Foreword

The Australia New Zealand Biochar Conference (ANZBC), held in Murwillumbah NSW, Australia in August 2017, saw the gathering of scientists, biochar producers, equipment manufacturers, farmers, enthusiasts and other potential biochar end-users. Presenters covered a wide range of topics ranging from reviews of recent science to advances in manufacturing technologies to novel end uses for biochar. The conference provided all in attendance with an up-to-date overview of the state of manufacture, use and potential uses of biochar as well as the opportunity for both presenters and attendees to exchange ideas and develop collaborative networks.

These proceedings are a compilation of papers submitted to ANZBC and summaries of presentations given. The proceedings are divided into three sections, namely refereed scientific contributions, non-refereed written summaries of oral presentations and non-refereed powerpoint summaries of oral presentations. The non-refereed summaries reflect the opinions of the authors at the time of writing, and do not necessarily reflect the opinion of all in attendance at the conference. The papers and summaries in this proceedings benchmark the current state of play of the Australia New Zealand biochar industry in 2017 from the perspective of scientists, manufacturers, marketers and end users.

John Harvey
Managing Director
AgriFutures Australia
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Conference Program

ANZBC17 PROGRAMME TIMETABLE

Day 1 and 2 will involve indoor presentations using PowerPoint type slide shows 30 minutes long for Keynote speakers and 20 Minutes for registered and invited speakers including Q&A.

Day 3 will involve indoor and outdoor workshops of a symposium type festival atmosphere with corresponding trade show. There will be indoor facilities available for PowerPoint presentations and outdoor areas for workshops that will range from 15mins to 1/2 hour long demonstrations.

THEMES

1. Technology & production for matching sustainable biomass sources
2. Value added bio-products
3. Applied science (discoveries & results)
4. Commercial applications (methods & results)
5. Supply chain & policy

Day 1 – Murwillumbah Civic & Cultural Centre

9am – 9.10am: Opening address- Tracey Stinson, Director of Community & Natural Resources Tweed Shire Council

9.10 – 9.20am: Opening Address- Tom Miles, International Biochar Initiative, Live Stream from Oregon, United States

9.20 – 9.30am: Introduction & housekeeping- Don Coyne, Event Coordinator ANZBC17

9:30 – 10:00am: Keynote Speaker Dr Lukas Van Zwieten from NSW DPI: The facts about biochar - What we know from 10 years of study (3)

10:00 – 10:20am: Ian Stanley & Peter Burgess from Rainbow Bee Eater: Introducing ECHO2: base load, low cost energy and biochar from organic residues (1)

10:20 – 10:40am: Frank Strie from Terra Preta Developments: Biochar for regional management - The cascading approach (4)

10.40 – 11am: Morning Tea

11:00-11:20am: Graham Lancaster, EAL Labs: Biochar analytical characteristics and benefits to agriculture (5)

11:20 – 11:40am: Ron Leng from Olsson’s Livestock Nutrition: The application of biochar in ruminant animal production and health (2)
11:40 – 12 noon: Terry Rose from Southern Cross University (Southern Cross Plant Science), Australian Tea Tree and rice industries - where making biochar from crop residue may be a viable economic option (3)

12 Noon – 12:40pm: Lunch

12:40pm – 1pm: Khory Hancock- Land management strategy for the future (5)

1pm – 1:20pm: Euan Beaumont, Energy Farmers Australia: FarmChar – Growing the Australian biochar market (5)

1:20 - 1:40pm: Dr Adrian Morphett, Green Man Char: Charmaker technology, Green Man Char & Wood Vinegar (1 & 2)

1:40-2pm: Ruy Anaya de La Rosa, Biochar for Sustainable Soils Project: Biochar for sustainable soils (B4SS) (4)

2pm – 2:20pm: Dr Paul Taylor, Editor of The Biochar Revolution: Simple biochar production for garden and farm-scale biochar usage: Kon-Tiki flame cap kiln development, operation, and testing (3)

2:20-2:40pm: Don Graves, Mycologist New Zealand Biochar: Recommended doses & location of application into soils. (4)

2:40 – 3pm: Kelly Bryant from AREMI Biomass Platform: The Australian Biomass for Bioenergy Assessment (ABBA) – a spatial view of Australia’s biomass resources (5)

3-3:20pm: Afternoon Tea

3:20 – 3:40pm: Don Coyne from Byron Biochar: Australia New Zealand Biochar Initiative, A not for profit Organisation

3:40 – 4pm: Dr John Thomas & Laura Fell – Evolving an economically viable power & biochar solution (5)

4pm – 4:20pm: David Boehme, Kakadu Wild Veges: Benefits of biochar in horticulture production in Northern Territory (4)

4:20-4:40pm: John McDonald Wharry from University of Waikato: Chars in construction, composites and additive manufacturing: Concepts and considerations (3)

4:40-5pm: Duncan Le Good from Australian Organics Recycling Association (AORA): Recycled Organics Industry and NSW Regulations Overview

5 -7pm: Dinner Break

7-7:45pm: Raffle draw & general industry announcements

7:45 – 8:15: Keynote Speaker – LIVE STREAM Berlin, Germany. Prof. Johannes Lehmann from Cornell University: The contentious nature of soil organic matter (3)

8:15 – 8:30pm: Close of Day 1
Day 2 – Murwillumbah Civic & Cultural Centre

9am – 9:10am: Introduction & housekeeping by ANZBC17 Coordinator Don Coyne

9:10-9:40am: Keynote Speaker Doug Pow from Powbrook: Proposing, implementing and analysing a biological carbon sequestration system utilizing ruminants and dung beetles. Where it has led in six years. (4)

9:40 – 10am: Russell Burnett from Applied Gaia: Farm scale biochar production with the “Big-Roo” (1)

10-10:20am: Dennis Enright from NZ Biochar: Understanding the value of biochar in vineyards (3)

10:20-10:40am: Dr Ashley Martin from Microbelabs: Who’s living in Your biochar? (5)

10:40-11am: Morning Tea

11 - 11:20: Michael Rocca from Tropic Earth Biochar: Biochar in the real world- A farmer & producer perspective (1)

11:20-11:40am: Greg Butler from SANTFA: Biochar as an agro-ecological solution on a landscape scale (4)

11:40 -12 noon: Mohammad Reza Ghaffariyan from Forest Industries Research Centre: Sustainable recovery of forest harvesting residues for bioenergy application (3)

12 – 1pm: Lunch

1 – 1:20pm: Peter Davies from ID Gasifiers: Biochar & Beyond – Multi output continuous plant for farm regeneration, resilience & energy self-sufficiency (1)

1:20-1:40: Kathy Dawson, Biochar Network of W.A: Biochar Innovative trials stimulate commercial adoption

1:40-2pm: Joerg Werdin: – The potential use of Biochar for green roof substrates (3)

2 – 2:20pm: Bill Brown from Torftech P/L: The biomass circular economy, adding value to biomass (1)

2:20 – 2:40pm: Jim Jones from Massey University: Small scale batch manufacture of biochar, balancing emissions compliance with carbon footprint (3)

2:40 – 3pm: Suchanya Wongrod from University of Paris: Biochar production from sewage sludge and the organic fraction of municipal solid waste digestates as sorbents for lead removal from aqueous solutions (3)

3-3:20pm: Afternoon Tea

3:20-3:50pm: Keynote Speaker Prof. Stephen Joseph, UNSW: The commercialisation of biochar; How biochar can be profitable

4-5pm: Panel Discussion – Biochar Industry in Australia & New Zealand: “How to move from research to commercialisation”
5pm - 7pm: Break
7pm – 9pm: Networking Dinner & General Meeting (ANZ Biochar Not For Profit Organisation)

Day 3 – Murwillumbah Showgrounds

Demonstrations

10-11am: Peter Davies from ID Gasifiers: IDG trailer mounted thermal reactor & multi-function retort for mobile biochar production (ongoing)

11-12noon: Steve Hardiman from Lignum Industries Pty Ltd: Operating the carboniser aka exeter retort kiln (ongoing)

12-1pm: Dr Paul Taylor, Editor of The Biochar Revolution: Operating a compact Kon-Tiki flame cap kiln and The ring of fire TLUD (ongoing)

1-2pm: Dennis Enright from N.Z Biochar Ltd: on behalf of Warmheart Foundation – Operating the trough kiln (ongoing)

2-5pm: Dolph Cooke from Biochar Project: Operating the flow pipe kiln and recycled gas cylinder gasifier stove

Workshops

1:30 – 2:30pm Frank Strie from Terra Preta Developments: How the regional/ local biochar potential and other climate farming initiatives can become reality

2:30 – 4:30pm: Don Graves, Mycologist, New Zealand: Biochar potting media as a carrier medium of mycorrhizal fungi, a practical & low cost method of making weed free inoculant for plant nursery propagation & no-tillage seed drill application methods.

END OF PROCEEDINGS. THANK YOU FOR YOUR ATTENDANCE. CHARS!
The facts about biochar (s): What we know from 10 years’ of study

Lukas Van Zwieten 1,2,4, Han Weng1,2, Eunice Agyarko-Mintah2,3, Peter Quin2, Stephen Joseph4, Genxing Pan5, Terry Rose6, Stephen Kimber1, Josh Rust1, Bhupinderpal Singh1, Ehsan Tavakkoli1, Annette Cowie1,2, Ruy Anaya de la Rosa7, Brenton Ladd9, Lynne Macdonald9

1NSW Department of Primary Industries, Australia
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4School of Materials Science and Engineering, University of NSW, Australia
5Center for Biochar and Green Agriculture, Nanjing Agricultural University, Nanjing 210095, China
6Southern Cross Plant Science, SCU, Australia
7Starfish Initiatives, Armidale, Australia
8Universidad Cientifica del sur, Lima, Peru
9CSIRO Agriculture, Waite campus, Glen Osmond, Australia

In memoriam of Tony Walker (Tuckombil Landcare, Richmond Landcare)- a farmer pioneering on-farm research on soil health and biochar

Abstract

Karl Popper (1902-1994) offered a clear criterion that distinguished scientific theories from metaphysical or mythological claims. Scientists do not use statistics as a means to attain certainty, but rather to test claims and to further develop and explain scientific theory. The mere fact that the science of biochar (s) now attracts in excess of 1200 peer reviewed scientific publications (each using robust statistical methodologies), per year, is a clear indication of the maturity of the science, and the broad understanding of the technology and its uses. Although “biochar” has become a generic term defining the charred residue following pyrolysis processes, the plethora of characteristics achievable in the manufacture of biochar necessitates the use of the plural form (biochars). Our understanding of the chemical and physical properties of biochars now allows us to predict, with a degree of certainty; 1) the residence time of the biochar in the soil, 2) the nutrient values of the biochars, 3) the role of biochars in addressing soil acidity constraints, 4) the interaction of biochars with soil physical characteristics and its role in altering soil water characteristics, and 5) its role in attenuating emissions of greenhouse gases (in particular nitrous oxide) from soils. While we attempt to gain a better understanding of the role of biochars on soil biology, we must remain conscious of the fact that soil biology itself is one of the most unexplored frontiers associated with the understanding the dynamics of soil resources and their subsequent health or quality (RM Lehman et al., 2015). Thus, it is not surprising that new science is continually developing our understanding of the interaction of biochars with soil biological processes. And not just its interaction in soil, understanding of the interaction of biochar in compost systems as an example, is continually developing. This review will address the knowns about biochars, areas where we are still developing an understanding, and will highlight some exciting new opportunities for development of products for use in agriculture.

Keywords

Meta-analysis, compost, soil constraint, soil carbon, negative priming, biological processes

Summary Review

It is well understood that soil organic carbon (SOC) is important for its contributions to food production, mitigation and adaptation to climate change, and the achievement of sustainable development goals (FAO 2017). Yet the authors of the FAO report (2017) demonstrate that soils have become one of the most vulnerable resources in the world. Human activities and land use changes are reducing SOC in agricultural lands by an estimated 0.5-2 tonne C ha⁻¹ yr⁻¹ (Ogle et al 2005). Biochar production for use as a soil amendment was proposed as a strategy to mitigate climate change with a technical potential to reduce GHG emissions by up to 9500 million tonnes of C (Woolf et al.,

| 1 |
The residence times for biochars in soil have been estimated to vary between 11 to over 1000 years, being dependent upon both the soil and biochar properties (Singh et al., 2012). Biochar properties such as the degree of carbonisation (measured by the lowering of the ratio of hydrogen to carbon), is an excellent indicator of the potential for biochar to persist in soil. Soil properties such as the level of microbial activity, the quantity and types of clay all play important roles in controlling both the degradation and stabilisation of the carbon from biochars. A recent manuscript by Weng et al., (2017) in Nature Climate Change has provided evidence from a decade old replicated biochar field study that a biochar derived from Eucalyptus can enhance the belowground recovery of new root-derived C (ie recently photosynthesised C) by 20% and can promote the negative priming in a ferralsol (volcanic soil) growing pasture. This means that more of the newly photosynthesised C from the pasture was allocated into the soil. Further, a significant quantity of this new C was found in the organo-mineral fraction (<53 µm) of the soil, indicating that it has been stabilised. Essentially the biochar accelerated the formation of micro-aggregates via organo-mineral interactions and resulted in measurable increases in soil C beyond the initial C addition by biochar. This may therefore provide an opportunity to strategically redevelop soils to further store soil C and improve soil microbial functionality.

