



## March 2014 News from the International Biochar Initiative

### **IBI Releases First Annual *State of the Biochar Industry Report***

IBI is pleased to announce the recent release of the first-ever State of the Biochar Industry report which provides a broad overview of the current state of the biochar sector as identified by surveys and other data throughout 2013. The report provides experts and laypeople a snapshot of commercial and non-commercial biochar operations and activities. Its findings confirm some early successes in biochar commercialization are evident in certain areas and a biochar supply chain has emerged—from equipment manufacturers to biochar purveyors to production and use consultants. The biochar industry at present is in a fledgling state but there is upward trending growth for those companies working in specific markets as well as optimism for growth across the industry. The future success of the industry will depend on further convergence of critical factors relating to research, investment, policy, innovation, and public education.

The report's findings are based primarily on information gathered through public surveys and internet based research, but also on accumulated knowledge of the present biochar landscape offered by IBI, the report authors, and contributors to this report. It is IBI's intent to produce this report on an annual basis to continue to track trends and growth in the biochar industry—both on the commercial as well as the project side.

For more information on the report, including a 4-page summary and a database of 175 global biochar companies, please see: [http://www.biochar-international.org/State\\_of\\_industry\\_2013](http://www.biochar-international.org/State_of_industry_2013).

IBI paying members have advance access to the full 61-page report which they can read by logging into the member-section of the website at <https://ibi.memberclicks.net/login>; for more information on joining IBI as a member, please see: <http://www.biochar-international.org/join>.

The full report will be made available publicly on IBI's website on April 15, 2014.

### **Update on Proposed Policy Revisions to the *IBI Biochar Standards***

In March, IBI hosted two webinars to discuss four proposed policy revisions to the *IBI Biochar Standards* Version 2.0, which were posted for a 30-day public comment period in December 2013—. The webinars were used as a forum to present the proposed revisions, the background behind the proposed revisions, respond to public comments, answer questions, and discuss any concerns and proposed alternative approaches with webinar participants. The March 17<sup>th</sup> webinar focused on proposed revisions around biochar weathering, post-processing, and sampling, while the March 25<sup>th</sup> webinar focused exclusively on proposed revisions around the use of biomass flyash from bioenergy production facilities. Recordings of both webinars as well as presentation slides are available at <http://www.biochar-international.org/characterizationstandard>.

The next steps for the policy revision process are for IBI to compile information gathered from participants during the webinar, to seek clarifying information from experts where necessary, and to publish a summary and tally of all comments received during the public comment period and webinars including an IBI response to each comment. Concurrent with the publication of comments, we post proposed final revisions for public review and a vote by IBI membership. IBI welcomes all feedback on the proposed revisions as well as general comments on the *IBI Biochar Standards* and invites you to email your thoughts to [standards@biochar-international.org](mailto:standards@biochar-international.org).

As a reminder, the process that IBI follows for making policy revisions is outlined in Section 7.1 of the *IBI Biochar Standards V1.1*, available for download here [[http://www.biochar-international.org/sites/default/files/IBI\\_Biochar\\_Standards\\_V1.1.pdf](http://www.biochar-international.org/sites/default/files/IBI_Biochar_Standards_V1.1.pdf)]. The proposed policy revisions are available for review here [[http://www.biochar-international.org/sites/default/files/Public\\_Comment\\_IBI\\_Biochar\\_Standards\\_V2.0.pdf](http://www.biochar-international.org/sites/default/files/Public_Comment_IBI_Biochar_Standards_V2.0.pdf)]. IBI thanks our members, stakeholders, and the biochar community for contributions to this important effort to support the growing biochar industry.

### **Business and Organization Member Profiles**

A listing of all current IBI [Business](#) and [Organization](#) Members can be found on our website. For more information on membership opportunities and benefits, or to join, please see: <http://www.biochar-international.org/join>. Please note, Business and Organization descriptions are submitted by each individual entity, and are not developed or written by IBI.

