

Practice Guideline: Using a Flame Cap Kiln to Make Biochar

The Flame Cap Kiln method uses a container to exclude air from the bottom and sides of a pile of burning biomass. This guideline covers two types of Flame Cap Kilns:

1. The Oregon Kiln – a steel fire pan with a pyramidal shape
2. The Ring of Fire Kiln – a steel ring with outer heat shield, sealed on the bottom with dirt

These kilns are the designs that we found to be most useful and effective for the forestry situations and feedstocks that we worked with in Oregon. We have made several versions of each type, some designed to break down into sections for easy transport, and some made with heavier steel for moving with a tractor.

There are many other shapes and designs that can work equally well, such as trenches, tubes, cones and simple pits in the ground. Some examples are shown below:

Many Types of Containers Can Be Used as Flame Cap Kilns		
		
The Oregon Kiln	The Ring of Fire Kiln	https://pacificbiochar.com/how-to-make-biochar-with-only-a-match/
		
http://www.thebiocharrevolution.com/blog/biochar-production-in-kon-tiki-australia-1	https://youtu.be/IOSDwp20EKM	http://warmheartworldwide.org/biochar-oven-specs/
For more examples, see BackyardBiochar.net		

This Biochar Practice Guideline was created in 2018 by South Umpqua Rural Community Partnership.
Updates available at UBETBiochar.blogspot.com and WilsonBiochar.com.
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Flame Cap Kiln Basic 3-Step Method

1. This method starts by building an open pile in the container, lighting it on top, and letting it burn until it collapses and coals begin to form.
2. The operator then switches to a second stage of adding small amounts of new material on top of the coals, one layer at a time, until the container is full.
3. When the kiln is full of hot char, and the flames are gone, it's time to put it out. Either flood it with water, or snuff it with a lid to exclude air.

A Flame Cap Kiln must be continually tended, adding new fuel before the charcoal turns to ash. As each new layer of fuel bursts into flame, the heat transfers by radiation into the partly charred material underneath which continues to char, releasing gasses for the flame. The flame also consumes all the air that might otherwise reach the char underneath. The combination of flame on top and the closed bottom preserves the char until it can be quenched and saved.

Successful biochar production will consider the following factors:

- **Feedstock moisture:** Ideally, moisture content should be below 25%. Wet wood should be tossed aside and not used until it dries out. You will burn up too much wood to create the heat needed to dry the feedstock. A moisture meter for checking firewood costs about \$30.
- **Feedstock size:** ideal size is between 1 and 4 inches thick. If the feedstock is very dry, thicker pieces can be successfully charred.
- **Initial filling of the kiln:** Best practice for lighting is to build an initial rick of medium size material (2" thick is ideal) that is open and loose on the bottom so it can get an air draft as air moves down the sides of the kiln and up from the bottom. The rick should fill the kiln up to about a foot above the kiln rim. On top of the rick of medium size material, place a densely-packed pile of small, very dry brush for kindling. This can be about 12 inches high.
- **Lighting:** Light the kindling and make sure the flame is even across the top. A propane torch is helpful but not necessary if you have dry fuel. Avoid using liquid accelerants.
- **Tending:** Add a new layer of wood when the previous layer begins to show a film of white ash. Try to keep each layer of wood the same diameter so charring is even. Add your biggest material in the middle stages of the burn so it has time to char completely.
- **Finishing:** As the kiln fills with red hot glowing coals, make the last few layers of medium sized material to allow any larger pieces to finish charring. The charring is complete when you no longer see any flames. Don't worry if bigger pieces are not fully charred. After you quench, just set them aside for the next burn.
- **Quenching – with water:** When all the flames are gone, begin adding water in a gentle spray to the top of the kiln. Take care not to use a strong spray because it can drive air into the kiln and force a cloud of black particulates into the steam. You can wear a face mask during this process to protect your lungs from steam and particulates.
- **Double-check your quenching:** Make sure that there is plenty of water. Too little may evaporate and the char can re-ignite. If you don't have as much water as you would like, take the time to stir the char in the water until it is all cool. You should be able to put your hand in it. Or dump the wet char on the ground and spread it thin so it loses heat.
- **Quenching – by snuffing:** An air tight lid can work to quench char. Best practice is to use at least some water to help cool the char. A good lid is a thin sheet of steel placed directly on top of the char layer inside the kiln. Seal the edges with dirt or clay. Cool for at least 12 hours.

