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Biochar's Role in Global Carbon Management

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Introduction

There is a growing scientific consensus that excess atmospheric CO_2 already emitted from fossil sources would take over 1,000 years to return to preindustrial levels, and more will be added before we can bring emissions to zero. Thus, human intervention will be required to remove several hundred petagrams (Pg) of carbon from the atmosphere [1].

Results and Discussions

The CO_2 concentration in the atmosphere is known to have fluctuated between 180ppm and 280ppm over at least the last 650,000 years, based on ice core data [2]. The current atmospheric CO_2 concentration is almost 400ppm, and is projected to reach a minimum of 450ppm, and very likely 500ppm, or higher, with continued emissions.

The figure 350ppm, popularized as a safe maximum figure, is not precise. It was simply a round number cited in response to arguments about whether we could safely go to 450, 550, or 650ppm, or beyond. Modeling now suggests that a safe level will more likely be closer to 300ppm, which is still significantly higher than the consistent interglacial maximum of 280ppm seen repeatedly over the past 650,000 years.

Each 1ppm of atmospheric CO_2 corresponds to approximately 2.1Pg (1Pg=1Gt) of carbon in the atmosphere. However, the carbonic acid concentration in the oceans is in equilibrium with the CO_2 concentration in the atmosphere, so as atmospheric CO_2 has increased, the oceans have absorbed a large fraction of that carbon. The acid level in the oceans will very likely become the most serious limiting factor, as calcium-shelled organisms that support life in the oceans appear to already be at serious risk, even at current acidity levels.

There is now a strong scientific consensus that the rate of natural carbon removal from the atmosphere is very limited, and that it would take at least 1,000 years, and likely much longer, for the existing atmospheric CO_2 concentration to drop back to around 300ppm. The heating that would result from existing CO_2 levels being maintained over such a prolonged period would drive warming of greater than 2°C.

To reduce the atmospheric CO_2 concentration from 400ppm down to 300ppm would appear to require removing about 300Gt of carbon. This does not include future overshoot, so the net carbon removal required to stabilize the atmosphere could easily be in the range of 600Gt before we bring emissions down to zero.

Many assume that producing biomass energy with CCS (carbon capture and storage) will be the way to remove large amounts of net carbon from the atmosphere. However, CCS remains largely technically unproven, and the sheer volume of suitable geologic formations required for the total amount of CO_2 in question could severely limit its potential.

Other proposals include synthetic trees, or adding large amounts of limestone (calcium carbonate) to the oceans. The energy required for these solutions would mean that one would have to create a vast amount of extra solar, wind or nuclear capacity to support them, or burn even more fossil carbon in an attempt to remove incrementally more than emitted [3].

Afforestation and changes in agricultural and rangeland practices may be the most cost effective way to remove net carbon from the atmosphere. However, such approaches can only correct the portion of the atmospheric imbalance caused by the corresponding carbon emitting agricultural and forestry practices since the dawn of humanity. The majority of excess atmospheric carbon is due to fossil emissions, therefore only a fraction of the total excess can be reversed by corrective land use practices.

The carbon sequestration efficacy of biochar, while not yet fully quantified, is reasonably certain. The biochar cycle can remove and sequester 40-50% of the total carbon in the biomass used to make the biochar, *for on the order of 1,000 years* [4].

Conservative estimates indicate that biochar produced from a sustainable fraction of existing agricultural waste could remove and retire about 1Pg/yr of carbon, while energy co-production could replace up to another 1Pg/yr of fossil emissions [5].

If forestry residues, particularly one-time surplus materials from pine beetle kill and other epidemics, and plantations were included, those numbers could be significantly larger.

