SECOND ANNUAL CONFERENCE: ADVANCING THE SCIENCE AND EVALUATING BIOCHAR SYSTEMS

Write up of our second annual conference, held 28–29th April 2010

August 2010

UKBRC Working Paper 6:

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www.biochar.org.uk

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Overall Impressions

- A lot of research groups
- A lot of research being done

Key Outcomes

- Set up of a UK research network
- A number of Biochar providers
- Pyrolysis Network
- Regulatory working group.
- Setting up of a database of char sample data – The Charchive

Biochar research and development in UK

Setting up a UK Biochar Research Network

One of the most striking features of the conference was the large number of research groups working on biochar issues. Some groups gave an overview of their work programs, which are detailed below It was therefore decided that a UK Research network will be set up, to be hosted on the UKBRC's website.
Full details will follow as the network is set up, and presentations were given by five groups describing their research agendas, facilities and staff. Those groups who presented on this topic are: the UKBRC, University of Reading, University of East Anglia (LCIC), University of Limerick, and IBERS at the University of Aberystwyth.

Discussion and Presentations divided by Topic

Biochar Production

Moderated discussion facilitated by Elisa Lopez-Carpel. Presentations from Andreas Hornung, Aston University; Laura Brown, Durham University; Edward Hodgson, Aberystwyth University; Zoe Wallage, LCIC, University of East Anglia.

How to make Pyrolysis Biochar Systems Commercially Viable

Two commercially ready pyrolysis biochar systems were described by attendees. Andreas Hornung's (Aston University) intermediate pyrolysis process called Biothermal Valorisation of Biomass (BtVB); capable of processing a wide variety of feedstocks such as twigs, leaves and sewage sludge; and Mike Roberts' (Environmental Power International – EPI) fast pyrolysis processing municipal solid wastes. Both systems emphasise delivery of energy, although the BtVB process produces more char.

Energy, and especially electricity, are highly saleable commodities with a clear market value. Biochar however does not have an established market value, and the motivations for widespread agricultural applications have yet to be established. The early commercial pyrolysis facilities therefore rely on energy production as the main source of income. Both also make use of waste feedstocks, which come at lower prices and are more generally available than other feedstocks.

"Why should a farmer want to spread biochar on his land?"

The economic case for biochar applications is not yet made. Biochar crop trials in temperate regions are underway, but the outcomes are still far from predictable. Diverse findings presented at this conference reflected that the relevant processes are not yet understood, and that it would be very difficult to convince a farmer to pay for biochar.

Logistical issues should also be addressed: an example from composting applications was cited: applications of >10t/ha resulting in net primary productivity (NPP) increases of 10% have a negative effect upon gross margins – i.e. applications cost more than the gains from increased NPP. Much of the focus of this conference however was on agricultural effects of biochar applications. Understanding and accurately predicting the effects of biochar applications on a farmers' crop was considered key to commercialising biochar.

The concept of biochar applications to grasslands was raised, and green keepers (of golf courses especially) have been doing this for hundreds of years, until it was recently banned.

Choice of Feedstock

Feedstocks can be divided crudely into three categories: wastes (e.g. municipal solid waste); residues (e.g. straws); and propose grown feedstocks (e.g. energy crops). Each has different issues associated with it, and a regulatory standard for all types of biochar should be developed.

Waste feedstocks are cheap and easily available; but pose challenges for applying biochar to agricultural land. Depending on the feedstock, high levels of contaminants may exist in the biochar; or even if the biochar is uncontaminated there are still regulatory difficulties in removing the designation of "waste". Andreas Hornung made the important point that a clear distinction should be drawn between 'biochar' for application to agricultural soils and waste 'char' which is not for agricultural soils, but may still be combusted for energy, or for some other purpose.

Rodrigo Ibarrola (UKBRC) outlined his work program to develop life cycle analysis assessing pyrolysis as a waste management tool. Laura Brown (Durham University) presented the findings of a study mixing biochar with organic wastes – compost like output (CLO) from aerobic digestion. Biochar was found to increase the stability of carbon in the CLO in lab trials. Like waste char CLOs are not suitable for application to agricultural soils. Such mixing with other wastes may be a beneficial use of waste char.

Residues from crops or forestry produce 'clean' biochar, and do not entail land use change in the way that purpose grown energy crops might. However, Tom de Luca (University of Bangor) stated that crop residues should not be used to produce biochar but be directly incorporated into agricultural soils to increase the very low organic carbon contents. Stephen Nortcliff (University of Reading) pointed out that diverse feedstocks produce better composts (when mixed); and that diverse amendments to soils are generally better because they provide a greater range of benefits. Following this logic, he suggested that biochar from a diverse range of feedstocks, or possibly mixed after processing, may be better for soil applications.