#### **New Business Member: Vertrolysis LLC**

Vertrolysis LLC is licensed to use the proprietary vacuum catalytic Vertrolysis Process for the production of the finest biochar possible. Unlike other pyrolysis processes utilizing gasifiers, furnaces, or combustion chambers, the Vertrolysis Process uses heating elements and other computer controlled equipment to precisely control process temperatures, vacuum pressures, and feedstock residence time throughout the carbonization process. This enables us to control porosity, density, and other characteristics important to maximizing the effectiveness of biochar on a variety of soil types, crops, or other industrial applications.



The Vertrolysis Process also produces highly uniform advanced cellulosic bio-oils as well as robust biogases that fuel the electrical generators which power our closed loop system. Our products are sold under the Vertro, Vertrol, and Vertane brand names and our facility is available for production of designer biochar for interested parties. The Vertrolysis Process is available for licensing by our affiliated company Frontier Biofractions, LLC. For more information, see <http://vertrolysis.com/>

#### **Renewing Business Member: Cool Planet Energy Systems**

Cool Planet Energy Systems is a developer of solutions for the energy, food, and water industries with drop-in fuels and advanced biochar products. Cool Planet is commercializing a technology to create green fuels and biochar in a way that can change the world for good. Our green fuels are chemically identical to fossil fuels, and our "Cool Terra™" biochar product enables fertilizer reduction and increased water retention for increased crop productivity, and more robust plant health, even in a drought structured environment. Cool Planet's business model of building small-scale, drop-in fuel facilities located close to the biomass source is believed to provide one of the lowest capital costs in the industry and compete directly with oil, unsubsidized. The CoolTerra™ has the capability of making the fuel "carbon negative" while making large potential impacts to industries as diverse as



agriculture, animal health, and pharmaceuticals. Cool Planet's technology has a broad portfolio of pending and granted patents. Global investors include BP, Google Ventures, Energy Technology Ventures (GE, ConocoPhillips, NRG Energy), and the Constellation division of Exelon. For more information on CoolPlanet, please see: [www.coolplanet.com](http://www.coolplanet.com) or [contact Mike Rocke](#) (Vice President of Business Development).

#### **Renewing Business Member: Rick Davies**

Dr. Rick Davies is a Monitoring and Evaluation consultant, specializing in the evaluation of development aid programs in Africa and Asia. He is not directly engaged in biochar research but is supportive of research into its potential uses for carbon sequestration, soil enhancement and carbon negative energy. He is especially interested in experimental uses of biochar in developing countries and is available to provide technical advice on the evaluation of those initiatives, especially their social and economic impact. Dr. Davies has worked with development aid organizations since 1980 and has specialized in evaluation consultancy since 1990. He is based in Cambridge, UK but maintains strong connections with Australia, where he was born. For more information on his work, visit his [own personal website](#) and the [Monitoring and Evaluation NEWS website](#), which he manages. Dr. Davies can be contacted via email [rick.davies@gmail.com](mailto:rick.davies@gmail.com) and skype: rickjdavies.



#### **Renewing Business Member: Sonnenerde**

Sonnenerde ("sun-earth" in German) is an Austrian company which produces high quality soil from compost, selling about 30,000 tons annually. The company is looking to raise the carbon content of soils and has built a pyrolysis plant to use Terra Preta for this purpose. Sonnenerde has been working with researchers at the University of Halle in Germany with 3 acres of test plots. Sonnenerde is looking to convert 4000 tons of wet paper fiber sludge into 300 tons of biochar per year. We market this carbon-rich product in Austria. In 2012, Sonnenerde was the winner of the *climate saving award* in Austria. On the webpage ([www.sonnenerde.at](http://www.sonnenerde.at)) there is a [movie about the company](#), the new biochar plant, and recent experiments. For more information please see: [www.sonnenerde.at](http://www.sonnenerde.at) or contact Gerald Dunst at: [g.dunst@sonnenerde.at](mailto:g.dunst@sonnenerde.at).



