

# Microorganisms proliferation by addition of biochar in food waste composting factory

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## Abstract

In Japan biochar has been used for a long time as environmental improver, soil improver in a firm, water purification material and odor adsorbent. 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. A recycle model of biomass resources using compost system is succeeded in Fukushima, Japan. The compost containing small amount of biochar is made from food garbage generated from hotels and manure from a beef cattle 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. Another model is introduced; a composting factory in a suburban area of Tokyo deals 100 tons of food industry waste a day added with several % of biochar. 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

Since wood and bamboo have several to several tens of micrometers of pores originated from tracheae, charcoal prepared from wood and bamboo has also almost the same size of the pores. And size of the pores is almost as same as that of the microorganisms. By adding charcoal from the beginning of composting, the proliferation of microorganisms was enhanced (Tanaka et al, 2005 and 2011; Yoshizawa, 2005; Yoshizawa et al, 2006). It is expected, therefore, that the time required for making matured compost is shortened and compost contains a lot of microorganisms.

In this paper, charcoals made from various kinds of biomass, bamboo, wood and corn-cob, were added to rice bran and complex microorganisms used for composting, and proliferation of microorganisms was studied by measuring adenosine triphosphate (ATP) concentration from the microorganisms.

Then, a composting factory dealing with 100 tons of food waste per day added with charcoal in Japan is introduced.

## Material and Methods

### *Charcoal preparation*

Charcoal was prepared from bamboo, wooden concrete frame waste and corn-cob as a raw material which were carbonized at ca. 650°C in a batch-typed furnace. In the pore volume distribution of the bamboo charcoal and concrete frame waste charcoal, the peak is centered in 0.1 to 1 µm. It is indicated that the pore diameter from 10 to 1,000 µm is major in the corn-cob charcoal.

### *Rice bran composting*

The charcoals pulverized and sifted into the size of 1 to 3 mm were used as a medium. Rice bran (17.8 g) as a nutrient was added into 15.5 g of bamboo charcoal powder in 300 ml flask. Weight ratio of the charcoal to the rice bran was 1: 1.15. Moisture content of the mixture was adjusted to 65% by adding distilled water. The mixture was treated at 120°C for 60 minutes with a high pressure sterilizer. Ten g of aerobic complex microorganisms (ACM) were added as a seed to the mixture. The samples were maintained in an incubated chamber with 53% of relative humidity (RH) at 23°C and stirred vigorously with spatula once a day for aeration.

### Measurement

The concentration of microorganisms was estimated by measuring the ATP concentration in the sample (Meidensha Corp., Luminometer UPD-4000). As ATP exists in mitochondria in the cytoplasm, the concentration of ATP can be used as an indication of microorganism activity. When ATP, to which d-luciferin has been added, changes to adenosine monophosphate in the presence of luciferase and  $Mg^{2+}$ , light at a wavelength of 560 nm is emitted. Distilled water (20 ml) was added to 2 g of the sample and stirred with a tube mixer at 2500 rpm for 1 min. Then 250  $\mu$ l of this suspension was withdrawn with a micropipette and an ATP measuring kit (Meidensha Corp., Lucifer AS) added.

## Results and Discussion

### Proliferation of microorganisms

The incubation time dependence of ATP concentration of the samples was measured. In Figure 1, in the system mixed with charcoal, rice bran and ACM, the ATP concentration increases accompanied with three concentration peaks with increase of incubation time. In the systems, the mixture of charcoal and rice bran without ACM and the single component, ACM alone, charcoal alone, and rice bran alone, no increase of the ATP concentration is observed.

For studying influence of the charcoal amount on the microorganisms proliferation in the mixture of charcoal, rice bran and ACM, the logarithmical incubation time dependence of the ATP concentration in the mixture with different amount of the charcoal, 1.0 g, 5.9 g and 15.5 g, is shown in Figure 2. Increase rate and extent of the ATP concentration are dependent on the charcoal amount in the system. The result that ATP concentration increases in the mixture system with charcoal, rice bran and ACM, means that the charcoal could proliferate microorganisms in the system. Several peaks of the ATP concentration were found; two peaks at about 100 hr and 1,000 hr in the system with 1.0 g of charcoal, three peaks at 100 hr, 500 hr and 1,000 hr with 5.9 g of the charcoal, and three peaks at 70 hr, 200 hr and 400 hr with 15.5 g of the charcoal. The shifts from each peak in the incubation time depended on the amount of the charcoal. It was found that as the amount of the charcoal increased, the microorganisms proliferation was accelerated remarkably. From those results, there should be at least three kinds of microbial communities in the system whose proliferation rate is different. It is suggested that this comes from difference of the proliferation rate of adaptive microorganisms as a specific response to the presence of nutrient such as glucide, protein and lipid contained in rice bran as a main component. The proliferation rate may reflect the biodegradation property of the nutrients.

### SEM observation of microorganisms

Figure 3 (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, respectively, 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.