Crombie et al (2015) describe the concept of “bespoke biochar” where feedstock and processing conditions are selected to create biochar with specific properties that deliver specific environmental functions to address identified constraints. Soil constraints can include a myriad of single or multiple issues that limit crop or plant productivity. While many of these constraints can be economically addressed with traditional amendments (e.g. lime lowers surface soil acidity), our understanding now allows us to make biochars that address such constraints and deliver additional benefits such as nutrient deficiency, soil structural and even biological characteristics. It is well understood that biochars have structural properties that can change soil physical properties such as bulk density, porosity and water holding capacity (Quin et al., 2015). These same physical properties which include sorptive capacity have also been shown to be particularly promising in composting processes (Agyarko-Mintah et al., 2016) where biochars have shown a range of benefits including lowering losses of the macronutrient nitrogen (N) during composting, increasing the C content of the compost and improving the fertiliser value of the finished product. These properties are being demonstrated in field trials in Peru and Ghana where biochars are improving nitrogen use efficiency for crop productivity. While the improved N use efficiency may be partly due to these direct sorptive mechanisms, the biochars also lowered acidity related constraints in field sites and increased P availability (Slavich et al., 2013), thus stimulating plant and root growth, and therefore increasing N uptake.

Biochars also have an important role in providing opportunities to lower soil emissions of greenhouse gases such as nitrous oxide (N₂O). Using a meta-analysis approach, Cayuela et al (2015) demonstrate that around 50% lower emissions are seen, on average, with the degree of carbonisation being an important factor in the efficacy of the technology. By lowering gaseous losses, there is greater N in soil for crop production. Also using a meta-analysis approach, Zhou et al (2017) have shown that biochar application can result in an average increase in soil microbial biomass C and N by 25%, while lowering the metabolic quotient by 13% on average. This means that the microorganisms were less stressed in the soil following biochar amendment.

Conclusions

Through pioneering inquiry and determination by farmers such as the late Tony Walker, we now have a sound understanding of the role of biochars in Australian soils; including their potential contribution to soil C and soil nutrient status, their ability to address certain soil constraints, and their role in climate mitigation. We are starting to get a better understanding of how biochars interact with soil biological processes, but there remains a challenge to better understand this field of science. The presentation will include some exciting new opportunities for biochars, such as the development of biochar- based enhanced efficiency fertilisers and as carriers for soil microbial inoculants. This
manuscript presents evidence that should give practitioners, regulators and advisors some confidence in moving the industry forward.

References


Introducing ECHO₂: base load, low cost energy and biochar from low value organic residues.

Rainbow Bee Eater is a single purpose Australian owned company, with origins from the first international biochar conference in 2007, that was formed to:

‘Develop and supply modular ‘biomass to energy systems’ with benchmark cost, environmental and social benefits’.

ECHO₂ converts local farming, timber, food processing or green wastes into low cost heat and electricity. On demand.

High quality biochar is produced as a byproduct.

ECHO₂ was developed after 10 years of R&D by Rainbow Bee Eater with support from SDA Engineering, AusIndustry, the WA Government, the SA Government and other local and national companies including food production and aluminium production.

The WA based commercial scale prototype has been tested on straw, hard and soft wood residues and vine wastes. In many cases those wastes are burnt or landfilled today.

Rainbow Bee Eater Directors, Kim Horne, Ian Stanley and Peter Burgess at the WA R&D facility.
ECHO₂ is an automated module that converts organic residues such as wastes from food or timber processing, crops, animals or green wastes, into low cost renewable energy. Where hot water is required, such as for a glasshouse, the boiler exhaust is a clean source of CO₂ enrichment for the glasshouse atmosphere.

ECHO₂ modules are offered as an economic alternative to LPG, natural gas and purchased electricity for businesses or communities where the heat and power demand is a few hundred kW.

Our feasibility studies into the potential application of ECHO₂ modules have indicated that the full cost of producing heat will be under $5/Gj and electricity under $50/MWh - with no reliance on government subsidies.

Capital returns of 2 to 8 years are indicated, driven mainly by the hours per year of operation and the logistics associated with the organic residues. These studies assume biochar revenue to be $100 or $200/t bulk FOB.

Our market research and feasibility studies suggest that early adopters of ECHO₂ modules will include:

* food and timber processors using process wastes for heat and electricity - replacing LPG & grid electricity
* hydroponic growers using local biomass residues for heat, electricity and CO₂ - replacing LPG & grid electricity
* poultry farmers using straw or wood chip based poultry litter for heating, cooling and electricity - replacing LPG & grid electricity

ECHO₂ is now ready for commercial demonstration.

Holla Fresh Pty Ltd has purchased the first ECHO₂ commercial demonstration module which will be installed at their Mt Gambier glasshouse in South Australia in early 2018.

Van Schaik's BioGro will supply timber residues which the ECHO₂ module will convert into glasshouse heat, power and CO2. BioGro will also receive the biochar.

ECHO₂ modules are developed and manufactured in Australia.
Frank & Karin Strie
82 Brady’s Lookout Rd.
Rosevears TAS 7277
Phone: 63 944 395

Our website: www.terrapretadevelopments.com.au
Associated with: the Biochar Journal
www.biochar-journal.org/en
Member of the International Biochar Initiative
www.biochar-international.org
“What is needed in this 21st century of ours, clearly, are solutions that deal with several of our major problems at once.”
Tim Flannery 2007

Biochar for Regional Management: The Cascading Approach
Beyond recycling
Cascading Biochar Systems

- growing the economy from the ground up
- transforming *unloved biomass* permanently
- effective carbon sequestration
- simultaneous production of chars and availability of renewable thermal energy
- healthy living, proactive fire risk reduction, insulation, clean air and water, averting hazards, pollution and waste
Biochar Markets

Original graphic design by Kathleen Draper, Finger Lakes Biochar
Ökoregion Kaindorf, Austria
Growing the economy from ground up

- Since 2007, the Eco-Region is a voluntary association of 6 rural village communities working together with one shared vision: “To become Carbon Neutral by 2020, in our lifetime “.

- Fostering an eco-friendly circular economy: Sustainability and economic viability do not exclude each other.

- [https://www.oekoregion-kaindorf.at](https://www.oekoregion-kaindorf.at)
Cascading values *simultaneous optimisation of growth & profitability*


- [http://www.ithaka-journal.net/55-uses-of-bc](http://www.ithaka-journal.net/55-uses-of-bc)
Yes Opa, our Biochar worked well again! 14 fruit from just 2 “Cundall’s Beauty” plants.
Biochar analytical characteristics and benefits to Agriculture
Graham Lancaster (Manager Environmental Analysis Laboratory)
graham.lancaster@scu.edu.au  Web: scu.edu.au/eal

EAL Background
• EAL is an independent University - research, teaching and commercial analytical laboratory; Founded around 1992 as a self-funded analytical facility – now 30 staff, $4M/yr turnover. NATA and ASPAC quality assurances; Large range of services (water, soil, leaf, compost, biochar, hair, fertiliser, etc) - ‘State of the Art’ equipment.

Biological Farming
• What is biological Farming:
  - Farming with Nature, Organic farming, Carbon Farming; No Tillage, reduced tillage, stubble retention; Low input farming- minimise fertilisers and pesticides; Pasture management- grazing, earthworm, legumes,…; Crop management – rotation, erosion control, irrigation; Organic amendments – animal manures, green manures, recycled organics, biochar
  - Soil Organic Carbon is the basis of sustainable agriculture

Environmental Issues
• Healthy soils not only provide increased agricultural productivity and sustainability but function to: Sustain biological activity; Store and cycle water and nutrients; Decompose organic matter; Inactivate (bind) toxic compounds; Suppress pathogens; Protect water quality and enhance catchment health

Possible Classification Criteria for Biochar:
• >65% Total Carbon >0.65% Total Nitrogen (ratio <100:1 CN)
• >0.35% Total Phosphorus pH above 8.5 (1:5 water extraction)
• Effective CEC above 40meq/100g
  – With >45% Exchangeable calcium
  – With <10% exchangeable sodium
• Note metals are concentrated: <20mg/kg lead; <30mg/kg arsenic; <1mg/kg cadmium; <80mg/kg chromium; iron/ aluminium (not unusual for low %)

Claimed benefits of Biochar:
• Long-term increases in SOC; C sequestration and greenhouse benefits; Improved CEC; Carbon Trading; Liming benefit; Improved soil biology; Improved crop yields; Slow release/higher plant available nutrients; Improved water holding capacity; Reduced off-site migration of agro-chemicals

In conclusion
• Biochar does provide major benefits to soil chemistry, biology and physical structure
• Just like compost, a diverse source of starting organic matter likely to produce the best biochar – synergistic benefit to both compost and biochar farm use
• Unlike compost, biochar more easily provides the long-term increases in SOC
### Figure 1 - Analytical Data for a diverse range of Biochar samples

#### BIOCHAR - ROUTINE AGRICULTURAL ANALYSIS REPORT (diverse data set of up to 20 biochar samples)

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BIOCHAR IN RUMINANT NUTRITION AND HEALTH

By R A Leng AO, D.Rur.Sc. Nutritional Advisor Ollsons Pacific Salt

Email rleng@ozemail.com.au

To date most of the emphasis given to biochar has been on its role as an amendment in soils and its potential to sequester atmospheric carbon. However, recent research shows that its role is much wider, with potential application in all components of farming systems that involve microbial activities. This appears to be particularly true for the addition of biochar to diets of ruminant animals which appear to improve the efficiency of digestion of available feed resources and lowers enteric methane production. Biochars have also been implicated in detoxifying deleterious secondary plant compounds in the rumen of cattle.

The microbial communities inhabiting the alimentary tracts of mammals, particularly those of herbivores, are estimated to be one of the densest reservoirs of microbes on Earth. The significance of these gut microbes that are present mainly as biofilms on/in surfaces of solids, in influencing the nutrition, health, physiology, toxicology, ecology and behaviour of their hosts is only beginning to be realised or rationalised.

In the rumen the major microbial service provided by the biofilm microbiota is that they facilitate the rate of solubilisation and fermentation of cellulosic biomass, polysaccharides in general and many other plant constituents that the monogastric animal cannot digest by intestinally secreted enzymes. Many, but not all secondary plant compounds (SPCs) are also degraded in the rumen to innocuous chemicals or to metabolites that can be used in energy metabolism of the host.

The biofilm essentially increases the rates of all reactions in the process of fermentation through the self-organised assembly of sessile bacteria/Archae attached to a matrix of Extracellular polymeric substances (EPS) produced by the microorganisms, this is a complex mixture of biopolymers primarily consisting of polysaccharides, as well as proteins, nucleic acids, lipids and humic substances. EPS make up the intercellular space of microbial aggregates and form the structure and architecture of the biofilm matrix. In this matrix microbes and adsorbed substances are in close association thus facilitating and enabling cross feeding where the products solubilised by one group of microorganisms becomes a substrate of a close associated group of microbes. In this way the feed is fermented to organic acids and microbes multiply. The organic acids supply a high proportion of the host’s energy requirements whereas the microbes provide essential amino acids and other nutrients (e.g. vitamins) to the animal when these are digested in the small intestine.

Rumen biofilms allow close association of individual species and also through their sorptive capacity greatly facilitate the degradation of organic chemicals at a rate commensurate with the animal achieving an intake of nutrients sufficient to meet growth and other productive processes. It is also proposed that microbes that use elements potentially toxic (to the animal) must also be sessile and brought close to their substrate by sorption on inert or solid surfaces where these biofilms form and are separated from the mainly fermentative biofilm microbes and thus result in a rapid rate of detoxification sufficient to prevent their absorption by the host.

In any microbial ecosystem the populations of organisms become organised entities, where each species has its own ‘liveable’ niche within a biofilm of self-produced extra cellular substances. The microbes in the fermentative biofilm may be synergistic, have little interaction or maybe antagonistic where for instance the products of their activities challenge the survival of fermenting biofilms i.e. phytotoxins degrading microbes v fermenting microbes. It is suggested that the detoxification of these poisons may need to be segregated in different sites. The concept is that inert porous material with large surface areas to their weight are needed in the rumen to ‘house’ microbes (that is the biofilm) with genes for detoxification close to where the same phytotoxins have been bound to the same surface.

Addition of biochars to the diet of ruminants provides niches for the development and growths of microbes that would otherwise only slowly digest feed materials and many toxic substances. The rumen appears to have considerable species of microbes that can degrade toxins and whilst the genes appear to be present in the rumen it is only when a suitable niche is present that these microbes (which are persister) are expressed. Long term in vitro incubation of a culture of rumen organisms with these toxins will adapt and degrade poisons such as fluoroacetate or mimosine even though the initial source of the inoculum had never experienced the toxins.

Biochar as an ingredient of feed for ruminants has been studied most intensively in SE Asia where by-product feeds from Cassava starch production are being developed. The emphasis has been on the development of integrated cattle feeding
systems from the available resources, for example 1000’s of tonnes of cassava root waste are being simply dumped and left in open pits which have been found to produce highly edible silage. The programme was initially to increase ruminant productivity and to minimise greenhouse gas emissions. Cassava root materials can contain prussic acid and also mycotoxins produced by a number of moulds and in the course of the research it has been shown that these deleterious elements may be the cause of poor productivity on such diets.