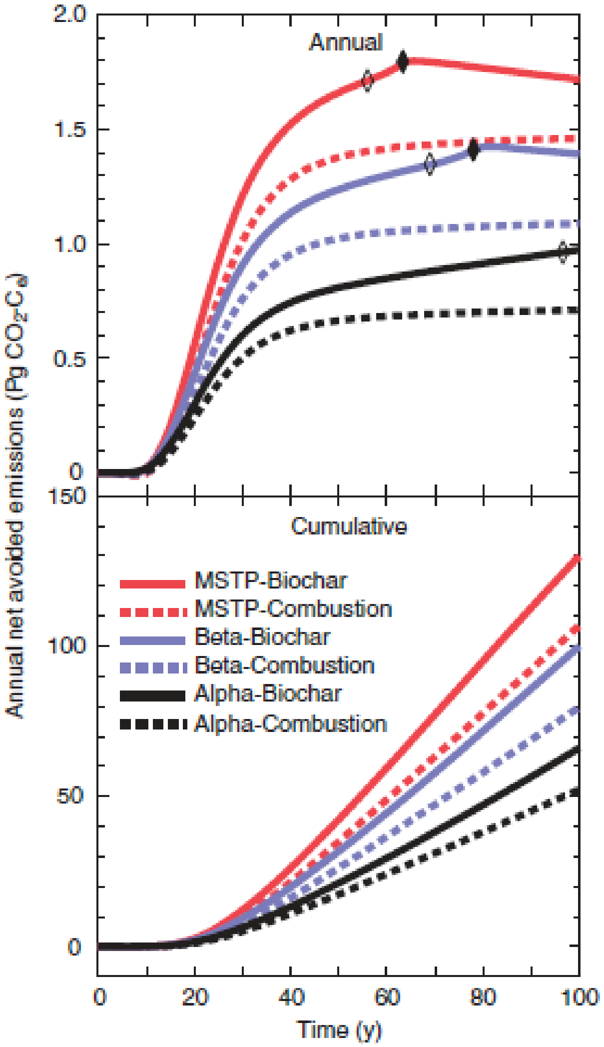

Figure 1. Avoided emissions attributed to biochar production or biomass combustion over 100 yrs relative to current biomass use. Results shown for 3 scenarios—biochar represented by solid lines and biomass combustion by dashed lines. Top panel shows annual avoided emissions; the bottom panel, cumulative avoided emissions. Diamonds indicate transition periods when top 15 cm of soil is biochar-saturated, requiring alternative disposal options [5].

The total benefit from biochar also includes increased biomass production and the potential to expand biomass production into now barren and degraded lands. This allows biochar to bootstrap increased total biomass production, increasing total food production and potentially reduce destructive pressure on intact forestland [6]. Moreover, the economic benefits of biochar accrue from soil fertility in advance of economic drivers for carbon management.

If N_2O emissions are considered, the CO_2 equivalent could make biochar economics even more attractive, even at low carbon prices. Ammonia reduction in agriculture and reduced need for fertilizers also contribute to both the climate carbon balance and the economics [7].

Biochar represents the only truly stable carbon retirement method currently available. If CCS does prove to work, CO_2 emissions from biomass energy coupled with biochar could also be sequestered via CCS, and total annual carbon retirement potentially almost doubled.

The global capacity to retire atmospheric carbon through biochar will depend on biomass allocation among competing uses. Near term, burning biomass to replace coal appears to maximize avoided emissions, but once the energy mix begins to shift to de-carbonized sources, biochar production will offer a uniquely valuable way to remove and retire atmospheric carbon, while also producing about half as much energy from the biomass. The goal of an 80% reduction in emissions by 2050 implies that the energy mix will be de-carbonized within 50 years. Producing a combination of biochar and energy offers true carbon retirement, which will be essential as we remove net carbon from the atmosphere to restore the climate over coming centuries.

Conclusions

It may appear to be more attractive to use biomass as a substitute for coal now, while we are still burning coal, however, once we begin to rapidly de-carbonize the economy, continuing to burn biomass will not be the best use of that carbon, and committing to long-term biomass co-firing projects now would be a mistake.

Acknowledgements

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[1] The Royal Society. 2009. *Geoengineering the Climate*, ix.
[2] Siegenthaler, H. et al. 2005. *Stable Carbon Cycle-Climate Relationship During the Late Pleistocene*, 3.
[3] MacCracken, M. et al. 2010. Asilomar Climate Intervention Conference.
[4] Lehmann, J. 2008. Live conversation. UNFCCC COP-14, Poznan, Poland.
[5] Woolf, D. et al. 2009. Sustainable Biochar to Mitigate Global Climate Change. *In: Nature Communications. 3*,5.
[6] Goodall, C. 2009. Exceptional Results from Biochar Experiment in Cameroon. Accessed online: http://www.carboncommentary.com/2009/10/01/761
[7] Singh, B. et al. 2010. Influence of Biochars on N_2O Emission & N-Leaching from 2 Contrasting Soils. *Am. Soc. of Agronomy.*