Illustrated Guide to Using the Oregon Kiln

Load dry feedstock loosely in the kiln, up to a foot or so above the kiln edge. Nothing should be more than 3 inches in diameter.



Make sure there is dry, kindling size material on the top. Light evenly across the top.



Keeping a flame cap across the top will burn up most of the smoke.



Once the first pile has burned down, start adding more material.



Now that the kiln is very hot, you can add some bigger material.



Some pieces may be too close, cutting off air. Pull them apart with a rake.



When all the flame is gone and ash starts to form, it is time to quench.



Use plenty of water. Too little may result in total evaporation and re-ignition of the char.



Illustrated Guide to Using the Portable Ring of Fire Kiln

Kiln components are lightweight and packable. 	Set up the inner ring and clamp sections together. 
Set up the heat shield. Load the initial charge – loosely packed. 	Light on top. Note: heat shield on blocks for air flow. Pre-heats combustion air. 
Wet quench method uses lots of water. 	Open up the kiln for final quenching. 
Dry quench method – place cap, seal edges with dirt. Check that bottom is sealed too. 	Let it cool overnight before opening. 

CHECKLIST FOR A BIOCHAR BURN – SAFETY FIRST!

Here's a checklist of things you need to consider when planning a biochar burn:

Keep a biochar burn log to record your results and promote learning from experience (see included burn log form).

You need a water source, both for safety and for quenching the char. Secure your water source before you light the kiln.

Even if you are quenching with a lid or with dirt, always have at least five gallons of water on hand for emergencies.

Have several shovels and rakes on hand to help control the fire.

Make sure flammable materials are cleared from around the kiln. Wet the area if it is dry.

Dry wood. A moisture meter is helpful. It's not very efficient to use wood that is more than 25% moisture.

Stage your wood nearby. The kiln will use about ten times its volume in feedstock.

It is very helpful to sort wood by size ahead of time for efficient layering of similar size material.

Safety – All helpers should have leather gloves and wear cotton or wool clothing that won't melt. These piles can put out a lot of heat. Heat exposure for long periods of time is exhausting. Protect yourself and drink plenty of water.

Burn only during legal burn days and safe conditions. Get a burn permit as required.

Ignition - You can use a propane weed burner type torch for ignition, but all you need is a match if you have plenty of dry kindling. Light it evenly across the top.

Make sure the kindling on top is somewhat densely packed so it will sustain a flame and allow the flame to move down to the lower layers. It seems slow to start but pretty soon you'll find the whole pile is ablaze.

If you get a lot of smoke, you may be adding too much material at one time. Always keep a strong flame on top of the kiln to burn the smoke.

Use a wind screen if conditions are breezy. Even if wind is not a factor, a wind screen will help hold in heat for a safer and more efficient biochar burn.

Stop when you are tired, not when the kiln is full. It's ok to fill the kiln, but it's also ok to stop before it is completely full, whether you run out of wood, or just run out of steam.

Tools and Supplies to Have on Hand

- Shovels and rakes
- Water buckets, hoses, nozzles
- Safety equipment: leather gloves, dust masks, eye protection, fire resistant clothing
- Propane torch or matches
- Wrench for installing and removing drain plug
- Chainsaw, hand saw or axe, if needed

Best Practices for Safe Biochar Operations



Wear fire-resistant clothing, and use a heat shield around the kiln.



Keep pets and children away from flames.



Shut off and stow propane torches after use.



Protect yourself from smoke.



Place kilns carefully. Make sure the flame won't torch overhanging tree limbs.



Have your water source ready to go before you light!



For safe and efficient production, place the kiln in a clear open area and stage your feedstocks nearby, but not too close. It helps to sort material by size.

Crushing Biochar



Biochar can be crushed by driving over it with a truck or lawn roller. A small leaf vacuum works fairly well, but a large one is much better, with a more effective and durable impeller for chopping char. You can also use a hammer mill or a roller mill. Be aware that dry char can be very dusty and that wet char can stick and clog machinery. Experiment with moisture levels to find the sweet spot for the equipment that you use for crushing.

Biochar Burn Log – Record Your Results

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