Letter to the UK Parliament from the International Biochar Initiative
www.biochar-international.com

October 23, 2009

The Lord Speaker
The Rt. Hon. Baroness Hayman
House of Lords, UK Parliament

The Rt. Hon. The Speaker
John Bercow MP
House of Commons, UK Parliament

Cc: House of Commons Library

Dear Lord Speaker, Mr. Speaker and Honorable Members of Parliament:

The International Biochar Initiative is pleased to provide some information to you on the topic of biochar. We wish to comment on Standard Note SN/SC/5144 from the House of Commons Library titled, "Biochar and Climate Change," dated 03 September 2009. We appreciate your interest in biochar, and are happy to provide any additional information or literature that may be of interest to you on this important technology which can help to restore the world's soils while combating climate change.

By way of background, the International Biochar Initiative (IBI) was formed in July 2006 at the World Soil Science Congress (WSSC) in Philadelphia. IBI is a non-profit organization that supports researchers, commercial entities, policy makers, development agents, farmers and gardeners, and others committed to biochar production and utilization systems that remove carbon from the atmosphere and enhance the earth's soils, following sustainability guidelines. IBI supports biochar production and utilization systems that reduce net greenhouse gas (GHG) emissions on a full GHG lifecycle analysis, that do not contribute to ecologically harmful direct or indirect land use changes, and that are supported by indigenous peoples and stakeholders.

IBI has held two international scientific conferences and is planning a third for 13–17 September 2010 in Brazil. IBI is working with the UN Convention to Combat Desertification and within the UN Rio Conventions to promote the adoption of biochar systems to combat multiple deleterious environmental issues while simultaneously enhancing food security. IBI has issued numerous papers and produced general information on sustainable biochar systems, and participated in publication of a book on biochar: *Biochar for Environmental Management* (Earthscan, 2009).

Biochar is a traditional technology in existence for thousands of years, as seen in the *Terra Preta* soils of the Amazon basin and other areas of the world. Although modern research into producing and utilizing biochar is still quite new, we have solid evidence that, at least in tropical soils, biochar significantly improves soil fertility. Large field trials in non-tropical soils are just now taking place in order to more fully characterize the various biochars made using different techniques, and to quantify soil and crop benefits in temperate cropping systems.

Biochar research is an active and growing field. There is much work yet to do, but the broad outlines of scientific knowledge about biochar, its inherent stability, its benefit to soils, and its potential to mitigate climate change, are sufficiently well understood to move forward on a robust program of biochar research and development, with pilot programs to establish systems for employing biochar as a climate mitigation tool. One way to accomplish the needed R&D and mobilization is to recognize the potential of biochar as part of the post-2012 United Nations Framework Convention on Climate Change (UNFCCC) agreement.

Biochar also has potential as a “fast-start” strategy to mitigate climate change in the immediate near-term. For instance, substituting low-emissions biochar-making cook stoves for traditional, high emissions cooking fires can reduce formation of soot and the impact of black carbon particulates on atmospheric warming and ice field albedo changes resulting from soot deposition, while protecting people’s health and productivity.

Given the urgency of the climate crisis, it is of utmost importance to pursue the potential for biochar systems as a beneficial climate mitigation option. We know enough about biochar today to warrant its inclusion as part of the climate mitigation toolkit over both the near and long terms. The remaining gaps in our knowledge should be addressed by strong, well-funded programs of research and development.

We respond below to some issues raised in the House of Commons Library Note on biochar:

1. Competition for land

Could large scale use of biochar systems result in detrimental land use changes due to improperly designed incentives that could either cause natural ecosystems to be replaced by tree plantations or cause farmers to switch from food production to biochar feedstock production? This concern is valid, and underscores the need for policies to account for these potential impacts and to avoid supporting incentives to destruction. This issue has been particularly well-addressed in the literature, and is a primary reason that the IBI and many biochar researchers and supporters have recommended that waste materials from agriculture and forestry should be the primary near-term source of biomass feedstock for biochar production.

Large amounts of agricultural residues, municipal green waste and forestry biomass are currently burned or left to decompose and release CO_2 and methane back into the atmosphere. IBI has produced a preliminary analysis of several different carbon offset scenarios titled, “How Much Carbon Can Biochar Systems Offset--and When?” based on the utilization of biomass solely from waste streams. Even a conservative scenario, using only 27% of the world’s crop and forestry wastes (the portion of wastes not currently used for anything else) for biochar, could by 2030 sequester 0.25 gigatons (Gt) of carbon a year from biochar alone. If the energy co-product of biochar production is used to offset fossil fuel use, then the annual carbon mitigation potential of biochar more than doubles to 0.6 Gt of carbon annually by 2030.

