WORLD STOVE

# Biochar for Climate Change Mitigation: Facts, NOT Fiction

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Efficient pyrolytic (that is, biochar producing) stoves save fuel, reduce both emissions of greenhouse gasses (GHG) and indoor- and outdoor air pollution. In this way, we improve soils, preserve forests and bring better health and economic independence to people. Our efforts are directed, in particular, to the developing nations. On Day 4 of the COP15 Congress, EcoNexus hosted a side event in which BioFuelWatch presented their case against Biochar. While we support and agree with many of the objectives of both Biofuelwatch and Econexus, to avoid that misunderstandings surrounding biochar limit the access developing nations could have to economic growth opportunities, we wish to correct some of the information they have presented. An audio transcript of BioFuelWatch's COP15 presentation is available at http://peaksurfer.blogspot.com/ and much of the information they presented is available in the BioFuelWatch publication: Biocharbriefing Feb 2009. entitled, "Biochar for Climate Change Mitigation: Fact or Fiction?" available at (http://www.biofuelwatch.org.uk/docs/biocharbriefing.pdf)

We offer the following brief list of corrections to some common misunderstandings about biochar in an effort to support organizations like BiofuelWatch, Econexus, the and others in their efforts to help save forests, protect native peoples, and improve the environment. **Time notations in this document, e.g. 1:15**, refers to time into the audio transcript of BioFuelWatch's COP15 presentation.

## EXECUTIVE SUMMARY

An essential mission of the COP15 Congress is to seek limitation of GHG emissions. However, present concentration of CO2 in the air is about 385 ppm, by several estimates this is already too high to avoid significant climate change. Therefore, an equally important task before us is to **remove and sequester CO2 already in the air**. Plants can do this. Large trees do this, and can keep the CO2 sequestered for centuries, providing they are left standing. In contrast, agricultural waste, annual plants, leaves and branches which fall from trees also sequester CO2 but in many parts of the world, they are disposed of either by burning, burying, or are left to rot. In a matter of months to a few years, all their CO2 will be released back to the atmosphere. If this short lived biomass, however, is pyrolyzed, (turned into biochar) it can provide low cost, clean, energy for cooking, heating, and the generation of electricity while sequestering 50% of the carbon, and returning nutrients back into the soil.

**1.What is biochar?**

When any form of biomass is heated in an oxygen-free or low oxygen environment such that it does not (or only partially) combusts, it becomes black carbon. Traditional charcoal is one example of biochar produced from wood. (Footnote #1).

**2. How long does biochar last in the soil?**

Certainly not forever, but a recent study indicated that the half life of buried biochar is in the order of thousands of years (Preston & Schmidt (2006)). In fact, dating in archaeology and anthropology is presently determined by analyzing carbonaceous biomass recovered from the age of materials from ancient civilizations. This system is considered reliable for materials up to about 58,000 to 62,000 years. (Footnote #2).

**3.What types of biomass are we (at WorldStove) talking about? Is there enough to have a real effect on CO2? What will be the carbon impact of char production?**

The landfills of the world are filling with waste biomass. WorldStove maintains that converting even part of this to biochar would have a major impact on CO2 reduction.

**Egypt** produces **20 million tons of rice straw every year**, 70% of which is burned in the open.

In the **USA**, landscape debris comprises more than **32 million tons a year**, 13 percent of all solid waste.

**Globally**, crop residues in 2006 were about **5000 million tons** of total above-ground residues. ( **Footnote #3)**

In that it is safe to assume a third of the original weight of biomass remains as biochar, and that 80% of biochar is carbon, if we use the above sited figure cited for global availability and converted only a fifth of that to biochar we, as a planet, could sequester 727,075,555 tonnes of CO2 per year with out cutting a single tree.

**4. Can biochar help stop desertification in semiarid lands?**

In semiarid regions, the little water that falls on semiarid or recently desertified soils is quickly drained away by gravity. This is because such soils are poor in organic matter and (to be brief) sandy. Glaser et al. (2002) have shown that adding 45% volume of biochar to sandy soils increases their water holding capacity significantly. The biochar thus serves as a reserve from which plants can draw moisture as they grow.. With water retained, vegetation can get established, deposits organic matter, rebuilds soil fauna and flora, retards erosion, and reverses desertification. It is not necessary to enrich the entire region with biochar. If seedlings of trees or vegetables are planted with a ball of about 290 ml of rich soil containing 45% biochar, this will increase the chances that their root systems will grow enough to reach deeper, richer, wetter soils and thus survive. Additionally the absorptive nature of biochar prevents nutrient runoff, dramatically reducing the need to reapply nutrients and decreasing the need for chemical fertilizers. (Footnote #4)

