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DIY: biochar benefits + build-your-own solar HWS; **The basics:** how solar panels work; **Electric bikes:** winning the race

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DIFFICULTY RATING: ★★★☆☆

Biochar benefits
An introduction to making biochar

John Hermans explains what biochar is, its environmental benefits and the process he uses to make it.

↑ Loose material goes in, but it needs to be compressed with a short post rammer. The photo shows the 200-litre TLUD drum as a single-skin unit, with secondary air vents visible at the top. John has since wrapped this drum with three 82 cm lengths of old corrugated iron, attached using Tek screws. This wrapping reduces heat loss, which helps maintain the secondary combustion.

IT WAS not until I read *The Biochar Revolution* by Paul Taylor that I began to think about biochar's agricultural and environmental value, and decided to make the effort to make biochar at home. This article won't attempt to summarise the book but rather focus on how I've used its approach to benefit our household.

What is biochar?

In a word, biochar is charcoal. Crushed into small particles, the charcoal can be used to improve the nutrient- and water-holding capacity of soil, and so improve plant growth and productivity.

Biochar is a relatively new word, but biochar's use has been documented as far back as the Amazonian Indians, who created *tera preta* or 'black earth'. These nutrient-enriched soils retain much of their higher fertility, and their char, thousands of years after they were created.

Biochar can also permanently lock up carbon to help neutralise our carbon footprint. In this world where governments are largely failing to mitigate a climate catastrophe, this is another path for a 'bottom-up' global effort.

Why make biochar?

Biochar is now commercially available as a soil conditioner, at around $10/kg, but if you are not confined by allotment size, it is quite easy and cheap to make instead. You can also then control what goes into it.

In my case, I have been using the sticks and leaves that I would otherwise have burnt to reduce summer bushfire risk.

Making it has also given our household another option for becoming truly carbon neutral, other than planting trees. Biochar means we can now lock up atmospheric carbon in the soil, potentially for thousands of years, rather than have it re-enter the atmosphere when the ground litter rots or is burnt. Once it is added to the soil, it remains mostly inert to oxidation and hence does not re-enter the carbon cycle. At the same time, it increases the soil fertility in our extensive food garden.

Biochar chemistry

When organic matter is burnt in the open air, it nearly all burns to ash, with only very small amounts of unburnt black char. It is

↑ Lighting the centre of a fully charged barrel. John has since found it's preferable to light around the outer periphery rather than the centre.

↑ Well-made biochar is almost pure carbon.

possible to make char in a controlled open-air fire by extinguishing it early with water, but smoke, heat, flames and gas emissions will result.

In biochar manufacture it is preferable to use enclosed steel drums to control oxygen delivery and to burn most, if not all, of the carbon monoxide, hydrogen and methane which otherwise are given off in smoke. If unburnt, most of these gases have a far higher greenhouse gas effect than CO_2. When the fuel is burnt in controlled conditions, they are converted to CO_2. An added advantage is that it is a fairly smoke-free production process—far more neighbour-friendly than open-air fuel reduction burning.

Ways of making biochar

The very early char-makers used pits dug into the ground and mud-covered wood piles to control the off-gas burning of solid wood. These were very smoky operations.

There are basically three methods currently used to produce biochar.

The first method involves an 'oxic' fuel burn using an open-air fire. To do this, a strip of ground litter raked into long narrow piles is lit along its upwind edge. After 10 minutes a high proportion of the material is converted to char and the fire is then completely extinguished using water from a hose. This method resembles standard leaf-litter burning and has several negative effects: smoke, heat, flames and gas emissions.

The second method is an oxygen-starved burn in a large (200 litre) drum modified into a 'top lit up draft' (or TLUD, pronounced tee-lud). A TLUD drum has two sets of air feed holes. Primary air holes in the bottom of the drum provide just enough oxygen to enable the fuel to pyrolise (chemical decomposition by heat), producing a small flame but a large quantity of volatile gases (smoke). Upper secondary air vents supply a sufficient amount of oxygen to these volatile gases so that they then burn, in a secondary combustion, to a nearly clear flue stream.

The third, and more traditional, method is an 'anoxic' (oxygen-free) burn, in an inverted steel retort. The retort is an open-top drum that is filled with wood and then turned upside down over a flat metal disk. The retort is held up above a wood-fuelled fire, contained within another larger steel drum. The gas driven from the inverted retort then burns to assist in heating the retort even more, so that the reaction becomes self sustaining.

