Potentials of Biochar to Mitigate Climate Change

The 1st FOREBIOM Workshop

4th–5th of April, 2013

Proceedings

Austrian Academy of Sciences
Dr. Ignaz Seipel Platz 2, 1010 Vienna

KORANET

PUKYONG NATIONAL UNIVERSITY

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Cover photo: Korean charcoal art (Photo by V. Bruckman)

Welcome address

Distinguished colleagues, dear friends!

As principal coordinator of the FOREBIOM project, on behalf of the project consortium, it is my pleasure and honor to welcome you to the 1st FOREBIOM Biochar Workshop "Potentials of biochar to mitigate climate change" in the capital of Austria, Vienna. The workshop aims to provide a holistic view of current expertise in biochar production, from biomass availability to pyrolysis combined with energetic utilization of by-products and effects of char amendment in soils.

Biochar is seen as a potential solution for mitigating climate change. In theory, additional carbon might be sequestered when using biochar as a soil amendment and the process heat during pyrolysis is directly used or converted to electricity via ORC. Bio-oil could be used alternatively to substitute fossil fuels. However, a range of issues is still not clear and further research is needed in various disciplines, starting from sustainable sources of biomass for pyrolysis.

Therefore, a key aim of the workshop is to identify knowledge gaps along the whole life cycle, from biomass production to biochar soil amendment. The set-up of the workshop facilitates intensive discussion and exchange of ideas by specialists in their respective fields. Day one is devoted to lectures in one general and three topical sessions, covering the three main topical areas of the FOREBIOM project: Sustainable forest biomass production, Biomass pyrolysis and Biochar soil amendment. An interactive group work on day two ensures multidisciplinary discourse and a structured gathering of relevant ideas in preparation for County Case Reports. These reports will contain practical information as well as recent scientific findings and potential knowledge gaps. They will be disseminated using the global IUFRO network.

The conference venue is located in the center of Vienna, just a few steps away from the famous St. Stephens Cathedral in the main building of the Austrian Academy of Sciences (ÖAW), which was founded in 1847. It is now the leading non-university research institution in Austria with more than 1.100 employees. I am confident that this venerable venue will create an inspiring atmosphere to exchange current research results, ideas and opinions and to get in touch with new colleagues.

I wish you a very pleasant stay in Vienna!

Dr. Viktor Bruckman
Principal coordinator – FOREBIOM

Useful information

Scientidic committee

Dr. Viktor Bruckman, Austrian Academy of Sciences, Austria
Ass.Prof. Jay Liu, Pukyong National University, South Korea
Assoc.Prof. Başak Burcu Uzun, Anadolu University, Turkey
Ass.Prof. Esin Varol, Anadolu University, Turkey

Name badge colour codes

Red: Member of the FOREBIOM project consortium
Yellow: Conference staff
Green: Regular participant

Side events

We are happy to invite you to participate at three side events. Participation is possible only after registration using the on-line form: http://tinyurl.com/forebiom. You may register for the following activities:

Activity 1 (A1): Guided city tour – in English – on 4th of April (day 01) from workshop venue to the restaurant where we will have our dinner (Augustinerkeller). Let our professional guide introduce you to some of the highlights of the historical center of Vienna, including the famous St. Stephens Cathedral. Also local participants are invited to discover secrets of Vienna! Duration: 1 hour, (6:00–7:00pm). Free admission for FOREBIOM participants!

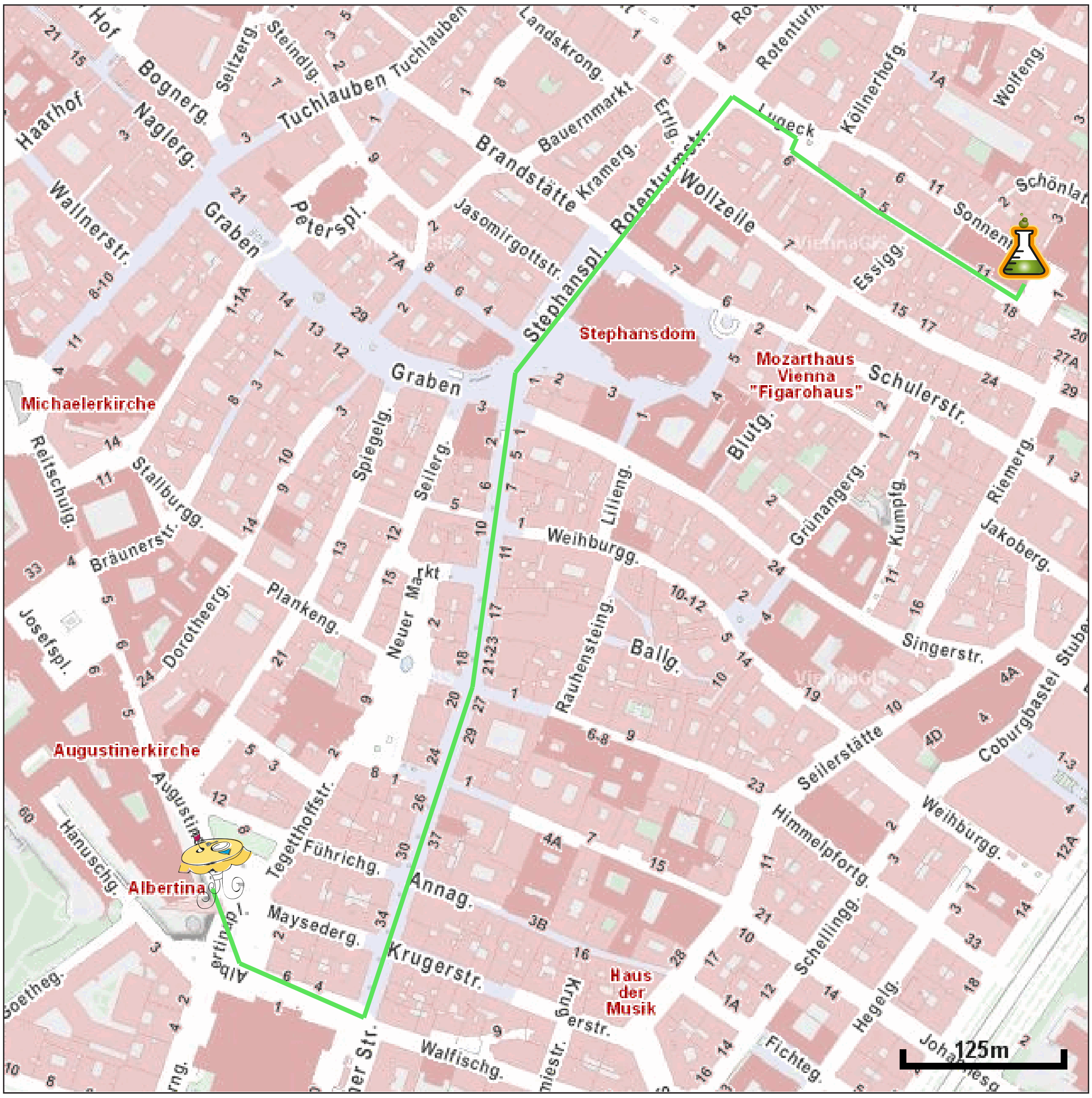
Activity 2 (A2): Social dinner at a typical Viennese style restaurant "Augustinerkeller"with a good choice of traditional dishes and a local wine selection. The guide of the city tour (Activity 1) will directly lead you to the restaurant. You may also go there on your own, a map will be provided. As the workshop participation is free of charge, we are not able to sponsor the dinner and hence everyone is asked to take care about his/her individual consumptions. We hope to see you there and kindly ask to indicate if you want to join as we have to reserve a table. Thank you!

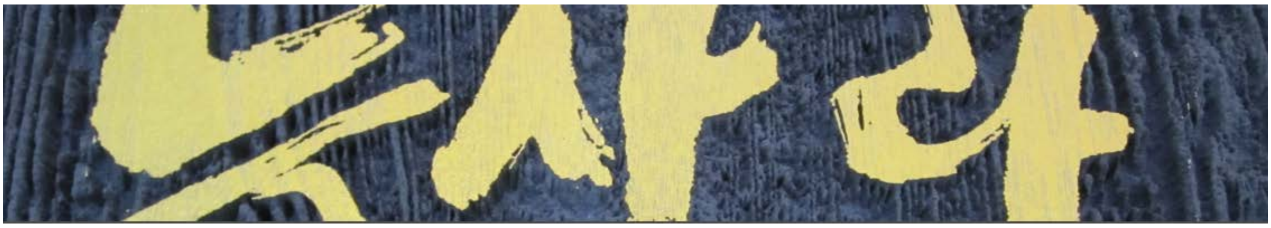
Activity 3 (A3): Technical excursion to the 1st industrial-scale biochar production facility in Austria. The excursion will start in the early afternoon of 5th of April and takes us to the company "Sonnenerde" (www.sonnenerde.at) where Mr. Gerald Dunst, speaker at the workshop, will present his biochar production facility. The ride from Vienna takes around 1 hour and 30 minutes. We will depart at 1:00pm at the workshop venue and will return at around 6:00pm. The costs for the excursion is € 20.– and will be collected at departure in cash only.

For your convenience, we have prepared a city map where you can find the way from the workshop venue (Austrian Academy of Sciences) to the restaurant "Augustinerkeller" where we will have joined dinner (A2).

City Map Vienna

Route from Workshop venue to Restaurant "Augustinerkeller" (dinner)





Final Workshop information – emailed on 1st of April, 2013 to all registered participants

Distinguished participants of the 1st FOREBIOM Workshop on Biochar potentials to mitigate climate change,

Only three days later, we´ll meet in Vienna for an exciting, interdisciplinary workshop with a number of very interesting contributions. As you can see from the final programme (http://www.oeaw.ac.at/forebiom/conference.htm) we have a very packed schedule and a range of topics to cover. For that reason, I kindly ask all speakers to use abbreviations and technical terms sparingly and explain them as not the entire audience comes from the same field.