**5. What can one small pyrolytic stove do?**

If a household cooks for 3 hours a day, they will produce at least 300 g biochar per day, about 110 kg. per year. When planting in semiarid soils, 90 ml (18g) of biochar can be mixed into a volume of 200 ml of soil for each seedling to enhance water holding capacity of the soil. A year's production of biochar, from one family, therefore, provides increased water reserves for over 6000 plants. At the same time, fuel consumption and GHG emissions are reduced, and over 250 kg of $CO_2$ are sequestered. (Footnote #5)

**6. Does a stove that produces biochar require more fuel than a stove that does not?**

Fully pyrolytic stoves release more energy from less fuel than do other stoves. This is because they produce clean burning gasses from biomass (rice husks, peanut shells, leaves, twigs, even animal dropping) and then burn only those gasses. It is much easier to burn gasses efficiently than it is to burn solid fuels l ike logs or branches. Solid fuels tend to have varying densities and inconsistent moisture and energy contents while gases tend to be more uniform. Increased efficiency comes from the proper mixing of air and combustible fuel, the more consistent the fuel the easier it is to burn it efficiently. To understand this, consider that switching a kitchen stove from city gas (methane burning) to bottled gas (propane burning) requires a stove technician to adjust to appliance. For standard biomass stoves which must burn a continually varying mixtures of gasses and solids, a high degree of efficiency is much more difficult to attain. Open fires, used by much of the world are 7-12% efficient. Pyrolytic stoves have a combustion efficiency of up to 93% so that they can be used for cooking and heating even while forming biochar, they do more with less, sequestering carbon in the process. (Footnote #6)

**7. Does adding biochar to soil cause the loss of carbon already present in soil?**

To understand this issue, consider that soils house a living community, one which takes in biomass for fuel, respires it in presence of air and thus releases $CO_2$. The soils under consideration here, those of the Boreal forest (those just warmer than the tundra) and fertile clay soils, common throughout the, however can present problems for the soil communities. Boreal soils are overly watered and thus poorly aerated which reduces respiration in the soil community. Clay soils, however fertile, tend to get very compact, and this too impedes movement of air and water into and out of the soil. Adding char reduces the density of both Boreal and clay soils, allowing the underground community to respire and grow improving soil biodiversity, rather than strangulate. Gardeners often correct heavy, "soggy", compacted soils by adding charcoal or a commercial compound, "Perlite", an expanded type of mineral which also reduces soil density and thus improves aeration. The increased release of $CO_2$ than occurs following the introduction of biochar to soils, far from being a negative, is an indication of soil improvement. Improved soils come from boosting the health of soil communities, this then promote greater plant growth and faster $CO_2$ sequestration. (Footnote #7)

**8. Does the application of biochar to soil involve risks?**

8:15 Biofuelwatch presentation**:** Spreading biochar it becomes a fine grained dust. Black soot is the second biggest contributor to climate change.

**WorldStove replies:** Many technologies must be applied correctly to minimize hazards. Composting, for example, can be a major source of the GHG methane, if not done correctly. However, banning composting for this reason would be illogical. Biochar can be produced and applied without generating or releasing biochar “fines”.

**9. Biochar and humus compared:**

Both biochar and humus can contain nutrients when first formed and placed in soils, and, in both, these nutrients will soon be consumed. The humus itself will also be consumed and released to the atmosphere as CO2. The biochar will persist and provide a long term carbon framework which will improve water holding capacity in those soils which most need it, sandy soils. Just as a coral reef provides niches and environments for more species than would a smooth granite surface underwater, this carbon framework, not to mention the extraordinary amount of surface area (up to 250 square meters per gram) present in the char, will provide a highly heterogeneous environment for the soil macro- and microflora and fauna. (Footnote #9)

**#10 Does biochar contain toxic PAH compounds?**

Ahmed et al. (1989) reports that “… whilst biochar should contain systems of PAH, existing evidence indicates that **no leachable PAH is present.”**

Analyses of biochar from WorldStove products indicate similar conclusions. Sohi et al. (2009) indicate that concentrations of PAHs, formed in all fires, are not a danger in biochar (Footnote #10)

We hope the readers find these clarifications helpful and that they serve to dispel doubts that could risk preventing developing nations and farmers from around the world from benefiting from the economic, environmental, and agricultural advatages of biochar.

## FOOTNOTES and TIME NOTATIONS

**#1.What is biochar?**

**Time notation 1:15 from BioFuelWatch presentation,:** "Biochar is actually charcoal but they give it a green sounding name to make it seem environmentally friendly."

