Biochar; Our Previous Research Outputs

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Abstract

We have been carrying out many kinds of research on bio-char for about 10 years.

At first, we studied biomass pyrolysis technologies and their use. We found that chars from sewage and cattle manure contain phosphorous and potassium respectively as citric type which are easily absorbed by crop. And it is possible to reduce the application amount of chemical fertilizer. Simultaneously, a pilot-scale pyrolysis instrument was made which facilitates activation, temperature control and singas recycling. It attributes lower maintenance cost and environmental friendly. High absorbent function-char from sewage sludge was manufactured. It has an excellent absorption function of any types of gas. And it was clarified that biochar from sewage sludge with activation can absorb more amount of odor gas from composting. In addition, some kinds of analysis with LCA were carried out.

Secondary, we proceeded to an executive scale and to material circulation research with pyrolysis at Miyak-island, Okinawa, Japan. We found that application of biochar from bagasse enables 1) to increase sugarcane production and 2) to reduce nitrate nitrogen concentration which is a dominant ground water contamination cause. In addition, we tried to make an optimal biomass refinery systems at the island including pyrolysis. Optimal allocation of the biomass and plant operation conditioned were studied with LCA (Life Cycle Assessment).

Thirdly, there is an ongoing research project with pyrolysis at the same island. We hope to make an farmland application manual of the converted biomass such as biochar, etc.
These kinds of research can be applicable to other materials and sites, hopefully.

Keywords; Pyrolysis, Carbon, Land application, Sustainable agriculture

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Biochar
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We have carried out considerable research on bio-char (charcoal from biomass) for the last decade as highlighted below. This research was principally funded by the Ministry of Agricultural, Forestry and Fisheries (MAFF), Japan mainly as the “Eco-system Research Project (2000-2002)”, and “Agricultural, Forestry and Fisheries Bio-Recycle Research Project (2003-2007)”.

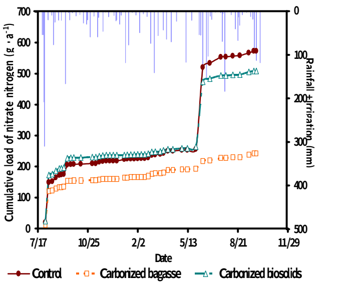
Bio-char Use

We have investigated the farmland application of bio-char from sewage sludge, bagasse (sugarcane squeezed residue), cattle waste and rice husk. The characteristics of bio-char include 1) lightweight, 2) black-color, 3) porous, 4) high EC (electric conductivities), etc. However, these characteristics differ depending on the source of materials and pyrolytic conditions such as temperature (Shinogi, et.al., 2003). Farmland application of bio-char enables improvement of soil physical and engineering properties such as water holding capacity, hydraulic conductivity, hardness and density. Finally, bio-char improves the physical conditions around the crop-root zone and enhances crop production (Shinogi, et.al., 2003). For example, 5% charcoal application per weight doubles the hydraulic conductivity of loamy soil. This effect is dependent on soil type and can last at least several years.

And bio-char from sludge such as sewage and cattle waste contain phosphorous (P) and potassium (K) with citric type that are essential nutrients for crops. Therefore, bio-char from sludge can replace chemical fertilizer. However, nitrogen in bio-char a major nutrient for crops is not easy to be used by crops (Table1, Chen .Y. et. al, (2007)).

Table1 The comparison in sugarcane growth in each experiment

Plot	Stalk length (cm)	Stalk diameter (cm)	Stalk weight (g)	Brix	Stalk crop (kg・a^{-1})	Sugar beet produced (kg・a^{-1})
Control	205	2.35	618	16.9	944.4	51.1
Carbonized bagasse	218	2.55	802	17.9	1000.0	91.1
Carbonized biosolids	233	2.43	693	14.8	1133.3	48.7



In addition, charcoal can absorb nitrate nitrogen, which is reported harmful for humans, so farmland application of bio-char can alleviate the contamination of ‘ground) water with nitrate nitrogen (Fig.1,Chen, et.al., 2008). Finally, bio-char can be effective for sustainable agriculture.