A scenario utilizing 80% of crop and forestry residues shows that by the year 2050, approximately 2.2 Gt of carbon could be stored or offset annually, reaching the gigaton scale of carbon sequestration that is the benchmark for significant climate mitigation technologies.

Using waste material for biochar as recommended by IBI will entail no competition with food production, will cause no land conversion from forests to plantations, and will create no pressure forcing indigenous people from their land. Furthermore, integrating biochar into food cropping systems and turning crop residues into biochar for use on the farm can greatly enhance food security. Biochar has been shown to improve the use efficiency of fertilizers, and depending on the soil type, it can also increase soil water holding capacity.

Ultimately, biochar can help restore the productivity of degraded lands, creating a positive feedback effect that can increase production of crops for food and energy, with additional waste biomass for biochar production.

2. Lack of evidence on soil/biochar interactions

Although the scientific literature on soil/biochar interactions provides ample evidence on agricultural productivity and on the stability of biochar in soil, it does not currently include detailed analyses of all the interactions and mechanisms that produce the results observed in the complex soil ecosystems that include biochar.

IBI agrees that we need more evidence from field trials in different regions, climates, and soils, and that it is important to practice adaptive management in this situation and to move forward to implement biochar systems in those soil types and under those conditions where scientific evidence clearly indicates a beneficial result.

We find ambiguous results in the scientific literature have sometimes been seized upon by critics as a way to cast doubt on biochar as a whole. We address some of these specific circumstances below, and conclude as a result that there is no rationale for slowing or stopping those deployment programs of biochar systems that are fairly well understood while continuing further investigations into all biochar production and utilization systems.

2.1 Soil improvement from application of biochar

The House of Commons Library Note cites a concern stated by "commentators" that "In some cases charcoal in the soil improves plant growth, in others it suppresses it." This is an example of exaggerated uncertainty. The actual field studies and the evidence from traditional practices do not support this exaggeration.

Field trials using biochar have been conducted in the tropics over the past several years. All showed positive results on yields when biochar was applied to field soils and nutrients were managed appropriately. Large scale field trials have recently begun on highly fertile Iowa Mollisols by the US Department of Agriculture's Agricultural Research Service (USDA-ARS). First year results are positive, yet it will take several years before definitive results are available (Laird, 2009).

Biochar itself is not a fertilizer. Adding unamended biochar to soils that are deficient in nutrients can result in suppressed plant growth, similar to some composts. The solution is to apply nutrients along with biochar. Research has shown that the amount of chemical fertilizer required to achieve a given yield level can be reduced when biochar is also applied. This carries important implications for climate change (nitrogen fertilizer production emits large amounts of greenhouse gases), environmental contamination from agricultural inputs, and the need to enhance agricultural productivity.

Positive evidence of the productivity benefits of biochar also comes from thousands of years of traditional use of charcoal in soils. The most well-know example is the fertile *Terra Preta* soils in Brazil, but Japan also has a long tradition of using biochar in soil, a tradition that is being revived and has been exported over the past 20 years to countries such as Costa Rica (see IBI's report: 20 Years of Biochar in Costa Rica – found at http://www.biochar-international.org/bokashi).

The Japanese tradition is described by Dr Makoto Ogawa, Osaka Institute of Technology, in his paper, "Charcoal Use in Agriculture in Japan," keynote address, Asia Pacific Biochar Conference, 17-20 May 2009:

> "…use of charcoal dwindled to 30,000 t/year by the 1980s but in the 1970s scientists began promoting its production and use, and in 1986 a technical group was established to study carbonization technology, soil amendment in agriculture and revegetation, activation of microorganisms and water purification. In 1990 the research results were published and widely distributed, and charcoal and wood vinegar were authorised for soil amendment by the Ministry of Agriculture, Forestry and Fishery."

The Brazilian and Japanese traditions together provide long-term evidence of positive biochar impact on soils, and considerable reason to further investigate.

Recent research also documents nearly ubiquitous occurrence of biochar-type materials in soils globally (Skjemstad et al., 2002; Hammes et al., 2008; Krull et al., 2008; Lehmann et al., 2008; Laird et al, 2008). While these were generated from wildfires, they share many basic properties with biochar generated from woody and grassy feedstock and provide a large-scale example of the impact of biochar on soils. In fact, soils high in naturally-occurring biochar found in fire-prone grasslands like the North American Prairie are some of the most fertile soils in the world.

