How to make high and low adsorption biochars for small research studies

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As the world of biochar expands, the need for definitive research to answer core questions grows. One such question is "What is the role of adsorption and when does it make a pivotal difference in growing situations?" Answering those questions has been hampered by the historical absence of adsorption as a monitored property in soils and soil components (as compared to CEC) and the lack of a reliable method to create low and high adsorption biochars. While there is little that can be done about the former situation, the later may have a fairly facile solution, which will be presented here.

During studies of various TLUD stoves and investigating the pros and cons of Natural Draft (ND) versus Fan Assisted/Forced Air (FA), it was noticed that certain FA operating conditions yielded biochars with significantly higher adsorption capacity. Studies are continuing to pin down this phenomenon, but an early conclusion is that a simple modification of the existing 1G Toucan (http://bioenergylists.org/en/mclauglintoucan) will allow high adsorption biochars to be generated in half-gallon quantities. Since the traditional natural draft 1G Toucan, as originally detailed on the bioenergylists website in January 2010, generates biochars with low but significant adsorption capacity, a similar biochar with high adsorption appears to be easily achieved.

The key modification for high adsorption biochar is the addition of a fan assisted "Air Base". The construction of the Air Base is detailed here. The starting point is the recycling center for some discarded tin cans – and one computer power supply fan, as shown in Figure 1.

A few observations before fabrication begins: The computer fan is used and dirty with accumulated dust – that doesn't matter. New ones can be bought at any place computers are sold – they are known as 80 mm case fans, or they can be removed from any dead computer power supply. In addition, the corners of the fan facing the label have been cut off – to improve the match with the can, as will be seen. Finally, the fan has been wired to a 9-volt battery plug – available at any Radio Shack-type store. This allows the fan to run off a standard 9-volt battery. Alternately, the fan can be run off any small transformer (often called "wall warts"), such as wireless telephones and older cell phones use, that supplies either 9 or 12 volts DC.

Any one of the cans in the front row can be used to hold the fan. The fan-can assembly then mounts in the larger can (known as a #10 can) shown in the back row. The preferred can type is the two on the right, but the smaller can also works well.

The fan is mounted in one end of the can, as shown in Figure 2 on the right. In this case, the coffee can was used and the fan mounted into the end with the lip at the top. The bottom of the can is removed with a can opener. The fan is attached to the can with electrical tape to seal the gaps at the sides of the fan and hold the fan to the can – tape is all that is needed.

Figure 1: Starting materials for the 1G Toucan Air Base

Figure 2: Layout of large can on left and finished "fan-can" on right

On the left of Figure 2 shows the start of the modifications to the larger can. First, the projection of the fan-can is drawn on the larger can – that is the shadow of the circular can projected perpendicular on the face of the larger can. Then a vertical oval is drawn and the anticipated cuts radiating out from the oval to the larger projection. Then the oval is cut out with tin snips – after making a hole to start the snipping inside the oval.

The next step is to cut the radial cuts from the inner oval to the outer projection. The tabs are then bent outwards to create an opening slightly larger than the fan-can, which is inserted in the opening as shown in Figure 3. This is a good time to trim any sharp ends off the tabs, but leave as much tab as possible to hold the fan-can.

Figure 3: Attaching the fan-can to the larger can

The final step is to secure the fan-can to the larger can, which is done with a large worm-gear clamp, available at any hardware store, as shown in Figure 4. Two worm-gear clamps can be joined together is one can't find one clamp large enough to do the job. After the worm-gear clamp is snug, a strip of electrical tape to cover the sharp edges completes the project. If the gaps between the fan-can and the larger can are excessive, due to over-zealous tin sniping, a little electrical tape or duct tape will render the overages "out of sight and out of mind".

Figure 4: The completed Air Base – with a different fan-can attachment shown

Figure 4 shows a fan-can made from a 28 ounce tin can shown in the middle front row of Figure 1. In this case, one end of the can is removed entirely and the other end has a hole cut in the end to match the opening of the fan – leaving a lip similar to the one utilized in the coffee can. In Figure 4, the fan is attached with wire to small holes drilled in the edge of the can, as shown.

Figure 4 shows the traditional 1G Toucan sitting on the Air Base – the units nest securely and do not wobble. When making high adsorption biochar, the fan is operated at either 9 or 12 volts. For low adsorption biochar, the 1G Toucan is operated in Natural Draft mode, as described in the original write up or by leaving the fan off during “TLUD-ing”. In both cases, the pyrolysis should be stopped when the flaming pyrolysis front reaches the bottom and the red glow is seen in the Air Base – as viewed through the fan into the Air Base. Both systems can be quenched by moving the 1G Toucan to a flat fireproof surface and replacing the crown with the original paint can lid, as described in the 1G Toucan instructions.

One final note: In Natural Draft Mode, the 1G Toucan typically has a flame that is up to one foot tall. **In Forced Air mode, the flame is more like four feet tall.** As such, it is recommended that the FA mode be done in a garage or similar open area with plenty of headroom to the nearest flammable surfaces or sprinkler heads. A taller chimney will improve the draft in FA mode, but the idea is to operate the 1G Toucan hotter, which results in high adsorption biochar.

The FA high adsorption biochar typically has about three times the adsorption capacity of ND biochar on a weight basis. The weight yield of FA biochar is lower than the ND operation, but the volumetric yield is similar. Both biochars have low ash, assuming high quality wood pellets are used as starting biomass, and low mobile matter – which is characteristic of all TLUD biochars due to the flaming pyrolysis carbonization conditions. The ash that is present is likely to act as lime, but the amount is normally minimal and should not adversely soil pH in growing situations – although this issue should be confirmed by the individual conducting the experiments.

In summary, both low and high adsorption biochars can be made in small quantities using the 1G Toucan TLUD. In Natural Draft (ND) mode, the biochars are low adsorption. By using an Air Base, high adsorption biochars are produced. In both cases, the same biomass is used, resulting in biochars that differ principally in adsorption capacity. While any source of dry biomass compatible with TLUDs can be used, premium wood pellets are recommended for any studies requiring low ash biochars.