**WorldStove replies**

"The term 'biochar' refers to black carbon formed by the pyrolysis of biomass i.e. by heating biomass in an oxygen-free or low oxygen environment such that it does not (or only partially) combusts. Traditional charcoal is one example of biochar produced from wood. The term 'biochar' is much broader than this however, encompassing black carbon produced from any biomass feedstock." The above quote is from Woolf, D. (2008) *Biochar as a Soil Amendment: A Review of the Environmental Implications.* See http://orgprints.org/13268/e

**#2. How long does biochar last in the soil?**

**Time notation 3:20; from BioFuelWatch presentation,** "The only form of long term carbon sequestration is terra preta. Other studies are no longer than three years."

**WorldStove replies**

"Except for anoxic peats or permanently frozen soil, the high end for the half-life of Pyrogenic Carbon (PyC) may be expected to be in the region of thousands of (maybe 5000-7000), for cold, wet environments, and for the PyC fraction with more recalcitrant structure. At the other extreme, a half-life in the order of 100 Y may be not unrealistic for some fraction of PyC from boreal wildfire, with less thermal alteration and especially with surface exposure (unpublished field observations from Canadian and Siberian boreal forest sites)". Preston, C.M. and Schmidt, M. W. I., 2006, "Black (pyrogenic) carbon: a synthesis of current knowledge and uncertainties with special consideration of boreal regions", *Biogeosciences*, 3, 397– 420.

BioFuelWatch's statement on the long term duration of buried biochar is negated, in this, their own presentation, they state, (at minute 10:06) that "One to 20 percent of biochar put underground oxidizes into $CO_2$". This means that BioFuelWatch maintains that between 80 and 99% of sequestered carbon remains underground.

**#3. Is there enough waste biomass to sequester?**

BioFuleWatch states "The reality is that there are no large quantities of wastes and residues lying around unclaimed; not on a scale that can supply facilities *over time* and substantially contribute to energy demands. From Ernsting, A. and Smolker, R. February 2009. Biochar for Climate Change Mitigation: Fact or Fiction? Biocharbriefing Feb 2009.pdf

**WorldStove replies**

**Esawy** M., M. Ibrahim, P Robin, N. Akkal-Corfini and Mohamed 2009. Rice Straw Composting and Its Effect on Soil Properties Compost Science & Utilization, 17:146-150. ***20million tons rice straw per year***

**Marinelli**, Janet, 2008. Greening your fall garden cleanup. National Wildlife; 2008, 46:20-21. Landscape debris comprises more than 13 percent by weight of all solid waste generated in the United States—or an astonishing ***32 million tons a year.*** Perhaps not surprisingly, solid waste landfills are the single largest man-made source of **methane** in the United States

**Strand, S.**; G. Benford. 2009. Ocean Sequestration of Crop Residue Carbon: Recycling Fossil Fuel Carbon Back to Deep Sediments. Environmental Sci. and Tech, 2009,

"Globally, crop residues in 2006 were about **5000 million tons** of total above-ground residues."

**WorldStove adds:** Currently, these vast amounts of agricultural biomass decay passively, or are burned or buried. In any case, within a short time, each of these processes will releases **all of** the bound carbon, much of it as methane. Alternatively, pyrolyzing stoves would provide energy to cook, heat and produce electricity while reducing reliance on fossil fuels and the dependence on trees for cooking fuel. The pyrolysis would also sequester 30% of the carbon, thus reducing CO2 in the atmosphere, and the resultant biochar and nutrients it contains, returned to the soil. Even leaving 80% of cited crop waste to preserve soil and avoid erosion, there is more than enough to have a significant impact on atmospheric carbon if 20% is converted to biochar.

**#4. Glaser, B. J. Lehmann, W. Zech, 2002. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – a review. Biology and Fertility of Soils 219- 223.** Soil water retention increased by 18% upon addition of charcoal to a sandy soil.. In loamy soil, no changes were observed, and in clayey soil the available soil moisture even decreased with increasing coal additions, probably due to hydrophobicity of the charcoal. Therefore, improvements of soil water retention by charcoal additions may only be expected in coarse-textured soils or soils with large amounts of macropores

For explanation, think of a general type of biochar as having a specific water holding capacity of 100 grams of water for 100 g of char. Sandy soils might have a capacity well below this value so adding biochar increases their capacity. Loamy or clay rich soils are known to have higher water holding capacity (than sandy soils at least) And adding biochar to them does not increase their capacity and may even decrease it if they are very well structured (aggregated). In sharp contrast to BioFuelWatch's claims (12:22 Biofuelwatch presentation), water retention decreases nutrient runoff which would indicate that biochar decreases dependence on fertilizers by reducing runoff and therefore also protects aquifers from contamination by fertilizers