**Biochar as an additive in diets of ruminant animals** Results of cattle feeding trials in Lao PDR (Leng et al 2012a,b,c) indicate that biochar reduced methane production in an in vitro incubation with rumen fluid taken from an un-adapted buffalo. When the biochar was fed at 1% of the diet to local cattle this was reflected in improved growth rates and concomitant reduction in enteric methane emissions. Cassava root contain considerable cyanoglycosides which are converted to prussic acid (HCN) in the rumen and it seems that HCN is metabolized in the presence of biochar presumably through provision of habitat (the surfaces) of biochar for microbes that can metabolize both prussic acid and the ubiquitous mycotoxins.

Further evidence for the effect of biochar on rumen microbial activity was that rumen fluid, taken from the cattle previously fed biochar, supported lower levels of methane production compared with rumen fluid from un-adapted cattle. When the in vitro system combined rumen fluid from cattle, adapted to having biochar in their feed, the reduction in methane production was three-fold that observed in the treatment with rumen fluid from un-adapted cattle. In vivo feeding biochar resulted in 22% reduction in methane and an increase in growth rate of yellow cattle by 25%.

**Biochar and chronic botulism.** In recent years, an increased frequency of a new form of bovine botulism has been observed in Europe. Chronic botulism in cattle differs from regular food-born botulism by its slow and chronic development. This protracted form may develop when small, sub-lethal amounts of botulinum toxin (BoNT) are taken up and/or absorbed over several days or are generated in the hind gut. In recent studies adding a variety of materials to the feed of dairy cows suffering this chronic disease had significant effects on the apparent absorption of botulinum toxin. Holstein cows suffering from chronic botulism were fed daily with 400 g charcoal (which the authors of the research compared favourably with biochar) for 4 weeks and various additives over a subsequent period. Bacteriological and immunological parameters investigated included *C. botulinum* and botulinum neurotoxins (BoNT) in faeces. From week 6 of feeding charcoal (400 g/head/day) and/or humic acid (120 g/day), there was a significant reduction in *C. botulinum* ABE and CD antibody levels in blood serum and no apparent loss of these in faeces. This may be explained if again charcoal and humic acid are shown to provide habitat for bacteria that metabolise and detoxify the botulinum toxin produced. This has huge significance for Northern cattle producers as the northern savannahs have extremely old and leached soils which are phosphorous deficient and where cattle will often seek out and consume parts of rotting carcases. Bone chewing results in ingestion of lethal levels of the botulinum toxin and is a major cause of production loss.

It is hypothesised that botulinum toxin is absorbed (or sorped) onto the inert surfaces of biochar and at the same time the bacteria with these genes sense the presence of the substrate and attach and form biofilms that metabolise and remove the toxic element. An interesting aside from this research is that the weedicide glyphosate, which is increasingly appearing in cow’s milk in Europe (and which is a serious carcinogen), was also found to be significantly reduced in urine over the same period when charcoal was fed indicating a similar process for degrading glyphosate may be generated by feeding biochar.

**Conclusion** Numerous studies point to a major role of biochars in the microbial ecology of aquatic systems such as the rumen. It appears that biochar at low concentrations provide habitat for these microbial cities where different biofilms can co-exist and provide the animal with nutrients (fermentative biofilms) and the metabolism of poisons (detoxifying biofilms), prevents the absorption of toxins. By specifically utilising plant phytotoxins it appears that the effects of many ‘binders’ used in feeding animals to prevent poisoning may be providing habitat for microbes that degrade the toxin rather than cause it’s excreted in the faeces. In recent times it has been demonstrated that often the genes are present in the rumen microbiota for metabolising deleterious feed components (e.g. fluoroacetate and mimosine) but they are not expressed but by incubation of rumen fluid in vitro with relatively high levels of these same compounds stimulates the microbe(s) growth and they can be introduced into the rumen and successfully detoxify their target substrate. The hypothesis is that the organisms require specific niches and a continuous supply of the substrate to maintain the protection for continuous growth. The conditions that may affect this are the availability of biofilm attachment sites for these communities where they are protected from amensalism.
Australian tea tree and rice industries: where making biochar from crop residue may be a viable economic option

Terry Rose

1Southern Cross University, Lismore, NSW, Australia

Abstract

In many farming systems there are clear environmental benefits from retaining stubble or crop residue in situ, and the removal of these residues for the purpose of producing biochar is therefore questionable. However, for some crops including rice and tea tree, where residues are not currently retained in the field in Australian production systems, producing biochar from these residues may be a viable option. Here, we review and discuss recent results from studies on biochars derived from residues or rice (straw) and tea tree (mulch) for their potential to mitigate greenhouse gas emissions or enhance nutrient cycling. The studies indicated that where rice straw biochar was applied to plots, methane emissions were not significantly greater than plots where straw was removed, while addition of raw straw to paddocks led to significantly higher methane emissions. In tea tree farming systems, the application of tea tree biochar (or tea tree mulch) with poultry litter substantially lowered soil N$_2$O emissions per unit of N applied. Energy balances of pyrolysis were not examined in the studies reviewed, and ultimately, a full life cycle analysis needs to be undertaken in these farming systems to determine if pyrolysing residues is an economically viable proposition.

Keywords

Methane, mulch, nitrous oxide, nutrient cycling, rice straw

Introduction

The use of crop residues as a feedstock can be contentious where there are clear environmental benefits from retaining the residues to provide soil cover and reduce the risk of erosion. Further, the removal of residues in an additional farming operation solely for the purpose of making biochar may not be economically viable if a full life cycle analysis is conducted. However, in farming systems where retaining crop residues in the field is problematic, or where residues are removed as an integral part of farming operations, producing biochar from the residues may be a viable option.

In Australian temperate rice farming systems, upwards of 15 t rice straw (dry matter) can remain after grain harvest. When coupled with slow rates of straw decomposition, this can lead to issues with subsequent sowing operations. As a result, rice straw is either removed or burnt in over 95% of the industry. In addition to causing air pollution, stubble burning of stubble leads to large losses of carbon (C), nitrogen (N) and sulfur (S) from fields, while straw removal leads to large losses of cations and phosphorus in addition to N, C and S. In tea tree farming systems, tea tree shoots are coppiced annually and removed from the paddock for oil distillation. This process removes 5-15 t/ha of biomass from paddocks (depending on yields), and a large amount of nutrients. Following oil distillation, the residue is typically stockpiled and sold as mulch, with few farmers re-applying the residue to paddocks owing to handling difficulties and the time taken to spread. In both rice and tea tree scenarios, the residues may provide an opportunity to create a soil amendment (and possibly energy production and recapture) through pyrolysis, which would enable carbon to be returned to soils. In this study we investigated this option and examined the impact of re-applying these residues to soil as biochar on nutrient cycling and greenhouse gas emissions.


Methods

The results of recent biochar studies in the Australian subtropical tea tree industry (Rose et al. 2016) and in the Australian temperate rice industry (Rose et al. 2017) were reviewed and summarised.

Results and Discussion

In tea tree farming systems, soil C and nitrous oxide emissions were quantified following the application of 5 t ha\(^{-1}\) poultry litter amendment (surface applied) or 5 t ha\(^{-1}\) poultry litter amendment (incorporated) versus 5 t ha\(^{-1}\) poultry litter amendment (incorporated) + 10 t ha\(^{-1}\) tea tree mulch, 5 t ha\(^{-1}\) poultry litter amendment (incorporated) + 11 t ha\(^{-1}\) tea tree biochar or 4 t ha\(^{-1}\) poultry litter biochar amendment (incorporated) + 11 t ha\(^{-1}\) tea tree biochar. Ultimately, the treatments had no significant impact on soil C fractions in the topsoil (0-100 mm depth) or subsoil (100-300mm depth) after 2 years (Rose et al. 2016). However, nitrous oxide emissions in the poultry litter + biochar or poultry litter + mulch treatments were substantially lower than those from the poultry litter alone treatments in the second year. The greatest reduction in nitrous oxide emissions was observed when the poultry litter was pyrolysed and applied with tea tree biochar (Rose et al. 2016), demonstrating the benefits of poultry litter biochar vs raw poultry litter in terms of nitrous oxide emissions.

In temperate (flooded) rice farming systems, studies were conducted to compare soil nutrient cycling and methane emissions when straw was burnt, removed, incorporated or are-applied as biochar (Rose et al. 2017). Incorporating the rice straw led to significantly higher cumulative seasonal methane emissions than when rice straw was baled and removed, but re-applying the straw following pyrolysis did not significantly increase cumulative seasonal methane emissions compared to the stubble removed treatment (Rose et al. 2017). Further, the addition of rice straw as biochar resulted in an approximate 2 t ha\(^{-1}\) grain yield increase (significant at P < 0.05) above all other treatments, which was likely due to higher nutrient inputs in the biochar treatment. One key question as a result of the trials in this project is whether pyrolysing stubble is economically viable, and a full life cycle analysis is required.

Conclusions or implications

Amending soils with either tea tree mulch biochar or rice straw biochar appears to be a means by which to recycle nutrients and carbon back to fields without increasing N\(_2\)O (in tea tree) or CH\(_4\) (in rice) emissions. Future work should scale up the technologies to enable assessment of the practicalities of implementing pyrolysis in these farming systems and full life cycle assessments need to be undertaken to determine whether pyrolysis is an economically viable option.

References


Rose, TJ, Bull, N, Kimber, S & Van Zwieten, L 2017, Rice stubble, fertiliser and water management options to reduce nitrous oxide emissions and build soil carbon, Department of Agriculture and Forestry Carbon Framing Initiative Action on the Ground Program Final report, Department of Agriculture and Forestry, Canberra
Land Management Strategy For the Future
By Khory Hancock¹ (Environmental Scientist)

Scientific communication has failed on a whole – needs story telling and ‘bigger picture’ perspective

Key point 2
Climate Change projections for the future
Will include carbon dioxide projections, temperature projections, crop yield statistics, evaporation predicted rates, extreme weather consequences

Key point 3
Solutions orientated
Land management strategy including habitat connectivity – how? Through Carbon Farming, coordinated conservation and Landcare groups, agriculture.
Challenges – policy, pricing, agricultural challenges (go into potential solutions for each)

Key Point 4
Present the coordinated Climate Action/Strategy Management Plan research project
Call to action – why should you participate?

Conclusion
Empower and inspire everyone into action, why should we care? How should we solve this problem?
Story telling is powerful – need to find a way to inspire an industry movement
**WHO WE ARE**

Energy Farmers Australia Pty Ltd was formed in 2010 by Euan Beamont and Tom Vogan.

Tom grew on a farm near Lancelin, has Bachelor of Engineering and has worked in the mining industry as an Engineer and Project Manager in construction and maintenance of heavy engineering plants for 11 years. More recently Tom has spent 6 years working for a large engineering consultancy gaining experience in feasibility studies and project development in the oil and gas sector.

Euan is originally a farmer from Mullewa, Western Australia and holds a degree in Agribusiness and a Diploma in Farm Management. Since leasing the farm in 2001, Euan worked internationally for the French aid organisation providing logistical support to medical teams in emergencies and since returning home has gained broad experience in the bioenergy and carbon sectors.

Together we decided to combine our skills to facilitate the development of bioenergy and biofuels projects in rural area of Australia.

**WHAT WE DO**

**Bioenergy Projects**
We work with farmers, organisations with a waste stream and technology providers to develop projects where there is a waste stream and an energy requirement.

**Pyrolysis Technology Development**
We are also developing our own pyrolysis technology based on Stephen Joseph’s design and are currently trialling the technology with a large oil and gas company on mine site waste reduction and producing biochar for trial work.
Biochar Research
We have trialled a range of feedstocks and are building a database of the characteristics of each. We look at handling ability, process conditions and outputs. Feedstocks include:

- Poultry Litter
- Macadamia Shell
- Sawdust & Woodchip
- Wheat Straw
- Lupin and Canola Trash
- Invasive Weeds
- Olive Pips and Trash

We are also trialling the biochar we produce in the horticulture and broadacre cropping. Currently we are conducting research on:

- Using biochar to reduce nutrient leaching on sandy soils in cucumbers
- Subsoiling biochar for yield in tomatoes
- Low rates of biochar blended with fertilisers and banded under the seed for fertiliser efficiency in wheat crops

Biochar Marketing and Sales
We have recently created and trademarked the FarmChar brand and are developing a multivendor platform website where biochar producers can list the types of biochar they produce, manage their inventory and sell their products throughout Australia.

Buyers of biochar will be able to find their nearest supplier and with a couple of clicks order the type and amount of biochar they require.

The website is supported by Jen Hanrahan from Blaze Digital, an online marketing expert who will use a range of strategies to reach, convert and grow the FarmChar business. We aim to provide both buyers and sellers an experience that is seamless and having them wanting to come back for more.
CharMaker Technology, Green Man Char Biochar & Wood Vinegar

by Dr Adrian Morphett¹, Dr John Sanderson¹

¹ Earth Systems, 14 Church St, Hawthorn, Victoria, 3122
Earth Systems has over many years developed and commercialised an efficient and mobile pyrolysis technology – the CharMaker.