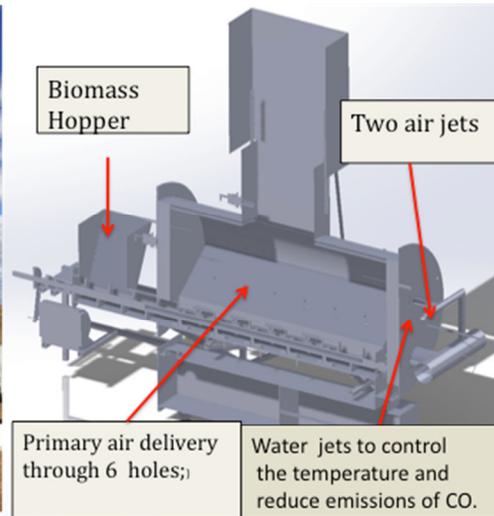
### **Profile Story: Making Biochar Production More Affordable and Sustainable Through Innovation in Design and Manufacturing**

*Russell Burnett, Sheila Mc Donald, Stephen Joseph and Genxing Pan*

The high capital cost of existing medium scale biochar kilns is a major barrier to the production of low cost biochar in developed and developing countries. To overcome these barriers, an alliance was formed between the Biochar Energy Systems—BES (a builder of biochar technology and producer of biochar and biochar mixes), Nanjing Agricultural University (China), Benenv Environmental Technologies Company (China), the University of Newcastle (Australia), associate professor Faris Christo at the University of South Australia, and Applied Gaia, to develop a transportable, low cost, low emission, multi-feedstock, continuous biochar unit that could be run by one person and that had an feedstock input of approximately 300 – 350kg/hr (at 15% moisture content). The unit was designed so waste heat could be utilized for heating animal sheds, greenhouses, aquaculture ponds, or crop/food processing plants. A target sales price for this unit is \$US50,000 once large scale manufacture is achieved (although the present price is \$US70,000).

Figure 1 A; Unit in Operation B; Cut out section

The initial concept was developed by Stephen Joseph in 2008 in collaboration with Cornell University (United States) for use in developing countries. It is based on existing advanced biomass combustion systems that use augers to move the biomass feed through troughs.

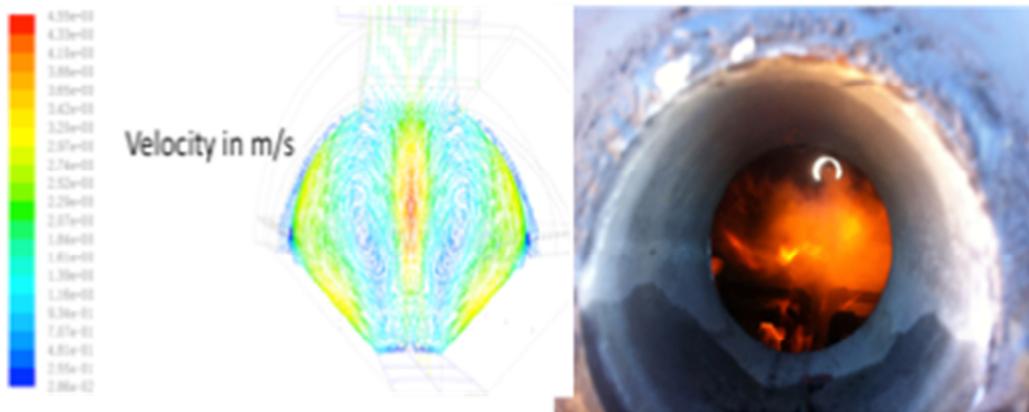


The pyrolyser was designed and built by BES and incorporates the experiences gained from a similar unit built by Nanjing University in 2012<sup>1</sup>.

This mobile unit is designed to be used in the field and is mounted on a dual axle chassis. It comes complete with a 10kva diesel generator with a 32 amp, 3-phase outlet for motor drives and single 15 amp outlets for a water pump and Siemens “LOGO” Logic Module.

The operation of the machine is based on a horizontal trough with solid steel plates on either side with an enclosed and double skinned combustion zone above it. Feed material is slowly moved along the trough with an auger that combines conventional spiral flights and paddles. The paddles stir the charring biomass and sweep it to the bottom of the trough, mixing it with the drying biomass. Primary air is introduced through the steel plates, with some pre-heating, and through two jets at the pyrolysis end wall. Secondary air is drawn through the double skinned combustion zone wall to clean exhaust gases.