**#5. What can a small pyrolytic stove do?**

A single stove will consume 300 grams of biomass per hour, producing about 100 g biochar. If a household cooks for 3 hours a day, that gives 300 g biochar per day. That is 109,500 g per year, about 110 kg. per year. One liter of biochar weighs 200 g. Glaser et al. (2009) found that adding 45% of char to soil volume increased water holding capacity of sandy soil significantly. Therefore, to plant in semiarid soils, mix 90 ml (18g) of biochar into 200 ml of soil for each seedling,. A year's production of biochar, from one family, therefore, provides increased water reserves for 6083 plants. (109,500 g divided by 18, g per plant) At the same time, fuel consumption and GHG emissions are reduced, and over 250 kg of $CO_2$ are sequestered.

Assume production of 109.5 kg of biochar, per family, per year. If burned to $CO_2$, instead of sequestered as biochar, this would release 250.5 kg of $CO_2$ to the air (Biochar is 80% carbon) see Charcoal production, marketing, and use (July 1961) USDA publication No. 2213 (Available as pdf).

Large systems of pyrolysis are also under development. See, for example, Pro-Natura (www.pronatura.org ) and Black Carbon (www.blackcarbon.dk )

**#6. Does a stove that produces biochar require more fuel than a stove that does not?**

7:06 **BioFuelWatch presentation: "**They are actually talking about small scale biochar stoves now. They are efficient but if they lock a third of the energy into charcoal, you need a third more fuel to cook."

**WorldStove replies:** "During pyrolysis the majority of energy embodied in feedstock (about 70%) is converted into combustible syngas, but with the liberation of only half of the feedstock carbon. This is because energy rich but less carbonaceous functional groups are liberated first." The above is from Sohi, S., E. Lopez-Capel, E. Krull, R. Bol. 2009. Biochar, climate change and soil: A review to guide future research. CSIRO Land and Water Science Report 05/09.

**#7. Does adding biochar to soil cause the loss of carbon already present in soil?**

9:44 **BioFuelWatch:** Biocharbriefing Feb 2009.quotes papers which indicate that adding biochar to soil causes release of carbon from both boreal forest soils and also from fertile clay soils. (We presume their sources are their references, numbers 13 and 14, dealing with boreal forest soils and fertile clay soils, respectively.

**#8. Does the application of biochar to soil involve risks?**

No footnote was necessary for this topic.

**#9 Biochar and humus compared:**

The Rodale Institute publishes the magazine "Organic Gardening" and ardently supports compost use. Their staff scientist, Dr. Paul Hepperly wrote, "Compost is great, but new bio-based process yields hydrogen and super-stable carbon as charcoal soil booster. …. Whereas many plant residues persist in the soil for months or days and compost can last for years, charcoal's soil lifetime has been measured in many centuries. See Soil erosion, energy scarcity, excess greenhouse gas all answered through regenerative carbon management. by Paul Hepperly. http://newfarm.rodaleinstitute.org/columns/research_paul/2006/0106/charcoal.shtml

10:43 **BioFuelWatch: "**Part of the soil carbon pool is the biomass which would be available if it hadn't been burned. Now this is actually critical. Biomass returned to the soil in the form of organic carbon, in the form of humus, gives the soil its nutrients, its bioflora and its biofauna. Biochar gives the soil organisms nothing to live on. So you've got an essentially dead soil."

**#10 Does biochar contain toxic PAH compounds?**

Ahmed, A., Pakdel, H., Roy, C., Kaliaguine, S., 1989. Characterization of the solid residues of vacuum pyrolysis of Populus Tremuloides. Journal of Analytical and Applied Pyrolysis 14, 281-294. Furthermore, Sohi, et al. (2009), report that, "A single published study examined the full PAH profile (40 individual PAH compounds) in a number of synthetic char samples manufactured at relatively high heating rate concentrations (Brown, 2006). Total PAH concentration was 3–16 µg g-1, depending on peak temperature, compared to 28 µg g-1 in char from a prescribed burn in pine forest. Sohi, S., E. Lopez-Capel, E. Krull, R. Bol. 2009. Biochar, climate change and soil: A review to guide future research. CSIRO Land and Water Science Report 05/09.

With regard to WorldStove products, all of our stoves undergo to the same extensive laboratory testing procedures that the appliance industry applies to modern appliances. Prior to being placed in the field, we conduct life testing and emissions testing for each new stove we develop. We take strong exception to BioFuelWatch's claims that stove producers are using people as "guinea pigs" (13:03 BioFuelWatch presentation)