Please be punctual for registration and stick to your presentation time

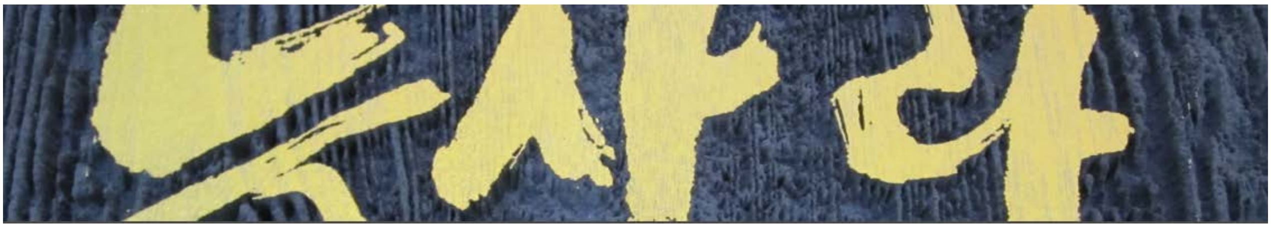
To avoid any delay with the schedule, we kindly ask all participants to register well in advance as we start punctually at 9:00 am. The registration desks are open from 8:30 am. You will receive the conference kit at the point of registration, which contains your name badge, the proceedings, a notepad and pen, a city map of Vienna, some touristic information and a little surprise. Additionally, speakers are asked to stick to their presentation time of 20 minutes. However, in practice, speaking time should be no longer than 18 minutes to allow short comprehension questions. A discussion for more in-depth questions is scheduled after each session block.

Speaker laptop and PowerPoint file handling

The speaker laptop is equipped with recent versions of PowerPoint and Adobe PDF Reader. You will be provided with a laser-pointer and remote control for PowerPoint presentations. We kindly ask you to submit your presentation in advance via Email or bring it with you on a USB-stick. Please note that there are sometimes incompatibilities with USB sticks and we are not able to test the file if you do not submit your presentation in advance. Please contact the session chair (see programme) and arrange presentation upload well before the session begins, in order to have the files on the presenting computer.

Side events registration

The organizing committee kindly asks you to register for the side activities programme (for those who haven´t registered so far). Please do so even if you are not planning to participate any of the side events (there is a dedicated checkbox for this as well). Please use the following form to do so:



www.tinyurl.com/forebiom. However, we hope to see you at most of the side events and the guided city tour will be very inspiring, even for local participants! Should you want to participate at the excursion on day 02 (Sonnenerde), we kindly ask to register soon since this activity is almost fully booked.

Wireless internet

There will be free wireless internet available during the whole workshop duration and you may find the login information in your proceedings.

Poster presentations

Poster presenters are kindly asked to be prepared to present their poster also oral. In case we have a speaker cancellation, I would like give our poster presenters some minutes speaking time (with or without PowerPoint slides). The posters will be directly in the conference room, visible during the entire workshop and we will have poster discussions all the way during the coffee and lunch breaks.

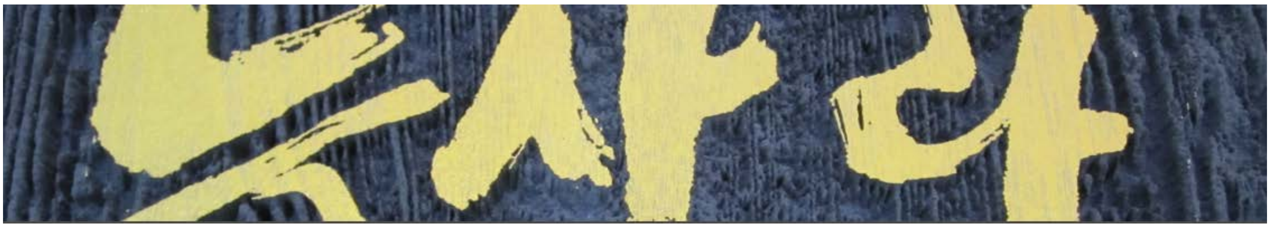
Workshop day 02 – Moving from multi- to interdisciplinarity

Now it is also time to roughly explain our plans for the 2^{nd} day of the workshop. This is the point, at latest, where we move from the multidisciplinary to the interdisciplinary level. That means we would like to tackle important questions from different viewpoints and try to connect them in a holistic approach. It might sound a bit technical, but the practical organization is rather familiar to all of us. Vienna is famous for its coffee culture and the large number of traditional coffee houses. We try to create a coffee house atmosphere where you are asked to contribute with your specific knowledge and experience. You are asked to share and connect ideas and to develop synergies. The framework, named “World Café Method” will be explained but you may find plenty of information online, e.g. http://www.theworldcafe.com.

Here are the three questions, we are going to address during the workshop:

1.) What are the premises for biochar production and utilization to help mitigate climate change?
2.) How about potential dangers and disadvantages for the environment when extending biochar production and utilization globally?
3.) Where do we need more research and what are currently the main obstacles to put biochar on the market?

You may start thinking about these questions and make some notes while you are on the way to Vienna, or when you have sleepless nights just before the workshop (we do not hope that is the case!). Subsequently, the findings will be discussed in the group and everyone has the chance to post his/her opinions again. This should be a basis for the planned publications where all presenters (posters and orals) are invited to contribute.
However, I am confident that it will be an interesting, inspiring and productive second day and hope, you are able to participate!



Current weather in Vienna

You may have noticed it, we are facing unusual weather conditions this year (it seems the winter doesn´t end), and scientists believe it is caused by high rates of arctic ice melt during the past years – as a consequence of climate change. You may find details here: http://www.news.cornell.edu/stories/June12/arcticWildcard.html, and more scientific background here: http://www.seas.harvard.edu/climate/seminars/pdfs/FrancisVavrus2012.pdf. As a consequence, be prepared for snowfall and temperatures around -2°C on Wednesday, up to 4°C on Thursday and up to 6°C on Friday.

On behalf of the scientific and organizing committees, I would like to wish you a safe journey to Vienna and looking forward to welcome you on Thursday morning for the 1st FOREBIOM Workshop.

Yours Sincerely,

Viktor Bruckman
Austrian Academy of Sciences,
FOREBIOM – principal coordinator

Scientific Programme

DAY 01 (4th of April, 2013)

08:30 – 09:00	Registration
	PLENARY SESSION Chairperson: Dr. Viktor Bruckman
09:00 – 09:05	Opening Remarks Prof. Dr. Helmut Denk, President, Austrian Academy of Sciences
09:05 – 09:10	Welcoming remarks by the FOREBIOM consortium Dr. Viktor Bruckman, Ass.Prof. Jay Liu, Assoc.Prof. Basak Burcu Uzun, Ass.Prof. Esin Varol (Austria, South Korea, Turkey)
09:10 – 09:30	Introduction of the FOREBIOM project .... p. 1 Dr. Viktor Bruckman, Austrian Academy of Sciences
09:30 – 09:50	IUFRO – Forest research cooperation worldwide and across disciplines Mag. Gerda Wolfrum, International Union of Forest Research Organizations, Austria
09:50 – 10:10	Biochar – building synergies between soil fertility, renewable energy production, and carbon sequestration .... p. 2 Dr. Christoph Steiner, Consulting services, Biochar.org, Austria
10:10 – 10:30	Charcoal production and utilization in Thailand .... p. 3 Dr. Maliwan Haruthaithanasan, Kasetsart University, Thailand
10:30 – 11:00	**Coffee break & poster viewing**
	SESSION I: Forest biomass resources for biochar production Chairperson: Florian KRAXNER MSc.
11:00 – 11:20	Sustainable Use of Biomass Feedstock – Global and Regional Aspects .... p. 5 Florian Kraxner MSc., International Institute of Applied Systems Analysis (IIASA), Austria
11:20 – 11:40	Sustainable forest biomass potentials in Austria .... p. 6 Dr. Michael Englisch, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Austria
11:40 – 12:00	Coppice forestry and biomass resources in Austria .... p. 7 Prof. Eduard Hochbichler, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

12:00 – 12:20 What technology for biofuel production in EU?
Dr. Sylvian Leduc, International Institute of Applied Systems Analysis (IIASA), Austria .... p. 8

12:20 – 12:30 Discussion

12:30 – 13:30 **Lunch break & poster viewing**

SESSION II: Biomass pyrolysis
Chairperson: Ass.Prof. Başak Burcu Uzun

13:30 – 13:50 Pyrolysis: A sustainable way from biomass to bio-fuels and bio-char........ p. 9
Ass.Prof. Başak Burcu Uzun, Anadolu University, Turkey

13:50 – 14:10 The etablisment of a biochar-production facility from waste........ p. 10
CEO Gerald Dunst, Sonnenerde, Austria

14:10 – 14:30 Biomass pyrolysis and biochar characterization .... p. 13
Prof. Frederik Ronsse, Ghent University, Belgium

14:30 – 14:50 Investigating the influence of production conditions on the energy distribution between the solid, liquid and gaseous products of slow pyrolysis........ p. 14
Kyle Crombie, UK Biochar Research Centre, United Kingdom

14:50 – 15:00 Discussion

15:00 – 15:30 **Coffee break & poster viewing**

SESSION III: Biochar and soil
Chairperson: Dr. Franz Zehetner

15:30 – 15:50 Effects of biochar application on soil functions: results from lab incubations, greenhouse pot experiments and field trials........ p. 15
Dr. Franz Zehetner, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

15:50 – 16:10 Rhizosphere effects of carboniferous and clay compounds in a sandy matrix .... p. 16
Dr. Bernd Uwe Schneider, Helmholtz-Zentrum Potsdam, GFZ, Germany

16:10 – 16:30 Biochar as yield promoter for agricultural crops? Conjectures and observations........ p. 17
Dr. Gerhard Soja, AIT Austrian Institute of Technology GmbH, Austria

16:30 – 16:50 Biochar arrests soil organic nitrogen cycling but promotes nitrification........ p. 18
Dr. Rebecca Hood-Nowotny, University of Vienna, Austria

16:50 – 17:00	Discussion, organizational remarks, closing day 01
17:00 – 18:00	Free time
18:00 – 19:00	**Guided City tour** (from workshop venue to restaurant "Augustinerkeller")
19:00	**Social dinner** (Augustinerkeller)

DAY 02 (5th of April, 2013)

	SESSION IV: FOREBIOM Workshop Chairperson: Dr. Viktor Bruckman
09:00 – 09:30	Wrap-up of day 01, input for workshop discussions
09:30 – 10:30	**Workshop part 1** Will be organized following the World Cafe Method – Groupwork, collection and presentation of relevant ideas
10:30 – 11:00	**Coffee break & poster viewing**
11:00 – 12:00	**Workshop part 2**
12:00 – 12:30	Presentation of Workshop results and group discussion
12:30	Closing remarks
13:00 – 18:00	**Excursion to "Sonnenerde", Austria's 1st commercial biochar production facility**

POSTER Programme (during both days)

PLENARY SESSION

Indruduction of the FOREBIOM project

Viktor BRUCKMAN[(1)]

[(1)] Austrian Academy of Sciences, Dr. Ignaz Seipel Platz 2, 1010 Vienna, Austria, viktor.bruckman@oeaw.ac.at, +43 1 51581-3200

FOREBIOM: Potentials for realizing negative carbon emissions using forest biomass and subsequent biochar Recycling

The transformation of forest biomass into raw materials for energy production (bio-oil and bio-gas) is facilitated using a process called “pyrolysis”. Unlike combustion, carbon is not gasified and retained as biochar, which could be applied on biomass production sites, having the potential to create negative CO_2 emissions and improving soil properties. However, a number of issues are not well understood, including long-term effects of biochar in soils, the anticipated environmental impact and the influence of the raw material on the pyrolysis process (yields, pollution etc.).