In operation, the syngas from pyrolyzing biomass in the trough and primary air mix are partially combusted above the bed. Radiant flux above the bed causes biomass to dry/torrefy and pyrolyze as the material moves along the trough.



<sup>1</sup> [www.biochar-international.org/sites/default/files/Commissioning\\_Open\\_Source\\_Twin\\_Trough\\_Pyrolyser\\_final.pdf](http://www.biochar-international.org/sites/default/files/Commissioning_Open_Source_Twin_Trough_Pyrolyser_final.pdf)

Figure 2. High turbulence and efficient air syngas mixing (A) results in clean efficient combustion (B); Modelling by Dr F Christo

Secondary air flows over the hot inside of the double skinned combustion zone wall. This secondary air then enters the reactor at the outlet exhaust, and mixes with the remaining unburnt syngas. The temperature can be controlled by changing the feed rate, the flow rate of fine water droplets onto the charring bed, and the amount of primary air entering the chamber.



The unit is started manually and once operating temperature is reached, an industrial quality controller controls the desired temperature of the biochar and ensures efficient syngas combustion with the temperature in the reactor maintained above 800°C.

In the above figures, the unit is running at a feed rate of 320 kgs of hardwood mulch with a stack temperature of 464°C, and a CO reading of 89 ppm at 16.1% O<sub>2</sub>.

Key features of the unit include:

- 24/7 operation
- 250 – 350 kgs/hr biomass input depending on moisture content/ type of feedstock
- >100 kgs/hr biochar out
- 500 litre Feed Hopper
- Diesel/oil warm-up
- Siemens Automation
- Transportable (Production units mounted on a dual axle chassis)
- Generator powered. 10kva unit is supplied
- Dual drive system (to enable the unit to handle a great variety of feedstock)
- Exportable thermal heat

Future work will involve scaling the unit up to 1 tonne/hour and having the capability of extracting clean syngas to run the engine. For further information please contact Russell Burnett at [rwgb@appliedgaia.com](mailto:rwgb@appliedgaia.com) or Sheila Macdonald at [slmk@appliedgaia.com](mailto:slmk@appliedgaia.com).

## **Biochar Briefs: News Roundup for March**

We update the website daily with new articles on biochar. For more information, please see: <http://www.biochar-international.org/newsbriefs>.

### **India**

A waterless toilet is being introduced in India that has the capability of using solar parabolic mirrors to heat human waste, producing biochar. This project is part of the Bill & Melinda Gates Foundation's 'Reinvent the Toilet Challenge'. Karl Linden, a professor of environmental engineering at University of Colorado Boulder has been working since 2011 as a principal investigator on one of 16 teams looking for more sustainable and sterile methods to deal with human waste. "The invention consists of eight parabolic mirrors that focus concentrated sunlight

to a spot no larger than a postage stamp on a quartz-glass rod connected to eight bundles of fibre-optic cables, each consisting of thousands of intertwined, fused fibres," said Linden. (link to: <http://gadgets.ndtv.com/others/news/worlds-first-solar-powered-toilet-set-for-launch-in-india-495760>)

### **Pakistan**

The University of Agriculture Faisalabad (UAF) recently held the first biochar workshop in Pakistan. Researchers and practitioners from around the world attended to highlight opportunities for Pakistan's agricultural sector. The UAF Vice Chancellor Professor, Dr Iqrar Ahmad Khan, stressed that approximately 60 percent of the country is under the grip of food insecurity and that biochar and biomass could potentially play a great role in creating more sustainable food and agriculture systems. (link to: <http://www.brecorder.com/agriculture-a-allied/183/1166067>)

### **United States**

Anne Merrill, a Greenwich High School student, along with 39 other high school seniors from around the country, recently had the opportunity to meet US President Barack Obama as recognition for reaching the finals of this year's Intel Science Talent Search, a major research competition. Merrill's research examined the environmental benefits of pairing biochar with worms. Working with E. coli and a common fungus that kills tomato plants, she studied the effectiveness of combating soil-borne pathogens by using Canadian nightcrawler earthworms to carry biochars through soil to tomato plants' roots. (link to: <http://www.greenwichtime.com/local/article/GHS-student-honored-in-Washington-5321043.php>)

