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Effect on Biodegration of Organic Matter and Change of Biomass in Aerobic Composting of Human Feces from Tempreture

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Abstract. Aerobic composting is a method for sanitary disposal of human feces as has been used in bio-toilet systems which can be used at family in city to save water and to control water pollution. In this study, batch experiments were conducted using a closed aerobic composting reactor with sawdust as the bulky matrix to simulate the condition of a bio-toilet for sanitary disposal of human feces. Attention was paid to the biodegration of organic matter and change of biomass under the thermophilic and mesophilic conditions. The results indicated that: more 70% fecal organic matters(mainly in first day) observed at 60℃ while more 63% fecal organic matters(mainly in first 4 days) observed at 35℃ in a two-week composting period during aerobic composting. it indicated that the change of biomass was a positive correlation with biodegradation of organic matters(COD)(r^2=0.9486 at 60℃ while r^2=0.9296 at 35℃) and 1.299×10^{12}cfu biomass/removal of organic matters(g) at 60℃ while 6.80×10^{11}cfu biomass/removal of organic matters(g) at 35℃.

Key words: aerobic composting , biomass, feces,biomass

1. Introduction

Aerobic composting has been recognized as a suitable technology for sanitary disposal of human feces in a dry toilet system[1]. It draws attention especially from regions and areas where provision of sufficient water for toilet flushing is difficult due to water shortage[2]. The operational temperature for the commercial bio-toilet of this kind has thus been recommended as 50-60℃ through an automatically controlled heating system[3]. Many studies have so far been conducted on the characteristics of aerobic composting for sanitary disposal of human feces. Attentions are mainly given to the process of biodegradation in which organics and fecal nitrogen are decomposed or transformed under the action of microorganisms, and the effect of pathogen inactivation which is the most important issue from the sanitary viewpoint. A thermophilic condition ranging from 50℃ up to 65℃ have been recognized to be optimum both for obtaining the best biodegradation effect[4] and effective removal of E. coli and other pathogens[5-7]. Some studies have indicated that addition of mixtures, as bulky matrices or composting additives, is important for maintaining an aerobic condition and their types greatly influence the process of organic decomposition and nitrification[8,9]. The mixtures with high lignocellulose contents, such as sawdust which in most cases is less biodegradable than other additives, can decrease nitrogen loss in the composting process[10,11]. The current study used a specially designed batch composting reactor to investigate the biodegration of organic matter and change of biomass under the thermophilic and mesophilic conditions.

2. Materials and methods

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2.1. Experimental device and raw materials

The experimental device used in this study is a closed composting reactor as shown in Fig. 1. The reactor chamber is a polymethyl methacrylate cylinder with inner diameter as 10 cm and height as 55 cm. An outer jacket space is provided as a water bath where hot water is circulated through a pump connecting to the thermo controlled water heater. A hand-driven shaft with agitation blades is mounted horizontally in the reactor for intermittent mixing. An air diffuser is set at the bottom of the reactor for introducing a constant air flow through the air supply unit. An exhaust pipe on top of the reactor is connected to a water cooled condensing unit where vapor is condensed and gas is led to an ammonia absorber containing sulfuric acid solution for absorbing the exhausted ammonia gas from the reactor.The bulky matrix used in this study was sawdust from a local timber processing plant. The human feces used in this study were collected from the university campus under the assistance of students. In order to keep the initial quality of the feces identical in different experimental runs, the collected substances were well mixed, divided into equal quantity stocks, and preserved at -20℃ for later use. The physicochemical properties of the sawdust and feces are shown in Table 1.

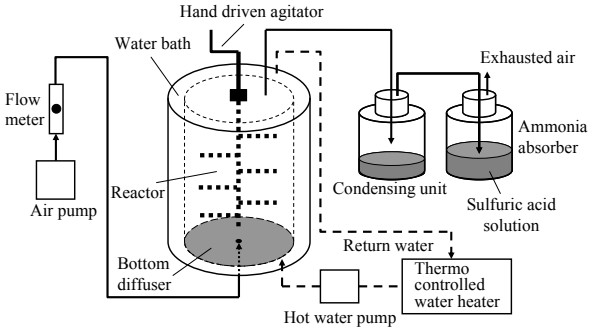


Fig.1 Diagram of the experimental composting reactor

Table 1 Physicochemical properties of the sawdust and feces used in the experiment

item	moisture content %	Sorg g/kg	TOC g/kg	COD g/kg	N_{tot} g/kg	N_{org} g/kg	N_{ino} g/kg
sawdust	11.1	956.9	378.1	1270.3	2.10	2.10	0
feces	81.8	901.0	497.9	1671.3	68.23	55.94	12.29

2.2. Operation conditions

The initial moisture content of the composting mixture, i.e. the feces and sawdust with dry weight ratio of 1:4[7,11,12] was adjusted to 60% using deionized water. During the composting operation, the condensed water collected in the condensing unit (Fig. 1) was sent back to the reactor daily for maintaining the moisture content. From the thermo controlled water heater, hot water with a constant temperature of 35℃ was circulated between the heater and the water both (Fig. 1) so that a constant temperature was kept in the reactor.The composting period for each experimental run in this study was set as 14 days[13].In order to maintain a completely aerobic condition in the reactor, air flow was controlled as 0.4 $m^3min^{-1}kg^{-1}$ for feces composting in this study. Intermittent mixing of the composting mixture was provided throughout the composting process by operating the hand mixer mounted in the reactor (Fig. 1) for about 2 min in every 8 hours for keeping the mixture in a homogeneous condition following the practice of normal composting operation[14].