Commercialised and patented technology in operation since 2010
Currently operating daily in Australia and regularly internationally.
Transportable (the MPP) or fixed install (the FPP). Mobility cuts out biomass transportation costs.
Thermal oxidiser used for emissions control. Minimal “smoke” emissions – OK in urban areas
Different models including batch (MPP) for large and continuous (CPP) for smaller sized biomass.
Efficient technology that uses energy of feedstock to drive the thermochemical process.
Computer controlled for minimal operator input.
• Green Man Char was launched in 2016 as a wholesale and retail outlet for products from the CharMaker technology.

• Diverting clean green waste from landfill the feedstock is a sustainable resource.

• Green Man outlet has various products including ultra-fine biochar, biochar, horticultural char and wood vinegar.

• Products provide multiple environmental benefits including to the soils they are applied to and carbon sequestration.

• Wood vinegar plant recently commissioned and now a regular product input to Green Man.

• Various end uses of products including:
  • Gardens, Agriculture, Horticulture, Stock feed, Pasture, Water filter, Aqua – fish, Odour control, Nursery, Winery
Contact:  Dr Adrian Morphett  
Principal Environmental Engineer  
Earth Systems  
P:  03 9810 7500  
E:  adrian.morphett@earthsystems.com.au  
W:  www.earthsystems.com.au  
The Biochar for Sustainable Soils (B4SS)

by Ruy Anaya de la Rosa

1Starfish Initiatives, Armidale, NSW, Australia

- Land degradation affects about 24% of global land area, with 24 billion tons of fertile soil and 12 million ha of productive land lost each year.
- Globally, 1.5 billion people live on degraded lands.
- Feeding the growing population is a major challenge, particularly as climate change increases pressure on resources.
- Maintaining soil fertility is fundamental for improving food security, reducing poverty and preventing conflict.
- The use of biochar offers potential in addressing these issues.
**B4SS Project Objective**: to demonstrate and promote adoption of sustainable land management practices involving soil amendments based on biochar, that: improve capture and efficient use of nutrients, enhance productivity, improve resilience to climate change, assist watershed management, and support livelihoods of smallholders.
Partners in eight countries

• Australia (Starfish Initiatives and NSW DPI)
• China (Nanjing Agricultural University)
• Ethiopia (Jimma University)
• Indonesia (Norwegian Geotechnical Institute, and Indonesian Soil Research Institute)
• Kenya (World Agroforestry Centre)
• Peru (APRODES)
• USA (Cornell University)
• Vietnam (Thai Nguyen University of Sciences)
Achievements

- 205 farmers evaluating biochar formulations in six countries.
- 34 combinations of biochar formulations/rates/soil type/crop type being evaluated.
- 13 biochar demonstration sites established.
- 216 people have visited the demonstration sites.
- 335 smallholders, resource managers, development agents, extension staff, researchers and students trained in the production and use of biochar.
- 7 biochar networks created, including the Africa Biochar Partnership (ABP).
Abstract for presentation at the ANZBC17 Biochar Conference.

TITLE: Simple biochar production for garden and farm-scale biochar usage: Kon-Tiki flame cap kiln development, operation, and testing.

PRESENTER: Paul Taylor, PhD, Ithaka Institute.

ABSTRACT: At an incipient stage of development of the biochar industry, small property holders, farmers and gardeners around the world seek to process their locally available waste biomass into biochars suitable to enhance their soils, with modest budgets in the $100’s to $10,000 range.

Much of the potential supply of feedstock is thinly distributed on small properties and local scales, and requires small-scale, hands-on processing. Yet small-scale designs that are promulgated on the Internet and in workshops have often been crude, complex to the initiate, smoky, ineffective in practice or in dealing with mixed feedstocks, and unlikely to replicate to impactful degree.

The deep cone Kon-Tiki kiln was developed in Jul 2014 to answer this need. Since then Kon-Tiki kilns have been built or marketed in 57 countries.

This presentation reports on the developments of deep-cone Kon-Tiki kilns, to evaluate the best design parameters and operation for efficient clean biochar making, and pre- and post-treatment. Data are presented on emissions, char quality, field trials, and extension of the design concepts to farm and commercial-scale batch and continuous pyrolysis machines.

12,400L of biochar was made in a 1.65m diameter Kon-Tiki, with overall volume and mass yield from the original wood biomass of 44% and 17% respectively. Six different biochar mixes were prepared, including biochar mineral complexes made in retorts heated within the Kon-Tiki, for a farm-scale trial on 28 x 200m broccolini beds. Cylindrical, and pit kilns were also compared with the Kon-Tiki for processing greenwaste. In further work the original deep cone Kon-Tiki concept, with cylindrical heat shield, was varied to study a double cone kiln, a 2.5m diameter shallow cone, and a 0.7m small cone, to compare convection dynamics and efficiency. The flame curtain kilns emitted significantly lower emissions than other simple batch kilns.
Kon-Tiki flame curtain kiln: Its development, operation, and testing

by Paul Taylor, Ithaka Institute Oz, Mt Warning, NSW, Australia

Goal: To develop biochar ovens up to 2 m³ in volume, which can process a range of biomass on and near small properties, with low and tested emissions, at minimal capital expense, to democratize biochar.

Outline of presentation:
• The Kon-Tiki flame curtain kiln since launch, July 2014 at Ithaka Institute
• A range of flame cover biochar makers.
• Using Kon-Tiki to produce tons of biochar.
• Quantitative studies and field trials done on the Kon-Tiki.
• Current directions of Kon-Tiki in Europe
KON-TIKI pyrolysis

Switzerland, July 2014

Clean Burning
Dries feedstock
Forgiving of feedstock
Flame can be enjoyed
Char is well preserved
Made 800L of biochar
Can recover quench water
Favorable convection flow
Heat shield is desirable
DISTINGUISHING FEATURES

FLAME-COVER KILN

• A cavity, closed at bottom and open near the top, with a flame curtain through which biomass can be continuously added till the kiln is full.

KON-TIKI

Flame cover kiln that Emphasizes:
• the natural self-regulating convection vortex that provides efficient clean pyrolysis and combustion.
• collection/recycling of smoke chemicals, bottom quenching, and HOT charging within the vessel.
FIRING THE KON-TIKI
OR ANY FLAME CAP CAVITY KILN

Light from the top a loose, or crisscrossed, pyre of sticks and kindling

During the run keep a full flame cap in the cone to:

• dry the biomass,
• burn the smoke,
• shield the char from oxygen.

For clean, fast production add material at a rate that keeps flames high and smoke low.

• If flame is too small feed dry thin material
• If flame is large feed heavier or moister material.

Continue till the kiln is full and yellow flames have died away, then quench the hot char.
QUENCHING - HOT CHARGING

Water with nutrients from bulk liquid tank is
• Pumped into kiln through it’s bottom
• Drained into the tank to recycle nutrients plus smoke water.

TO CONDITION BIOCHAR ADD:
- Minerals
- Ash
- Smoke chemicals
- pH adjustment
- Nitrogen

➤ Add microorganisms, possibly nitrogen, after biochar has cooled
• Highest treatment temperature, 650°C.
• Mass Yield 17% (from hardwood block).
• Kon-Tiki Biochar fulfills all conditions for EBC Premium Certificate. Schmidt, Taylor 92014) Ithaka J.
• Hot quenched Kon-Tiki biochar has high content of oxygenated functional groups.
• Emissions are well below other simple tech pyrolyzers, including TLUD. Cornelissen, Pandit, Schmidt, Taylor (2016) PLoS ONE
• Heat was used for water heating or essential oil distillation.
• Kon-Tiki biochar method is in >70 countries after 3 years.
Biochar Application: Rates and Locations

Don Graves, B.Sc. M.Sc (hons) Plant Biology; Nelson Bays Mycorrhizas, Motueka, New Zealand,
www.mycorrhiziz.wixsite.com/mycorrhiziz  email mycorrhiziz@gmail.com

How much?
- Biochar is precious, it costs valuable raw materials, time and energy to make.
- Biochar should be valued and used as carefully as composts.
- Apply at rates of between 1 to 4 tonnes per hectare.
- Don’t risk ‘overdosing’ or ‘shocking’ soils or plant roots with too much ‘raw’ charcoal.

How often? Regularly when sowing seeds, when transplanting seedlings, when under-sowing pastures, or when side-dressing crops.

How? Where? Why?
1. Layered or mixed with composts and or animal manures / urine to produce nutrient- and microbial-enriched and ‘aged’ biochar.
2. Combined with NPK fertilizers, limestone or ash, or “fertichar”
   - Nutrients adsorbed onto biochar surfaces reduce leachate losses, and acts like a slow release fertiliser
3. In seed trays, seed-balls, or potting media prior to transplanting.
4. No-tillage methods or “banded” adjacent to ‘Root-Zone’ soils and ‘Mycorrhiza-zone’ soils.
   - Root-zone (“rhizosphere”) application concentrates biochar around the root zone and soil microbial communities, reduces costs and maximises effects of biochar per plant, reduces amounts of Nitrogen fertiliser required, and potential GHG emissions.
   - Root exudates and soil biology effects on biochar increase soil aggregate formation, and increases accumulation of fresh soil carbon.
5. Handling of dusty biochar has health and safety risks which can be minimised by using biochar slurry, or small biochar granules that are suitable for earthworms to ingest and mix into soils.

- Methods of biochar application into soils and or making seedbeds should avoid loss of three “invisible” things:
  1. Water vapour lost from drying of soil surfaces and seedbeds
     - Micro manage crop residues to advantage
     - Avoid vegetation clearance or bare soils
     - Protect soil surfaces from erosion and drying using anchored mulches, plants with roots
  2. Carbon dioxide (CO₂) lost from oxidation of soil organic matter
     - Minimise soil disturbance during biochar application and seeding
  3. Soil Biology and Health protection and maintenance of:
     - Nutrient rich and biologically diverse microbial communities in plant root zones; and porous soil ‘crumb’ structure.
Ancient Biochar Production and Use in Amazonia, Australasia and Pasifika

- Ancient Amazonians supported huge populations by adding charcoal to improve nutrient poor soils. These human modified soils (“anthrosols”) which still exist today, are now known as “Amazonian Dark Earths” or “Terra Preta de Indio”
- Throughout and surrounding the Pacific Ocean traditional ‘pit kilns’ or earth ovens produce embers to heat glowing red hot rocks, which in turn are used to steam cook food, “hangi”. Hot embers that are quenched with water are suitable for use as biochar. In New Zealand earth ovens are known as “umu”. Dark-coloured charcoal amended Māori garden soils are known as “para umu” soils.
- Eastern Polynesian tropical agricultural practices were well-established when migration to Aotearoa occurred. The people who became the Māori brought tubers of important food crops with them, but faced a far colder climate and different soils.
- Customary gardening practices enabled New Zealand’s first gardeners to adapt to a different environment, growing crops brought from warm tropical conditions, by modifying cool garden soils using raised beds, pathways, and soil amendments of charcoal, sand, pumice and gravels to assist soil heating, aeration, drainage, soil-water holding capacity and nutrient retention.
- Some Māori traditional practices such as charcoal / biochar amended soils, aka “para umu” soils, serve not only adaptation but also mitigation of climate change

Conclusions:

- *Participatory Technology Development*” is a ‘peer to peer’ mutual learning and research method of rural development. Expert farmers and scientists listen to and learn from each other’s knowledge, and collaborate to design and test economically & ecologically ‘appropriate technologies’ and practical techniques.
  - Biochar research needs to be focused on the practical needs of farmers, growers and biochar makers. Biochar research may also offer possible solutions to environmental and social risks of climate change:
  - Scientists are not the only people who learn from experiments, observing and discussing results, and making suggestions to modify and or expand future experiments.
    - Many gardeners, growers and farmers experiment or make small-scale trials to discover whether a local planting site, light conditions, nutrient inputs or soil amendment treatments are suited to the successful establishment and prolonged health and nutrition of a particular soil type, plant or crop rotations.
    - The ecological effects of biochar dose are dependent on biochar production methods and type; soil, compost and crop type; and local environmental conditions including climate, hydrology, soil pH; and the site histories of nutrient inputs, soil disturbance and vegetation clearance.
Australian Biomass for Bioenergy Assessment – A Spatial View of Australia’s Biomass Resources

The Australian Biomass and Bioenergy Assessment (ABBA) is an Australia-wide assessment of biomass resources and biomass resource supply chains. The project is collecting and publishing information about the location, amount, current usage and projected future demand of all types of biomass across Australia. It is also collecting information about relevant infrastructure such as transport networks, and existing users or producers of biomass. The information is being collated in a centralized location – the Australian Renewable Energy Infrastructure (https://nationalmap.gov.au/renewables/) – where it can be viewed by anyone with an interest in biomass.