While the larger questions concerning overall biochar benefits to soils have been answered in the affirmative, significant questions remain, including the need for a better understanding of some of the details of biochar production and characterization. Work is ongoing to develop methods for matching different types of biochar to soils for the best results. IBI is working with private and public researchers around the world to develop protocols to answer these questions and to further research and development in this important area.

2.2 Recalcitrance of biochar in soils

Biochar is not a single material, and its properties vary according to how it is made and what it is made from, but even the most unstable biochar will store carbon in soil for orders of magnitude longer than its uncharred counterpart. The prevailing scientific understanding of biochar degradation in soil is that some portions of it are quite readily decomposable (termed “labile”), while the core structure of the material is highly resistant to degradation (termed “stable”). Standard analyses of biochar will indicate the relative amounts of labile and stable materials in each biochar material. Depending on how the material is made and from what, the size of these fractions varies, but the degradable portion of biochar (composed of condensates, bio-oils, etc) is usually small (less than 20 percent). Once this portion degrades in the years following application (the degradable portion is metabolized by soil microbes), the leftover will remain in soil for very long periods of time.

Despite the evidence that the labile fraction of biochar is small, a concern has been cited that "Although the black carbon that makes up the bulk of biochar is thought to be biologically unavailable to most microbes, research suggests that some microbes might be able to metabolize it. If so, it would be less stable in soil than currently thought." This statement mischaracterizes the actual mechanisms of char degradation.

While it is certain that soil microbes are capable of degrading biochar, the chemical nature of “stable” biochar fractions makes this an extremely slow process. Furthermore, all organic carbon in soil becomes stabilized when it is coated with soil minerals, making it less available to microbes. This is also the case for biochar. When “stable” charcoal in soil degrades, it is most likely due to the interaction of abiotic (e.g. temperature, moisture) factors and microbes. For example, a 7,000 year-old piece of biochar that was on the inside of a soil aggregate, coated with minerals, might be transformed by going through an earthworm's gut, and then be exposed to air and more moisture which causes chemical changes to its surface, eventually making it more "palatable" to a soil microbe.

Biochar carbon in *Terra Preta* soils of the Amazon has been dated up to several thousand years old. The Amazon is a tropical climate where organic matter degradation is very rapid due to constantly high temperatures and moisture levels. In Australia, estimates of mean residence time for naturally occurring biochar carbons are 1,300 – 2,600 years (Lehmann et al., 2008). Organic matter decomposition rates in temperate regions are slower and the carbon resides in the soils for much longer periods of time.

Controlled experiments where biochar decomposition is monitored are underway, but results extending over long periods of time are not now available. However, applying scientifically robust mathematical models to describe the degradation of organic matter in soil, and using currently available data, multiple independent estimates show that biochar has a mean residence time in soils on the order of 1,300 to 4,000 years. Following is a partial list of some results, adjusted for an environment with a mean annual temperature of 10 ºC:

- 3,300 yr (Major *et al*, 2009) Field study
- 1,335 yr (Cheng *et al.* 2008) Laboratory study
- 4,035 yr (Liang *et al.* 2008) Laboratory study
- 2,000 yr (Kuzyakov *et al.* 2009) Laboratory study.

In summary, a good deal is known about the recalcitrance of biochar in soil. Certainly there is enough scientific information to make conservative estimates in most cases that are suitable for basic carbon accounting.

2.3 Potential loss of soil carbon as a result of biochar applications

Another cited concern is that “In some cases charcoal stimulates bacterial growth, causing carbon emissions from soils to rise.” This concern stems from the results of a study by Wardle et al (2008). The study placed mesh bags of charcoal in the humus layer (consisting of needles and litter, usually called an organic or O horizon, not a mineral soil) of a forest and observed a subsequent loss of carbon. Increased microbial respiration is one possible mechanism for the observed carbon loss, but the investigators did not measure the physical transport of carbon to areas outside the mesh bags they used in the experiment. Organic carbon that is leached into deeper, mineral layers of soil has repeatedly been shown to become stabilized by interactions with minerals, and thus to remain within the soil system.

Further, the study was not designed to determine whether the carbon loss observed came from "resident" soil carbon or actual biochar-carbon. The source of the observed carbon loss was most likely a combination of both resident soil carbon and the labile fraction of the biochar-carbon, but the Wardle study did not account for either, and so the effects of biochar on other forms of soil carbon cannot be determined from that single study.