ABSTRACT. On a country basis, profound information on biomass potentials is missing and local conditions have to be considered as forests represent an ecosystem with a multitude of environmental services. We use a cascade approach to jointly study the potential of our proposed approach to mitigate climate change while sustaining biomass yields. In a first step, biomass potentials will be assessed, while minimizing the impact on other ecosystem services of the forest sites considered for biomass production. In the second step, we will assess the pyrolysis process, considering different qualities of feedstock, pyrolysis conditions and associated energy and biochar yields. The third step in our cascade approach focuses on the application of biochar at forest sites (and the potential to use it as a filter agent for sewage or exhaust air before application), storing carbon for a long term-period in soils and improving soil properties as indicated in a large number of scientific articles. Country reports for Austria, Korea and Turkey will be published to serve as a basis for further research and for policy making, and a final report will focus on synthesis effects and the benefit of multinational collaboration. The final report will be peer-reviewed and published in an international scientific book series.

OBJECTIVES. Forest bioenergy can considerably contribute as a source for green energy in countries with a high forest cover (such as Austria and Korea). Biomass pyrolysis has the potential to realize negative emissions since carbon is not oxidized and released as CO_2. We propose a promising cascade of biogas production for energy by pyrolysis and subsequent utilization of activated carbon (biochar) as a filter agent. Biochar may be replaced on biomass production sites to sustain production by enhancing soil properties. The project has the following objectives:

1. to combine current state-of-the-art knowledge of different steps in the proposed cascade and therefore come up with possible pathways of realization in consortium member countries (case studies)
2. to organize a scientific workshop series with keynote lectures and posters which covers topics of the cascade and to discuss options
3. to conduct small-scale laboratory experiments in each member country
4. to publish country-case reports for each consortium member country with focus on local conditions
5. to publish a summary report in the “Interdisciplinary Perspectives” book series
6. to establish of an on-line platform and information resource focusing on knowledge dissemination and active discussion by means of an on-line interactive forum
7. to establish a decision support system (DSS) focussing on criteria for the steps and subsequently suggest proposal(s) for an integrated project of European level in the Energy or Environment domain using the momentum created by the KORANET consortium.

Funding institutions

- Federal Ministry for Science and Research (BMWF), Austria
- Ministry of Education, Science and Technology (MEST), Korea
- The Scientific and Technological Research Council of Turkey (TÜBITAK), Turkey

Duration

10/2012 – 09/2014

Principal coordinator

Viktor J. Bruckman (viktor.bruckman@oeaw.ac.at)

Austrian Academy of Sciences, Commission for Interdisciplinary Ecological Studies

Dr. Ignaz Seipel-Platz 2, 1010 Vienna, Austria

http://www.oeaw.ac.at/kioes

www.koranet.eu

Biochar – building synergies between soil fertility, renewable energy production, and carbon sequestration

Christoph STEINER[1]

[1] Biochar.org, Technisches Büro
Salzburgerstr. 17/3, 5165 Berndorf bei Salzburg, Austria

Throughout the world intensive agriculture often has resulted in soil physical and chemical degradation, to due erosion and higher output than input rates of nutrients and organic matter. In contrast, the intentional and unintentional deposition of nutrient-rich materials within human habitation sites and field areas has in many cases produced conditions of heightened fertility status. Terra Preta soils in the Amazon are among the most prominent examples of human enriched soils. The difference between Terra Preta and ordinary soils in its vicinity is striking. In contrast to yellow or reddish Ferralsols the Terra Preta is dark (black). Terra Preta is rich in calcium and phosphate. These two elements are scarce in the Amazon Basin and its presence alters fertility and ecology of the landscape distinctly. Sustainable soil fertility management is a major constraint in the humid tropics. Current major environmental threats such as deforestation and global warming contribute to Terra Preta's wide public perception. Its existence proofs that long-lasting soil fertility improvements and carbon sequestration is possible, even under the most unfavorable circumstances (fast mineralization and leaching) and gives rise to hope to overcome these environmental challenges. Terra Preta may offer an opportunity to learn from the past and improve our current wasteful material flow management.

Due to the Terra Preta's distinctiveness to the surrounding soils, it is not surprising that early explorers of the Amazon noticed its existence. The Austrian Friedrich Katzer conducted pioneering analytical work on these soils and was apparently the first scientist noticing that Terra Preta contains charred plant material. Since the 1980 Terra Preta received intensive scholarly attention. The first field experiment with the intention to replicate Terra Preta and study the effects of charcoal (biochar) on soil fertility was established in the Brazilian Amazon in the year 2001. As a result slash and char was described as an alternative to slash and burn agriculture. Carbon sequestration by the burial and landfilling of charcoal was suggested in 1993. However this proposal neglects the removal of essential nutrients contained in the biomass and the beneficial effects of carbon on soil fertility.

On a global scale, it is projected that by 2050, the food demand will double. In addition, agriculture is pushed to provide more fiber and biofuels, even while land is continuously lost to erosion and to urbanization. Previous productivity gains were largely attributable to, and food production now depends on non-renewable resources such as rock phosphate and fossil energy. Moreover, considering the environmental damage already done, climate change and declining resources, the challenge to double food production – and to do so without causing more environmental harm – is extremely daunting.

Meeting that challenge will require timely, effective action on several fronts, including:

- Judicious use of natural resources (renewable and non-renewable).
- Using fertilizer and water more efficiently.
- Reversing soil degradation.
- Mitigating global warming.
- Adapting to a warming climate.

Keywords: Terra Preta, Global Challenges, Soil Fertility, Food Security

Charcoal production and utilization in Thailand

Maliwan HARUTHAITHANASAN[1], Nikhom LAEMSAK[2], Kasem HARUTHAITHANASAN[1]

[1] Department of Biomass and Bio-energy Technology, Kasetsart Agricultural and Agro-industrial Product Improvement Institute, Kasetsart University, Bangkok, Thailand, aapmwt@ku.ac.th, +66 2 9428700

[2] Department of Wood Technology, Faculty of Forestry, Kasetsart University, Bangkok, Thailand

Thailand is a tropical country with an area of 513.115 km^2 and a population of about 66 million, one of the strongest agro-based country which rich of biomass resources. Renewable energy, which compose of fuel wood and charcoal are the main sources of biomass energy mainly used by rural households. There are various kinds of charcoal kiln in Thailand, temporary kiln which made from clay, 200l gasoline container, half-permanent and permanent kiln using brick construction. The Thai-Iwate kiln, the modified Iwate kiln, was recommended for charcoal production in commercial scale currently. These kiln does not produce only charcoal but also collect condensed pyroligneous liquid which can be used as wood vinegar for various purposes, agriculture, household and cosmetic ingredients. The popular size for Thai-Iwate kiln is 12 m^3 which can produce 1 ton of charcoal from 5 tons of wood. The maximum temperature in these kiln is 600 °C, the production period is 15 days for 12 m^3 size. The collection of pyroligneous liquid for wood vinegar starts since the temperature inside kiln is 300–400°C using distillation method. Compositions of wood vinegar are acitic acid, phenolic compounds and methanol. Quality of charcoal produced from Thai-Iwate kiln is much higher than those produced from conventional or temporary kiln. Volatile matter, ash, moisture content are <10%, 2–5%, 6–8%, respectively. The heat value of this charcoal is 7.000–7.600 kcal/kg. Almost charcoal which is produced in Thailand use for household and restaurant. However some is exported to Korea, Japan and Mid-east. There is residue from charcoal production which is the cracked charcoal is use to produce briquette coal and apply into the soil. The yield of wood vinegar is 200–300 l from one batch of charcoal production using Thai-Iwate kiln.

Keywords: Charcoal, Thailand

SESSION I

Forest biomass resources for biochar production

Sustainable Use of Biomass Feedstock – Global and Regional Aspects

Florian KRAXNER[1]

[1] Ecosystems Services and Management Program (ESM) International Institute for Applied Systems Analysis (IIASA) Schlossplatz 1, 2361 Laxenburg, Austria, kraxner@iiasa.ac.at, +43 2236 807-233

Most scenario projections of future feedstock demand indicate the need for an increased production. This necessary increased production should ideally take place under sustainable management and can be sourced from various land-use types such as agriculture, managed forest, plantation forest etc. At the same time there will be and increased competition for the same or similar feedstock and also for the land the feedstock will be produced on. The latter might lead to local, regional and supra-regional direct and indirect land use change.

This presentation aims at providing an overview and insight in sustainable feed stock potentials for e.g. bioenergy production and other uses of the same feedstock (i.e. biochar) for Europe and globally while trying to identify benefits and trade-offs at various scales and under different assumptions and scenarios.

Sustainable forest biomass potentials in Austria

Michael ENGLISCH[1]

[1] Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft, Department for Forest Ecology and Soil, Vienna, Austria, michael.englisch@bfw.gv.at, +43 1 87838/1203

Energy from wood-based biomass met 45% of the 411 PJ gross inland consumption of renewable energy in 2010 in Austria. Net annual increment of the Austrian forest reaches 30.3 M cme and exceeds significantly the total Austrian forest production (23.7 M cme in 2010). However, a crucial question is if the rising demand of wood-based biomass can be met by sustainable forestry in the future.