ABBA is being undertaken by a consortium of State and National organisations coordinated by RIRDC with funding support from the Australian Renewable Energy Agency (ARENA) and in collaboration with biomass producers and users through Bioenergy Australia. Work commenced in 2016 and is currently funded to continue until 2020. Information already available on AREMI includes:

- Forest industry residues for all of the eastern States
- Field and processing residues from a range of the most widely planted broadacre and horticultural crops in major cropping regions across Australia (e.g. Figure 1).
- Organic components of municipal solid waste and biosolids across 2 of the 3 most populous states (Victoria and Queensland)
- Intensive animal industries across Queensland, Western Australia and Victoria

**Figure 1**: Output from AREMI showing an example of ABBA data
As well as presenting data about feedstocks, ABBA is also building a set of analytical tools that will allow users to synthesize and interrogate the data on AREMI to answer questions such as:

- Where is the best place to locate a biomass processing plant that requires particular amounts of certain types of feedstock?
- If I locate my processing plant at place ‘x’ how much of what types of feedstock can I confidently expect to be able to obtain?

Whilst the stated objective of ABBA is to grow investment in the renewable energy sector, the information being assembled by the project is just as relevant to other biomass-dependant industries such as those involved in the production and use of biochar. In fact, given the world-wide trend in biomass-based industries towards high tech. integrated processing facilities generating multiple products it is becoming more and more difficult (and less and less relevant) to distinguish between companies that make energy and those that make soil enhancers such as biochar or compost/organic fertilizers. The ABBA team would appreciate hearing any advice/suggestions from the BioChar industry that would help us to better meet your needs.

**Bio – Jim Payne**

Jim is a professional Soil Scientist with more than 12 years experience in soil mapping, seismic survey and informatics. Jim has worked mainly in Queensland but has also in recent years worked in a combined research/consulting role at Landcare Research in New Zealand. His passion is to improve the access and utility of soils information for end-users by making better use of our substantial legacy land resource datasets through the power of newly evolving computer-based data management, simulation and analysis tools. Jim is currently working as a member of the Queensland ABBA team mapping suitability across Queensland for a range of dedicated biomass crops including novel species such as agave.

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AUSTRALIA NEW ZEALAND
BIOCHAR INITIATIVE
(A NOT FOR PROFIT ORGANISATION)

Don Coyne – info@anzbc.org.au
Dear Client,

Re: AUSTRALIA NEW ZEALAND BIOCHAR INITIATIVE INCORPORATED

Reservation No: 11571

I refer to your Application for reservation of name under the Associations Incorporation Act 2009.

The name has been reserved for a period of 3 months from the date of this letter.

The following should be lodged within the reservation period:

- An Application for registration of incorporated association (Form A2)
- The prescribed fee.

If the Application Form A2 is not lodged by 02/11/2017, the reservation will lapse and the name may become available for reservation to any other applicant.
Why, where, how?

• 5 Members required to move forward
• Until November to write the Rules & Regulations for the NFP
• Membership based
• Eligible for more Grants
• Philanthropic funding
• United voice to lobby Government
• Building a community, building an Industry
• About being financially sustainable moving forward
• Building on what’s already been done
BECOME A MEMBER AND SUPPORT A COLLABORATIVE EFFORT

• YOU CAN BECOME A MEMBER OF ANZBI THROUGH

• Approx $50K raised since October last year and ANZBC17 will break even to small profit moving forward

• Provide feedback and input

• Collaborative effort

• A stronger, more resilient community and industry

• If you can see what we’re trying to do imagine what we could achieve by coming together and obtaining a Grant or Philanthropic funding?!
Thank you from ANZBC17!!

A Social Enterprise

AUSTRALIA NEW ZEALAND
2017 BIOCHAR CONFERENCE ANZBC17

10-12 AUGUST 2017
MURWILLUMBAH CIVIC & CULTURAL CENTRE & SHOWGROUNDS, NSW, AUSTRALIA

- Showcasing pyrolysis and gasification technology.
- Celebrating biochar science and commercial applications in agriculture, horticulture, remediation and building.

www.anzbc.org.au
Evolving an economically viable power & biochar solution

by R John Thomas & Laura A Fell

Environmental Energy Australia Pty Ltd

Abstract

Much of the focus on renewable power generation for Kangaroo Island has been on wind, solar and battery solutions (Dunstan C., 2016), with biomass generation assessed by many as sub-economic. In Europe most biomass energy plants are typically combined heat and power, with much of the revenue flow from subsidised “district heating” arrangements (Puigjaner, 2011). Challenges in using bio-mass to generate electricity include the energy loss to the drying process, the removal of nutrients with the biomass harvested and overall plant economics. Our research was to identify meet these challenges.

Keywords

Integrated Gasification Combined Cycle Torbed woodchip

Introduction

In 2016 Environmental Energy Australia Pty Ltd responded to a “Non Network Options Report” suggesting a power plant to remove the need to replace a power cable to Kangaroo Island. EEA put forward a solution based on a combustion plant, using plantation timber wastes. The solution needed a subsidy to be economic, which would have been provided by a Network Support Services Agreement.

As it turned out, the tender for a new undersea cable was at a far lower price than expected, and the idea of a generation alternative was shelved. However, there was a desire by the Kangaroo Island community to examine the feasibility of a biomass fuelled power plant, so we set to work to find a way to deliver a cost-effective solution despite the context of low wholesale power prices, and lack of markets for heat energy by-product.

Analysis of the economics of the mooted combustion / steam power plant identified the challenges in biomass combustion, include:

1. The feedstock is often at 50% moisture content;
2. Ash produced by combustion needs to be safely disposed of;
3. Power prices and fuel supply prices are mismatched, unless:
   a. High efficiency plant; and /or
   b. Valuable by products arise from the process.
Examination of combustion technologies lead us to conclude that combustion with steam raising was not viable. Our potential supplier of such technology advised that you need 2.5 tons of biomass to generate 1 MW hour of power. (Vyncke, 2016)

An Island-based study of biomass options calculated the cost of harvesting and transporting biomass from plantation to a power plant. It set a range of cost between $25 and $35 per green ton. (Kangaroo Island Council, 2011) before a return to the asset owner.

Power had a value of around $50 to $65 per MW hour (AEMO, 2017). In South Australia during 2017, “black” power has risen to around $120 / MW hour, but is predicted to decline (Daley, 2017).

In the regions where we were interested in there are also multiple concerns, including:

1. Contribution to employment;
2. Reliability of operation;
3. Ability to meet national electricity rules (NER);    
4. The ability to vary power plant output in less than 6 seconds;
5. Environmental credentials, including particulate matter emissions, oxides of nitrogen and sulphur emissions, and acoustic properties; and
6. The management of nutrient removal when compared to leaving biomass waste in situ.

Methods

The mooted operational process was modelled using data published in GER series of publications (Brooks, 2000) supplemented by data provided to EEA by Torftech and our gas turbine consultant on operational characteristics of the drier / gasifier and gas turbine plant. The Fleurieu Power Company generating system dynamic model (Hill Michael Strategic Engineering, 2012) provided information on critical generator characteristics of the selected generator and mooted network connection.

The resulting technical power plant model was incorporated into an overall economic model, incorporating data from AEMO (AEMO, 2017) and Daley (Daley, 2017). Operating expense modelling incorporated data from Fair Work Australia (Fair Work Ombudsman, 2017).

Results and Discussion

Modelling of the economic performance revealed that for the mooted plant to be viable in the time frames required for plant amortisation, fuel efficiency is critical. Use of open cycle gas turbines or combustion with steam raising was found to be sub-economic. Plant design utilising waste heat streams optimises green tons input to MW hours. Biochar production in the process adds economic and non-cash benefits. An Integrated Gasification Combined Cycle model, using Torbed reactor to dry wood chips using HRSG exhaust streams was found to be economically viable. Employment benefits include more than twelve full time jobs in the plant, and biochar is used to capture nutrients.

Conclusions or implications

Use of IGCC and Torbed CBR can deliver cost effective power with biochar as a by-product.

References


Chars in Construction, Composites and Additive Manufacturing: Concepts and Considerations

John McDonald-Wharry

1University of Waikato, Hamilton, New Zealand

Abstract

Charring the outside of wood as a timber preservation technique and adding charcoal to paints, adhesives and building foundations are practices with origins dating back thousands of years. Factors such as biomass feedstock and heat treatment temperatures have great influence on the properties and performance of the range of carbonaceous materials known as chars, charcoals, biochars, activated carbons, and biocarbons. Unsurprisingly, given the range of techniques and product-types possible with charring/carbonising biomass, reports on the effectiveness of their use as construction materials vary considerably over history.

Since 2010 there has been growing interest in adding biochars and other biomass-derived carbonaceous into composite material formulations. A diverse range of approaches to designing, formulating and making these char-containing composites have been used by various research groups around the world. In this growing list of mainly laboratory examples chars have been combined with plastics, resins, cements, plasters and in a few cases metal. Implementation of char-containing composites beyond prototypes and small-scale demonstrations is still rare; however the concept and its implications are now being discussed more widely.

This presentation will give a brief overview of the history of chars in construction. Early scientific and patent literature on char-containing composites with be covered and recent developments in the field will be summarised. Important considerations for the design, production and use of char-containing materials will be a major focus of this presentation. The scope for wider use of biomass-derived chars in additive manufacturing (3D printing) and construction materials in the future will also be discussed

Keywords

Carbonisation, pyrolysis, building, biochar, charcoal, 3D printing

Historical and Traditional Examples

Intentionally charring wood as a timber preservation technique in construction dates back at least a two thousand years because it is mentioned in the writings of a Roman engineer (Vitruvius, 1914). Vikings charring timbers on their ships to provide resistance to flame and water is occasionally mentioned (Rowell, 2006) along with the Japanese tradition of charring cedar boards to resist termites (Zwerger, 2012) known as Shou Sugi Ban. There is a history of United States patents concerning various approaches to charring the outside of timber (Tenney and Bennett, 1857, Lapparent, 1862, Lee and Chaiken, 1979). Charring of wharf piles to protect against marine worms was report to be practiced in Tasmania (Buchanan, 1876). Although charring post ends is sometimes reported to be a common practice a few post durability studies have reported reduced post lifespans due to charring (Morrell et al., 1999, Maguire, 1963) indicating that its effectiveness is variable.

The use charcoal particles as an additive to in beeswax or plant-based latex adhesives for traditional arrow-making is reported to occur in Botswana (Wadley et al., 2015) and in Bolivia (Stearman et al., 2008). A recent study focused on prehistoric tool-making techniques demonstrated that addition of 10% char by weight reinforces wood pyrolysis pitch based adhesives (Kozowyk et al., 2017).

Recent Research and Development

Before 2012, published studies on wood char-based composites where strength and stiffness values are reported were relatively rare. Earlier scientific literature focused on composites where a liquid resin was infused into the cellular channels of larger carbonised wood pieces (Jenkins and Kawamura, 1976, Byrne and Nagle, 1997a,
Publications have also featured wood-resin composite objects or fibreboards which were carbonised to convert the composite object in a single carbon monolith structure (Kercher and Nagle, 2002, Okabe et al., 1996, Okabe et al., 2013, Xie et al., 2009, Krzesinska et al., 2008, Krzesińska et al., 2009, Kwon et al., 2013, Park et al., 2014).

Since 2012, there has been a large increase in publications and presentation featuring composites materials where chars, carbonised biomass or biochars are added in particle form to resins or polymer-based formulations. Table 1 features examples of these newer particle and resin/polymer composites. Some of these composites contained ~70% char by weight although most examples focus on char loadings below 30% by weight. Stiffness of composites typically increases with increasing levels of char addition. Strength of composites has been reported to both increase and decrease with various levels of char addition with complex (and sometimes apparently contradictory) trends reported across these publications. This is unsurprising given range of different chars and resin types investigated along with differences in manufacturing and testing approaches use. Some combinations of char type and resin type are inherently more compatible than others.

Table 1: Composite materials composed of char particles and resins/polymers

<table>
<thead>
<tr>
<th>Resin or polymer type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester resins (thermoset)</td>
<td>(Hassan et al., 2012, Watt and Pugh, 2015)</td>
</tr>
<tr>
<td>Epoxy resins (thermoset)</td>
<td>(Ahmetli et al., 2013, Song et al., 2015)</td>
</tr>
<tr>
<td>Polypropylene, PP</td>
<td>(Das et al., 2016a, Behazin et al., 2017)</td>
</tr>
<tr>
<td>Low-density polyethylene, LDPE</td>
<td>(Chen et al., 2016)</td>
</tr>
<tr>
<td>Polylactic acid, PLA</td>
<td>(Ho and Lau, 2014, Ho et al., 2015)</td>
</tr>
<tr>
<td>Ethylene vinyl acetate, EVA copolymer</td>
<td>(Belaid et al., 2013)</td>
</tr>
<tr>
<td>Nylons</td>
<td>(Ogunsona et al., 2017), Biochar Now LLC</td>
</tr>
<tr>
<td>Ultra-high molecular weight polyethylene, UHMWPE</td>
<td>(You and Li, 2013, You and Li, 2014)</td>
</tr>
<tr>
<td>Confidential/unspecified</td>
<td>(Dring, 2013, McDonald-Wharry et al., 2014, McDonald-Wharry, 2015), Biochar Now LLC</td>
</tr>
</tbody>
</table>

Recent publications also feature examples where chars, biochars or wood-derived activated carbons are added to wood-plastic composites or wood-resin composites such as medium density fibre boards. Numbers of publications featuring natural fibre composites or wood plastic composites with char addition have also increased great in the last 3-4 years (Li et al., 2014, Ayirlmis et al., 2015, Mohanty et al., 2015, Das et al., 2015, Das et al., 2016b, DeVallance et al., 2015, Zhu et al., 2016). Studies on charcoal and activated carbon addition to common wood and thermoset resin composites has focused on reducing formaldehyde emissions and/or accelerating curing times in particle boards (Kowaluk et al., 2016) or medium density fibre boards (Kumar et al., 2013, Darmawan et al., 2010).