For simplicity, I will only describe the second method in detail: making biochar using a TLUD drum.

Creating a TLUD combustion vessel

The TLUD drum needs to have about eight 40mm primary air holes in the bottom and eight 40mm secondary air holes around the sides near the top. The holes should be evenly distributed. Ensure there is a central air hole in the bottom of the drum.

The drum also needs a lid and a flue pipe on top. I use a flue with a diameter of 150mm and 1.8m long. The simplest lid and flue connection is made by making eight star-arranged angle grinder cuts in the centre of the lid, like an asterisk, with each cut extending out to the diameter of the flue. You then fold up the triangular sections, place a section of flue over them and rivet the flue to the triangulated lid folds.

Loading the drum

I use a mat of crumpled steel wire mesh at the bottom of the drum to enable better air flow and assist pyrolysis of the fuel near the bottom. Over this, I place a capped pipe (of about 90mm diameter and 90cm in length) in the centre of the drum, resting on the wire mesh and just above a central air hole in the bottom of the drum.

The next step is loading the collected dry leaves and sticks around the central pipe; I use a short wooden post as a ram to compress the fuel. Once the drum is full, the central pipe is removed, leaving a hole in the centre of the compressed organic material so that air can pass through it. It's important not to move or shake the drum after the pipe's removal or the hole may become blocked.

I also raise the drum on three small blocks of 20mm pine offcuts, so that fresh air can enter under the drum and into the primary air holes. When the fire gets to the bottom of the drum the pine blocks will burn out, subsequently shutting off the primary air flow and slowing the final burn process. As the bottom of the drum gets very hot, it is important that at least a two-metre radius is raked clear of combustible matter.

The process of pyrolysis

To start the combustion process, I ignite the fuel at the top of the drum, around the outer periphery, and cover the container with the flued lid soon after lighting.

As long as the fuel is fairly dry and the central air passage remains open, the secondary combustion process should maintain itself, giving a smoke-free burn. It's important to check the burn progress of the

↑ Raking up small ground litter for the charring procedure.

↑ Inspecting the previous charred batch, while the next one is being fired. Notice that minimal smoke is being emitted.

TLUD regularly, as the time taken to complete the charring process will vary, due to moisture content, particle size and degree of fuel compaction. I have a 40 mm observation hole drilled in the outer edge of the lid which allows for easy inspection. I find that it usually pays to let it burn a bit longer after I think it's ready! As a rough guide, my burns usually take about three to four hours.

Once I think it's ready, I remove the lid and use water from a hose to quench the glowing char mass. If water quenching is not done, the char will all turn to ash and the product will be lost to the atmosphere as CO_2. I spray water in the top until it comes out the bottom—as reignition often occurs and you could lose the lot overnight. Note that if the burning fuel is quenched too soon then a proportion will remain unburnt. Some trial and error may be needed, but it's all good fun!

The fuel weight of a 200-litre drum of compressed litter is around 40 kg and the final char weight is around 10 kg.

When to make biochar using a TLUD

The best time to prepare your TLUD drums is on warm or hot days, when the organic matter is fully dried. The drier the fuel, the hotter the burn and the less chance there will be of the secondary fire going out (which would lead to a very smoky chimney plume). After loading, you can seal up the drums and keep them for firing up on cooler or even rainy days.

I did all of my char-making through the summer season, on days following rain, when ground fires were not permitted. This represents a fuel reduction option during the fire restriction season as the fire is fully contained and (should be) smokeless. I have never observed live embers coming from the flue stack, but, of course, never light up on hot days or fire ban days.

Carbon offsetting

My estimation is that a kilogram of biochar holds the same amount of elemental carbon as 1.6 litres of petrol. Having vehicles that run on vegetable oil and biodiesel, and a house that is powered 100% from the sun and micro hydro, my offsetting challenge is not as great as most, but there are a lot of other products and services that I wish to offset. In addition to the value of carbon offsetting, my productive food garden will reap the benefits of biochar for a long time to come. ✸

If you have an interest in biochar, I strongly recommend Paul Taylor's book *The Biochar Revolution*. Otherwise try Googling TLUD—there's a lot going on out there!

Warning

Extreme care should always be taken when working with combustible materials. It's a good idea to have a fire hose or water fire-extinguisher handy when making biochar. Only use steel 200-litre drums or similar steel or stainless steel drums, never aluminium. The ATA encourages readers to always place safety first.

→ Quenching the glowing char mass, before it all turns to ash.