2nd FOREBIOM Workshop

Potentials of Biochar to Mitigate Climate Change

February 13th - 14th, 2014

Busan, South Korea

2nd FOREBIOM Workshop

Potentials of Biochar to Mitigate Climate Change

CONGRESS	: 2nd FOREBIOM WORKSHOP
THEME	: Potentials of Biochar to Mitigate Climate Change
DATE	: February 13th - 14th
VENUE	: Emerald Hall, Centum Hotel, Busan, Korea

ORGANIZING COMITEE : FOREBIOM partners

Dr. Viktor Bruckman, Austrian Academy of Sciences, Austria (principal coordinator)
Prof. Jay Liu, Pukyong National University, South Korea (Korean coordinator)
Prof. Basak Burcu Uzun, Anadolu University, Turkey (Turkish partner)
Prof. Esin Varol, Anadolu University, Turkey (Turkish partner)
DI Alexander Buck, International Union of Forest Research Organizations (Austrian Partner)

ADMINISTRATIVE SECRETARY : Petar Žuvela, M.Sc., Pukyong National University, South Korea

SPONSORS : Korean National Research Foundation, Brain Busan 21

WELCOME ADDRESS

Distinguished colleagues and dear friends!

On the behalf of the FOREBIOM project consortium, it is my immense pleasure and honour to welcome You to the 2nd FOREBIOM Biochar Workshop "Potentials of biochar to mitigate climate change" in Busan, South Korea. The workshop aims to provide a holistic view of current expertise in biochar production, from biomass availability to pyrolysis combined with energetic utilization of byproducts 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 alternatively used, in order 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 two sessions: “General” and “Sustainable Forest Resources”. On day two, respective speakers from a variety of countries will have presentations in two more sessions: “Thermochemical Conversion of Biomass to Energy and Other Products” and “Applications of Biochar”. The conference venue is located in the city of Busan, Republic of Korea’s main port, 5th busiest in the World, in Centum Hotel, nearby Shinsegae Department Store, the World’s Largest Department Store (Guiness World Record Holder), and Korea’s largest beach, the beautiful Haeundae beach.

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 Busan !

Professor Jay Liu, PhD

Korean FOREBIOM Coordinator

USEFUL INFORMATION

ORGANIZING COMMITTEE

Dr. Viktor Bruckman, Austrian Academy of Sciences

Prof. Jay Liu, Pukyong National University, South Korea

Prof. Basak Burcu Uzun, Anadolu University, Turkey

Prof. Esin Varol, Anadolu University, Turkey

DI Alexander Buck, International Union of Forest Research Organizations

ADMINISTRATIVE SECRETARY

Petar Žuvela, M.Sc., Pukyong National University, South Korea

EVENTS

CONFERENCE BANQUET (19:00 PM, 13TH FEBRUARY, 2014)

Final Workshop Information – emailed on February 07th, 2014 to all registered participants

Distinguished participants of the 2nd FOREBIOM workshop on Biochar potentials to mitigate climate change,

Only six days later, we shall meet in Busan, for another exciting, interdisciplinary Workshop with a number of interesting contributions. As you may see from the final programme (Page 5), we have a very busy and packed schedule and a range of topics to cover. With that in mind, 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

In order to avoid any delays with the schedule, we kindly ask all participants to register well in advance as we start 14:10 sharp. Accordingly, the desk for registration will open at 13:00. You shall receive a conference kit at the point of registration, which will contain your name badge, the proceedings book, a notepad and a pen, a city map of Busan and some touristic information. Furthermore, speakers are asked not to exceed their presentation time of 30 minutes. However, in practice, speaking time should be no longer than 26 minutes, to allow short comprehension questions. A discussion for more in-depth questions is scheduled within the closing remarks after each session block.

Speaker laptop and PowerPoint file handling

The speaker laptop is equipped with recent versions of PowerPoint, as well as Adobe PDF Reader. You will be provided with a laser-pointer and remote control for your presentations. We kindly ask you to submit your presentation in advance or, in case of late submission, please bring it on an USB flash drive. However, please note that there are sometimes incompatibilities with USBE flash drives, 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.

Wireless Internet

The venue, Centum Hotel is equipped with high-speed free Wireless internet which will be available during the whole Workshop duration.

Current Weather in Busan

The current weather in Busan is highly unusual for the end of winter, and temperatures range from 4 to 14 degrees Celsius. Quite a mild winter, even for a seaside area. With that in mind, please be prepared for a mild, however, unpredictable weather. Today the rain surprised everyone. However, the weather should clear up until the conference.