Within the project HOBI (Holz- und Biomasseaufkommensprognose, prognosis on supply on wood and biomass) carried out at BFW (Federal Research and Training Centre for Forests, Natural Hazards and Landscape) the biomass potentials in the Austrian forest was calculated using different utilization scenarios.

Basic data for the prognosis of the sustainable biomass utilization potential were provided by the Austrian Forest Inventory (BFW 2012). In addition to legal restrictions (protective forests, protected areas) and economic restrictions (costs of harvesting), nutritional sustainability was taken into account in order to estimate the available biomass potential. The theoretical potential without restrictions was estimated to lie in a range between 32.7 and 38.4 M cme (standing, solid over bark); the available potential considering restrictions was estimated between 24 to 31 M cme (solid over bark, including harvest losses).

The estimation of nutritional sustainability was based on available information from different data sources using a nutrient balance approach. Actual soil nutrient stocks were calculated using the dataset of the Austrian Forest Soil Inventory of 1988/89 and extrapolated to the production forest plots of the Austrian Forest Inventory using transfer functions.

Atmospheric deposition was up-scaled by combining input data of 20 monitoring sites of the ICP Forest Level II plots and precipitation data available in high resolution. Long term supply by weathering was calculated using the soil type – texture approximation method including the above-mentioned soil information, a coarse scale hydrogeological map (1:500 000), and interpolated soil temperatures as input.

Leaching was estimated using literature values. For nutrient extraction estimates, literature values and data from the Austrian Bio-Indicator grid (Fürst 2009) for nutrient concentrations of tree compartments were used. They were combined with utilization calculations for the different tree compartments in WTH-scenarios (extraction of timber with bark minus harvest losses and extraction of 70% of branches, twigs and needles both in thinning and final harvest operations) over a rotation period of 150 years carried out with the growth simulator PROGNAUS. Potential extractions were compared to short to medium term available stocks of Ca, Mg and K (exchangeable soil stocks + atmospheric input + weathering input - leaching) and to the long-term available N- and P-stocks. A sustainability classification was based on the ratio of nutrient amounts extracted via whole tree harvesting to soil nutrient stocks.

Keywords: Forest biomass potentials, Austria, nutrient balance

Coppice forestry and biomass resources in Austria

Eduard HOCHBICHLER[1]

[1] University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

Objectives and regulations from the EU and from national programmes (Biomass Action Plan) on using renewable resources for producing energy lead to increasing demand for woody biomass products. The feasibility of utilization of woody biomass as an important energy resource in Austria is discussed on its amount and availability. This presentation describes the potential of biomass production and productivity for energy wood from managing coppice forests (coppice, coppice with standards) and short rotation forestry on agricultural land. Due to site conditions, various types of coppice management systems have been a widespread silvicultural practice in the eastern part of Austria for centuries. Coppice forests cover an area of about 130,000 ha. Ongoing demand for high quality timber of oak and valuable broadleaved trees and for biomass (energy wood) increased the interest for these silvicultural systems once again. Contemporary energy wood production in short rotation coppice systems (SRC) becomes increasingly important to meet the demands of the growing bioenergy sector. During the last decade, research activities were conducted to improve silvicultural knowledge for managing various types of coppice forests. Tree- and shrub-specific biomass functions were derived. Stand characteristics and biomass production and/or productivity were calculated for different types of coppice forests and short rotation coppice systems. The opportunities to enhance energy wood production depending on these management strategies are discussed based on the landowners structure, ecological criteria (biomass), management practices (silvicultural systems and operations), technical aspects (harvesting techniques and logistic networks) and economic parameters.

What technology for biofuel production in EU?

Sylvain LEDUC[1], Elisabeth WETTERLUND[2], Erik DOTZAUER[3], Georg KINDERMANN[4]

[1] International Institute for Applied System Analysis (IIASA), Laxenburg, Austria, leduc@iiasa.ac.at, +43 2236 807 599

[2] Linköping University, Linköping, Sweden, elisabeth.wetterlund@liu.se

[3] Mälardalen University, Västerås, Sweden, Erik.Dotzauer@mdh.se

[4] International Institute for Applied System Analysis (IIASA), Laxenburg, Austria, kinder@iiasa.ac.at, +43 2236 807 452

The European Union has set a 10% target for the share of biofuel in the transportation sector to be met by 2020. To reach this target, second generation biofuel is expected to replace 3–5% of the transport fossil fuel consumption. But the competition on the feedstock is an issue and makes the planning for the second generation biofuel plant a challenge. Moreover, no commercial second generation biofuel production plant is under operation, but if reaching commercial status, this type of production plants are expected to become very large. In order to minimize the transportation costs and to tackle the competition for the feedstock against the existing woody based industries, the geographical location of biofuel production plants becomes an issue. This study investigates the potential and the optimal technology for producing second generation biofuel economically feasible in Europe by 2020 in regards with the competition for the feedstock with the existing woody biomass based industries (CHP, pulp and paper mills, sawmills...).

To assess the biofuel potential in Europe, a techno-economic, geographically explicit model, BeWhere, is used. It determines the optimal locations of bio-energy production plants by minimizing the costs and CO_2 emissions of the entire supply chain. The existing woody based industries have to first meet their wood demand, and if the amount of wood that remains is sufficient, new bio-energy production plants if any can be set up. The model will determine the location, number and technology of the biofuel production plants.

Preliminary results show that CHP plants are preferably chosen over biofuel production plants. Strong biofuel policy support is needed in order to consequently increase the biofuel production in Europe. Methanol via gasification is the biofuel of choice when it comes to increase the biofuel production, whereas ethanol can be produced at different level of policy tools. Including pyrolysis in the system lower the logistic costs consequently and therefore is a promising technology.

Keywords: CHP, pyrolysis, second generation biofuel, biomass competition, energy policy, Europe, residual wood, mixed integer model

SESSION II

Biomass pyrolysis

Pyrolysis: A sustainable way from biomass to bio-fuels and bio-char

Başak Burcu UZUN(1)

(1) Anadolu University, Faculty of Engineering, Dept. of Chemical Engineering, Iki Eylul campus, Eskisehir, Turkey

Energy from biomass is known as one of an essential renewable source with the highest potential to sustainable development. Biomass provides 14% of the world's primary energy production, but is largely wasted by inefficient use and unsustainable exploitation. To exploit the full potential of this energy source, new approaches and modern technologies such as pyrolysis, gasification are needed to avoid them burnt directly or left them where they are. As can be known, biomass is a mixture of hemicellulose, cellulose, lignin and minor amounts of other organics such as energy crops and all kinds of organic wastes. To collect such organic disposals/residues from agriculture and forestry is a sustainable way for waste minimization and bio-energy production. In the medium and long term, residues from especially agriculture and forestry, and energy crops will develop the bio-energy industry. Due to the targets to decrease in greenhouse gas emission, desire to secure and diversify the supply of energy and uncertainties related to oil price are rendering various biomass types more interesting fuels in industrialized countries, and the modern use of biomass is increasing rapidly in many parts of the world [1, 2].

Pyrolysis is the thermal decomposition of organic matters in the absence of oxygen. The process produces a solid (char or charcoal), a liquid (bio-oil) and a mixture of gases. Depending on pyrolysis conditions, bio-char for soil amendment, activated carbon, carbon fibers, bio-fuels, value added chemicals such as PF type adhesives, phenolics, levoglucosan, octane enhancers, fertilizers and gas products such as hydrogen, methane, ethane, propane could be achieved. The ratio of the products varies with the chemical composition of the biomass and operating conditions such as pyrolysis temperature, heating rate, reactor configuration, pyrolysis atmosphere, reaction time, particle size, etc. [3].

In this talk, biomass and its types, thermal behavior of biomass and its components, fundamentals of pyrolysis process, and effects of the process parameters on yields and composition of products, characterization, and some examples from literature and our group's previous works will be discussed. Moreover, application of bio-fuels and bio-char and its future are evaluated.

[1] Renewable Energy 35 (2010) 232–242.

[2] Biomass and Bioenergy 33 (2009) 1310–1320.

[3] Journal of Analytical and Applied Pyrolysis, 79, Issues 1–2, May 2007, Pages 147–153.

The etablisment of a biochar-production facility from waste

Gerald DUNST[1]

[1] Sonnenerde, Oberwarterstraße 100, A-7422 Riedlingsdorf, g.dunst@sonnenerde.at

Terra Preta experiments by the company "Sonnenerde"

In 2008, on our second symposium on humus, Prof. Bruno Glaser showed the results and shared the knowledge of Terra Preta research. Since that time, we are also working intensively on this subject and scientific composting experiments are continuously conducted.

In the first series, activated carbon was used, which (as it later turned out) was not good for the earthworm after the application of compost as a soil additive. Since 2009, several series of experiments were performed with different amounts of charcoal, and other additives like rock flour and sulfur in the composting process. In summary, after six trials we can present the following results:

- From an addition of 10% biochar, we found measurable benefits. The more biochar is added, the more carbon and nitrogen remain generally retained in the system.
- The carbon-losses during the composting process can be reduced from 50% to 20% by the addition of 50% biochar. The N-losses can be reduced from 30% to 15%.
- By the use of EM (so called "Effective Microorganisms" – a mixture which consists mainly of lactic acid bacteria, yeasts and photosynthetic bacteria), no additional effects could be measured.
- With the combination of 5–10% rock flour plus 20% biochar in the compost mix (both by weight), the microbiology of the compost approaches to Terra Preta biology (90% similarity).
- We found no positive effect by decreasing the pH-value during the composting process.

Carbon stabilization in soil

The Terra Preta phenomenon proves that it is possible to create artificial soil systems with stable high carbon content and a very high fertility. This provides not only the certainty that the carbon-stabilization in soil is possible to a large extent, but also the hope that by using this technology, the soils start to sequester additional carbon (keyword: self-regenerative capacity of Terra Preta).

So there is reason to hope that by this system of humus structure, a high contribution can be made to protect the climate.