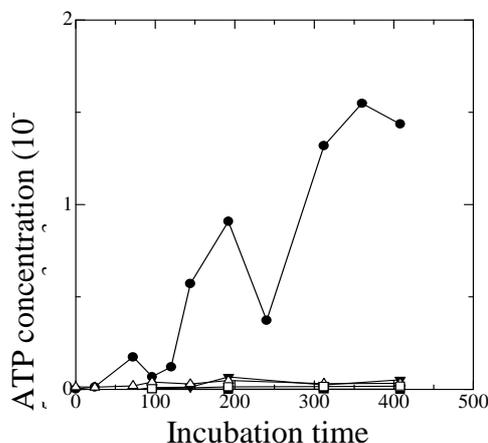


Figure 1. Incubation time dependence of ATP concentration of the systems.  
●; ACM, charcoal and rice bran, ▼; charcoal and rice bran, Δ; ACM, ■; charcoal and □; rice bran.

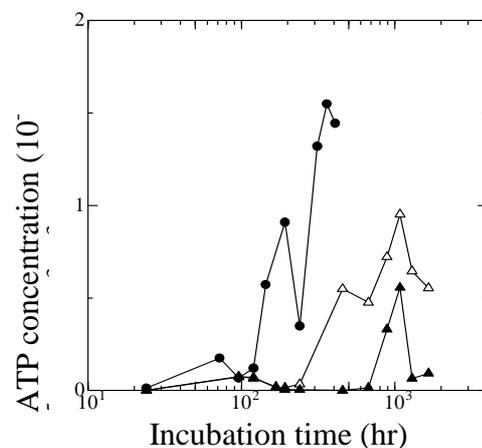
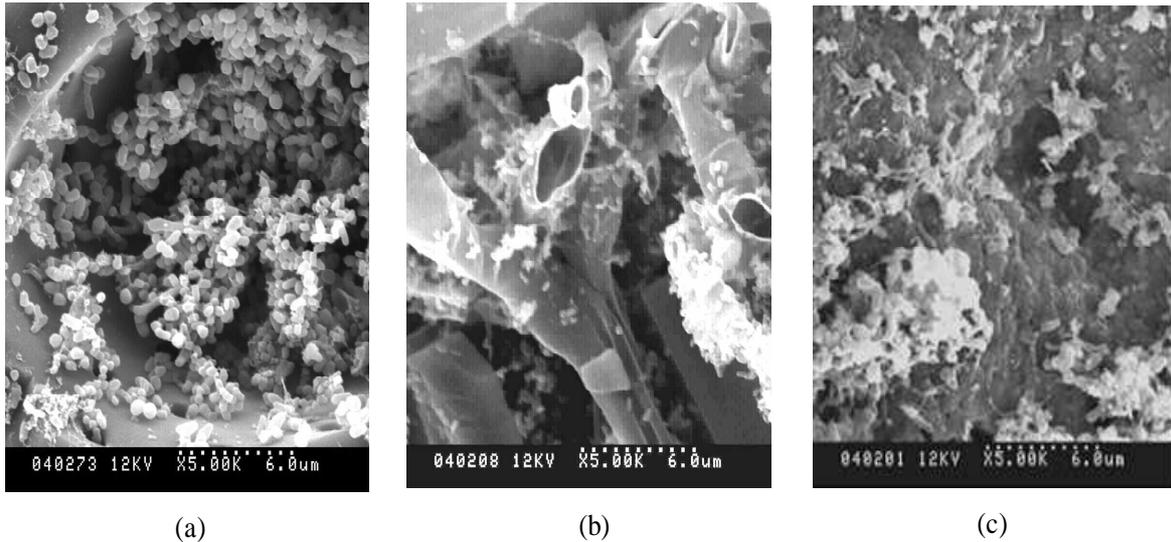


Figure 2. Incubation time dependence of ATP concentration of the systems.  
Charcoal amount : ▲; 1.0 g, Δ; 5.9 g and ●; 15.5 g.



**Figure 3. SEM photographs of microorganisms in the surface of various charcoals; (a) bamboo, (b)concrete frame waste and (c) corn-cob.**

#### *Food waste composting factory*

Composting factory (Tama Fresa Co., Ltd.) in a suburban area of Tokyo deals with 100 tons of food industry waste a day added with charcoal. Undesired materials such as plastic, steel and aluminum materials are separated from food garbage with a separator (Figure 4). Then, several percent of charcoal and returned compost are mixed to the garbage where the moisture content was adjusted to 60%, and the mixture is thrown into the top of a fermentation tank as shown in Figure 5.



**Figure 4. Separator of garbage from plastic bag.**



**Figure 5. Twelve fermentation tanks of 65 m<sup>3</sup>.**

The temperature of the mixture increases to 60-70°C, because aerobic microorganisms proliferate largely on the surface of the charcoal. After one week, the first fermented compost is pulled out of the tank. Then, the compost is piled for two months with aeration, and finally the matured compost is obtained.

#### **Conclusion**

The appearances of microorganisms during the composting of rice bran by aerobic complex microorganisms in the existence of bamboo charcoal were investigated. The ATP concentration of the mixture was increased in stages, namely three peaks occurred, during the composting. Bamboo charcoal was considered to be available as a supporting matrix for microorganisms. In conclusion, the addition of charcoal into rice bran was considered to be effective for its composting by ACM.

#### **Acknowledgement**

This work was partly supported by the Japan Soil Association, 2009 – 2011. The authors express their sincere thanks to Mr. O. Onozawa for the useful discussion for food garbage composting.

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