Purpose grown feedstocks would also produce 'clean' biochar; providing they were grown on 'clean' soils with 'clean' amendments. Energy crops could also be grown on non-agricultural land, with wastes added as soil amendments. Concern was expressed that if biochar becomes commercially viable and is scaled up it will inevitably lead to proliferation of unsustainable energy crops and plantations, following the agri-business model of palm-oil plantations in Indonesia or soy-bean plantations in Brazil. The use of well-selected feedstocks and proper regulation were both counter arguments to this fear. Dominic Wolf (Swansea University) pointed out that his research shows that 1GtC/yr abatement is possible from only waste and residue feedstocks.

The role of charcoal fines was discussed. Fines may either be used as a biochar or a fuel. The research community at present is moving towards study of purposefully selected chars and therefore away from charcoal fines. It can also be troublesome to apply them to land, depending on if they are classed as waste or not.

Pyrolysis facilities

The following facilities were represented at the conference:
Aston Unviersity.
Environmental Power International (EPI) (fast pyrolysis).
Aberwstywth – 500kg batch process.
UKBRC @ Edinburgh – 20kg biochar per hour slow pyrolysis unit.
University of East Anglia (gasification).

Key Points

Setting up of a pyrolysis network.
Differentiation between ‘biochar’ as clean char intended for application to agricultural soils; and waste char, potentially contaminated and not intended for agricultural soils.

Biochar properties, characterisation and function

Moderated discussion facilitated by Liz Shaw. Presentations from Elisa Lopez-Capel, UKBRC, Newcastle University; Nils Borchard, University of Bonn, Germany; Saran Sohi, UKBRC, Edinburgh; Corinna Byrne, Feasta, University of Limerick, Ireland; Will Meredith, University of Nottingham; Mark Durenkamp, UKBRC, Rothamsted Research; Yu Luo, Rothamsted Research.

Predictability

Saran Sohi (UKBRC, Edinburgh) argued in his presentation that a level of predictability in biochar-soil interactions was essential for commercialisation of biochar. Predictions must be accurate however, as false predictions or promises would have a negative effect upon the reputation of biochar businesses. There are different levels of predictability and different ways of building predictive capacity; all of which are being undertaken in one means or another by research groups at present. A further challenge is that many of the important biochar physio-chemical characteristics change at different rates over time, and they are very hard to measure once the char is in the soil. However, much work is underway, and many results were reported through the presentations.

Biochar Testing methodologies

Methods for assessing biochar properties and characteristics are not yet well developed. Establishment of relatively cheap, quick and reliable tests was a key theme of the conference; both for biochar characteristics and for biochar-soil interactions. If a bench mark test suite could be developed and sued in every experiment the comparable data would aid the research community immensely.

Elisa Lopez-Capel (UKBRC, Newcastle University) presented results from the carbon ring trials to assess biochar carbon stability using eight different characterisation techniques, as well as adapting techniques for assessing coal to assess biochars. Will Meredith (University of Nottingham) presented findings of using hydropyrolysis as a method of biochar characterisation. Saran Sohi (UKBRC, Edinburgh) described work on the rapid assay toolkit, five techniques to provide quick indications on labile carbon, stable carbon, soil organic matter priming, nutrient delivery and soil structure effects.

Sorption

Stephen Nortcliff (University of Reading) asked what is known about biochar sorption and desorption – can nutrients be desorbed to plants, although they have been sorbed from the soil? DeLuca (Bangor University) responded that biochar in forest soils does not absorb nitrate, but does absorb ammonia and phosphate. There remain many questions about soluble nutrients, nutrient availability, and how this changes through time. Some chars are high in apatite, which slow releases phosphate. Biochar Sorption and pesticides: if biochars adsorb pesticides, does that mean that more pesticides will need to be added for the same response? What impacts, if it occurs, might this have? Nils Borchard (University of Bonn) reported some of his findings from gasification char. Calcium, Magnesium and Phosphates we found in the ash of the biochar and released through time. After two years, the soils are still better than they were before biochar addition. He also reported that biochar activated with steam shows better adsorption.

Pore Size

Micheal Hayes (University of Limerick) stated that pore size and surface area are important indicators of beneficial crop effects, because of benefits to micro-organisms and mycorrhiza. Producing biochars at ambient pressures is better, because the pore integrity is maintained in the biochar. Corinna Bryne (University of Limerick) presented found the nitrogen fixing bacteria Azospirrilum spp. In biochar amended soils, and evidence of fungi colonisation on plant roots, as yet untested but potentially a beneficial mycorrhizal fungi; Yu Luo (Rothamsted Research) made the point that micro-organisms can live within the microscopic pores of biochar.