Construction and operation of a pyrolysis plant

After three years of fighting with authorities, our biochar-plant was approved and built as "experimental operation". Around € 800.000.– has been invested. It includes hall, place attachment and accessory development. In our system, the following commodities are charred:

- paper fiber sludge (waste from a board mill)
- municipal green waste
- grain husks

During the pyrolysis-process we generate a heat of 150 kW. It comes from an exhaust gas heat exchanger and we use it for drying the fiber sludge from 20% DM (dry matter) to 65% DM. During the subsequent screening on 15 mm, the material properties are adjusted by addition of grain husks on a dry matter content of 65%. The material is charred continuously at 500–600°C under exclusion of air and moistened to 30% water content and discharged by a screw conveyor. In a 24-hour operation cycle, the system is able to process about 5 Mg raw materials and produce around 1.5 Mg of biochar.

The big challenge was to shift the investment from the status of a prototype into a production-ready system and to develop and integrate an overall strategy including full use of heat. This has been achieved during the first year. Here we present a realistic operation cycle in the area of waste management:

- Monday morning: cleaning of the entire system - slag and ash container, exhaust gas-carrying pipes, cyclones and reactors. Duration: 2 men, 2-3 hours. Re-activation of the plant at the latest 10:00 am.
- Continuous operation until the next Monday.
- Every month, extended cleaning is necessary. It takes about 6-8 hours for two persons.
- So we can achieve an operation time of 7.000-8.000 hours per year.

The quality of the produced biochar corresponds to the premium quality according to the guidelines of the "European Biochar Certificate." This means not only a sustainable and environmentally friendly production method, but also a correspondingly low level of contaminants, a very small H/C- and O/C ratio and a high C content (in our case 60%).

We sell this biochar to farmers in Germany and Austria for their own manure-preparing to bind the nitrogen and improve the soil permanently. The price per Mg is € 450.00 (ex VAT).

Tests for activation of biochar

1. There is no terra preta (yet)

For us, the term "terra preta" represents a sustainable soil system that is able to regenerate itself and to maintain the fertility. Such a system must be able to bind nitrogen from the air and with a part of root exudates, it builds up stable humus. The proof of this crucial function was achieved long ago and yet no one succeeded. We see it as a bad habit and short business idea that pure mixtures of biochar and composts are sold as "Terra Preta". Moreover, many of these offered substrates work in practice worse than conventional substrates.

Many of the offered substrates get their "biochar" also from unknown sources - often from third world countries at the lowest possible prices. This also shows that this is not in correspondence with the idea of sustainability, and the short-term profit is in the foreground.

We (from Sun Earth) create income from the sale of finished substrates and of course we are very interested into the development of a terra preta like soil. Our practice tests run for three years with a variety of mixtures. The focus of interest is not only the fertility of the soil - that is as healthy growth and maximum yield, but also the sustainability of this fertility. A "terra preta" must remain fertile for decades without fertilization.

2. Riedlingsdorfer black soil

For the above reasons, and from the economic pressure to bring a new soil on the market as quickly as possible, we have decided to sell a new soil, which we call "Riedlingsdorfer black soil". This extreme fertile soil contains 20% biochar and 10% rock flour in the raw compost mixture. We mix also some mineral components into the ready compost, like lava, sand and clay. Only when the sustainability and self-recovery is proven, we will promote it as "Terra Preta".

3. The soil activator

Simultaneously in the Eco region Kaindorf, we run intensive research in the form of field experiments to develop a soil-conditioner to start the terra-preta-effect in the soil (self-enrichment of carbon and nitrogen).

The produced biochar is first charged with various forms of nitrogen to saturation. The biochar is then biologically activated with humus, which contains fair amounts of microorganisms. (The biochar is mixed into the final phase of the composting process). To stimulate the N-binding effect, the necessary trace elements selenium and molybdenum are added.

As a next step, the trace element cobalt is added. According to studies by Virtanen, 1924 (cited in Brown, 2010) maize plants in the presence of vitamin B12 can fix atmospheric nitrogen and assimilate it themselves.

Our research therefore focuses on the microbiology of the N-cycle. Only trough optimization of the free air-nitrogen fixing capabilities, it is possible that the carbon-content of the soil increases, or at least remains stable. From the root exudates we have enough carbon in the soil - the humus increasing always fails on continuous nitrogen deficiency.

Conclusion

- Commercial production of biochar works.
- There is no "Terra Preta" to buy (yet) – the current sale is profiteering.
- We try to develop different products from biochar like a black soil.
- The great challenge is to develop a "soil activator". With this product the soil should start to increase humus itself (terra preta effect).

Biomass pyrolysis and biochar characterization

Frederik RONSSE[(1)], Dane DICKINSON[(2)], Robert NACHENIUS[(3)], Wolter PRINS[(4)]

[(1)] Ghent University, Biosystems Engineering, 9000 Ghent, Belgium, Frederik.Ronsse@Ugent.be, +32 9 264 62 00

[(2)] Ghent University, Biosystems Engineering, 9000 Ghent, Belgium, Dane.Dickinson@Ugent.be, +32 9 264 61 90

[(3)] Ghent University, Biosystems Engineering, 9000 Ghent, Belgium, Robert.Nachenius@Ugent.be, +32 9 264 61 90

[(4)] Ghent University, Biosystems Engineering, 9000 Ghent, Belgium, Wolter.Prins@Ugent.be, +32 9 264 61 30

Biochar holds significant potential as a carbon sequestration method and as a soil amendment. Despite significant research effort in the subject matter, little is known with respect to the production conditions to obtain an 'optimal' biochar. The results presented further elaborate on specific and functional biochar characteristics and how these relate to the biomass feedstock type and to the process conditions that were applied during biochar production.

Biochar can be produced through a variety of thermochemical conversion processes, starting from a wide range of available feedstocks. First, an overview of the different conversion processes (fast & slow pyrolysis, gasification, torrefaction and hydrothermal processes) and the potential integration of biochar in pyrolysis-based biorefinery schemes is given.

Next, emphasis will be put on the slow pyrolysis process, given its flexibility in process conditions and the high char yields obtained. More specifically, results from finished and ongoing studies in biochar production from fixed-bed slow pyrolysis of various feedstock biomasses (a.o. pine wood, straw, dry algae and green waste) under a range of process conditions (temperature and residence time), are presented. Resulting biochars were characterized both physico-chemically as well as functionally (incubation tests in soil microcosms, microbial degradation testing). In soil incubation tests, specific attention is paid to the 'priming effect', the enhanced cometabolization of soil organic carbon and volatile carbon present in the char which results in net elevated CO_2 effluxes in soil after biochar application.

Throughout the study, it was found that certain physico-chemical and functional properties (e.g. specific surface area, pH, volatile matter content,…) are highly sensitive to the temperature applied during pyrolysis, whereas sensitivity towards feedstock composition is usually less pronounced. Uncovering the relationship between feedstock, process conditions and biochar (functional) properties could help to explain the (sometimes contradictory) results obtained in biochar application, as well as to identify key production conditions for 'tailor-made' biochar.

Keywords: Biochar, slow pyrolysis, fast pyrolysis, physico-chemical biochar characterization, biomass feedstock, functional biochar testing

Investigating the influence of production conditions on the energy distribution between the solid, liquid and gaseous products of slow pyrolysis

Kyle CROMBIE[(1)], Ondřej MAŠEK[(1)]

[(1)] UK Biochar Research Centre, School of Geosciences, University of Edinburgh, Edinburgh, UK, k.crombie@ed.ac.uk, +131 6505103

Slow pyrolysis is a well established technology for converting biomass into a more stable form of carbon (biochar) while also producing energy rich by-products of bio-oil and syngas. Biochar is the porous, carbonaceous material produced by thermo-chemical treatment of organic materials in an oxygen-limited environment. Biochar can be incorporated into soils to improve soil fertility, reduce greenhouse gas emissions as well as provide long term storage of carbon or alternatively it can also provide additional energy to a pyrolysis system through combustion. Biochar production conditions have a significant influence on the yield as well as physiochemical and functional properties of the final pyrolysis products, resulting in a selection process aimed towards either agricultural benefits and carbon mitigation or heat/energy generation.

This work aimed to investigate the effect of temperature, residence time and gas flow rate on the product energy distribution as well as the physical, chemical and soil functional properties of biochar, in order to optimise conditions best suited to maximise both energy value and agronomic benefit. Biochar samples were produced from wood pellets (WP) and straw pellets (SP) at two temperatures (350°C and 650°C), with three residence times (10, 20 and 40 minutes) and three carrier gas flow rates (0, 0.3 and 0.6 l min^{-1}). The energy balance of the system was determined through the calorimetric analysis of biochar and bio-oil, while the higher heating value for the syngas was calculated from the gas composition measured via mass spectroscopy. Biochar was also analysed for the physiochemical properties of proximate analysis and ultimate analysis as well as the functional property of environmentally stable carbon (C) content.

As expected the yield of biochar decreased with increasing temperature resulting in elevated yields of liquid and gas fractions. Increased temperature also resulted in higher values of fixed C, total C, stable C and calorific value due to the increased emission of volatiles. The higher heating value for the syngas was also shown to increase with temperature due to greater release of combustible gas species at higher temperatures. The impact of residence time and gas flow rate were not as clear as for temperature but still demonstrated decreasing biochar yields as the respective parameters were increased. However the greatest impact occurred at 350°C and diminished when temperature was increased to 650°C. An understanding of the influence that production conditions have on the long term stability of biochar as well as the energy content of the solid, liquid and gas fractions obtained from pyrolysis is critical towards the development of specifically engineered biochar to deliver a specific function be it for agricultural use, carbon storage, energy generation or combinations of the three.

