COMPOSTING OF FOOD GARBAGE AND LIVESTOCK WASTE CONTAINING BIOMASS CHARCOAL

Shuji Yoshizawa*1, Satoko Tanaka1, Michio Ohata1, Shigeru Mineki2, Sumio Goto3, Kenji Fujioka4 and Toshie Kokubun5

1Asian Center for Environmental Research (ACER), Meisei University, 2-1-1, Hodokubu, Hino, Tokyo 191-8506, Japan, yoshizaw@es.meisei-u.ac.jp
2Tokyo University of Science; 2641, Yamazaki, Noda, Chiba 278-8510, Japan
3National Institute for Environmental Studies; 16-2, Onogawa, Tsukuba, Ibaraki 305-8506, Japan
4Venture Viser Inc.; 1-5-4, Kasuga, Bunkyo, Tokyo 112-0003, Japan
5Kokubun Farm Inc.; 82, Kotakakura, Tamai, Ohtama, Fukushima 969-1302, Japan

Abstract

In Japan biomass charcoal has been used for a long time as environmental improver, soil improver in a firm, water purification material and odor adsorbent. Recently, both carbonizing biomass waste such as wasted construction biomass materials, wasted paper and thinned wood and bamboo in forest and composting of garbage generated by homes, restaurants and livestock waste and their utilization are receiving attention from the viewpoint of recycling biomass wastes. It was found that proliferation of composting microorganisms was enhanced in and on charcoal as a medium added with rice bran as nutrient. A couple of examples of composting of biomass waste and charcoal mixture succeeded in Japan was introduced. In Suwa City, Nagano Prefecture, preparation of compost with charcoal was verified in demonstration program for garbage composting. Compost was made from garbage generated from 55 homes in Suwa City. The garbage was mixed with charcoal and complex microorganisms as seed. The mixture was heated over 55°C in aerobic condition for three hours. After one or two months the aged compost was obtained. Another recycle model of biomass resources using compost system is succeeded in Dake Spa Area, Fukushima Prefecture. The compost is made from garbage generated from hotels and cow manure from a dairy farm. The prepared compost is supplied to agriculture farms which cultivated vegetables organically. The hotels generating garbage purchase the vegetables and serve them for their guests. For realizing environmental recycle system of biomass resources, the system should be profitable for all the members concerning the recycle system. The small size of the system is inexpensive dependent on characteristics of a suburban area compared with a huge garbage treatment system.

Introduction

Charcoal, ashes and compost from biomass waste as a soil improver and fertilizer in a farm have been used for a long time in Japan. Y. Miyazaki and R. Kaibara described their effect on farming in Encyclopedia of Agriculture published in 1697.1 It is well known that symbiosis microorganisms play an important role in growing plants. Recently, both carbonizing biomass waste such as wasted construction wooden materials, wasted paper and thinned wood and bamboo in forest, and composting of garbage generated by homes, restaurants and food industries and livestock waste and their utilization are receiving attention from the viewpoint of recycle of biomass wastes and food safety by organic cultivation.
As wood and bamboo have pores of several to several ten micrometers originated from tracheae, charcoal prepared from carbonized wood and bamboo has also almost the same size of the pores. And size of the pores is as almost same as the size of the microorganisms. By adding charcoal from the beginning of composting, the proliferation of microorganisms was enhanced. It is expected, therefore, that the time required for making compost is shortened and the compost contains a lot of microorganisms.

In this conference, on various charcoals made from various kinds of biomass, bamboo, wood and corn-cob, added with aerobic complex microorganisms used for composting, the proliferation of microorganisms was studied by measuring incubation time dependence of adenosine triphosphate (ATP) concentration from the microorganisms, and morphology of the microorganisms in the mixture was observed by a scanning electron micrograph (SEM) technique. Then, R & D of the composting of garbage with

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Fig. 1. Y. Miyazaki, R.Kaibara, Encyclopedia of Agriculture, 1697, vol. 1-11.

Fig. 2. SEM photograph of cross section of bamboo.
charcoal and examples of environmental recycle of biomass resources using the compost in Japan are introduced.

Finally low cost carbonization of wood and bamboo waste by using an oil drum and composting of garbage by a handmade wooden composter are also introduced.

**Microorganisms Proliferation on/in Charcoal**
Charcoal was prepared from thinned bamboo, wooden concrete frame waste and corn-cob as a raw material which were carbonized at 600°C to 700°C in a bach-typed furnace (Ventuer Viser Inc., type-VI). Relative pore volume distribution of the bamboo charcoal, concrete frame waste charcoal and corn-cob charcoal is shown in Figs. 3 (a), (b) and (c), respectively. In the distribution of the charcoal from bamboo and concrete frame waste, the peak is centered in 0.1 - 1 µm. It is indicated that the pore diameter from 10 - 1,000 µm is major in the corn-cob charcoal.