Elemental Analysis of Chars

Many participant presented data on the various elements found within biochar, both nutrients and metals/contaminants. There are two factors of key importance: the quantity of each and the availability of each. A char with a high nutrient content may not be so good if those nutrients are unavailable to the plant. A char containing a high level of contaminants may in practice be suitable for application to agricultural soils if those contaminants are not available from the char. Whether that would satisfy regulators is another matter.

Charchive Database

Saran Sohi (UKBRC, Edinburgh) outlined the proposal for an electronic biochar database – named the ‘charchive’. Hosted by UKBRC, this would be an online library of data on biochar production method, characteristics, experiments performed and results measured. A small physical sample of biochar could be sent to UKBRC or other storage location for tests in the future storage. This proposal was enthusiastically supported.

Key Points

Establishment of relatively cheap, quick and reliable tests for both biochar characteristics and for biochar-soil interactions would be very useful. Charchive proposal supported.

Field trials and Experiments

Moderated discussion by Neil Hipps. Presentations by Jean Fitzgerald, East Malling Research; Neil Hipps, East Malling Research; Corinna Byrne, Feasta, University of Limerick; Alfred Gathorne-Hardy, Imperial College London; Madeleine Bell, Durham University.

Active field trials

10 people attending the conference were actively running field trials at the time of the conference, a few of whom presented their findings. Jean Fitzgerald (East Malling Research) tested biochars on already high yielding high input barley, strawberry and potato crops, and found no significant yield increases with biochar addition. Madeleine Bell (Durham University) presented findings from a biochar to pasture experiment; NPP and net ecosystem respiration (NER) did not increase significantly, but nitrate leaching from fertilised soils did decrease significantly. Moving on to pot rials, Neil Hipps (East Malling Research) tested biochar made from seaweed in pot trials, and found levels of sodium and potassium to be too high to sustain plant life. Corinna Byrne (University of Limerick) tested biochars on maize in pot trials and found miscanthus biochar to be promote the most growth, and all biochars to enhance crop growth. Alfred Gathorne-Hardy (Imperial College London) found that biochars helped legumes germinate in saline soils but did not help barley of wheat germinate. Nils Borchard (University of Bonn) measure soil responses to biochar additions and found increased nutrient availability, change in pH and increase in soil organic matter content and quality. Indeed, all studies showed pH change and change in available nutrients in soil.

Standardisation of data collection

More field trials were considered to be obviously desirable. One way to improve the utility of field trials would be to collect certain standard data from each trial, to facilitate comparisons and inclusion into modelling frameworks. A discussion on what these tests should be covered various points, but was ultimately undecided, nor was it decided who should develop this protocol.

Kelly Farrer (University of Aberystwyth) pointed out that the minimum protocol must be cheap and relatively easy, or it will not be performed, as those running field trials have a limited budget and have their own particular hypotheses being tested. It should also be kept in mind that any tests performed are also going to be used to construct the assessment protocols and regulation for biochar applications to land, so this must be also considered (Michelle Morrison – Wardell-Armstrong)

There was a discussion on what should be measured from field trials: the fate of biochar carbon, possibly using spectro-photometric techniques; nutrients in biochar, and availability in both conventional and organic farming; bulk density; water holding capacity; pH, contaminants. Tony Hutchinson (Yorkshire Charcoal) suggested more focus on the plant responses, as plants are a good indicator of what is going on in soils. Planning of replicates, replicability, and sampling methods and timings were considered to be important and should be planned carefully. When publishing results, full details on what tests were done, how and when should also be published.

The variability of labs performing the analyses is a potential problem even if the same techniques are used. One way around this suggested was to send the same sample to various labs.

Key Points

Development of a cheap and easy standard protocol of factors and methods for all field trials to assess.
When publishing results from field trials, state which assessments were made and using what method.

Biochar systems, incentives and regulation

Moderated discussion facilitated by Simon Shackley. Presentations from Dominic Woolf, Swansea University; Simon Shackley, UKBRC, University of Edinburgh; Jim Hammond, UKBRC, University of Edinburgh; *Alfred Gathorne-Hardy, Imperial College; Rodrigo Ibarrola UKBRC, University of Edinburgh*

Carbon Accounting and Life Cycle Analysis

Four talks were given on carbon abatement and biochar, of which the overriding message was that biochar seems to offer potentially great carbon abatement, and great carbon abatement efficiency compared to other potential uses of the biomass.