Keywords: Biochar, carbon sequestration, pyrolysis, calorific value, environmental stability

SESSION III

Biochar and soil

Effects of biochar application on soil functions: results from lab incubations, greenhouse pot experiments and field trials

Franz ZEHETNER[1], Stefanie KLOSS[1,2], Jasmin KARER[2], Andrea WATZINGER[2], Sonja FEICHTMAIR[1,2], Sophie ZECHMEISTER-BOLTENSTERN[1], Eva OBURGER[1], Jannis BUECKER[2], Shady SELIM[1], Johannes LEHMANN[3], Barbara KITZLER[4], Bernhard WIMMER[2], Gerhard SOJA[2]

[1] Institute of Soil Research, University of Natural Resources and Life Sciences Vienna, Austria, franz.zehetner@boku.ac.at

[2] Department of Health and Environment, AIT Austrian Institute of Technology, Tulln, Austria

[3] Department of Crop and Soil Sciences, Cornell University, Ithaca, New York, USA

[4] Institute of Soil Biology, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, Austria

Soils fulfill a number of vital functions that are essential for the maintenance of ecosystem services. They provide the basis for biomass and food production, harbor an enormous diversity of (micro)organisms, and act as buffers, filters and transformers of pollutants. Furthermore, soils represent important compartments in the global carbon and hydrological cycles. They store large amounts of organic carbon and modulate the runoff-infiltration behavior during rainstorms. The application of biochar to soils may affect these functions to varying extents. Here, we report results from an Austrian project on biochar application to agricultural soils and specifically highlight effects on soil functions.

In our experiments, biochar had a clear liming effect, raised cation exchange capacity and soil nutrient levels, with strongest effects in a sandy, acidic soil. Biochar addition also increased the soils' water retention capacity. On the other hand, effects of biochar application on soil microorganisms were generally minor. In incubation experiments with isotopically labeled biochars, we detected very slow degradation rates and high stability of biochars, with mainly actinomycetes contributing to biochar degradation. Biochar addition to soils had strong effects on the sorption and leaching of contaminants; for example, nitrate leaching was strongly reduced and the sorption of cationic trace metals (like Cd and Cu) as well as herbicides (like chloridazon and terbuthylazine) was strongly enhanced by biochar addition.

Many open questions remain; to name but a few: how lasting are the observed effects, how do they change with biochar aging, what are the consequences of the heterogeneous distribution of biochars in the field and how does this change with soil tillage over time? This calls for long-term experiments under realistic agricultural management conditions.

Keywords: soil fertility, cation exchange capacity, nutrients, microorganisms, nitrate, trace metals, herbicides

Rhizosphere effects of carboniferous and clay compounds in a sandy soil matrix

Bernd Uwe SCHNEIDER(1), Reinhard HÜTTL(2)

(1) Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany, schneider@gfz-postdam.de, phone +49 331-288 1065

(2) Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, huettl@gfz-potsdam.de, phone +49 331-288 1010

The chemical and physical environment of ash ameliorated lignitic sandy mine spoils is extremely heterogeneous due to the spatially random distribution of pyritic and lignitic compounds, fly ashes and ongoing secondary mineral formation and dissolution processes. Hence, high salt and/or proton concentrations alternate with high pH and low electrical conductivity on a very small scale throughout the soil profile and prevent trees from developing a deep root system which is commonly found in natural forest ecosystems of this region under the given continental low precipitation regime. Despite these restrictions no negative impact could be found on stand performance under these circumstances indicating that trees benefit from the potential of lignite compounds to store water and nutrients in the porous structure, thus compensating for the restricted space for roots to grow.

Similarly, proliferation of fine roots in a raw soil from quaternary sands was found to preferably respond to randomly distributed clay fragments showing significantly higher root length densities in fragments than in the surrounding sand matrix. Experimental findings gave evidence for the positive impact of such fragments on water and nutrient availability, and, hence, on plant nutrition and growth. Greenhouse experiments indicated that mycorrhizal fungi and bacteria lignite are rapidly entering into the porous space of clay fragments and that penetration of respective fragments by hyphae instead of roots is prevailing in case phosphorus has been amended inside. These findings also show that high bulk density will not keep roots and fungal hyphae from penetrating clay fragments. In return this underlines the importance such porous media have for soils with low water retention and nutrient storage capacity. Since benefits apply to both clay fragments and those derived from lignite compounds research should strive for a direct comparison of long-term stability and biogeochemical effects of such components under natural conditions. This may also raise the question whether the combination of both carboniferous and mineral components in the biochar production should be considered more thoroughly.

Biochar as yield promoter for agricultural crops? Conjectures and observations

Gerhard SOJA[(1)], Stefanie KLOSS[(1,2)], Jasmin KARER[(1)], Barbara KITZLER[(3)], Sophie ZECHMEISTER-BOLTENSTERN[(2)], Bernhard WIMMER[(1)], Franz ZEHETNER[(2)]

(1) Health and Environment Department, AIT Austrian Institute of Technology, Tulln, Austria, gerhard.soja@ait.ac.at, +43 50550 3542

(2) Institute for Soil Science, University for Natural Resources and Life Sciences Vienna, Austria

(3) Federal Research and Training Centre for Forests and Natural Hazards, Vienna, Austria

Biochar has a multitude of potential benefits that are powerful incentives in the search of evidence for the assumed advantages: biochar may sequester carbon in the soil for centuries or even millennia, it may provide nutrients as promoters of plant growth, it may reduce soil greenhouse gas emissions and nitrate migration towards groundwater, it may improve the physical and chemical characteristics of soil, thereby supporting soil biology, and it may immobilize soil pollutants, thereby protecting plants from mobile contaminants. Current research shows that it does not always show all of its benefits simultaneously, sometimes reducing the advantages to one or two. When will this be the case and which circumstances determine the overall efficiency of a biochar application? This presentation focuses on the yield promoting potential of biochar as exemplified by the results of our own field experiments in Austria in comparison with other international field tests.

At two locations in North and South-East Austria, two identical field experiments on two different soils were installed in 2011 with varying addition rates of pure biochar (0, 24 and 72 t DM.ha^{-1}) at 2 nitrogen levels (crop-specific). The experimental plots were arranged according to a 4x4 Latin square design. The biochar was a product from slow pyrolysis of wood (SC Romchar SRL). In 2011 and 2012, barley and sunflower (at a Chernozem soil, pH=7.3) and maize and winter wheat (at a Cambisol, pH=6.4) were cultivated according to standard agricultural practices.

The results of the first 2 years of Austrian field experiments showed that in temperate soils without severe fertility deficits, biochar without supplement was not able to raise crop yields. Any use of biochar as soil amendment should consider that addition of nitrogen as mineral or organic fertilizers is required to set off an unbalanced C:N-ratio and to counteract competition between plant roots, microorganisms and biochar binding sites. One experiment during a year with severe precipitation deficit showed that the water storage capacity of biochar improved the water supply during drought periods and may improve crop production during stress periods in rain-fed agriculture.

These and other European field experiments show that the exceptional yield increases observed in biochar-amended tropical soils cannot be expected to the same degree in temperate European soils. However, the absence of negative yield effects even under very high application rates confirmed the possibility of using biochar as long-term carbon sequestration strategy, good biochar quality (not exceeding accepted thresholds for pollutant concentrations) and complementary nitrogen supply provided. Biochar can only be expected to contribute to yield increases under European conditions if it is applied to soils that are acidic, sandy, low in soil organic matter and/or at risk from drought.

Keywords: soil amendment, carbon sequestration, pyrolysis, biomass, plant nutrients

Biochar arrests soil organic nitrogen cycling but promotes nitrification

Rebecca HOOD-NOWOTNY(1), Wolfgang WANEK(1), Judith PROMMER(1), Daniela TROJAN(2), Tim URICH(2), Barbara KITZLER(3), Bernhard WIMMER(4), Gerhard SOJA(4)

(1) Department of Terrestrial Ecosystem Research, University of Vienna, Vienna, Austria

(2) Department of Genetics in Ecology, University of Vienna, Vienna, Austria

(3) Institute of Forest Ecology and Soils, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna, Austria

(4) Department of Health and Environment, AIT Austrian Institute of Technology, Tulln, Austria

Biochar production followed by soil incorporation could provide humanity carbon farming solutions to global climate change and escalating food demand. There is evidence to suggest that biochar amendment causes fundamental changes in soil nutrient cycles, often resulting in marked increases in crop production, particularly in tropical infertile soils with low soil organic matter contents. Variable results have been found for temperate soils with higher nutrient availability [1, 2]. We offer insight into the mechanisms by focusing attention on the soil nitrogen (N) cycle, specifically on hitherto unmeasured processes of organic N cycling in arable soils.

In this study we investigated the impacts of biochar addition on soil organic and inorganic N pools and on gross transformation rates of both pools in a biochar field trial on arable land (Tchernozem) in Traismauer, Lower Austria. Biochar increased total soil organic carbon (SOC) and soil organic nitrogen (SON) pools but negatively affected the soluble organic nitrogen pool. Concurrently SON dynamics were reduced by 50–80%. In contrast, biochar promoted soil ammonia-oxidizer populations (bacterial and archaeal nitrifiers) and accelerated gross nitrification rates more than two-fold. These findings indicate a de-coupling of the intrinsic organic and inorganic soil N cycles. We invoke a "mesopore protection hypothesis" [3] to explain the retardation of SON cycling by biochar. It suggests that SON is adsorbed into mesopores which are highly abundant in biochar [4] and this occlusion hinders SON decomposition by exclusion of decomposer microbes [3]. The large surface area of macropores in biochar, in contrast, could provide soil microbes like ammonia-oxidizers, with favorable microhabitats through the protection against grazers or competitors and the co-location of nutrients and increased soil water retention [4]. This might explain the increases in soil nitrification rates observed.

Impediment of SON cycling ultimately leads to the dichotomy of two intertwined agronomic processes; the build-up of SON and the slowing-down of inorganic N release from SON essential for crop growth. Addition of fertilizer-N in combination with biochar effectively compensates for the reduction in SON mineralization, with plants and microbes drawing on fertilizer-N for growth, in turn fuelling the belowground build-up of SON. SON and particularly refractory soil organic matter are peptide dominated materials [5]. The accumulation of SON therefore is expected to enhance soil carbon sequestration due to non-biochar derived soil organic matter.

[1] T. J. Clough, L. M. Condron, Journal of Environmental Quality 39, 1218 (2010).
[2] S. Jeffery, F. G. A. Verheijen, M. van der Velde, A. C. Bastos, Agriculture Ecosystems & Environment 144, 175 (2011).
[3] A. R. Zimmerman, J. Chorover, K. W. Goyne, S. L. Brantley, Environmental Science and Technology 38, 4542 (2004).
[4] J. Lehmann et al., Soil Biology & Biochemistry 43, 1812 (2011).
[5] H. Knicker, Soil Biology & Biochemistry 43, 1118 (2011).