A recent study testing this very same interaction between litter, char and soil organic matter in a laboratory incubation (Bruun, et al, 2009) found no evidence that biochar increases the decomposition of soil organic matter. The authors conclude: “There is thus no indication the carbon sequestered in the biochar will be offset by an increased release of carbon dioxide because of increased decomposition of soil organic or recently added plant litters. All of this supports the assertion that biochar presents a potentially very effective method for soil carbon sequestration.” The same conclusion was drawn from two further studies (Liang et al., 2009; Spokas et al., 2009) that used more comprehensive approaches than the study by Wardle et al. (2008).

Finally, the effect of biochar on plant growth was not captured in the system studied by Wardle et al. (2008) and this can make a significant difference in the total carbon accounting. A study by Major et al. (2009) showed a net gain in soil organic carbon beyond the biochar additions that was caused by greater plant productivity and accumulation of dead roots and other organic matter in the soil. Consequently, with more organic matter available to microbes, soil respiration was greater. Such greater carbon cycling should not be identified as a loss of soil carbon caused by biochar additions. The Major study stresses the fact that the effect of biochar on non-biochar soil carbon must be studied in the field, at a scale that includes plant reactions to the presence of biochar.

3. Other Issues

Other concerns cited are addressed below.

3.1 Changes in soil albedo

Adding biochar to soil darkens it and questions have been raised about the impact this may have on climate. After centuries of agriculture, soils globally have become depleted of carbon, compared to pre-agricultural conditions. Agricultural development goals include restoring carbon to carbon-depleted soils. Adding any form of carbon to soil, not just biochar, changes soil albedo (a measure of sunlight reflectance). Fortunately, darker, carbon-rich soils are more fertile and will be more easily re-vegetated. Vegetation has a lighter albedo, so the albedo problem is neither specific to biochar nor a simple cause and effect but requires detailed study.

3.2 Toxics in soil

In its report titled *Biochar, climate change and soil: A review to guide future research*, the Australian science agency CSIRO states, “…the apparent success and longevity of the civilization that created the *terra preta* provides some reassurance as to the long-term safety of biochar incorporation to soil…Nonetheless, a critical and non-prescriptive experimental analysis of risks that might arise from the deployment of biochar has not been undertaken according to modern criteria…” Below is a brief summary of the potential toxic compounds that could be associated with biochar:

Heavy metals. Some feedstocks that could be used for biochar might contain heavy metals, however, these are unlikely to be present in harmful concentrations in agriculture and forestry wastes. Caution is necessary in choosing feedstocks to avoid those containing toxic compounds. Treated lumber is an example of biomass that should never be used to produce biochar. There are rules for metal contents in soil-applied materials like composts and sludges, and biochar should be subject to such rules. The IBI is able to provide the expertise through its members to advise in the development of guidelines that would meet environmental standards.

PAHs. Polycyclic aromatic hydrocarbons (PAHs) are chemical compounds that are produced as byproducts of fuel burning (whether fossil fuel or biomass). Some PAHs are carcinogenic to humans, but many are not. PAHs are found naturally in soils as a result of wildfire and many microbes are able to metabolize them. An investigation by M. Jones, et al (2008) found PAHs in biochar amended soils to be at levels similar to or below PAH concentrations found in many unamended soils. One analysis of PAH profiles in biochar samples found a lower concentration of PAHs than in char formed by a prescribed burn in pine forest (Brown, 2006).

Dioxins. Dioxins are predominantly formed at temperatures above 1000 degrees C. Most pyrolysis technology operates well below that temperature. Dioxins should not be a concern with biochar, but any proposed high temperature pyrolysis technology should be assessed and monitored for possible dioxin production.

3.3 Technical and economic feasibility of biochar incorporation into soils

Biochar may be produced by many different methods and at many different scales. Several chapters in IBI's book *Biochar for Environmental Management* address the technical and economic feasibility of producing and applying biochar: Ch. 8 - Biochar Production Technology, Ch. 9 - Biochar Systems, Ch.12 - Biochar Application to Soil, Ch.18 - Biochar, Greenhouse Gas Accounting and Emissions Trading, Ch. 19 - Economics of Biochar Production, Utilization and Greenhouse Gas Offsets, Ch.20 - Socio-economic Assessment and Implementation of Small-scale Biochar Projects, Ch. 21 - Taking Biochar to Market: Some Essential Concepts for Commercial Success, and Ch. 22 - Policy to Address the Threat of Dangerous Climate Change: A Leading Role for Biochar.