Flow chart of samples preparation is shown in Fig. 4. The charcoals which were pulverized and sifted into 1 - 3 mm of the size were used as a medium. Rice bran (17.8 g) as a nutrient was added into 15.5 g of charcoal powder in 300 ml flask. Weight ratio of the charcoal with the rice bran was 1: 1.15. Moisture content of the mixture was

![Fig. 3. Pore distribution of each radius in various charcoals; (a) bamboo charcoal, (b) concrete frame waste charcoal and (c) corn-cob charcoal.](image-url)
adjusted to 65% by adding distilled water. The mixture was treated at 120°C for 60 minutes with a high pressure sterilizer. Aerobic complex microorganisms of 10 g were added as a seed to the mixture. The samples were maintained in an incubated chamber with relative humidity (RH) of 53% at 23°C and stirred vigorously with aspatula once a day in order to contact the system with air.

Microorganisms proliferated on and in the charcoal were observed with a scanning electron microphotography (SEM). SEM photographs of microorganisms found on the

![Fig. 5. SEM photographs of the different types of microorganisms on the mixture surface of bamboo charcoal and rice bran.](image-url)
surface of mixture of the bamboo charcoal and the rice bran after 696 hours of the incubation were shown in Fig. 5. Granules like spores of *Actinomadura*, that have many bumps, were detected as shown in Fig. 5 (a). Microorganisms also shown in Fig. 5 (b) are similar to *Actinomyces* which have ramified structure observed in *Cellulomonas* and *Agromyces*.

Figs. 6 (a), (b) and (c) show SEM photographs of microorganisms on and in the surface of the charcoal made from bamboo, concrete frame waste and corn-cob.

![Fig. 6. SEM photographs of microorganisms in the surface of various charcoals; (a) bamboo, (b) concrete frame waste and (c) corn-cob.](image1)

![Fig. 7. Incubation time dependence of ATP concentration.](image2)

Fig. 7. Incubation time dependence of ATP concentration. ●; bamboo charcoal, ○; concrete frame waste, △; corn-cob charcoal and □; without charcoal.
respective, after 336 hours of the incubation. Morphologically rod and short rod microorganisms can be observed on the surface and in the pores of charcoals. It was confirmed that charcoal functions as the matrix for these microorganisms and the composting microorganisms on and in the charcoal were morphologically diversified.

Amount of the microorganisms was estimated by measuring ATP concentration in the samples (Meidensha Corp., Luminometer UPD-4000). Incubation time dependence of ATP concentration of the samples is shown in Figs. 7. In the systems used charcoal as a medium, the ATP concentrations increase continuously up to 100 - 200 hours and then decrease. It is mentioned that proliferation of the composting microorganisms is influenced scarcely by difference of the pore diameter distribution and the specific surface area among charcoals from bamboo, wooden concrete frame waste and corn-cob. This is because that the microorganisms proliferate only on the surface of the charcoal and in the surface vicinity of the pores of the charcoal, where microorganisms can come into contact with the rice bran, but cannot proliferate in the inner part of the pore without nutrient. The composting microorganisms used in this study proliferate in the presence of oxygen (aerobic). It should be mentioned that as the charcoal contains a lot of pores, the charcoal in the system brings about enough oxygen for microorganisms proliferation. Since size of the composting microorganisms is sub-micron meter to several micrometers, it seems impossible for them to intrude into micropores and mesopores in the charcoal. ATP concentration in the system without charcoal increases up to 50 - 100 hours, and then decreases. After 100 hours the ATP is almost zero value. Those results in the system without charcoal indicate that the system became acidic state accompanied with production of lower fatty acids such as acetic acid, isobutyric acid, n-butyratic acid, iso-valeric acid and n-valeric acid. This phenomenon was also supported with the other observations; color of the system changed from dark to reddish brown and smell of the system felt sour. It is suggested that in the system without charcoal the content was under anaerobic condition in spite of vigorous stirring of the system once a day.

**Verification of Compost with Charcoal in Suwa City**

In Suwa City of Nagano Prefecture, preparation of compost with charcoal was verified during two months, from the beginning of April to the end of May, 2005 in demonstration program for garbage composting by Suwa City Designing Conference (Chairman: Mr. Kenichi Tanaka). Compost was made from garbage containing head and bony parts (Fig. 8) generated from 55 homes in Suwa City. The average amount of the garbage was

![Fig. 8. Gathered garbage from homes.](image-url)
Fig. 9. The first fermentation apparatus. (a) External form and (b) perspective view. (2) stirrer, (4) ventilator, (5) heater, (6) radiator and (7) fan.

Fig. 10. Mesh box for aging.