Keywords: biochar, nitrification, soil organic nitrogen dynamics

Poster presentations

Centennial time scale effects of large incorporation of pyrogenic carbon in soils: Carbon sequestration and soil fertility (Poster 1)

Irene CRISCUOLI[(1)], Giorgio ALBERTI[(2,3)], Silvia BARONTI[(4)], Cristina MARTINEZ[(1,4)], Cornelia RUMPEL[(5)], Franco MIGLIETTA[(1,4)]

[(1)] Fondazione E.Mach, FoxLab, Forest & Wood Science, San Michele a/Adige (Trento), Italy, irene.criscuoli@fmach.it, cristina.martinez@fmach.it, +39 0461 615389

[(2)] European Forest Institute, MOUNTFOR Project Centre, San Michele a/Adige (Trento), Italy, alberti@uniud.it, +39 0461 615597

[(3)] University of Udine, Agriculture and Environmental Sciences Department, Udine, Italy, alberti@uniud.it, +39 0432 558608

[(4)] National Research Council, IBIMET-CNR Institute of Biometeorology, Firenze, Italy, s.baronti@ibimet.cnr.it, f.miglietta@ibimet.cnr.it, +39 055 3033711

[(5)] Centre national de la recherche scientifique, BIOEMCO laboratory, INRA Bât. EGER – 78850 Thiverval-Grignon, France, cornelia.rumpel@grignon.inra.fr, +33 01 30815479

Carbon content and fertility of three charcoal hearths have been assessed in the Pejo alpine valley of Trentino, Italy (2100 m a.s.l) where pyrogenic carbon (C) was left on the soil surface in large quantities in 1858 following charcoal production in the area. The charcoal hearths are easily recognized today in the alpine site, which is characterized by grasslands with sparse larch trees. The first aim of the study was to quantify the C stock in charcoal hearth soils and control areas and separate the fraction derived from charcoal (fragments and charcoal dust) from that present in soil organic matter (SOM). This separation was achieved using stable isotopes and a mass balance approach. The second aim of the study was to estimate the decay rate of charcoal in the soil (decay constant; k) via two different approaches. The first involved the comparison of the present C content of charcoal fragments with the original one, whilst the second approach involved the comparison of the pyrogenic C found today in the hearths with what was supposedly left 155 years ago. Both pathways led to similar results enabling carbon losses due to charcoal degradation and lateral transport to be distinguished. Finally the impact of charcoal on the long term fertility of the soil was assessed via soil chemical analyses and a plant growth experiment.

Our study aimed to address such key questions by identifying and studying areas where charcoal was added to soil in the past without other confounding C sources, such as biomass and organic wastes, or any major anthropogenic disturbance since application. The charcoal hearths of Val di Pejo therefore appear to be an ideal analogue of a deliberate experiment where the effects can be observed now, more than 150 years after the addition of charcoal to the soil. Furthermore, looking into the past may often be a strategy to better interpret processes that will happen in the future.

The results of this long-term study show that the C content of hearth soils is significantly larger than the adjacent control soils and this is mainly attributed to the presence of charcoal. The charcoal decay rate is lower than what was recently reported in a meta-analysis by Singh et al. 2012, but is in line with the results of another long term study on charcoal furnaces in North America (Cheng et al., 2008). Even if more than 150 years have passed since charcoal application, such hearth soils still have a higher fertility compared to control soils, as demonstrated by a higher concentration of nutrients. In fact, according to the plant growth results, plants show a higher growth rate in hearth soils than in control soils.

Keywords: Charcoal, long-term stability, decay rate, long-term fertility

Influence of herbicides on the respiration of charcoal-affected forest soil (Poster 2)

Astrid FAJTAK[1]

[1] University of Natural Resources and Life Sciences, Institute of Forest Ecology, Vienna, Austria, astrid.fajtak@students.boku.ac.at

For centuries, native people in the Amazonas added charcoal for manuring purpose – eading to Terra preta do indio soils. Recently, biochar became popular in agricultural practice due to its supreme storage capacity in regard to water and nutrients, its improvement of the microbial community and the pH value in soils and to mitigate climate change. In Middle Europe, including Austria, similar soils to Terra preta do indio developed locally from charcoal production from wood. These soils contain aged biochar, and soil metabolism (e.g. evidenced by soil respiration rates) is likely different to charcoal free soils although few measurement exists to date for "European Terra preta" soils. Recently, large scale application of biochar to forest soils got in sight of international research, mainly to increase the C storage in forest soils as a climate change mitigation measure. Herbicides are commonly used in agriculture and forestry. While it is known that certain herbicides can decrease or increase soil metabolic activity, knowledge is very limited in respect to the effects of herbicides on soil respirations rates of freshly biochar amended forest soils and aged European Terra preta soils.

In consequence, this research will investigate if there are differences between soil respiration rates with and without herbicides added to soils with aged biochar, freshly added biochar and no biochar.

The "Austrian" Terra preta and non-charcoal affected soil originates from the BOKU University Forest Rosalia, Burgenland. Part of the soil from the vicinity of the aged charcoal site will be mixed with a conventional biochar product from wood at a ratio similar to field applications. Two common herbicides used in forestry (i.e. Glyphosate, Hexazion) will be applied in three different concentrations (i.e. no herbicide (Ctrl), normal, and high dose) to determine (concentration) effects. Soil respiration measurements will be conducted in a closed chamber system with a connected IRGA (PP Systems); temperature and soil moisture conditions will be controlled and six replicates will be measured per treatment.

Keywords: biochar, forest, herbicide, respiration, soil

Bio-briquetting and char production in Nepal (Poster 3)

Shalabh POUDYAL[1]

[1] Kathmandu University School of Management (KUSOM), Kathmandu, Nepal, shalabh.ccg@gmail.com, +977 9841534693

Nepal relies heavily upon traditional fuel resources such as fuel wood, agro-residues and animal dung which meet over 87% of the energy demand. In spite of Nepal's huge potential of energy resources, its per capita energy consumption of 15 GJ is one of the lowest in the world. Biomass briquetting was introduced as a promising technology to displace the dependency on fuel wood use and meet energy demands by utilizing the vast resources of agro-forest residues to produce briquette fuels. Briquetting is a process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Briquette fuels are very versatile and come in many different forms like pure biomass briquettes, charcoal briquettes, Refused Derived Fuel (RDF) and shapes to suit the different requirements of domestic, commercial and industrial use.

Nepal is basically an agricultural country which has vast agro-residues which can be utilized for the production of briquettes. Assessment of some important cereal and cash crops show that Paddy is the largest source of agricultural residue at nearly 7.6 million MT per year followed by maize, millet, wheat and barley. Besides agro-residues, the country also has large forest resources which generate large amount of forest residues such as saw dust from the wood processing industries, leaves and invasive weeds which are fire hazardous and very problematic.

The herb processing plants which are abundant in Nepal also generate biomass residues. More than 95% of the weight after oil extraction of herbs and medicinal plants is biomass which can be used as a raw material for briquette. Yet another unutilized resource is the municipal solid waste where the combustible portion can be used to produce fuel briquette for the industry. As the raw material resources are distributed throughout the country, large scale briquetting industries using piston press or screw extruder technology can be set up in the Terai regions where the bulk of the residues exist. Small scale industries using the screw extruder and beehive briquettes/pellets will be suitable in the hill and mountain regions.

Altogether there are fifty five companies/cooperatives that produce briquette in Nepal. At the local level, it is manufactured in simple steps comprising initially of biomass identification, biomass collection, charring of biomass, grinding, mixing, moulding and finally drying. The briquettes so formed are used by villagers as a replacement for firewood during cooking process. The use of briquettes also reduce carbon emission substantially. Thereafter, they are sold to the urban residents who normally use it for heating purpose. The women earn up to $ 93.– per month by producing briquettes. One group (3-4 women) produces around 1.000 briquettes per day. Hence, efforts should be made to promote biomass briquettes as a reliable source and alternative source of energy in all sectors viz. domestic, commercial as well as industrial sectors and subsidy on fossil fuels should be diminished.

Keywords: Nepal, bio-briquette, biomass, fuel

Pyrolysis of Almond Shell: Product Yields and Chemical Activation of Chars (Poster 4)

Esin Apaydın VAROL[(1)], Başak Burcu UZUN[(1)], Ayse Eren PÜTÜN[(1)], Ersan PÜTÜN[(2)]

[(1)] Dept. of Chemical Engineering, Anadolu University, Eskisehir, Turkey

[(2)] Dept. of Materials Science and Engineering, Anadolu University, Eskisehir, Turkey

This study involves the pyrolysis of almond shell using a fixed–bed reactor operating under atmospheric pressure to investigate the influence of pyrolysis temperature on the product yields, and to investigate different chemical activating agents on the quality of solid product. Final temperature range of 400–700°C was carried out with the samples having an average particle size when the heating was 10°C/min. Final temperature of 500°C gave the highest bio-oil yield of ~22%. For the solid product the yield of 26% was attained at the same temperature. Elemental analysis was performed with the bio-oil and its calorific value was determined. 1H-NMR and FT-IR spectra of the bio-oil were taken to examine the chemical structure.

Chars obtained at the temperatures of 500°C and 600°C were impregnated with sulfuric acid and sodium hydroxide solutions and a second thermal treatment was applied at 500°C to obtain activated carbons. Activation conversions were achieved to be 89% for acid impregnation and to be 93.5% for base impregnation. All chars produced at different temperatures and activated carbons were characterized by proximate and ultimate analyses. FTIR spectra and SEM images were investigated to examine the changes on the surface properties. Surface areas of all solid products were determined by BET equation. In addition, for activated carbons, removal of phenol from aqueous solutions was investigated.

Analysis has shown that it is possible to obtain valuable liquid products similar to petroleum and activated carbons from the renewable source, almond shell.