2.3. Sampling and analytical methods

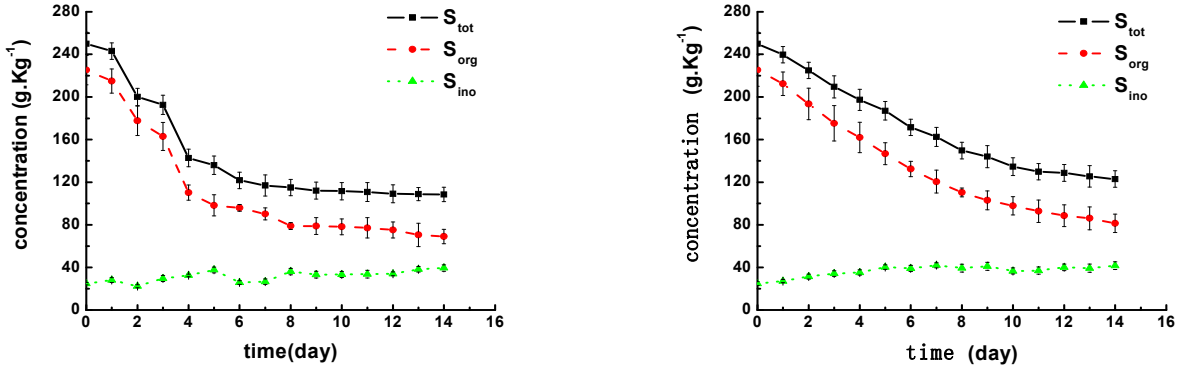
The composting mixture was sampled everyday during the composting process after completely mixing the mixture in the reactor. The wet weight of each sample was 10 g which took 1% of the total substance in the reactor. The daily loss of mixture by sampling was accounted in material balance calculation in this study. Each sample was immediately stored at -20℃ for analysis later. For analysing the moisture content and total

solid content (S_{tot}), each sample of the composting mixture was dried at 105℃ following the standard method[15]. The organic solid content (S_{org}) was analyzed by drying the sample at 600℃[15]. organic matter analysis was conducted regarding COD and TOC. The COD was analyzed by a modified fast digestion-spectrophotometric method[13,15]. The TOC was measured directly using Shimadzu SSM-5000 with TOC-Vcph analyzer on dry weight basis as g/kg.

3. Results and discussion

3.1. General performance of the fecal matters decrease

As shown in Fig. 2, the composting reactor performed organic degradation well in the experimental period under the aerobic condition. Total solid matters(S_{tot}) of feces included organic matters(S_{org}, about 82% of S_{tot}) and inorganic matters(S_{ino}, about 28% of S_{tot}). Feces organic matters was quckly degraded and decreaed under aerobic condition with more than 70% of organic matters removal(at 60℃ in first 6 days) while with more than 63% of organic matters removal(at 35℃ in first 11 days). the composting reactor performed organic degradation well in the experimental period under both the aerobic mesophilic condition and the aerobic thermophilic condition.

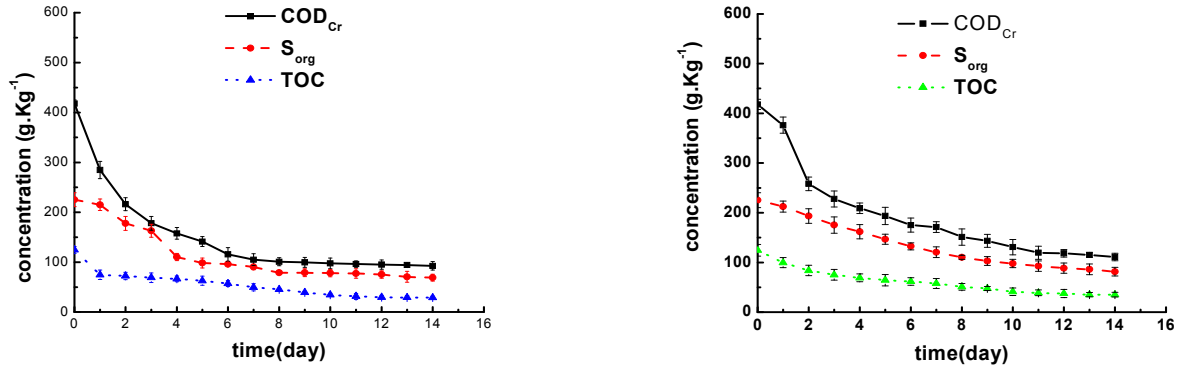


a 60℃ b 35℃

Fig. 2 Variation of fecal solid contents in the composting process

3.2. General biodegradation of the fecal organic matters

As shown in Fig. 3, the composting reactor performed organic matters biodegradation well in the experimental period under the aerobic thermophilic condition. it was almost halved in the first two days and the final removal of 73.5% was achieved after 6 days composting at 60℃ while the final removal of 68% achieved after 11 days composting at 35℃. it indicated that the biodegradation of organic matters under mesophilic composting was less than that under thermophilic composting.