Although the technical issues surrounding the production and application of biochar are not complex, ramping up production and application to levels that can make a difference in climate change is a major undertaking. However, this is true of every climate mitigation technology under consideration. The advantage of biochar is that it can address several additional problems at the same time: soil health, water scarcity, food security, waste management, economic development and energy independence, among others.

Another advantage of biochar is its scalability and penetration options, from the subsistence farmer making biochar in a cook stove, to larger agriculture, forestry and energy companies. A 2009 report by the UK Biochar Research Centre (*Biochar, reducing and removing CO_2 while improving soils: A significant and sustainable response to climate change*) submitted as evidence to the Royal Society Geoengineering Climate Enquiry stated:

> "Biochar provides an opportunity for involving farmers and landowners as participants in carbon markets; this is important to rural livelihoods and diversification in all countries, and lends itself particularly well to poverty alleviation in developing countries."

More information on biochar systems and profiles of current practices are available on IBI's website at www.biochar-international.org/

4. Distraction from emissions reductions

From the Note to Parliament: "Some are concerned that biochar sequestration could distract from the need to reduce greenhouse gas emissions…"

The IBI agrees wholeheartedly that neither biochar nor any other mitigation technology should serve as a distraction from the urgent task of reducing emissions of greenhouse gases. But reducing emissions may not be enough to avoid the dangerous climate tipping points that are looming ahead. The *University of Copenhagen Synthesis Report* issued in March 2009 states:

> "Recent observations show that greenhouse gas emissions and many aspects of the climate are changing near the upper boundary of the IPCC range of projections. Many key climate indicators are already moving beyond the patterns of natural variability within which contemporary society and economy have developed and thrived."

The global climate threat is now so grave that in order to avoid catastrophe, it is likely that we must both reduce emissions and find viable pathways for removing CO_2 from the atmosphere.

5. The way forward

IBI is in agreement with assessments by CSIRO and others that more research is needed on biochar. Questions remain as to the underlying mechanisms that explain the observed beneficial effects of biochar application to soil; not all soil types have been tested for response to biochar; and biochars made from processes other than traditional, slow pyrolysis need more testing before widespread use. However, answering all mechanistic-level questions related to biochar use is a project for the long term, and it is not necessary to know all these answers before proceeding with applications that are understood.

The IBI believes that the two main observed field effects of biochar (crop yield improvements and soil carbon sequestration) justify investing in more practical research leading toward immediate implementation of biochar systems where the benefits are clear and the risks are small. These would include building on established traditional uses of biochar as well as expanding on successful field studies to form robust pilot programs that address economics, carbon trading, standards and other implementation issues.

IBI agrees that standards and methodologies must be developed before biochar can be used as a carbon offset, and we are working to address and achieve those goals.

A recent report by the UK Biochar Research Centre (*Biochar, reducing and removing CO_2 while improving soils: A significant and sustainable response to climate change*) provides a valuable checklist of the readiness of biochar to be deployed as a soil improvement and climate mitigation tool:

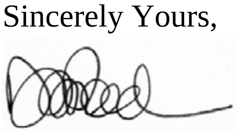
- On biochar recalcitrance in soil: "…timescales look sufficient for biochar to qualify as a viable option for atmospheric CO_2 reduction…"
- On the potential for biochar to reduce atmospheric carbon: "A reasonably conservative assumption would be that biochar has the potential to offset global atmospheric carbon emissions at the gigaton per year scale by 2050 (and probably by 2030 if a concerted effort were made)…"
- On potential negative impacts of biochar on soils: "To our knowledge, there are no evident negative impacts arising from applying biochar to soils."
- On the affordability of biochar: "PBS [Pyrolysis Biochar Systems] has a relatively low-capital intensity and a short lead-time….Herein lies an important advantage of biochar compared to low-carbon energy projects which are capital-intensive and have a long lead-time – such as CCS and nuclear power."

UKBRC also identified "lack of reliable off-the-shelf pyrolysis technologies at a suitable price" as a key barrier to adopting biochar systems. The kind of technology development that is needed is precisely the kind of activity that can be supported by inclusion of biochar in the UNFCCC flexible mechanisms for carbon credits.

Conclusion

IBI believes that biochar must be considered as a viable climate mitigation technology in the current round of UN climate negotiations. Biochar is a gigaton-scale CO_2 removal technology with ancillary energy supply and food security benefits. The world cannot afford to remove this technology from the table at this time. Governments should agree to fund the remaining R&D and scale-up needs of this critical technology to achieve global deployment of biochar systems as soon as possible.

Sincerely Yours,



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