make biochar

There are many ways of making biochar at home. Some involve items you may already, such as a BBQ oven (e.g. Weber), wood fired pizza oven or fire pit. With the fire pit, biochar can be made by quenching the fire with nutrient rich water (e.g. worm juice) (or soil) before the wood turns to ash.

Another way is to put the biomass e.g. dried grass, leaves, sticks, mulch, wood chips etc into a steel canister containing small holes and char the biomass in there. This can also be done in a BBQ oven, fire pit or pizza oven. TTV have also made a couple of special biochar ovens, called Top-Lit UpDraft (TLUD) biochar ovens which can be obtained from the Vincent Tools n Things library (as can the steel canisters).

14

How to make biochar

Gather Biomass: Collect plant materials like grass, wood chips, crop residues, or other organic waste and dry (<20% moisture).

Pyrolyze the biomass: Put the biomass in a special container and heat it up without much oxygen. This creates biochar a.k.a. charcoal, gases and oil.

Cool, pulverise, and collect: Cool down the biochar e.g. using nutrient rich water or soil, and pulverise or crush it as finely as you can. One way is to put it in a bag and then run over it with your car.

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How to activate biochar

Biochar should be activated (inoculated) with organic or inorganic fertilisers or microbes for it to work optimally in the garden. If it isn't activated then it can pull nutrients away from plants and have a negative effect on their growth.

Source: Joseph, S. & Taylor, P. (2024) A farmer's guide to the production, use and application of biochar. ANZBIG

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How to activate biochar

01. Co-compost with biochar

Co-composting is when you mix biochar with organic matter at the start of the composting process. Use a ratio of at least 10% biochar (mass) to organic matter.

02. Mix with compost

Mixing biochar with finished compost, an organic fertiliser, will charge the biochar with nutrients and improve its effectiveness. Mix with compost and water (also worm juice) and leave for about 2 weeks before using.

03. Feed to your worms

Feeding biochar to your worms is a great way of activating your biochar and enrich your castings

04. Feed to the chooks

Include a sprinkle of biochar with the scraps you feed to the chooks to enrich their manure and keep them healthy

05. Soak in liquid fertiliser or teas

Soak the biochar in liquid nutrients such as worm juice, compost tea. Leave for about 2 weeks and then apply as a slurry or liquid.

17

How to use biochar

There are many ways to use biochar in the garden. Here are a few.

Incorporate into garden beds, seedling trays, pots or planting holes:

Mix the activated biochar into your garden soil. Aim for a ratio of between 10-20% biochar to soil. For example, if you are amending a garden bed with 100 litres of soil, you would add 10-20 litres of activated biochar.

Incorporate into Trenches and Wells:

Incorporate activated biochar into wells or trenches around existing trees. Aim for a ratio of about 50% activated biochar to soil and between 0.5 to 1 metre away from the plant or under the drip zone.

Trenches and wells can also be used for stormwater and grey water management.

18

How to use biochar

Top Dressing

For existing garden beds, you can also sprinkle a thin layer of biochar on the soil surface and gently work it into the top few inches of soil. Give a good drink.

Water and Monitor

After applying biochar, water your garden thoroughly to help integrate the biochar into the soil. Monitor plant health and soil moisture levels regularly.

Acknowledgements

- Professor Stephen Joseph
- Australia New Zealand Biochar Industry Group (ANZBIG)
- North Perth Community Garden

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Transition Town Vincent

Contact Information

Phone
+61 401 521 895

Email
ian.kininmonth@ttv.org.au

Website
https://transitionaustralia.net/projects/my-healthy-soils/

Thank You.