a 60℃ b 35℃

Fig. 3 Variation of fecal organic contents in the composting process

3.3. Changes of microbial biomass during composting of feces

The further studies are needed from the viewpoints of microorganical activity in the macro and micro environment in the composting reactor. Biomass was analyzed by Phospholipid fatty acids (PLFA). The Biomass of compost during composting was shown as Fig. 4. the biomass reached to max at 11th day firstly and decreased abviously from 11th day to the end of composting under mesophilic condition while to max at 6th day firstly and decreased abviously from 6th day to the end of composting under thermophilic condition with the biodegradation of organic matters.it was indicated that microbe was worker mainly during the removal of organic matters.

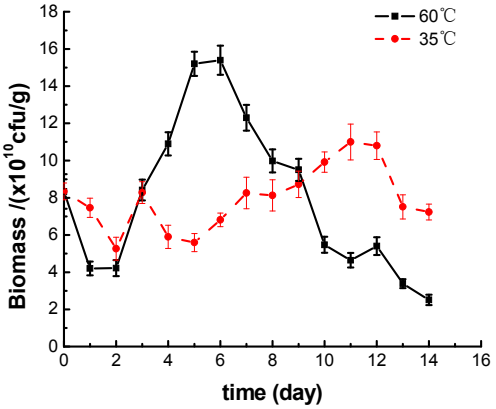
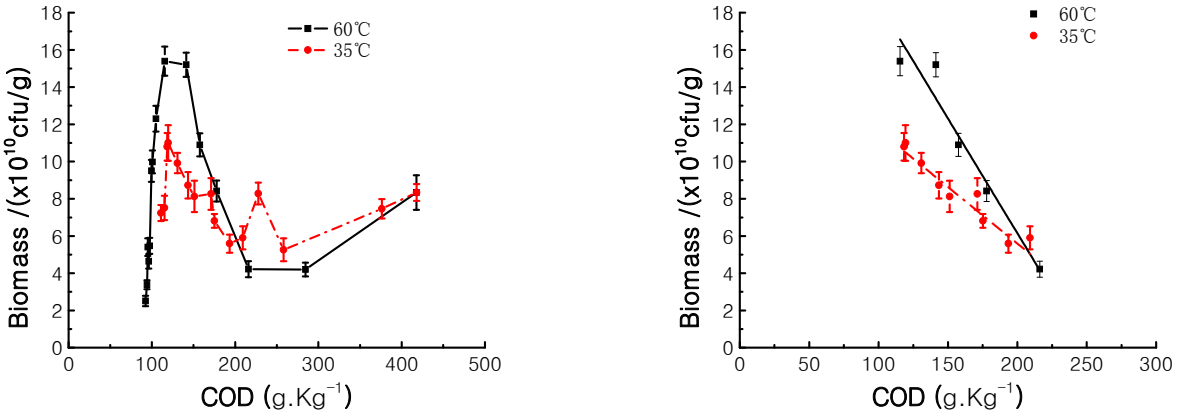


Fig. 4 Changes of microbial biomass during composting of feces

3.4. Correction of changes of biomass and biodegration of organic matter

As shown in fig.5 a, the biomass have three periods:(1)adjustment stage;(2) increased stage;(3) decreased stage during biodegradation of organic matters(COD) in accoding with the change of biomass during composting(fig.4). The change of biomass was a positive correlation with biodegradation of organic matters(COD)(r^2=0.9486 at 60℃ while r^2=0.9296 at 35℃) and 1.299×10^{12}cfu biomass/removal of organic matters(g) at 60℃ while 6.80×10^{11}cfu biomass/removal of organic matters(g) at 35℃ as shown in fig 5 b, and The former is about 20 times of the latter. It indicated that the biomass under thermophilic condition incresed more quickly and more than that under mesophilic condition.



a during composting b during increase of biomass

Fig. 5 Correction of changes of biomass and biodegration of organic matter

4. Concluding remarks

This study investigated the fecal biodegration of organic matter process in an aerobic and mesophilic composting reactor using sawdust as bulky matrix. Under a condition of controlled temperature and moisture content at 60%, more than 63% fecal organic removal was obtained at 35℃ while more than 70% fecal organic removal at 60℃. The biodegration of organic matter occurred mainly in the first 11 days with slowlly depletion of organic matter at 35℃ while mainly in the first 6 days with quickly depletion of organic matter at 60℃. The change of biomass was a positive correlation with biodegradation of organic

matters(COD) and 1.299×10^{12}cfu biomass/removal of organic matters(g) at 60℃ while 6.80×10^{11}cfu biomass/removal of organic matters(g) at 35℃, and the former is about 20 times of the latter. It indicated that the biomass under thermophilic condition incresed more quickly and more than that under mesophilic condition.

5. Acknowledgement

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