Residents of the NW Alaska village Kivalina will have the opportunity for a new sanitation system. Two organizations, Re-Locate and the Climate Foundation, were awarded an \$85,000 grant through the Commission for Environmental Cooperation to work with tribal and municipal governments in the community to revamp the village's sanitation system so that the human waste produced by villagers will be turned into biochar. (link to: <http://www.alaskadispatch.com/article/20140323/kivalina-project-would-turn-waste-much-needed-fuel>)

## **Submit an Application to Participate in the 3<sup>rd</sup> Annual Biochar Training Course in China**

In October 2014, biochar researchers and enthusiasts will have the opportunity to participate in a week-long training course on biochar to be held at Nanjing Agricultural University, Nanjing, Jiangsu, China. This will be the 3<sup>rd</sup> annual training course and allow participants the opportunity to meet some of China's leading experts as well as to interact with biochar researchers and practitioners from other regions. Participants will be able to view commercial businesses producing biochar, energy, and biochar/NPK fertilizers as well as run a small- and medium-scale biochar plant at the university. For more information on this event as well as an application, please see: <http://www.biochar-international.org/node/4694>. For reports from the first and second year training courses, please see: <http://www.biochar-international.org/sites/default/files/2nd International Biochar Training Report final.pdf> and <http://www.biochar-international.org/sites/default/files/Nanjing Training Report.pdf>.

### **Opportunities in Biochar**

- Job postings in biochar (as well as research/educational opportunities) can be accessed at: <http://www.biochar-international.org/network/jobs>.
- Submit an abstract for a session entitled: "The Biochar Effect along the soil-rhizosphere-plant-atmosphere continuum" at the ELS 2014 Conference (Italy) **due March 30**. For more information: <http://www.biochar-international.org/node/4705>.

- Submit an abstract to the Special Symposium on “Biochar: Production, Characterization and Applications” at CLEAR 2014 Conference, in Chuncheon, Korea, **due April 30**. For more information: <http://www.biochar-international.org/node/4827>.
- Submit an abstract to the 3rd Annual Global Conference on Environmental and Water Resources Management, Climate Change, and Energy in the UK, **due April 30**. For more information: <http://www.biochar-international.org/node/4774>.
- Contribute to the *Biology and Fertility of Soils* special issue with your research on biochar. For more information, see the website of the Mediterranean Biochar Symposium: <http://www.meditbiochar.org/index.html>. Submissions **due May 31**.
- Looking for potential grant funding? Check out the Terra Viva Grants Directory which develops and manages information about grants for agriculture, energy, environment, and natural resources in the world's developing countries at: <http://www.terravivagrants.org/Home>.

## Upcoming Calendar Events

- March 30 – April 2: The 29th International Conference on Solid Waste Technology and Management. Location: PA, USA. For more information: <http://www.biochar-international.org/node/4115>.
- April 8: Alberta Biochar Initiative Technical Seminar and Networking. Location: Edmonton, AB, Canada. For more information: <http://albertabiochar.ca/abi-technical-seminar-and-networking-2014/>.
- April 9 – 11: Northeast Biomass Heating Expo 2014. Location: Portland, ME, USA. For more information: <http://www.biochar-international.org/node/4625>.
- April 27 – May 2: EGU 2014: "Strategies for effective soil carbon sequestration through synergies in pyrogenic carbon, charcoal and biochar research". Location: Vienna, Austria. For more information: <http://www.biochar-international.org/node/4612>.
- June 8 – 13: Biochar Symposium entitled “Biochar Soil Amendment for Environmental and Agronomic Benefits” at the 20th World Congress of Soil Science. Location: Seoul, Korea. For more information: <http://www.biochar-international.org/node/4494>.
- June 15 – 20: 3rd Annual Global Conference on Environmental and Water Resources Management, Climate Change, and Energy. Location: London, UK. For more information: <http://www.biochar-international.org/node/4773>.
- June 22 – 27: The 10th International Symposium on Earthworm Ecology session "Earthworm interactions with biochar as a soil amendment". Location: Athens, Georgia, USA. For more information: <http://www.biochar-international.org/node/4743>.
- June 23 – 26: 22nd European Biomass Conference and Exhibition. Location: Hamburg, Germany. For more information: <http://www.biochar-international.org/node/4485>.
- June 26 – 28: ORBIT 2014 Conference on Biochar. Location: Gödöllo, Hungary. For more information: <http://www.biochar-international.org/node/4716>.