Fig.1 Changes in cumulative load of nitrate nitrogen losses

Bio-char Production

We constructed a pilot-scale pyrolysis plant (30 kg/hr input weight) with internal heating and a rotary type kiln in collaboration with Toshiba Co. Ltd. Japan. This plant can facilitate reuse of syn-gas, so charcoal can be made with lower costs, energy and environmental burdens. We investigated the characteristics of operation and maintenance of this plant.

Activation was assessed by the absorption function of the produced charcoal. The activated bio-char made from sewage sludge with phosphate ions attached to the surface can absorb any type of gas, including ammonium, methyl mercaputhane and formaldehyde, comparing with commercial activated carbon .

Bio-char Assessement

Life Cycle Assessment (LCA) was used to evaluate impacts to the environment. For example, environmental burdens of various processes of pyrolysis plant with observed data were calculated. For the biomass with higher water contents, environmental burdens from the drying process were larger than those from the carbonizing process.

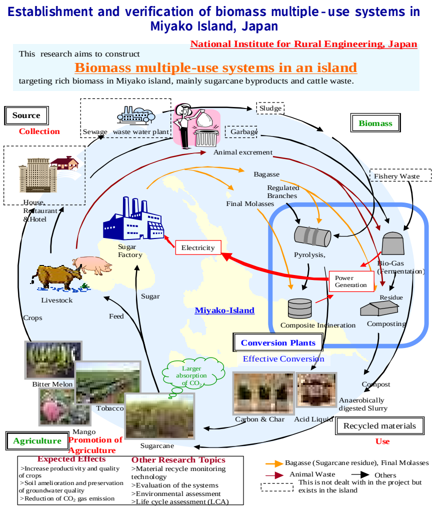
Environmental burdens originated from different carbonization devices were also calculated using the data of specification for those carbonization devices. The results showed that large differences in environmental burdens existed between different devices. The CO_2, NOx, and SOx emissions decreased as the capacities of carbonization devices increased (Table 2, Y. Kanri, et. al., 2007) .

Table 2 LCA analysis

Group	capacity	kg-CO_2/t-waste		kg-NOx/t-waste		kg-SOx/t-waste	
	kg/h	average	s.d.	average	s.d.	average	s.d.
A)	15-20	1044	314	1.239	0.504	0.553	0.177
B)	30-60	865	345	1.087	0.579	0.463	0.170
C)	90-300	413	191	0.416	0.199	0.210	0.093
D)	800-1200	111	61	0.102	0.059	0.065	0.031

Effective Biomass-use

Effective biomass refinery systems were studied at Miyako-Island, located in southern Japan (Fig.2) . Two types of pyrolysis plants were installed for bagasse and sewage sludge. Additionally compost, bio-gas and gasification plants were also installed. Finally, four type, five conversion systems were installed. The capacity of two pyrolysis plants were 30 kg/hr (rotary kiln, external heating for sludge as mentioned above) and 200 kg/hr (rotary kiln, inner heating for bagasse), respectively.



Effective biomass allocation and linkage were studied by linking various biomass conversion systems through materials and energy. Finally, optimal biomass refinery systems were developed and an optimal biomass allocation plan proposed taking into consideration lower CO_2 emissions.

Fig.2 Schematic idea of biomass refinery model at Miyako, Japan

A new research project (Regional activation research on biomass, 2007-2011, funded by MAFF Japan) was initiated last year based on the outcomes of the previous studies. In the new research project, bio-ethanol production is taken into consideration for refinery systems. Hopefully we can consistently provide biomass to end users and simultaneously achieve sustainable agriculture and environmental conservation. This research is a small trial but may become applicable throughout the world.

Literature

・Y. Chen, M. Taira, M. Ueno, Y. Shinogi (2008); Effect of digestive slurry and bagasse charcoal applied to Shimajiri Maji soil(Japanese with English Abstract), TRANS, JSIDRENo.254, pp.31-37
・Y. Kanri, Y. Shinogi, K. Tahara (2004); Case study of carrbonization technology for recycling waste biomass, Proc. The sixth International Conference on Eco-Balance,pp.489-490
・Y. Shinogi.・Y. Kanri. (2003) ：Pyrolysis of plant，animal and human waste：physical and chemical characterization of the pyrolytic products，Bioresource Technology，90，pp. 241-247.