On behalf of the organizing committee, as well as all FOREBIOM partners, I would like to wish you safe journey to Busan and looking forward to welcome you on Thursday afternoon for the 2nd FOREBIOM Workshop.

With kind regards,

Professor Jay Liu, PhD

Korean FOREBIOM Coordinator

OVERVIEW

2nd FOREBIOM Workshop brings together researchers and practitioners to discuss recent developments in the forest biomass production and its use for energy and other products. Both theory and applications will be covered on topics such as:

1. **Sustainable biomass production**
2. **Sustainable energy production from biomass**
3. **Thermochemical conversion of biomass to energy and other products**
4. **Use of biochar (including soil applications)**

INVITED SPEAKERS

- **Professor Joon Weon Choi** (Seoul National University, Korea)
- **Mag. a. Jasmin Karer** (Austrian Institute of Technology, Austria)
- **Professor Joo-Sik Kim** (University of Seoul, Korea)
- **Dr. Koichiro Koike** (Shimane University, Japan)
- **Professor Nikhom Laemsak** (Kasetsart University, Thailand)
- **Tang Kok Mun** (Malaysian Biomass Industry Confederation, Malaysia)
- **Professor Jun-Hyung Ryu** (Dongguk University, Korea)
- **Professor Byung-Ho Song** (Kunsan National University, Korea)
- **Professor Akira Shibata** (Ritsumeikan University, Japan)
- **Professor Thavivongse Sriburi** (Chulalongkorn University, Thailand)
- **Dr. Dong Jin Suh** (Korea Institute of Science and Technology, Korea)
- **Professor Seung Han Woo** (Hanbat National University, Korea)

PROGRAM

DETAILED PROGRAM

DAY ONE (FEBRUARY 13TH)

TIME	TITLE AND SPEAKER
13:00~14:00	REGISTRATION
14:00~14:10	OPENING REMARKS
SESSION 1 GENERAL (CHAIR: DR. JAY LIU, KOREA)	
14:10~14:40	**VIKTOR BRUCKMAN**: "The FOREBIOM Project - aiming at negative carbon emissions"
14:40~15:10	**AKIRA SHIBATA**: "Cooling the Earth from the dinner table: COOL VEGE™ and the Carbon Minus Project in Japan"
15:10~15:40	**DONG JIN SUH**: "Pyrolysis of woody and algal biomass into liquid fuels"
15:40~16:00	COFFEE BREAK
SESSION 2 SUSTAINABLE FOREST RESOURCES (CHAIR: DR. VIKTOR BRUCKMAN, AUSTRIAN ACADEMY OF SCIENCES, AUSTRIA)	
16:00~16:30	**TANG KOK MUN**: "Towards Environmental and Economic Sustainability in Malaysia via Biomass Industry"
16:30~17:00	**NIKHOM LAEMSAK**: "Carbon is sequestered while employing biomass as feedstock for energetic utilization"
17:00~17:30	**KOICHIRO KOIKE**: "Renewable Energy Source-Heat/Cool (RES-H/C) from peasant forestry in Northern and Northeastern Thailand"
17:30~18:00	**JUN-HYUNG RYU**: "A Preliminary Study on Sea-based Biofuel Supply Chain Management: Korean case"
18:00~18:20	CLOSING REMARK
19:00~21:00	DINNER

PROGRAM

DETAILED PROGRAM

DAY TWO (FEBRUARY 14TH)

TIME	TITLE AND SPEAKER
8:30~09:00	LATE REGISTRATION
SESSION 3 THERMOCHEMICAL CONVERSION OF BIOMASS TO ENERGY AND OTHER PRODUCTS (CHAIR: PROF. BAŞAK BURCU UZUN, TURKEY)	
09:00~09:30	**JOON WEON CHOI**: “Features of the fast pyrolysis of lignocellulosic biomass and evaluation of biooil upgrading process with noble metal catalysts”
09:30~10:00	**JOO-SIK KIM**: “Production of furfural from corn residue through catalytic fast pyrolysis using $ZnCl_2$ in a fluidized bed reactor”
10:00~10:30	**BYUNG-HO SONG**: “The product yield of pyrolysis of Biomass and a kinetic study of gasification of biomass char”
10:30~10:50	COFFEE BREAK
SESSION 4 APPLICATIONS OF BIOCHAR (CHAIR: PROF. ESIN VAROL, TURKEY)	
10:50~11:20	**SEUNG HAN WOO**: “Application of biochar produced from wood and seaweed for the removal of dye in wastewater”
11:20~11:50	**THAVIVONGSE SRIBURI**: “Biochar production for white radish cultivation for higher productivity and CO2 capture”
11:50~12:20	**JASMIN KARER**: “Effects of biochar on immobilisation of heavy metals in historically contaminated soils”
12:20~12:30	CLOSING REMARK
12:30~13:30	LUNCH