Fig. 11. SEM photographs of the microorganisms (a) in the pore of charcoal and (b) on the surface of rice husks of compost in Suwa City.
about 60 kg, twice a week. The garbage was thrown into the first fermentation apparatus shown in Fig. 9. The garbage was mixed with 10 wt% of powdered charcoal, rice husks as a moisture lowering material and complex microorganisms as a seed. The mixture was heated over 55°C in aerobic condition for 3 hours. In the first fermentation process, aerobic microorganisms are substituted for anaerobic microorganisms which are sterilized by heating. The content was transferred into metal mesh box in Fig. 10, and after one or two months the aged compost was obtained.

Fig. 11 shows SEM photographs of the microorganisms in the pore of charcoal and on the surface of rice husks of compost in Suwa City. Many kinds of microorganisms are observed.

Recycle Model of Biomass Resources in Dake Spa Area
Recycle model of biomass resources using compost is succeeded in Dake Spa Area of Fukushima Prefecture. The compost is made from garbage generated from 10 hotels in Dake Spa (Fig. 12) and manure from 600 cows in meat cattle farm (Fig. 13). The compost was prepared in the Kokubun Farm Inc. near Dake Spa. About 10 tons of garbage and manure a day was thrown into the lane-typed composting system in Fig. 14. As the cow manure is lack of nutrition for the composting microorganisms, in order to increase heat of fermentation, it is effective to mix garbage into the cow manure. Then,
Fig. 14. Lane-typed composting system. 68 m long, 5 m wide and 1.5 m high.

Fig. 15. Aging of compost.

Fig. 16. Organic farming using Dake Spa Compost.

Fig. 17. Dishes using organically-grown vegetables and beef served in Dake Spa Hotels.
the compost was turned over several times a month for aging in two months as shown in Fig. 15.

The aged compost is supplied to 8 agriculture farms which cultivate vegetables organically in Fig 16. Garbage from food industries such as bread, noodles, cakes, etc was fermented to feed for cows. The hotels generating garbage purchase the vegetables and serve them for their guests. Fig. 17 shows dishes using organically-grown vegetables and beef served in Dake Spa Hotels.

In this way environmental recycle system of biomass resources is realized in Dake Spa Area.

Fig. 18 shows flow of environmental recycle system of biomass resources. For realizing the environmental recycle system, the case in Dake Spa Area indicates that the system should be profitable for all the members concerning the system. The small size of the system is inexpensive dependent on characteristics of a suburban area compared with a huge garbage treatment system.

Low Cost Biomass Recycle System
Low cost carbonization of wood and bamboo waste by an oil drum and composting of garbage by a handmade wooden composter are introduced. Fig. 19 shows carbonization apparatus using two oil drums, which are covered with soil for thermal insulation. Wood and bamboo of 400 liters are inserted into drums. After 24 hours carbonization, about 50 liters charcoal can be obtained.

Wooden composter of 1 m$^3$ was made by a volunteer group concerning biomass recycling shown in Fig. 20. Garbage mixed with powdered charcoal and aged compost as seed microorganisms. In order to keep the garbage in aerobic state, air flows from lower front mouth through garbage to outlet opened in the roof. It is designed that the aged compost is completed.
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REFERENCES


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<td><strong>Author(s)</strong></td>
<td>Shuji Yoshizawa¹, Satoko Tanaka¹, Michio Ohata¹, Shigeru Mineki², Sumio Goto³, Kenji Fujioka⁴ and Toshie Kokubun⁵</td>
</tr>
</tbody>
</table>
| **Address** | ¹Asian Center for Environmental Research (ACER), Meisei University, 2-1-1, Hodokubu, Hino, Tokyo 191-8506, Japan  
²Tokyo University of Science; 2641, Yamazaki, Noda, Chiba 278-8510, Japan  
³National Institute for Environmental Studies; 16-2, Onogawa, Tsukuba, Ibaraki 305-8506, Japan  
⁴Venture Viser Inc.; 1-5-4, Kasuga, Bunkyo, Tokyo 112-0003, Japan  
⁵Kokubun Farm Inc.; 82, Kotakakura, Tamai, Ohtama, Fukushima 969-1302, Japan |
| **Telephone** | +81-42-591-7346 |
| **Fax** | +81-42-591-7346 |
| **E-mail** | yoshizaw@es.meisei-u.ac.jp |
| **Short CV for Introduction Purposes (100 words max)** | Professor in Department of Environmental Systems, Meisei University  
Guest Researcher of National Institute of Advanced Industrial Science and Technology  
Guest Researcher of National Institute for Environmental Studies  
Guest Researcher of National Institute of Fusion Science  
1978 Doctor Course in Graduate School of Tokyo University of Science (Dr. of Science)  
1981 Toshiba Corporation  
1989 Dowa Mining Co., Ltd. |

Photograph attached (jpg)