Chars or biochars have also been recently investigated as a partial replacement for carbon black in the rubber composite formulations commonly used for car tyres (Peterson, 2013, Meng et al., 2013, Zhang et al., 2015). Molten aluminium has been injected into the cellular channels in carbon wood to create a carbon-aluminium composite with lower thermal expansion than the aluminium (Wang et al., 2006).

The addition of biochars and carbonised biomass to plasters, cements and concretes has been investigated in a number of recently published studies (Khushnood, 2016, Ahmad et al., 2015, Restuccia and Ferro, 2016, Cheng, 2016, Kua et al., 2016). In many of these publications low levels of char are added in order to improve strength and fracture toughness while providing electromagnetic interference shielding properties to the cement.
Chars in Additive Manufacturing and 3D Printing

Additive manufacturing and 3D printing used computer controlled machines to deposit and/or solidify materials to fabricate objects. Recent experiments at the University of Waikato have involved 3D printing with formulations containing biochar. Pine wood biochar from Massey University’s New Zealand Biochar Research Centre (Bridges, 2013) was milled and mixed with polylactic acid resin and other additives. Prototype filaments containing up to 30% char by weight were produced. These prototype filaments were 3D printed using a fused-filament-fabrication style machine which etrudes the molten plastic material (MakerGear MK2). Printed demonstration objects are shown in Figure 1.

Figure 1: Small 3D printed objects made from a polylactic acid based formulation containing 30% biochar by weight. Cubes were printed with 20mm and 10mm sides.

Major Considerations and Implications

The properties of chars change greatly with processing conditions such as the highest temperature (Keiluweit et al., 2010, Thomas, 1961, McDonald-Wharry et al., 2015, McDonald-Wharry et al., 2016, Zickler et al., 2006, Rhim et al., 2010, Antal and Grønsli, 2003). This means it is important to select appropriate chars for the intended applications. Variable char quality will often lead to variable composite performance. If substantial carbon sequestration is the main aim then a focus on ‘high-volume’, ‘low-cost’ processes, formulations and applications will be needed. However in the short-term, smaller-volume, higher-price, niche products will likely be more economically viable. Similar to recent biochar for soil activity it is important to be aware of emerging attempts at patent overreach and also to learn from earlier activity not labelled as “biochar” and known by other terms such as “charcoal” and “carbonized wood”.

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Recycled Organics Industry & NSW Regulations Overview

Duncan Le Good
Australian Organic Recyclers Association
AORA is the peak industry association representing organics processors across a wide range of state and national stakeholders
AORA’s ideology is organic residues are Not a waste but a Wasted Resource
Current regulation in NSW determines what organic residues can be used in a pyrolysis process for conversion into bio-char.
AORA members have an opportunity to work with the bio-char industry via the supply of eligible waste fuels
Duncan is a Director of the Australian Organics Recycling Association and the current NSW Deputy Chair. Duncan has been actively involved in the Organics Recycling Industry in NSW following the completion of his bachelor degree (with honors) at the University of Western Sydney, Hawkesbury in 2003. Duncan has a passion for the beneficial re-use of recycled organics agriculture, horticulture, sports turf and other urban amenity markets and has held various roles in operations, compliance, quality assurance and sales with commercial composting companies since the year 2000. Duncan currently works for SUEZ recycling and recovery as an organics specialist.
The Continuum Model of Soil Organic Matter and Biochar: Oops or Oh-yeah?

Johannes Lehmann
Cornell University, Ithaca, NY 14853, USA

Abstract

Recent changes in the way we understand soil organic matter properties have profound implications for biochar. For one, biochar has to fit into the new model of soil organic matter cycles, and second, the new model provides opportunities to get it right. Separating litter decomposition from soil organic matter dynamics may provide a path forward, but current proposals for such an approach require different metrics than are currently embedded in leading mathematical models such as Century or RothC. The profoundly different material properties of biochar than uncharred plant residues provide a challenge in the effort to move away from recalcitrance and selective preservation towards mineral stabilization as well as aggregation as the mechanisms for soil organic matter stabilization. However, it is clear that charring is conferring more persistence than mineral interaction to plant litter and makes mean residence times more similar between contrasting litter types and less influenced by mineral interaction over the relatively short periods of time that we typically measure. Over long periods of time, biochar decomposition appears to generate the same products that are also produced from uncharred plant matter and therefore should behave similarly to these. Due to the very long-term nature of these interactions, we require mathematical models to test our short-term experimental evidence. Since new mathematical models are developed at present to cater to our shift in understanding of the behavior of organic matter in soils, this should be taken as an opportunity to include biochar in modeling efforts, so as to provide one conceptual and modeling umbrella for all types of organic matter in soil.

Keywords
Persistence; recalcitrance; mineral interactions; modeling

Introduction

Our understanding of the nature of soil organic matter in general has changed over the past decade. While the concept of microbial synthesis of large and refractory molecules, so-called humic substances, has dominated the discourse, the ‘soil continuum model’ is by now a more attractive concept (Lehmann and Kleber, 2015). In the soil continuum model, plant biopolymers, such as cellulose or lignin, are decomposed to smaller and smaller molecules until they are returned as carbon dioxide to the atmosphere. This change in concept was long overdue, as experimental data did not present evidence of the existence of large and refractory molecules and as their biotic production does not make thermodynamic sense. Rather, persistence of organic carbon in soil is conveyed primarily by the soil environment itself (Schmidt et al., 2011). Among temperature and moisture, these include interactions with mineral surfaces and location away from decomposers within aggregates which reduces mineralization. A new generation of mathematical soil organic matter models adapts to this new concept and moves towards including microorganisms (Wieder et al., 2014) and stabilization by minerals.

How does biochar fit into this emergent model? And how can we include biochar into mathematical models to better understand long-term soil carbon dynamics and predict its behavior over long periods of time? In many ways, a very persistent type of litter such as biochar, runs contrary to current efforts that include finding ways to rethink the concept of recalcitrance, and to see recalcitrance as persistence in specific environments.
Discussion

Over the past decade, evidence is mounting that similar to non-biochar plant residues (Lehmann and Kleber, 2015), the decomposition of biochar generates the type of microbial products that are generated from uncharred organic matter (Heymann et al., 2014). This would mean that biochar would obey the same rules that also apply to uncharred organic matter, once it has been metabolized by soil biota. However, these are very long-term dynamics, and biochar remains as a particulate residue for decades to centuries and these interactions may also matter. The mineral environment is known to matter greatly for uncharred organic matter (e.g., Schmidt et al., 2011), and this is also relevant for short-term litter dynamics (Woo et al., 2016). Mineralization of biochar is much less influenced by different minerals than uncharred organic matter over short time periods (ie months) (Woo et al., 2016). Indeed charring confers more persistence to organic matter than does different soil minerals. Charring makes mineralization rates of vastly different plant biopolymers very similar (Woo et al., 2016).

Also the presence of other metabolizable organic matter in soil is relevant as a source of energy that can change the mineralization of biochar itself and cause native organic matter to mineralize differently in the presence of biochar, increasing or decreasing carbon dioxide evolution. Some of the mechanisms of this so-called ‘priming’ are by now well recognized for soil organic matter in general. A stabilization of native organic matter on biochar surfaces (Whitman et al., 2014), however, is not included in conceptual or mathematical soil organic matter models. While such a process is important to include in mathematical models, the ensuing changes in the soil carbon balance are dwarfed by biochar carbon itself (Woolf and Lehmann, 2012). Nonetheless, it is imperative that biochar dynamics are harmonized with and included in such models. Since model development in soil organic matter models currently experience a veritable revolution (e.g., Wieder et al., 2014), there is an opportunity and a need to make a new generation of models fit to include biochar as well as natural pyrogenic organic carbon from vegetation fires. Including biochar in such models ideally does not require greater complexity, but hopefully simplification and a more realistic representation of soil carbon dynamics as shown for the substitution of an ‘inert’ soil carbon pool in the RothC model by pyrogenic carbon (Lehmann et al., 2008).

Biochar in the New Soil Carbon Model: What next?

Biochar cannot exist in a separate world of rules, but our understanding of its short and long term dynamics has to be harmonized with that of any other organic matter in soil. If recalcitrance fails as a principle of organic matter persistence in soil, then this has also to apply to biochar. Biochar is then persistent because of the soil environment, and not because it is intrinsically stable. Using the appropriate term “persistence” in lieu of “recalcitrance” or “stability” may prove necessary to open up pathways for conceptualizing biochar dynamics in soil. Although mineral interactions may be less important over short periods of time than charring itself, the long-term persistence of biochar may make these interactions still quantitatively relevant. Testing and quantifying these interactions may require modeling approaches, as the time periods required may exceed those available for empirical observation. Simple and therefore robust mathematical models are needed that include biochar without further complicating model structures.

References


Proposing, Implementing and Analysing a Biological Carbon Sequestration System Utilising Ruminants and Dung Beetles

Doug Pow – doug@powbrook.com.au
**Farm Scale Biochar production with the “Big-Roo”**

**Principal Design Features of the Big-Roo:**

- Simple robust design.
- Economical to run. No need for gas or diesel at start-up or for operation.
- Decent Capacity. Each batch holds 4 m³ of feed material.
- High Biochar yield of ≥33%.
- Processes Timber Industry & Agricultural waste such as: cereal straw/unusable hay, orchard/vineyard pruning's & trimmings, old wood fencing material, fallen timber, skids & pallets, larger green waste material etc.
- Designed as either a Fixed or a Transportable Unit.
AVAILABLE AS A TRANSPORTABLE OR FIXED LOCATION BATCH PYROLYSER
Understanding the role of biochar in vineyards

Dennis Enright - NZ Biochar Ltd
Rhys Millar - Ahika Consulting Ltd

Summary

Vineyards in Central Otago NZ are located on a wide variety of free draining soils that have little structure and require irrigation and fertilisers to achieve optimum yields. A common practice to assist with nutrient management and water retention is to compost grape marc and vine prunings and return it to the soil.

It is established that adding biochar to the soil can increase the quality and longevity of effects from fertilisers and compost and so these wine producers wanted to know whether biochar can provide benefits for their operations.

A cooperative research project between New Zealand Biochar Ltd, Ahika Consulting Ltd and a group of wine producers coordinated by Grape Vision Ltd was undertaken, with funding from the New Zealand Ministry for Primary Industries Sustainable Farming Fund, to assess this potential.

Treatments consisting of various proportions of biochar mixed with vineyard compost [100% compost (B0C100), 10% biochar/90% compost (B10C90), 20% biochar/80% compost (B20C80), 50% biochar/50% compost (B50C50), 100% biochar (B100C0)] were incorporated midway between rows of an existing vineyard and the effects on soil moisture and nutrients compared with a nil control (B0C0). Biochar was made from chipped Pinus radiata at 600 °C and the compost was made from predominantly grape marc and prunings.

Both biochar and compost significantly increased soil moisture, and by similar amounts (Figure 1).

Figure 1 Soil moisture measured over time during an irrigation event in the first season following treatment application, and on one occasion in the second season.

Compost increased soil nutrients, and biochar caused positive synergistic effects that were statistically significant in soil Olsen-P, Potassium, Magnesium and Cation Exchange Capacity.
A carbon assessment of this vineyard business showed a carbon footprint of approximate 58 t/an CO₂ equivalent that could be offset by applying this biochar at 2.5t/ha over 28 ha annually. However, the biochar loading capacity of these soils has not been quantified.

This experiment has shown; that incorporating either vineyard compost or biochar into these soils will increase soil moisture holding significantly and to an equivalent extent, that compost increased soil nutrients, and that biochar enhanced that effect by causing positive synergistic effects on soil nutrients over the two-year period of this field experiment.

From these results, and an assessment of the carbon emissions from this vineyard, it is concluded that biochar can have practical benefits that contribute to more sustainable production of grape crops, as well as providing meaningful contributions to offsetting carbon emissions.
Biochar in the Real World

by Michael Rocca.

Director of Tropic Earth Pty Ltd, Atherton Tablelands, North Queensland.

Farmer, biochar producer, developer of continuous flow biochar technology.

Website - tropicearth.com.au

Contact - michael@tropicearth.com.au
Prototype Development History

• 1st prototype - 23 kg per hour, commissioned 2012

• 2nd prototype - 45 kg per hour, commissioned 2014

• 3rd prototype - 680 kg per hour, approx 2,900 kw/hr gross heat energy, potential 1 Mwh electricity production, to be commissioned September 2017

Assistance provided by Terrain NRM - Reef Rescue Innovation Programme.

Design motto - ‘Keep it Simple, Low Cost’.