VENUE

CENTUM HOTEL (HTTP://ECENTUMHOTEL.COM/)

1505, WOO2-DONG, HAEUNDAE-GU, BUSAN, KOREA 612-202

ACCOMMODATION

CENTUM HOTEL (HTTP://ECENTUMHOTEL.COM/)

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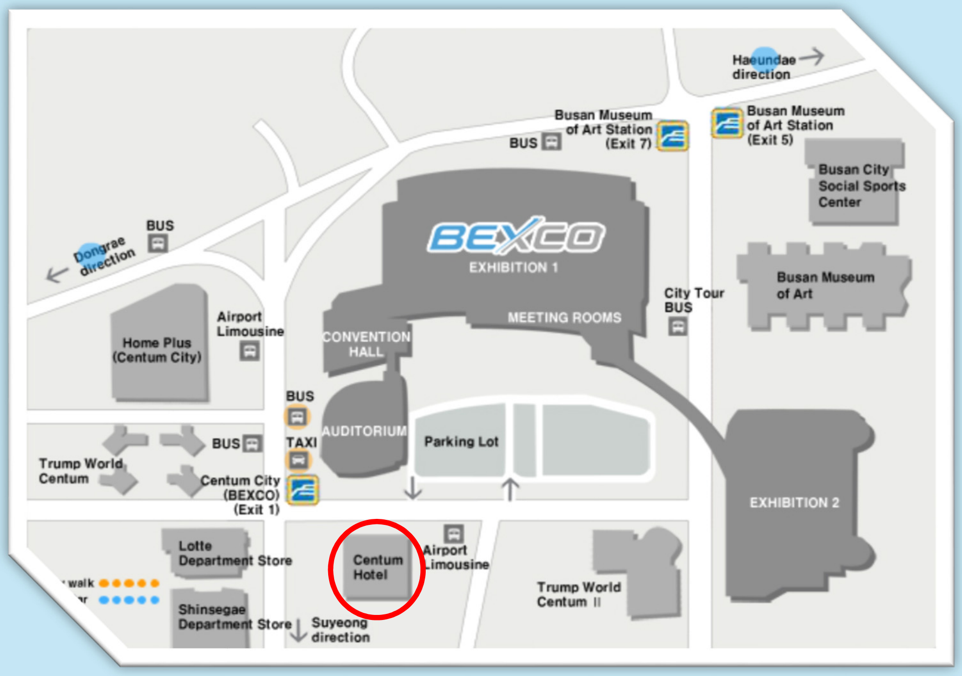

DIRECTIONS TO CENTUM HOTEL

Directions to the Venue may be found at the following ADDRESS:

HTTPS://ECENTUMHOTEL.COM/ENGLISH/01_ABOUT/ABOUT03.HTML?MENU=3

EVENTS

CONFERENCE BANQUET (19:00 PM, 13TH FEBRUARY, 2014)

SESSION 1

GENERAL

The FOREBIOM Project - aiming at negative carbon emissions

Viktor J. Bruckman[(1)]

(1) Commission for Interdisciplinary Ecological Studies, Austrian Academy of Sciences, Vienna, Austria, viktor.bruckman@oeaw.ac.at, +43-1-51581-3200

FOREBIOM is the acronym for a holistic scientific project aiming at international cooperation in the field of Green Technology. The project consortium consisting of partners from Austria, South Korea and Turkey proposes an approach where carbon is sequestered while utilizing biomass as feedstock for energetic utilization and thus, a negative carbon balance may be achieved. The holistic systems approach ensures detailed considerations on potentials and sustainability of individual steps during biomass production and utilization. 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 three-step cascade approach to jointly study the potential 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, 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.

So far, the project consortium has successfully organized two workshops and a joint field trip. Experimental plots were set up in Northern Austria to test the effects of biochar amendment in managed Picea abies dominated woodlands. The biochar used (derived from the so called pyreg-process) and the associated feedstock material (Picea abies woodchips) were characterized according to international standards.

The lecture will introduce the project aims and milestones as well as past activities. In addition, preliminary results from the experimental plot field-scale experiments and main conclusions from the first FOREBIOM Workshop in Vienna will be presented and discussed.