Dominic Woolf (Swansea University) outlined his global model for feedstock availability and biochar processing, using only residues and wastes which involved no land use change. The main finding was that a potential abatement of 1GtC/yr would be possible by 2050. Jim Hammond (UKBRC, University of Edinburgh) presented lifecycle carbon abatement and electricity production for a range of likely UK feedstocks and processing scales; carbon abatement ranged from 0.7-1.2 tCO_2e/ t of feedstock. Carbon abatement was greater than for gasification of biomass combustion, but electricity output less; implying that as electricity is financially more valuable than carbon abatement; biochar will not be commercial unless agronomic benefits can be quantified and marketed. Rodrigo Ibarrola (UKBRC, University of Edinburgh) presented carbon abatement for various waste stream feedstocks compared to other management options such as landfill, anaerobic digestion and combustion; finding that carbon abatement efficiencies were highest from fast pyrolysis – offering a mixture of biochar and relatively high energy production. Alfred Gathorne-Hardy (Imperial College) presented a critique of the typical bioenergy LCA method of assuming biomass fuels to be carbon neutral; arguing that as climate change is a time sensitive issue, time horizons relevant for carbon abatement should be shorter than the time it takes some biomass feedstocks (e.g. trees) to re-grow, thus re-sequestering the carbon which was released upon combustion.

Good carbon abetment efficiency, but will it be effective?

For biochar systems to be effective in combating climate change, or to be perform any other useful function, they must be widely deployed. There are various practical issues which must be addressed to facilitate this kind of wide spread deployment which received attention throughout the conference. Key issues are safety and contamination of biochars, leading to regulation for biochar application to soils; the economic viability of biochar systems, which must be provide more benefits than costs in a clear and predictable manner; and that biochar systems must not lead to further inequalities, or to counter productive situations such as deforestation.

Making Money from Biochar

There is not yet any methodology for crediting carbon abated through biochar into either voluntary or mandatory carbon markets. There is a working group in USA and Canada attempting to create a protocol for the voluntary market. Opportunities for biochar to be funded, *if* a carbon accounting methodology was in place, might include joint implementation schemes in Europe, or CDM projects in Africa, possibly at the small scale (e.g. cookstoves). Nick Marshall from ICECAP ltd has a project on biochar cookstoves in Africa. Green Energy International operates rice husk gasification plants in North Africa and generates 1,000 t/yr of biochar, which is not used at present. Dick Quinnel (blacksmith) plans to set up a micro-initiative, sending the charcoal fines from his smithy to soil, and selling the carbon abatement (at a low cost). He suggested this kind of DIY carbon trading might be good publicity for biochar.

Biochar could also have financial value because of its agronomic effects, but these effects must be predictable and reasonably uniform in order to be sold. The ability to predict and sell the agronomic benefits of biochar is a goal for research community.

Regulation

The question was asked: “Is it ever illegal to put biochar to soils?”, and the representative from the Environment Agency (Jonathon Atkinson) responded: “yes.” Biochar made from waste is still classed as waste, and therefore the rules regarding application of waste to soils apply. Generally, this means that biochar from waste cannot be added to soils.

In the case of compost or anaerobic digestate dedicated regulatory criteria have been developed (PASS 100 or PASS 110). Stephen Northcliff (University of Reading) suggests developing a similar set of criteria for biochar (e.g. PASS 120: Biochar), to allow the process to move faster if and when biochar should be ready for deployment. The Environment Agency were keen for this pro-active approach, and the name Brian Wynne was mentioned as a potential contact. The UKBRC volunteered co-ordinate a working group on this topic, and would develop a number of ‘baseline chars’ which could be tested and regulated for. Other biochars which met the same standards could then be deployed.

Other regulatory routes were discussed, both through European Directives and devolved states (e.g. Wales). Biochar could be also be incentivised through agricultural policies instead of through carbon markets, perhaps through the UE CAP.

Key Points

Setting up of working group on Biochar regulation process.

Life cycle assessments of carbon abatement show promising outputs, but to be an effective solution there are a number of practical issues – such as clear agronomic benefits or access to carbon markets.

Annex 1 Programme

Wednesday 28th April 2010

Biochar Research and Development: State of Play in the UK

The aim of this day will be to present the latest insights and understanding of biochar in the context of UK research and development. The audience will comprise scientists, technologists, as well as industry, finance and policy makers.