No computer controls, requires 2 persons to operate,

Mobile and requires only two semi trailer tilt trays to move.

Third prototype design will cross a zero of the price tag of a continuous flow biochar machine!
• EPA permitting system is a key impediment to Biochar projects in Australia.

• The environmental benefits of Biochar far outweigh any perceived environmental detriments.

• The Biochar Industry is not a waste disposal industry and we need to stop referring to ourselves as using ‘Waste’ as a feedstock for Biochar production.

• With a ‘Free’ fire permit thousands of tonnes of cane trash can be openly burned, releasing double the amount of emissions compared to processing it into Biochar and the EPA wont even bat an eyelid.

• As soon as it is baled and taken to a Biochar facility it is considered by the EPA to be a waste?

• For every 2 tonne of biomass processed approx 1 tonne of CO² is removed from the earth’s atmosphere.

• Another approx 2 tonnes of CO² can be prevented from being emitted from a coal fired power station if the heat from this process was used to generate electricity and it would be a renewable source of base load power supply.

• That Biochar can then be used to increase agricultural productivity and reduce pollutant run off into rivers and marine environments such as the Great Barrier Reef.

Who is protecting the environment here, and why aren’t we being treated like we are?
• The Australian Biochar market is tenuous at best though the last year has seen interest in Biochar re-
surging.

• The message is most farmers want to try Biochar but the cost is prohibitive.

• The research on Biochar’s benefit is there but it doesn’t give farmers the information they need!

• What they need is a ‘Cost to Benefit Ratio’ they can take to their Bank Manager and Accountant.

• The Government needs to be lobbied to setup a ‘Biochar Grant Scheme’, a dollar for dollar grant for
farmers to buy 10 tonnes of Biochar.

• This is the Catalyst needed to stimulate a Biochar market and on the way to being a ‘Best Management
Practice’, the market would develop over time.

• Biochar producers could then develop their business model capatilising on the other 50% of their
product, ‘Renewable Energy’ which is currently wasted.

• This would bring the cost of Biochar down by 50% where it needs to be, to be affordable for a farming
business.

• Biochar would become a new industry contributing to renewable energy, employment and economic
growth in Australia and answering the need for ‘Serious Action on Climate Change’.

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• The Government needs to stop beating farmers with an ‘Environmental Stick’ and ‘Offer a Carrot’ instead, so they can trial ‘Biochar in the Real World’.

• The scientific evidence is there but doesn’t give the farmers the information they need, what they need is 10 tonnes of Biochar to trial on one hectare of land.

• Something they can put a harvester into and say,

• I got X amount of tonnes more crop there than the rest of the farm.
• Next year I can use this much less fertiliser.
• I saved that many megalitres of water.
• I sprayed this many times less because my crops where healthier.

• This will give the farmers the information they need and they will do the rest!

In Conclusion

• The EPA needs to help us Protect the Environment.

• The Government needs to support the Biochar Producers and the Farmers.

• Biochar is the only truly Carbon Negative Technology the world has and the future of our children depends on what happens next.
Sustainable recovery of forest harvesting residues for bioenergy application

by Dr Mohammad R. Ghaffariyan¹, Forestry research fellow
¹University of the Sunshine Coast, Sippy Downs, QLD, Australia
The presentation includes a summary of five research projects on different biomass harvesting systems in Australian plantations.

The first trial assessed the productivity and cost of slash-bundling the harvesting residues in clear felled area using Pinox slash-bundler in Eucalypt plantation in Tasmania.

Second project investigated the efficiency of a European mobile chipper to collect pine harvesting residues Green Triangle (Victoria) while in the third project a conventional forwarder was studied to recover the pine residues logs (called Fibre plus material) as an integrated biomass operation in Western Australia. The product quality and fuel consumption of the biomass harvesting systems have been also assessed within the trials.

Whole tree biomass harvesting (including feller-buncher, grapple skidder and chipper) was another trial carried out in low-productivity Eucalypt stands in Western Australia to produce biomass chips for bioenergy purposes.

The operating costs and environmental impacts (including remaining residues assessment to sustain soil quality in biomass recovery operations) of different technologies will be compared/discussed in the presentation.

Finally the impact of storage the residues for natural drying to reduce moisture content and optimisation of forest residues biomass supply chain (using a tool called BIOPLAN developed by Acuna el al. 2012) will be presented within a simulated biomass supply chain case study.
Sustainable recovery of forest harvesting residues for bioenergy application

by Dr Mohammad R. Ghaffariyan¹, Forestry research fellow
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IDG On Site Bio-refinery
ANZBC Conference 2017 - Summary

ID Gasifiers - Company background

ID Gasifiers Pty Ltd (IDG) is a privately-held company established in 2013 and headquartered at Delegate River Victoria. The core business of IDG is the manufacture and application development by means a proprietary technology of Thermal Processing Equipment designed to homogenize diverse solid organics into a clean feed stock gas for a variety of purposes including onsite energy and advanced manufacturing, along with generating synergistic co-products such as biochar & wood vinegar as well as holding knowledge on complimentary production of natural inoculants such Protein hydrolysates as biostimulants to boost productivity from farms & forests from which the original material might be sourced, thus providing a key tool in transition to more resilient circular economy.

IDG first commercial continuous production system
IDG-RH Thermo Reactor CHP Module – Key Points

IDG designs were originally developed for our own needs after failing to find genuine commercial systems able to meet basic operational criteria. All development work has been conducted without public subsidy or external investor funding support, this alone makes them unique amongst their competitors and this critical difference in design philosophy shows. Only success allows such development to continue. This has included significant breakthroughs achieved in “lean” design and consistent clean gas outputs across carbonaceous feed stocks allowing reliable engine operation.

- Minimal footprint - Compact reactor module, complete with continuous char removal to for easy cleaning, fits within a “standard” 20’ & 40’ ISO container; three sizes of reactor 50, 150 & 300 kWe capable for broadest application and scale, including 1 tonne/hr output truck portable biochar modules.
- The ability to natively handle “real world” biomass fuels – The IDG reactor system is comfortable running on field dried materials that have simply been sized with an ordinary wood chipper or “fit for purpose” matched low cost densification plant of IDG design;
- Feed stocks can generally be changed or mixed “on the fly” without requiring expensive or difficult recalibration of the reactor, making it the first successful “Universal” design;
- “Open Core Operation”–That is the top of the reactor is open to atmosphere during operation allowing simple loading through inexpensive conveyors rather than complex lock hoppers, the slight negative pressure within the system preventing gas escape. IDG units only require some sealing on shut down, achieved with simple slide gates;
- Clean gas output suitable for IC engine fuel using only single reactor - gas quality issues are addressed within the reactor vessel, not relying on or needing expensive and problematic engineered post gas scrubbing as adopted by other manufacturers or need for fossil fuel burners. Measured gas quality is amongst the highest in the world for a naturally aspirated design and in the upper range (5-6.5MJ/m³);
- Emission management by design and use of natural synergies between retort types for “smokeless” operation.
- Charcoal production – IDG units can be configured to produce a high quality char co-product with similar characteristics to activated carbon suitable for water & air filtration amongst other uses;
- Consistent performance– IDG units are designed for mass fabrication and uniform operation across a wide range so are forgiving of fuel variations;
- Fast start-up and quick reaction time for load following. Clean gas can be produced in as little as 5 minutes from a cold start.
- Operators are easily trained and systems managed under common experience;
- O&M service based on a “service exchange” approach, resulting in minimal down-time, reduced on-site disruption, with consequently optimised operational profile;
- Modular, containerised design concept allows for phased expansion to meet end-user future requirements with minimal space utilisation. *Alone the reactor is extraordinary and has many applications, but matched to a modern IC engine design makes an integrated power plant that is truly exceptional.*
Innovative trials stimulate commercial adoption

by Kathy Dawson¹, ²

¹Warren Catchments Council, Manjimup Western Australia,
²Biochar Network of Western Australia Inc

Agricultural application of biochar – Western Australian research stimulus and barriers

Prior to 2010 very limited research was applied to the agricultural use of biochar in Western Australia. WA cereal growing regions are impacted by dryland salinity and landholders were encouraged to incorporate an oil mallee agriforestry system as a salinity amelioration strategy. The Oil Mallee Company of Australia endeavoured to develop an integrated processing operation, producing energy, activated carbon and eucalyptus oils. This led to the early biochar research in the mid-west. Dr Paul Blackwell, then a research scientist with the Department of Agriculture WA, led the trials, incorporating arbuscular mycorrhiza (from Western Minerals Fertilisers) in the treatments.

Warren Catchments Council’s 10,000km² footprint falls in the high to medium rainfall zones, now subject to significant drying conditions. Soils are varied though the intensive agriculture area’s deep gravelly loams do not share the same constraints as the shallow acidic sandy soils of the early trial sites, roughly 600km north east. The presence of clay (cation exchange enabler) and higher organic matter levels were assumed to alleviate the need for a biochar amendment in the south west.

Investigations into the multiple benefits of biochar at Warren Catchments Council (WCC) coincided with the political will to sequester carbon. WCC facilitated sawmillers’ and farmers’ interests in exploring avenues to enter the Carbon Market by arranging guest speakers – initially Barry Batchelor (Black Earth) and Dr Syd Shea (Rainbow Bee Eater Project), and to alert them, through workshops, to biochar’s agronomic potential.

Doug Pow was an early adopter of biochar, applying his concept of using biological tools to sequester carbon – cattle and dung beetles. WCC secured a low budget grant from the WA State NRM Office to replicate what was proving to be a very successful strategy. Applications for funding through Action on the Ground or Filling the Research Gap for further research were unsuccessful, and, with a change in government, that funding opportunity ceased.

Biochar – cattle and dung beetles

A chance meeting between Doug Pow and Prof Stephen Joseph at a biological farming forum in 2015 sparked the latter’s interest in quantifying the effects of dung beetle buried biochar-infused manure. The assembled research team drew together findings from other studies to help explain the visible effects – healthy cattle and improved pasture performance - as well as data confirming nutrient cycling through laboratory analysis and the use of X-ray photoelectron spectroscopy.

Mat Daubney agreed to replicate the trial on his 1,000 head Bannister Downs Dairy to see if the dung beetle-biochar action could assist in renovating perennial pastures without the conventional practice of taking them out of rotation during establishment. This was an ideal green-field site since there was minimal dung beetle activity. The trial was too short-term to build up the dung beetle population to have a measurable impact on soil nutrient analysis. However, the immediate reduction in dairy odour was appreciated by staff! Bannister Downs Dairy won Dairy Australia’s 2017 cream award – motivation to develop a more comprehensive research project, based on Archim Gerlach’s study, to determine biochar’s effects on animal health, growth rate, fertility, milk properties, feed conversion efficiency and emissions reduction.

Feeding biochar to beef cattle is gaining momentum with several producers known to be implementing the practice and interest is obviously widespread as WCC regularly receives queries from further afield.
Biochar-amended rhizosphere in avocados

The success of biochar’s effect on pasture improvement inspired Doug Pow to consider biochar’s structural properties and how they could be utilised to re-engineer the soil in an avocado orchard so it more closely resembles its native andosol soil. Another low budget grant was awarded through National Landcare Programme funding to test whether increased porosity would alleviate locally prevalent waterlogging conditions to mitigate Phytophthora cinamomomi infestation. As avocados are largely surface feeding, it was speculated increased aeration and infiltration would enhance growing conditions.

The trial comprised a row of 36 treatment trees matched with a control row 36 divided into three blocks of 12 according to their soil type: karrri loam on clay, gravelly loam on deeper clay, sandy loam on gravel. Each block had four trees of 5%, 10% and 20% v/v biochar incorporated into the top 300mm (to determine influence of application rate). All trees were mulched with a poultry manure/sawdust/woodchip mulch but two trees from each treatment had biochar included in the mulch mix (to determine influence on plant performance). There were insufficient replicates – in treatments and samples - in this trial for statistical reliability however visible differences in early growth impressed local producers sufficiently for there to be rapidly increasing uptake of the practice, coinciding with the dramatic expansion of the local avocado industry.

Measurements taken in September 2016 recorded the treatment row mean out-performed the control row in tree height (18%), trunk girth (21%) and diameter (21%). However, the effect was greatest in the karrri loam on clay: height (20%), trunk girth (26%) and diameter (27%).

Soil testing didn’t indicate any significant difference in nutrient availability suggesting greater efficiency in nutrient use (or acquisition) in biochar amended soil to generate such superior biomass production. Tissue sampling (composite samples of treatment and control rows) conducted in July 2015 recoded 8% less Cl in the treatment row. Irrigation water at the time had a reading of 486μS. However the Cl reduction in most recent tissue testing (July 2017) was insignificant.

Final tests and detailed analysis of soil, tissue and microbial biomass data, and physical measurements are to be conducted in this trial that ends in December 2017. Producers who have maintained regular observations have multiple reasons for adopting the practice: salinity mitigation, accelerated early growth to foster resilience, Phytophthora cinamomomi control tool, increased interest in biological inputs. Most have opted to use the 5% application rate as there is little observable difference between treatment rates.

This trial has generated many more questions than answers! Much more research is needed to explain biochar’s role in this trial and whether similar results will be achieved in different tree crops, soil and climatic conditions.