Keywords: FOREBIOM, biochar, carbon sequestration, mitigation, biomass, soil.

Cooling the Earth from the dinner table: COOL VEGE™ and the Carbon Minus Project in Japan

Akira Shibata [1]

(1) Japan Biochar Association/Ritsumeikan University Regional Information Center, Kyoto, Japan, ashibata@fc-ritsumei.ac.jp, +81-75-465-8224

Now In rural Japan, various problems such as depopulation due to downturned industries, the decline of agricultural viability and the associated devastation of rural environments, exist. It has been quite a while since people started arguing for development of such areas.

While it is anticipated that businesses and companies will face restrictions on greenhouse gas emissions within several years in urban areas as a climate change mitigation measure, there are in fact only a few specific and effective methods for greenhouse gas reduction. In addition, although general consumers (citizens) may be highly conscious of the necessity of cooperation regarding environmental problems, they do not have many avenues via which to take action.

Before biochar can contribute fully to carbon sequestration efforts in Japan (and elsewhere), it must first help to solve the puzzle of rural socio-economic and agricultural decline that diminishes farmer livelihoods and devalues forest resources—a similar challenge exists in many countries that are experiencing the loss of family farms and rural livelihoods.

CO2 reduction through biochar use as significant climate change mitigation can only be accomplished if it is part of a sustainable, regional, socio-economic, and multi-stakeholder system with holistic aspect. These systems must necessarily form a bridge between resource-rich rural areas and urban actors such as consumers and companies.

Accordingly, we would like to suggest an outline and identify the issues associated with a general social scheme of sequestering carbon through biochar CCS on agricultural lands in farming villages for agricultural revival and other regional development. More specifically, the biochar CCS should be carried out for agricultural lands to generate carbon credits, and simultaneously a regional brand should be established for agricultural products from the agricultural lands.

Carbon Minus Projects are multi-stakeholder schemes that seek sustainable rural development through biochar carbon capture & storage in agricultural lands. In this presentation, the Carbon Minus Project scheme is explained with special emphasis on the eco-branding campaign “COOL VEGE™“ which means “vegetables that cool the earth” to increase their commercial value and sales appeal to consumers as “Environment conscious agricultural brand”. This is a new concept as “Environmental Friendly”, because normal consumer understands concepts of “safety” and “taste good” only.

As a result, the system will promote the purchase of carbon credits and Company Social Responsibility by businesses and companies in urban areas and other entities, as well as the sales of regional brand agricultural products with high additional value to regional and urban consumers.

We can consider this fund reflux method from urban to rural areas by greenhouse gas reduction by utilizing biochar as an effective measure in creating a sustainable low carbon society where urban and rural areas can coexist.

The final goal of the Carbon Minus Project is “Sustainable rural landscape”. As its essential factor, “Sustainable rural management system” such as monetary influx to rural area from urban area is needed.

Keywords: biochar, Cool Vege, CCS, Carbon Minus,

Pyrolysis of woody and algal biomass into liquid fuels

Dong Jin Suh[1]

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Biomass is recognized as a renewable energy source due to the depletion of fossil fuel reserves. Direct combustion is the most convenient way to generate heat and power but cannot produce liquid fuels with high market value and a versatility of uses. Pyrolysis is a relatively simple, inexpensive, and robust thermochemical technology for transforming biomass into liquid biofuels. Pyrolysis is a thermal degradation of organic materials into liquid, solid, and gaseous products at high temperatures in the absence of oxygen. The liquid product known as bio-oil can be upgraded to a high quality product for transportation fuels and chemicals. The yields and properties of the liquid product are very dependent on the feedstock, the reactor type and the operating conditions. This presentation will provide an overview of the pyrolysis technologies and issues, and discuss some examples of typical results for wood and algae pyrolysis and bio-oil catalytic upgrading obtained in my laboratory.

Keywords: Pyrolysis, Catalytic upgrading, Bio-Oil, Bio-Char.

SESSION 2

SUSTAINABLE FOREST RESOURCES

Towards Environmental and Economic Sustainability in Malaysia via Biomass Industry

Tang Kok Mun [1]

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The sustainable development agenda has always been one of the key macro targets in Malaysia that covers three aspects of development i.e. social, economy and the environment. Being located in the tropical zone with high soil fertility, Malaysia is fortunate to be endowed with high growth rate of biomass and vegetation coverage. The commercial agricultural sector, which contributes 7.3% to the nation's economy generates large amount of biomass, that just two decades ago was considered a waste but now increasingly valued as a resource for economic exploitation.