09.30 Registration opens (coffee)

10.00–10.15 **Welcome and introduction to Rothamsted Research**
Prof John Lucas, Rothamsted Research

10.15–10.45 **Summary of UKBRC activities in Year 1**
Prof Stuart Haszeldine, University of Edinburgh

10.45–11.30 **A global assessment of carbon abatement from biochar**
Dominic Woolf, Swansea University

12.00–12.30 **Integrated Assessment of sustainable biochar systems**
Dr Simon Shackley, UKBRC, Edinburgh

12.30–13.00 **Are the effects of biochar in soil predictable?**
Dr Saran Sohi, UKBRC, Edinburgh

13.00–14.00 Buffet lunch (foyer)

14.00–17.00 **Facilitated thematic discussion** (coffee at 15.30)

Biochar production

Biochar properties and function

Field trials

Biochar systems and incentives

17.00–19.00 **Poster session and drinks**

CONFERENCE DINNER @ 7pm

(Lewis Hall, Rothamsted Conference Centre)

Thursday 29th April 2010

UK Biochar Researchers Network

This day is an opportunity for UK biochar researchers to get together, compare experiences, share insights and knowledge and forge joint research questions and strategies. The formal sessions will consist of short (10 minute) presentations and facilitated discussion.

Morning Session: Chaired by Saran Sohi, UKBRC, University of Edinburgh

09.15–10.45 Production and characterisation of biochar for R&D

Bio-thermal valorisation of biomass the BtVB process at Hainhaus/Odenwald
Andreas Hornung, Aston University

Biochar Production and Application - Ancient Techniques with Modern Technology
Edward Hodgson, Aberystwyth University

Evaluation of hydropyrolysis as a method for the quantification of biochar via the testing of standard reference materials; Will Meredith, University of Nottingham

Biochar produced from Miscanthus x *giganteus* **and its effect on growth of Maize**
Corinna Byrne, Feasta, University of Limerick

Biochar characterisation prior to soil application
Elisa Lopez-Capel, Newcastle University

11.15–13.00 Biochar function in soils

Effects on soil properties by biochar from slow pyrolysis, fast pyrolysis and gasification; Nils Borchard, University of Bonn, Germany

Biochar application to temperate soils: a carbon sink with environmental co-benefits? Madeleine Bell, Durham University

An overview of biochar research at the University of Reading
Liz Shaw, University of Reading

The influence of biochar on the stability of a compost-like output
Laura Brown, Durham University

Impact of biochar and substrate addition on soil microbial biomass
Mark Durenkamp, Rothamsted Research

Biochar allows biomass crops to be grown on saline soils
Alfred Gathorne-Hardy, Imperial College London

Afternoon Session: Chaired by Ondrej Masek, UKBRC, University of Edinburgh

13.45–14.40 Design and planning for experiments and trials

Biochar production – exploring the opportunities available with biomass gasification combined heat and power; Zoe Wallage, LCIC, University of East Anglia

Assessing the effects of bio-char incorporation on soil fertility and crop growth
Jean Fitzgerald, East Malling Research

Biochar and problem waste types
Neil Hipps, East Malling Research

14.40–15.30 Life cycle assessment, economics and systems

Life Cycle Assessment of Pyrolysis-Biochar Systems in the UK
Jim Hammond, *UKBRC, University of Edinburgh*

Full carbon accounting shows minimal greenhouse gas savings associated with biochar use
Alfred Gathorne-Hardy, Imperial College

Pyrolysis for waste treatment: a Life Cycle Assessment of biochar and bioenergy generation from different waste sources; Jim Hammond, *UKBRC, University of Edinburgh*

15.30–16.15 Networking and wrap-up

CLOSE

Annex 2 List of Posters

CO_2 implications of spreading biochar onto UK pastures – Madeleine Bell and Fred Worrall

Laboratory scale pyrolysis apparatus – Peter Brownsort and Ondrej Masek

System analysis of integrating a Pyrolysis Biochar System within a working arable farm in Scotland – Jason Cook

Effect of Biochar addition on soil respiration partitioning and nitrogen leaching in an apple orchard – Giacomo Fava, Maurizio Ventura, Pietro Panzacchi and Giustino Tonon

Biochar: impact on soil microbial ecology – Sundeep Marluthi, Komang Ralebitso-Senior, Pattanathu Rahman and Chris Ennis

Research on production of Bespoke Biochar – Ondrej Masek and Peter Brownsort

Charcoal effects on plant roots - implications for biochar – Miranda Prendergast-Miller and Saran Sohi

Properties of biochars from slow pyrolysis of brown seaweeds – Andrew Ross, Toby Bridgeman and Konstantinos Anastasakis