Biochar Network of Western Australia Inc

Recently incorporated, the Biochar Network of WA seeks to provide a mutually beneficial forum to build the capacity of users and producers of biochar. WA is a large state and a website, in development, will assist in knowledge sharing. BNWA will lobby for a WA biochar industry and seek to secure resources for research and development.

References:


The potential use of biochar for green roof substrates

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• Key properties of biochars for green roof substrates
  • Low bulk density
  • High capacity for plant available water
  • High physical and chemical stability
  • High nutrient retention capacity
  • Free of toxins
  • Consistent in quality and local supply
  • Particle size to ensure sufficient hydraulic conductivity
• Preliminary research results indicate (17 Eucalyptus spp. common in SE Australia, pyrolysed in a slow batch process with long residence time at 500 – 600 °C highest treatment temperature investigated)
  • Fibre lumen diameter and fibre wall thickness of woody feedstock material are correlated with wood density
  • Lower feedstock bulk density results in lower biochar bulk density
  • Feedstock cell structure cannot be used as a predictor for the water holding properties of the resulting biochar

• Future research will investigate
  • How biochars alter the physio-chemical properties of green roof substrates
  • The influence of biochar amended green roof substrates on plant water stress
  • If nutrient runoff loads from green roofs can be reduced by amending green roof substrates with biochar
Creating a Biomass Circular Economy: 
Adding Value to Biomass

William Brown
Managing Director
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• Company Background
• Global Applications of the TORBED® Technology
• Description and Functionality of the Technology
• Challenges of Processing Biomass-A Matrix of Issues
Creating a Biomass Circular Economy:  
Adding Value to Biomass

• Electrical Power Generation from Gasification and Combustion of Biomass
• Production of Valuable By-Products
• Reducing the Cost per MWe Through the Production of By-Products
• Successful Use of Biochar for the Absorption of Environmental Pollutants
• Opportunity to Create a Circular Economy Through the use of Animal Waste
• Schematic of Circular Process
• Other Examples of TORBED’s Ability to Process Biomass
Batch pyrolysis for biochar manufacture: balancing emissions compliance with carbon footprint

Jim R. Jones1*, Nadeem S. A. Caco1, Rhonda P. Bridges1, Georg D. Ripberger1 and Anthony H. J. Paterson

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This paper details the experiences with the Massey 50 kg batch pyrolyser and determines that the net environmental benefit of small-scale biochar manufacture is relatively minor. Pyrolysis is the thermal decomposition of biomass in the relative absence of oxidising air. It is a self-determining reaction because, giving enough residence time, adequate insulation and when heat and mass transfer gradients are in the same direction, a natural end-point is reached when all the biomass is consumed. Because the end-point is self-controlling, batch pyrolysers can make biochar with consistently high H:C ratios (~0.3) and low volatile matter content (~4 wt%). It has several advantages over continuous pyrolysis [1]. First, it allows for the easier exclusion of oxygen to maximise char yield, because loading and unloading are simple operations and do not necessitate air locks and so avoid hazards associated with combustion moving upstream into the feed hopper. Second, the particle size can be large because load and unloading are single step operations rather than continuous feeding. Third, there are no moving parts in the high temperature zone which are liable to soften and fail when an over-temperature occurs. Fourth, residence time is not a design limitation as it is in continuous systems where augur length is limited by design strength and residence time is limited by production rate. Fifth, the end-point of pyrolysis is easily attained because pyrolysis continues until all the biomass has been converted to char, volatiles and non-condensable gas. This latter advantage is particularly important because char quality is not something that can be determined easily by an in-line measurement. The simplest test of char volatile matter content is a thermogravimetric laboratory test where results are at minimum returned some hours later. As a batch process goes to completion over a long residence time, the char quality is determined by the highest treatment temperature (HHT). For these reasons, the Massey 50 kg reactor is batch (Figs. 1 & 2). It is a down-scale version of a small mobile reactor. Disadvantages are that operating temperature is not able to be controlled because pyrolysis is mildly exothermic; instead, the HTT of the biomass in the reactor is determined by the biomass type, its volume, the shape of the reactor and its insulation. Second, there is less opportunity in batch systems than for continuous systems to recycle heat, which negatively affects the sequestration potential (SP) of the process.

Figure 1. Schematic of the batch pyrolyser showing the instrumentation and control (adapted from [1]).

Figure 2. Smoky emissions leaving the top of the batch pyrolyser stack.
Heating occurs over about one and a half hours until the reactor core temperature reaches 340°C (Fig. 3), when the major combustion burner (LPG) is turned off and its air flow is diverted away from the combustion zone. Only the smaller secondary burner remains on. Heating then continues for the next ~3 hours when the reactor reaches its highest treatment temperature (HTT), after which the pyrolysis reaction is complete and the temperature starts to fall because the exothermic reactions driving the heating have stopped. This is the signal of the end-point. The resulting char yield is ~29 wt% on a dry feed basis with ~4 wt% volatile matter [1].

The Massey 50 kg batch reactor system is designed so that combustion of the pyrolysis gases is partial rather than total in order to avoid the possibility of overheating the reactor, which is rated to 1050°C (stainless steel 304). Limiting the reactor to partial combustion is achieved by limiting the natural draft air supply by limiting the stack diameter to 80 mm and height to 2.4 m. In this way, only a limited amount of secondary air can be drawn into the system. Therefore, during the period when the greatest quantity of pyrolysis gases is evolving, a flare is used to ignite the pyrolysis gases.

Batch reactors require a heat source to start the pyrolysis and, because the flammability of the pyrolysis gases is not high, supplementary fuel is always needed to; (i), ignite the pyrolysis gases to provide heat economy; and (ii), to ensure complete combustion of the flue emissions both to optimise the global warming potential (GWP) and to ensure emissions compliance. To be clean burning, particularly for small-scale units, it is necessary to use high-flammability fossil fuels with the downside that they detract from the sequestration potential (SP) of the process. Because the release of pyrolysis gases from the reactor is uncontrolled, the design of a variable rate flare system is a non-trivial matter. The most difficult operational period for the flare is when the reactor core temperature is between ~280°C and ~500°C when peak production of pyrolysis gases occurs. This range is not dissimilar to that observed in a small laboratory fixed bed reactor [2]. At peak gas and volatile production, smokey emissions resulted (Fig. 2) which were far from being emissions compliant. A Testo 350 gas analyser sampled for CO, CO₂, NOₓ, and SO₂, and a % by weight concentration of O₂. The US EPA has a number of pollutant emission limits [3] which vary based on energy output of the reactor, fuel consumed and reactor design. The most lenient of these is a stack concentration of 2,400 ppm of CO over 1 hour minimum sampling time, for biomass suspension burners exceeding ~3 MW heat generation. This reactor exceeded this limit by seven times. For this reason a new flare system has been built. It contains three 3 kW burners, mounted to impart a swirl. A guard protects the flame from the wind, concentrates the heat and provides residence time. The combustion chamber has been modified to remove the natural draft air, which cools the flue gas (Fig. 3). Control is by turndown of the burners and is based on a set-point flare temperature and on the stage of pyrolysis. Together these cope with the uncontrolled pyrolysis gas evolution, which is biomass type, particle size and moisture content dependent. The new system has been certified by gas engineers. The new system will be commissioned in September 2017.

The purpose of this study has been to determine the practicality of dedicated mobile pyrolysers for the manufacture of biochar from agricultural and forestry residues. Mobile plants move between residue sources and do not to provide other services such as process heat, except within their own operation. When these plants are above 3 MW heat output at peak flow, they must comply with relatively stringent emission standards. This means the products of incomplete combustion must be eliminated in a flare system. However, the pyrolysis gases have low flammability and low calorific value and so it is necessary to supplement the flare with additional heating in order to reach 750°C for 1.5 seconds. This additional fossil fuel detracts from the sequestration potential of the process. The flare must also cope with the uncontrolled nature of gas evolution during the heating profiles, which will vary depending on the initial moisture content of the biomass. Through these efforts to design an emission compliant...
mobile biochar system, this work highlights that both the risk of non-compliance and poor sequestration potential are significant.

Acknowledgements
The authors wish to thank Judith and (the late) Llewellyn Richards for their support of a Masters stipend for RPB.

References


The commercialisation of biochar-based products: A review

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Abstract

This short paper summarises the recent studies that have been carried out to determine the costs and benefits of applying biochar in broad acre and horticultural crops and as a feed supplement for animals. The only large scale production and utilisation of biochar is in China, driven in part by government policy banning the burning of straw in fields and the high price received for production of energy from biomass.

Keywords

Cost benefit analysis, wood vinegar, horticulture, broad acre, subsidy, standardisation

Introduction

The production and utilisation of biochar and wood vinegar for both agricultural and non-agricultural (but excluding use as a fuel) uses has been practised in many societies for thousands of years in non-industrial societies and in parts of Asia, Africa and Latin America. Biochar was either produced in households, fields and small scale village enterprises. Uses included growing of seedlings, crops and trees, water filtration, use in animal husbandry, cooking, odour removal and medicinal remedies. Little data exist on the production volumes of non-fuel biochar production in Asia although it probably exceeded 20,000 tonnes per year before and during WWII. Much of this production occurred at a village level using high polluting mud and brick kilns. It is only since concerns related to environmental degradation that larger scale commercialisation of biochar has commenced initially in China but in more recent times in USA, Australia and parts of Europe.

Methods

To determine the state of the industry a review of the peer reviewed literature, summaries of newsletters produced by IBI and Ithaca Journal, information from conferences, web sites, blogs and biochar groups is undertaken.

Results and Discussion

China is the only country where large scale uptake of biochar for cereal crops and horticulture has occurred. This has been driven by government policy banning the burning of straw in fields, subsidies for the collection of the straw, a policy to reduce the use of NPK fertilisers and increase soil organic matter and a higher price for electricity generated from biomass. Clare et al. (2015) found that one-off high applications of straw and husk biochar (>20t/ha) to cereal crops was not profitable for the farmer unless very high subsidies were given, however the application of a combined biochar mineral NPK granule applied at the same application rate as straight NPK could increase the return to farmers. Qian et al. (2013)
showed a significant reduction in greenhouse gas (GHG) emissions as well as crop yield increase with these advanced fertiliser products based on biochar. Interviews with farmers and suppliers has also found that even at $300/t, vineyards, herbal medicine and tea growers will apply high rates of biochar in parts of China. Shackley et al. (2015) reported that applications of small amounts of poultry litter biochar with NPK at less than 200kg/ha in a no-till wheat farming practice in South Australia produced a greater return than the equivalent amount of NPK. They also reported a small positive return for the generation of electricity and the production of biochar at a large scale production facility at a waste management site.

Dickenson et al. (2015) found that one off application of biochar produced in simple pits at 13t/ha for cereal crops carried a positive NPV for cereal cropping in Sub Sahara Africa in several scenarios where the duration of the biochar yield effect was assumed to extend 30 years into the future. Conversely, in North Western Europe, biochar produced in a large modern plant applied at 12t/ha did not yield a positive return on investment.

Numerous studies have found that horticulturalists can increase their profits by adding biochar enhanced with minerals and macronutrients when applied at rates <10 t/ha. Farrar et al. (2017) noted that a biochar mineral complex could increase returns from growing organic ginger by 36% when applied at a rate of 5 t/ha.

Wrobel-Tobiszewska (2015) carried out an economic analysis that considered on-site biochar production systems using post-harvest forestry residues, with biochar being utilised within the system, or sold as a product. A positive return was achieved if

1. part of the biochar replaced fertiliser used for growing the trees,
2. if biochar reduced the costs of new forestry site preparation and for growing seedling and
3. approximately 40% of the batch was sold at a price greater than $400/t.

Joseph et al. (2015) examined the financial benefits when biochar was fed to cows at approximately 0.3 kg/day and dung beetles were introduced to bury the dung and biochar up to a metre into the soil. They found that, for a herd of 60 cows, an additional profit of $12,000/yr could be achieved compared with conventional practice using fertiliser to grow hay and drenching. Other studies on the costs and benefits of utilising biochar for both cereal and horticultural crops in developing countries have been published. Details of these studies will be presented in an expanded paper.

Given the obvious benefits of biochar and nutrient-enhanced biochars it is surprising that there are so few commercial companies selling biochar products in bulk in North America, Europe, Australia/New Zealand and South and South East Asia. There appears to be a number of major impediments to the commercialisation. Regulatory issues both on production and utilisation exist in many countries and to address these requires significant financial input by companies. Some international standards (European) have defined a biochar as having a carbon content greater than 60% and thus can exclude high mineral ash biochars such as rice husk and chicken litter. Much of the biochar that is being produced in Australia, Europe and USA has a price greater than $500/t which many farmers consider too high. Companies that produce large quantities of organic and inorganic fertilisers are reluctant to invest in a new product, especially when they have expended capital on an existing facility. There has been little long term support from both governments and venture capital for the development of the industry.
Conclusions or implications

Biochar has the potential to improve profitability to farmers who are producing cereal as well as horticultural crops and graziers, dairy and fish farmers. To achieve this returns standardised fit for purpose biochars need to be developed and produced at a scale and at a price that is equivalent or less than chemical and/or organic fertilisers.

References