The amount of biomass generated annually in Malaysia totals to about 96 million wet tonnes. The types of biomass available include palm-based biomass (empty fruit bunches, kernel shell, mesocarp fibers and liquid effluent), rice-based biomass (rice husk and straw), forestry waste (saw dust, timber offcuts), rubber wood, municipal solid waste as well as sewage waste.

Malaysia is moving towards achieving higher level of economic and environmental sustainability via the utilization of the biomass resources in areas such as bio-energy generation, production of compost and biofertilisers, manufacturing of eco-products and even the production of bio-based fuels and chemicals. Both large corporations as well as the small and medium enterprises (SMEs) are actively participating, investing and innovating in this new area of economy.

This presentation will cover the current situation in Malaysia in terms of biomass generation, availability and utilization of this resource towards the sustainable consumption and production (SCP) agenda. This will include the challenges and limitations faced by the industry as well as policies, strategies and actions of the Malaysian government to drive the biomass industry forward. The potential of the biomass resources for the biochar production in the context of Malaysia will also be explored.

Malaysia's total carbon emission is relatively high at about 123,000 ktCO2e, numbering 30th in global ranking. In terms of per capita emissions, Malaysia stood at 10.8 ton CO2e/capita while its carbon intensity emission was at 0.58 CO2e/GDP. Therefore, there is the urgent need to decouple Malaysia's economic growth from her dependency on unsustainable resource. Larger scale of biomass utilization has the potential to shift Malaysia towards S sustainable development pathway as well as enhancing the country's role and contribution to the global climate change agenda.

Keywords: biomass industry, sustainable production, biochar

Carbon is sequestered while employing biomass as feedstock for energetic utilization

Nikhom Laemsak[(1)], Maliwan Tanasombat[(2)]

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The ACMECS is a cooperation framework among Cambodia, Laos, Myanmar, Thailand, and Vietnam to utilize member countries diverse strengths and promote balanced development in the sub region. The most well-known of ACMECS is a high potential in renewable natural resources. Biomass resources such as wood and agriculture residues are abundant also in the ACMECS and have strong potential as fuels for green power generation. The amount of residues produced from bagasse, rice hulls, palm oil waste and wood waste in this subregion is about 110 million tons. Of this total, bagasse accounted for 22%, palm oil waste 17 %, rice hulls 43 % and wood waste 18 %.

ACNECS capacity of renewable energy for electricity generation, both captive and on grid was more than 50,000 MW. Besides the existing biomass, ACMECS has potential for energy plantation, especially in Myanmar, Laos and Cambodia which available land to produce biomass is still abundance.

The way ahead is for the ACMECS bioenergy network and their government to mobilize the market forces by setting up policies, regulatory, framework, and appropriate incentives to address the above mentioned challenges. Thailand can be a recent example of a government facing the challenge.

Keywords: ACMECS , Biomass , Energetic utilization

Renewable Energy Source-Heat/Cool (RES-H/C) from peasant forestry in Northern and Northeastern Thailand

Koichiro Koike[1]

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In order to attain sustainable development, we have to find efficient and safe way to utilize natural resources, such as secondary deciduous forest. We are estimating biomass supply potential, viable market, and also suitable technology for efficient utilization.

In northern and north eastern Thai, huge amount of steep terrain had been converted to Maze field. People shifting from Lao have not enough knowledge to use these forest. In steep terrain substantial area are burnt and now covered with pesticide intensive crops. Peasant are growing maze with serious erosion. But areas apart from road network or villages, there are still substantial secondary forest. These forested area will be conserved and create income by wood fuel production from coppice regenerated forest

In tourism sector, high end hotels purchase vegetables grown with cooling facility and cold transportation chain, as the Royal project in Northern Thailand.

The workshop on RES-H/C in rural area at Khon Kaen University, farmers admitted the presence of “cool” demand in rural region.

Additionally in Thai, tourism sectors consume so much energy for hot water supply and space cooling. Also cities like Chiang Mai and Khon Kaen, large shopping complexes and public facilities now introduce electricity intensive cooling equipment.

On the demand side, to meet these heat/cool demand, northern and north eastern mountain region has rich potential for renewable energy supply.

For collection of biomass, existing tractors are available. End use of energy, proven, small scale combustion technology and adsorption/absorption chiller technologies has been investigated.