See the [IBI Calendar page](#) for more events. To add an event to the calendar, send the information to [info@biochar-international.org](mailto:info@biochar-international.org).

## Regional Group Updates

To read more on the 57 regional and national biochar groups, please see IBI's website (link to: <http://www.biochar-international.org/network/communities>). This month includes a new group

from Costa Rica, the Biochar Ambassadors of Costa Rica/Embajadores del BIOCarbón Costa Rica and an update from the Illinois Biochar Group (United States).

### **Biochar Ambassadors of Costa Rica/Embajadores del BIOCarbón Costa Rica (EMBIO)**

EMBIO was started to develop, demonstrate, and share environmentally sustainable information and tools about the uses and benefits of biochar in Costa Rica. The mission is to adopt the daily practice of carbon negative living, to assure a clean atmosphere, intact forests, healthy soils, and responsible communities. EMBIO will work towards expanding the knowledge, production, and use of sustainable biochar in Costa Rica through outreach to communities, collaboration with research organizations, and by providing opportunities for the overall expansion of biochar in the country. For more information, please see: [http://www.biochar-international.org/regional\\_EMBIO](http://www.biochar-international.org/regional_EMBIO).

### **Illinois Biochar Group (United States)**

The Illinois Biochar Group just held their Spring Meeting at the Illinois Center for Sustainable Technology on March 10<sup>th</sup>. Presentations from that meeting can be viewed at: <http://www.biochar.illinois.edu/ibg.shtml>. The group is pleased to announce the 2<sup>nd</sup> Annual Midwest Biochar Conference will be held in Champaign, Illinois, on August 8<sup>th</sup>, 2014. The call for papers/posters was announced on March 17<sup>th</sup>, and more information on this conference can be found at: <http://www.biochar.illinois.edu/conference>.

## **Recently Published Biochar Research**

IBI tracks all published research on biochar and includes it in our [online bibliography](#). The following articles were added in the last month. Please visit the website bibliography for more information on any of these articles. Due to copyright infringement laws, we cannot provide full copies of articles unless we have permission from the publisher. If you have published work that is not included, [please email us](#).

Akhtar, Saqib Saleem; Guitong Li; Mathias Neumann Andersen; Fulai Liu (2014). Biochar enhances yield and quality of tomato under reduced irrigation. *Agricultural Water Management*. Volume 138, Pages 37–44.

Anderson, C.R.; K. Hamonts; T.J. Clough; L.M. Condon (2014). Biochar does not affect soil N-transformations or microbial community structure under ruminant urine patches but does alter relative proportions of nitrogen cycling bacteria. *Agriculture, Ecosystems & Environment*.

Asuming-Brempong, Stella; Kenneth K. Nyalemegbe (2014). The use of earthworms and biochar to mitigate increase in nitrous oxide production - A minireview. *Global Advanced Research Journal of Agricultural Science*. Vol. 3(2) pp. 035-041; <http://garj.org/garjas/pdf/2014/February/Asuming-Brempong%20and%20Nyalemegbe.pdf>.

Bian, Rongjun; Stephen Joseph; Liqiang Cui; Genxing Pan; Lianqing Lia; Xiaoyu Liu; Afeng Zhang; Helen Rutledge; Singwei Wong; Chee Chia; Chris Marjo; Bin Gong; Paul Munroe; Scott Donne (2014). A three-year experiment confirms continuous immobilization of cadmium and lead in contaminated paddy field with biochar amendment. *Journal of Hazardous Materials*.