Experiences with biochar in horticulture (Poster 5)

Roland KARIGER[1]

[1] Department of Crop Sciences, Division of Vegetables and Ornamentals, University of Natural Resources and Life Sciences, Vienna, Austria, roland.kariger@students.boku.ac.at, +43 699 12574624

Compared to agriculture in horticulture, the use of biochar in higher quantities, as a soil amendment could be economically feasible due to relatively small areas and intensive cultivation almost all over the year. In the experiment to find out how selected horticultural plant species react to biochar, 10 vol-% charcoal-biochar was mixed into a fresh substrate. In one variant the biochar was soaked in a liquid NPK-fertilizer for 24 hours to test the reaction of the plants to this treatment. The main idea was that a high percentage of biochar will significantly influence the properties of the substrate and could reduce the need for further application of fertilizers, reduce, irrigation and reduce bulk density, all compared to a substrate-only and a compost enriched variant. Our plant species, mimicking a possible horticultural crop rotation, reacted to the biochar quite differently. The outcomes have to be discussed and may lead to further research with an altered experimental setup.

Keywords: Biochar, horticulture, priming effect

Forest Biomass Potential in Thailand (Poster 6)

Roongreang POOLSIRI[1], Maliwan HARUTHAITHANASAN[2], Piteekorn SUPAWONG[3]

[1] Department of Silviculture, Faculty of Forestry, Kasetsart University, Bangkok,Thailand, fforrrp@ku.ac.th, +66 2 579 0171/109

[2] Kasetsart Agricultural and Agro-Industral Product Improvement Institution, Kasetsart University, Bangkok, Thailand, aapmwt@gmail.com, +66 2 942 86003/101

[3] Department of Silviculture, Faculty of Forestry, Kasetsart University, Bangkok,Thailand, fforpks@ku.ac.th, +66 2 579 0171/117

The natural forest in Thailand consists of evergreen and deciduous forests covering about 33.44% of the total area in 2008. This forest area continues to decrease because of pressures from wood demand and land utilization for cultivation especially in rural areas. However, tree harvesting from the natural forest was prohibited by a logging ban enacted in 1989. Following the ban, the Royal Forest Department (RFD) tried to promote forest plantations to provide wood to replace the resource formerly sourced from the natural forest. Thus, forest plantation is one of the methods to decrease deforestation. At present, there are many tree species both indigenous and exotic that have been planted on arable and degraded land, including teak, eucalypts, acacias, bamboos, etc. Nevertheless, exotic trees are more favored than indigenous trees because of their fast growth and high tolerance to severe environmental factors. Natural forest can produce biomass of about 80–300 t/ha while exotic tree species such as eucalypts, acacias and bamboos plantations can produce about 60–90, 35–40 and 30–50 t/ha biomass, respectively. However, tree improvement by either government organizations or private companies is still underway to develop good performance from hybrids of exotic tree species to increase the growth and biomass for future utilization.

Keywords: forest biomass, exotic tree species, forest plantation, Thailand

Forest waste biomass as a means of producing innovative charring retort for energy: some empirical evidences from Nepal (Poster 7)

Dharam UPRETY[1]

[1] Multi Stakeholder Forestry Programme (MSFP), Kathmandu, Nepal, d-uprety@msfp.org.np

Forest waste biomass in Nepal is defined as fuel wood, timber waste, invasive species, and other non-timber woody biomasses (e.g., small branches and twigs extracted during the regular pruning operations and woody understory biomass removed during regular cleaning operations) extracted from the forests. Regular silvicultural operations like harvesting, thinning, pruning, weeding and cleaning, carried out on regular basis by the forest users those who are practicing community forestry are the sources of forest biomass, and are main sources of producing improved charring retort. At present, those non-timber woody biomasses are utilized only to fulfill the subsistence need of poor people living nearby the forests. Besides, some of the CFUGs are involved in non-timber woody biomass-based carbonized fuel (bio-char/charcoal) production. Nepal imports 420.000 metric tons of coal annually and brick industries are said to be the largest consumers. A study shows that brick kilns in Kathmandu Valley alone require 68.5000 tons of coal annually. A brick kiln produces an average of 3 million bricks annually, which requires an average of 300 tons of coal. Even if only 50% substitution of coal with char is assumed in a brick kiln then 150 tons of charcoal will be required for a single brick kiln only. Forest waste biomass can be a substitution for this, if they can be used widely in making improved charring retort.

A study carried out in early 2013 in seven districts of Nepal in order to know the potentiality of forest waste biomass for ICR production revealed that 76% of community forests in Nawalparasi; 49% in Rupandehi; 22% in Kapilvastu; 34% in Parbat; 60% in Baglung; 88% in Myagdi; and 25% in Dang are potential for improved charring retort (ICR) establishment. The study further revealed that a total of 154.361,363 kgs of non-timber woody biomass is available for charcoal making and a total of 2.568 ICR with charcoal production potential of 39.290 tonnes/year can be feasible in seven study districts.

Key words: Charcol, forest waste, silviculture, community forests

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List of registered participants

Last name	First name	Affiliation	Country	Contact
ADEDOTUN	Michael	Federal Capital Territory Agricultural Development Program	Nigeria	agricproject2009@yahoo.com
BISTA	Reema	Austrian Academy of Sciences – ÖAW	Austria	welcome@atmacoaching.at
BRAUN	Karl	Consultant, Optimum Land Use Mix	United Kingdom	karlbraun@homtmail.com
BRUCKMAN	Viktor	Austrian Academy of Sciences – ÖAW	Austria	viktor.bruckman@oeaw.ac.at
CRISCUOLI	Irene	Fondazione Edmund Mach	Italy	irene.criscuoli@fmach.it
CROMBIE	Kyle	UK Biochar Research Centre	United Kingdom	k.crombie@ed.ac.uk
DARABANT	András	University of Natural Resources and Life Sciences – BOKU	Austria	darabant@gmail.com
Delpesh Clairget VAUDEVIRE	Lounda	ONG AJCd (statut consultatif spécialà l'Ecosoc)	Congo	ajcdrenove@yahoo.fr
DONG	Liu	University of Natural Resources and Life Sciences – BOKU	Austria	ld19871015@hotmail.com
DUNST	Gerald	Sonnenerde	Austria	g.dunst@sonnenerde.at
ENGLISH	Michael	Federal Research and Training Centre for Forests, Natural Hazards and Landscape – BFW	Austria	michael.englisch@bfw.gv.at
FAJTAK	Astrid	Univ. of Natural Resources and Life Sciences – BOKU	Austria	astrid.fajtak@students.boku.ac.at
FREUDENSCHUSS	Alexandra	Umeltbundesamt	Austria	alexandra.freudenschuss@umweltbundesamt.at
HARUTHAITHANASAN	Maliwan	Kasetsart University	Thailand	aapmwt@gmail.com
HOCHBICHLER	Eduard	University of Natural Resources and Life Sciences – BOKU	Austria	Eduard.hochbichler@boku.ac.at
HOOD-NOWOTNY	Rebecca	University of Vienna	Austria	Rebecca.Clare.Hood-Nowotny@univie.ac.at
KARER	Jasmin	Austrian Institute of Technology GmbH – AIT	Austria	jasmin.karer@gmx.at
KARIGER	Roland	University of Natural Resources and Life Sciences – BOKU	Austria	roland.kariger@students.boku.ac.at
KLOSS	Stefanie	University of Natural Resources and Life Sciences – BOKU	Austria	stefanie.kloss@boku.ac.at
KRAUS	Guenther	University of Natural Resources and Life Sciences – BOKU	Austria	guenther.kraus@boku.ac.at
KRAXNER	Florian	International Institute for Applied Systems Analysis – IIASA	Austria	kraxner@iiasa.ac.at
LEDUC	Sylvian	International Institute for Applied Life System Analysis – IIASA	Austria	leduc.sylvain@gmail.com
LIU	Lay	Pukyong National University	South Korea	j.jay.ryu@gmail.com

Last name	First name	Affiliation	Country	Contact
LUNAN	Anders	School of Economics and Business, Norwegian University of Life Sciences	Norway	anders.lunan@umb.no
POOLSIRI	Roongreang	Kasetsart University	Thailand	fforrrp@ku.ac.th
POUDYAL	Shalabh	Tribhuwan University	Nepal	shalabh.ccg@gmail.com
PROMMER	Judith	University of Vienna	Austria	judith.prommer@gmx.at
RONSSE	Frederik	Ghent University	Belgium	Frederik.Ronsse@ugent.be
Runejean Ridhy CRISTANAND	Biyoudi	AJCD	Congo	ajcdrenove@yahoo.fr
SCHNEIDER	Bernd Uwe	Helmholtz-Centre Potsdam – GFZ	Germany	schneider@gfz-potsdam.de
SELIM	Shady	Institute of Hydraulics and Rural Water Management	Austria	shady_selim@yahoo.com
SOJA	Gerhard	Austrian Institute of Technology GmbH – AIT	Austria	Gerhard.Soja@ait.ac.at
STEINER	Christoph	Engineering consultant	Austria	christoph.steiner@biochar.org
STOIBER	Helga	Environment Agency Austria – Umweltbundesamt	Austria	helga.stoiber@umweltbundesamt.at
TATZBER	Michael	Federal Research and Training Centre for Forests, Natural Hazards and Landscape – BFW	Austria	michael.tatzber@bfw.gv.at
UNGER	Matthew	Planet Earth Industries Inc.	Canada	matt@matthewunger.com
UPRETY	Dharam	Multi Stakeholder Forestry Programme	Nepal	dharam.uprety@gmail.com
UZUN	Başak Burcu	Anadolu University	Turkey	bbuzun@anadolu.edu.tr
VAROL	Esin Apaydın	Anadolu University	Turkey	eapaydin@anadolu.edu.tr
VESELINOVIC	Bojana	Austrian Academy of Sciences – ÖAW	Austria	bojana.veselinovic@boku.ac.at
WAWRA	Anna	Austrian Institute of Technology GmbH – AIT	Austria	anna.wawra@ait.ac.at
WINDSTEIG	Karin	Austrian Academy of Sciences – ÖAW	Austria	karin.windsteig@oeaw.ac.at
WOLFRUM	Gerda	International Union of Forest Research Organizations – IUFRO	Austria	wolfrum@iufro.org
WONDIE MULU	Menale	University of Natural Resources and Life Sciences – BOKU	Austria	menalewondie@yahoo.com
YAN	Shuai	University of Natural Resources and Life Sciences – BOKU	Austria	yanshuai111@gmail.com
ZEHETNER	Franz	University of Natural Resources and Life Sciences – BOKU	Austria	franz.zehetner@boku.ac.at