Keywords: biomass, renewable energy, rural income

A Preliminary Study on Sea-based Biofuel Supply Chain Management: Korean case

Jun-Hyung Ryu(1)

(1) Department of Nuclear & Energy Systems Engineering, Dongguk University, Gyeongju Campus, Republic of Korea, 780-714, jhryu@dongguk.ac.kr

Interest on renewable energy sources are widely witnessed and the importance of replacing environmentally damaging fossil fuels are globally highlighted. Because other renewable sources such as wind, solar energies are mainly electricity oriented, biofuels is particularly promising as a transportation fuel. Biofuels such as bioethanol or biodiesel is also attractive because their transition cost from oil based infrastructure is assumed to be relatively not that much high in comparison to the entire changeover of other renewables. However it should be acknowledged that the current level of the existing infrastructure in terms of public availability and low cost affordability is the result of significant time and investment. The replacement does will require quite a large investment as well. Therefore we should be concerned with minimizing the investment and reducing the time in order to delay the global environmental disaster. For this purpose, there are many issues remaining unsolved and how to construct competitive biofuel supply chains is one of them.

Numerous governments, institutions, research laboratories have been actively involved in developing cutting edge technologies for improving the efficiencies of biofuel production. Once they are technologically matured and commercially scaled up, they should be implemented in various areas for public usage. Such introduction of biofuels in practice is another challenging task against already commercially matured competitors in the face of its advantage of reducing greenhouse gas emission. Separately pursued commercial technologies should be coordinated with the universal objective of reducing the overall costs. Therefore the coordination in the most effective and cost competitive way is a new important technology that binding the entire facilities besides developing specific biofuel technologies for establishing the foundation for biofuel infrastructure. In the literature, researchers addresses this in terms of supply chain management (SCM).

Some works have been carried out in the literature but they are mainly investigating the land based crops. For the small countries like South Korea, there should be different approaches from the existing land based energy supply chain studies or relevant biomass supply chain materials. In this presentation, the focus is more given to how to construct sea based biofuel supply chains and their supply chain management issues. Desirable research directions are also discussed.

Keywords: biofuel supply chain, biomass feedstock, supply chain management, biofuel infrastructure

SESSION 3

THERMOCHEMICAL CONVERSION OF BIOMASS TO ENERGY AND OTHER PRODUCTS

Features of the fast pyrolysis of lignocellulosic biomass and evaluation of biooil upgrading process with noble metal catalysts

Joon Weon Choi[(1)], Hyewon Hwang[(1)], Shinyoung Oh[(1)]

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Fast pyrolysis of yellow poplar wood was performed under different temperature ranges and residence times in a fluidized bed reactor to maximize the yield of biooil.Pyrolysis temperature ranged from 400ºC to 550ºC, and the residence time of pyrolysis products was controlled between 1.2 and 7.7 seconds by inert nitrogen gas flow. The distribution of thermal degradation products (biooil, biochar, and gas) was heavily influenced by pyrolysis temperature, as well as residence time. The highest yield of biooil was approximately 68.5 wt% (wet basis), with pyrolysis conditions of 500ºC and 1.9s of residence time. Water content of the biooils produced at different temperatures was 25 wt% - 30 wt%, and their higher heating values were estimated to be between 15 MJ/kg and 17 MJ/kg.

Fast pyrolysis of yellow poplar wood under various potassium concentrations and temperatures were performed to investigate catalytic effects of potassium and its behavior during pyrolysis. TGA revealed that overall decomposition temperature of biomass increased due to potassium. Properties and chemical compounds of bio-oil as well as char formation were also largely influenced. Water content and small molecules in bio-oil increased due to dehydration, demethoxylation and secondary reactions promoted by potassium. Aromatic hydrocarbons were identified from non-condensed pyrolytic compounds trapped in acetone. Most of inorganic metals remained in bio-char and their release behavior during pyrolysis depended on temperature.

The biooil was subjected to hydrodeoxygenation (HDO) for the purpose of reducing water content as well as increasing heating value. HDO was performed in an autoclave reactor at three different reaction factors: temperature (250-370°C), reaction time (40-120 min), and Pd/C catalyst loading (0-6 wt.%) under hydrogen atmosphere. After completion of HDO, gas, char, and two immiscible liquid products (light oil and heavy oil) were obtained. Liquid products were less acidic and contained less water than crude bio-oil.