Brennan, Aoife; Eduardo Moreno Jiménez, Markus Puschenreiter, José Antonio Alburquerque, Christine Switzer (2014). Effects of biochar amendment on root traits and contaminant availability of maize plants in a copper and arsenic impacted soil. *Plant and Soil*.

Buss, Wolfram and Ondrej Mašek (2014). Mobile organic compounds in biochar – A potential source of contamination – Phytotoxic effects on cress seed (*Lepidium sativum*) germination. *Journal of Environmental Management*. Volume 137, Pages 111–119.

Carvalho, M. T. de Melo; A. de Holanda Nunes Maia; B. E. Madari; L. Bastiaans; P. A. J. van Oort; A. B. Heinemann; M. A. Soler da Silva; F. A. Petter; H. Meinke (2014). Biochar increases plant available water in a sandy soil under an aerobic rice cropping system. *Solid Earth Discuss.* 6, 887–917; <http://www.solid-earth-discuss.net/6/887/2014/sed-6-887-2014.pdf>.

Cely, P.; A. M. Tarquis; J. Paz-Ferreiro; A. Méndez; G. Gascó (2014). Factors driving carbon mineralization priming effect in a soil amended with different types of biochar. *Solid Earth Discuss.*, 6, 849–868; <http://www.solid-earth-discuss.net/6/849/2014/sed-6-849-2014.pdf>.

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De Gisi, Sabino; Luigi Petta; Claudia Wendland (2014). History and Technology of Terra Preta Sanitation. 6(3), 1328-1345.

Dechene, Annika; Ingrid Rosendahl; Volker Laabs; Wulf Amelung (2014). Sorption of polar herbicides and herbicide metabolites by biochar-amended soil. *Chemosphere*.

Fang, Yunying; Bhupinder Pal Singh; Balwant Singh (2014). Temperature sensitivity of biochar and native carbon mineralisation in biochar-amended soils. *Agriculture, Ecosystems & Environment*.

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Hamzah, Zainab; Ainatul Alia Allias; Othman Hashim; Lee Boon Beng (2013). Characterization of physicochemical properties of biochar from different agricultural residues. *Advances in Environmental Biology*. Vol. 7 No. 12 pp. 3752 – 3757.

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Huang, Min; Liu Yang, Huadong Qin, Ligeng Jiang, Yingbin Zou (2014). Fertilizer nitrogen uptake by rice increased by biochar application. *Biology and Fertility of Soils*.

Jaafar, Noraini; M Peta L Clode; Lynette K Abbott (2014). Microscopy Observations of Habitable Space in Biochar for Colonization by Fungal Hyphae From Soil. *Journal of Integrative Agriculture*. Volume 13, Issue 3, Pages 483–490.

Jing, Xiang-Rong; Yuan-Ying Wang; Wu-Jun Liu; Yun-Kun Wang; Hong Jiang (2014). Enhanced adsorption performance of tetracycline in aqueous solutions by methanol-modified biochar. *Chemical Engineering Journal*.

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Liebeck, Miriam; Timo Dörr; G. Herbert Vogel (2014). A Sustainable Concept for the Supply of Pure CO<sub>2</sub> as a C-Source for Solar Fuels—Synergies of Biochar and Biogas. *ChemBioEng Reviews*.

Liu, Liang; Guoqing Shen; Mingxing Sun; Xinde Cao; Guofeng Shang; Ping Chen (2014). Effect of Biochar on Nitrous Oxide Emission and Its Potential Mechanisms. *Journal of the Air & Waste Management Association*.

Lu, Ning; Xingren Liu; Zhangliu Du; Yiding Wang; Qing zhong Zhang (2014). The effect of biochar on soil respiration in the maize growing season after 5 years of consecutive application. *CSIRO Publishing*.

Lychuk, Taras E.; Roberto C. Izaurrealde; Robert L. Hill; William B. McGill; Jimmy R. Williams (2014). Biochar as a global change adaptation: predicting biochar impacts on crop productivity and soil quality for a tropical soil with the Environmental Policy Integrated Climate (EPIC) model. *Mitigation and Adaptation Strategies for Global Change*.

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