Water content of heavy oil were ranged between 0.4 wt.% and 1.9 wt.%. Heating values of heavy oil were estimated between 28.7-37.4 MJ/kg, which was about twice higher than that of crude bio-oil. Elemental analysis revealed that heavy oil had a lower O/C ratio (0.17-0.36) than crude bio-oil (0.71). H/C ratio of heavy oil decreased from 1.50 to 1.32 with an increase of temperature from 250°C to 350°C, respectively.

Keywords: fast pyrolysis, biooil, water content, heating value, potassium, hydrodeoxygenation, heavy oil

Production of furfural from corn residue through catalytic fast pyrolysis using $ZnCl_2$ in a fluidized bed reactor

Joo-Sik Kim[1], Seung-Jin Oh[1]

(1) Department of Energy and Environmental System Engineering, Univ. of Seoul, 90 Jeonnong-Dong, Dongdaemun-Gu, Seoul 130-743, Republic of Korea, +822-2210-5621, joosik@uos.ac.kr

Furfural is an important renewable, non-petroleum based, chemical feedstock. It is used as a solvent in petrochemical refining and can be used for the production of lubricants. It, as well as its derivative furfuryl alcohol, can be used together with phenol, acetone, or urea to make solid resins.

It is generally produced by acid hydrolysis of the pentosan contained in biomass, especially corn residue and sugercane bagasse, which is accompanied by acidic waste stream production and high energy consumption.

In this work, corn residue was pyrolyzed with $ZnCl_2$ in a pyrolysis plant equipped with a fluidized bed reactor to produce furfural. The effects of reaction conditions, the washing with water, and the $ZnCl_2$ content on the yield of furfural were investigated. The pyrolysis was performed within the temperature range between 310-430 °C, and the bio-oil yield were 30-60 wt% of the product. Washing with water gave rise to the increase in bio-oil and furfural yield. A higher $ZnCl_2$ content favoured the formation of furfural. The furfural yield increased up to 11.5 wt%. A high selectivity for furfural in bio-oil would make the pyrolysis of corncob with $ZnCl_2$ very economically attractive.

Keywords: Fast pyrolysis; Furfural; Catalyst; Fluidized bed; Corn residue

The product yield of pyrolysis of biomass and a kinetic study of gasification of biomass char

Byungho Song[1]

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A prediction of product yields from pyrolysis of solid fuel is quite important for a simulation and design of biomass conversion processes as biomass contains much volatile components. The change of gas, liquid, and char yields with variation of temperature have been predicted through several empirical or semi-empirical relationships from the literature. Also, each gas component have also been quantitatively evaluated by selected relationships. The biomass char can be converted to syngas by gasification for chemical synthesis and power generation. Woodchip, sawdust and lignite were gasified with steam in a thermobalance reactor in order to evaluate their kinetic rate information. The effects of gasification temperature (600?900?) and partial pressure of steam (20?90kPa) on the gasification rate were investigated. The modified volumetric reaction model was used to evaluate kinetic parameters in this study. The observed activation energy of biomass, sawdust and lignite gasification reactions were found to be in reasonable range and their rank was found to be sawdust > woodchip > lignite. The expression of apparent reaction rates for steam gasification of the three solids was proposed to provide basic information on the design of coal gasification processes.

Keywords: Biomass, woodchip, sawdust, pyrolysis yield, gasification kinetics

SESSION 4

APPLICATIONS OF BIOCHAR

Application of biochar produced from wood and seaweed for the removal of dye in wastewater

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Biochar is being considered as a potentially significant means of storing carbon to mitigate greenhouse gases as well as a soil additive increasing crop yields. In this study, biochars produced from wood and seaweed were applied for the removal of dye in wastewater to examine the feasibility of biochar as an adsorbent. The biochars were produced with four different raw materials: oak, bamboo, kelp, and green laver by slow pyrolysis. The different conditions such as final temperature, holding time, and rising temperature were adopted to produce the biochars. The biochars were characterized with CHONS elemental analyzer and scanning electron microscope. The chemical components of bio-gas and bio-oil produced during pyrolysis were analyzed with GC-MS. The carbon contents were low in seaweed biochars compared to woody biochars due to the higher amount of ashes in seaweed biochars. The biochars were applied for the removal of methylene blue as a cationic dye and congo red as an anionic dye. The kelp biochar showed more effective adsorption capacity on both dyes compared to woody biochars.

Keywords: adsorption, biochar, congo red, methylene blue, pyrolysis

Biochar production for white radish cultivation for higher productivity and CO2 capture

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Food production processes contribute significant emissions of greenhouse gases to the atmosphere. The use of biochar from crop residues has been advocated as a means of increasing crop yield and at the same time reducing net CO2 emissions by long-term sequestration of carbon in the soil. Soil incorporation of biochar produced from crop wastes is one of several climate change mitigation measures under study at Padeng Biochar Research Center (PdBRC), Petchaburi Province, Thailand. The PdBRC has developed an inexpensive biochar retort that agriculturists can build themselves from locally available materials, enabling them to produce high quality biochar via slow pyrolysis, following guidelines issued by the Food and Agriculture Organization (FAO), and in so doing contribute to reduction of GHG emissions.

This study investigates the use of biochar as a soil additive in white radish (Raphanus sativus var. longipinnatus) cultivation, and examines its effect on production and net CO2 emissions. Field experiments were conducted over 2 growing seasons (dry and wet), with five treatments (untreated soil only, untreated soil+organic fertilizer, and 3 sets of untreated soil+organic fertilizer+biochar).

Six types of biochar feedstock were tested, including corn cobs and 5 types of locally available wood. The controlled temperature in the retort was set in the range of 500-600oC. The biochar produced was analyzed for C-H-N content, calorific value, surface and interface structure and water holding capacity.

Preliminary results show differences in the suitability of the biochars tested, with Samanea saman and Leucaena leucocephala offering optimal combination of matrix surface area and water-holding capacity. Such materials are likely to be suitable for use in soil amendment, especially when combined with organic fertilizers.

The findings of this study confirmed our hypothesis that high quality biochar can boost yield and contribute to climate change mitigation through carbon sequestration in the soil. In soil amended with 13 % of biochar the length, diameter, weight and dry weight of the harvested radish were, respectively, 37.85%, 11.58%, 134.38% and 55.39% greater than in control plots. CO2 capture also was 40.68 % higher than in untreated soil. This provides new evidence to support the hypothesis that untreated soil incorporation of farm-produced biochar can contribute to mitigation of GHG emissions from agricultural activities, while boosting productivity.

Keywords: Biochar, white radish, climate change, mitigation, carbon capture, Thailand

Effects of biochar on immobilisation of heavy metals in historically contaminated soils

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The industrial development in the region around Arnoldstein in Carinthia, Austria, dates back to the 15th century. For centuries lead and zinc ores were processed – with impacts on the surrounding soil, being polluted with heavy metals such as Cd, Pb and Zn. Up to now, the concentrations of NH4NO3-extractable heavy metals are far above the trigger values for soils (derived for feed quality according Prüeß, 1994). Cu and Ni concentrations are low and do not contribute to the heavy metal contamination of the soils. The aim of our study was to investigate the effects of various biochar mixtures on immobilisation of heavy metals in this contaminated soil. If biochar successfully immobilises heavy metals, quality of biomass production could be improved. We conducted a pot experiment with ryegrass (Lolium multiflorum) consisting of three different biochar (BC) treatments mixed with compost, a gravel sludge combined with siderite bearing material as well as a lime treatment and an untreated control (n=5). In the analysed treatments, lime significantly lowered the NH4NO3-extractable heavy metal concentrations in the soil compared to the control, except for Cu.

Similarly, throughout the study, a combination of gravel sludge and siderite bearing material led to an immobilisation of the heavy metals in the soil. On the contrary, the Miscanthus biochar mixed with compost had no effect on the immobilisation; however, Cu concentration was significantly lower than in all other treatments.

The immobilisation of the heavy metals in the soil was generally not reflected in the plants (Lolium multiflorum), except for Zn, showing a significant decrease after lime, poplar BC and gravel sludge with siderite bearing material. However, Zn as well as Cd and Pb remained above the phytotoxicity level of 200 mg kg-1; lime treatment reduced the Zn concentration in Lolium multiflorum to 513 mg kg-1, gravel sludge to 531 mg kg-1 and poplar BC to 560 mg kg-1 while in the control plot 713 mg kg-1 Zn were measured. While decreased heavy metal concentrations in the plants were recorded after liming (Cu and Zn) and poplar BC treatment (Cd, Ni, Zn), Cd and Pb reacted differently after the lime treatment; the increased pH (between 6 and 7) caused higher concentrations of these heavy metals possibly because soluble metal-organic complexes were formed in this pH range.

Overall, the different biochar mixtures showed positive effects on heavy metal immobilisation in the studied soil. While these effects were not all directly reflected in the plant, there was a general qualitative improvement of biomass (except for Pb and Cu).

Keywords: Soil amendment, soil pollutants, Cd, Pb, Zn, Cu, Ni

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