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Continuous thermophilic composting (CTC) for rapid biodegradation and maturation of organic municipal solid waste

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ABSTRACT

Fewer and fewer municipal solid wastes are treated by composting in China because of the disadvantages of enormous investment, long processing cycle and unstable products in a conventional composting treatment. In this study, a continuous thermophilic composting (CTC) method, only a thermophilic phase within the process, has been applied to four bench-scale composting runs, and further compared with a conventional composting run by assessing the indexes of pH, total organic carbon (TOC), total Kjeldahl nitrogen (TKN), C/N ratio, germination index (GI), specific oxygen uptake rate (SOUR), dissolved organic carbon (DOC) and dehydrogenase activity. After composting for 14 days, 16 days, 18 days and 19 days in the four CTC runs, respectively, mature compost products were obtained, with quality similar to or better than which had been stabilized for 28 days in run A. The products from the CTC runs also showed favorable stability in room temperature environment after the short-term composting at high temperature. The study suggested CTC as a novel method for rapid degradation and maturation of organic municipal solid wastes.

1. Introduction

In China, about 180 million tons of municipal solid wastes (MSW) are disposed in 2007 with an annual growth rate from 8% to 10%, and millions of tons of MSW have caused serious pollution to urban environment, threatened citizens' living environment, economy and society's sustainable development. Presently, the main MSW disposal method in China is landfill method, which occupies amount of land and produces much of secondary pollutants, such as landfill leachate, greenhouse gases and odor. Composting, whose chief aim is to convert the organic waste into a relatively stable material with a low readily degradable organic matter content and without obvious phytotoxicity to plants, is coming increasingly under consideration in many cities throughout the world because it has several advantages over current disposal strategies for reducing the waste volume by 40–50%, killing pathogens by the heat generated during the thermophilic phase and providing a final product as a soil conditioner or fertilizer (Fuerhacker and Haberl, 1995; Wong et al., 1995; Larney et al., 2003). However, only a few MSW are treated by composting in China because of the disadvantages of enormous investment, long processing cycle and unstable products in a conventional composting treatment.

In previous reports (Ishii et al., 2000; Hassen et al., 2001; Schloss et al., 2003; Narihiro et al., 2004), temperature has always been considered one of the most important factors impacting the composting processes due to its key role in screening various microbes degrading organic matters and promoting the compost maturity. Usually, the conventional composting process has been divided into four different phases, mesophilic (S), thermophilic (T), cooling (C) and maturing (M), according to the temperature in the compost pile. Furthermore, a lot of reports on compost microbes show that various microbe groups dominate in the piles during the composting process, such as mesophilic microorganisms in S phase, the thermophilic bacteria (including actinomycetes) and fungi in T phase and revived mesophilic microorganisms in C or M phase.

This study claimed a novel method of continuous thermophilic composting (CTC) for MSW composting, in which the compost materials was incubated in high temperature during the whole composting process. Operating parameters of interest included aeration, temperature and moisture dynamics, and organic material decrement. Compost stability and maturity refer to the rate or degree of organic matter (OM) decomposition and phytotoxic organic substances during the active composting stage, respectively, and are used to evaluate the composting product quality (Wu et al., 2000). Despite numerous investigations of the maturation process of composts, no one simple and straightforward parameter which can predict plant response upon compost

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application has yet been defined (Wang et al., 2004), and five parameters, C/N ratio, germination index (GI), specific oxygen uptake rate (SOUR), dissolved organic carbon (DOC) concentration and dehydrogenase activity (DA), have been chosen for the determination of compost stability or maturity and the comparison of the two composting technologies.

2. Methods

2.1. Materials for composting

MSW was collected from a municipal transfer station near the campus of Hunan University in Changsha, the central south of China. After initial screening, the waste materials were segregated for other inorganic materials such as glasses, plastics and other inert. The resource materials for composting consisted mainly of kitchen discards, leaves, little branches and grass, and a complete chemical characterization of the resource materials was shown in Table 1. The materials were shredded to a size of 1–3 cm, and then the moisture ratio was adjusted to about 60% by natural air drying for 12 h since some studies reported that suitable value for resource materials was about 60% (Suler and Finstein, 1977; Liang et al., 2003; Lin, 2008).

2.2. Composting experiment

Specially designed bench-scale composting reactors were applied for MSW composting in this study. The reactors were cylinders (30 cm in diameter, 45 cm in depth), made of Pyrex glass and equipped at the bottom with perforated plate to distribute the air supplied from air compressors. Each reactor was placed into an incubator (0.7 by 0.7 by 0.75 m) to control the pile temperature. A thermocouple was inserted in the core of compost pile and linked with a recorder.

Each 20 kg (wet weight, about 28 L) resource materials of MSW, with a density of about 0.714 kg L^{-1}, was packed into a reactor and sequentially was composted with five different protocols for 60 days, which were designated as a conventional composting run of A and four CTC runs of B-1, B-2, C-1 and C-2. In run A, the incubator temperature was maintained at 30 °C during the whole composting procedure. The incubator temperature was maintained at 50 °C during the first 30 days in runs B-1 and B-2 while it was maintained at 40 °C on the first day and then was raised to 50 °C during the remaining 29 days of thermophilic composting in runs C-1 and C-2. Air from a compressor was supplied at a specifically flow rate, 0.25 l min^{-1} kg^{-1} (wet weight), to maintain aerobic conditions throughout the experimental runs, and a bigger flow rate of air was supplied to bring down the temperature to 60 °C in runs B-2 and C-2 when the compost pile temperature exceeded 60 °C. Each run was triplicated to check the reproducibility of the experiments, each sample was tested triplicately and here the means with standard deviation of the nine tests were shown. The compost was turned manually every 24 h, and samples with a total weight of 50 g (wet weight) were collected daily at five random locations (10 g from each location) in each pile immediately after windrow turning and subjected to physicochemical properties analyses simultaneously.

2.3. Physicochemical properties determination

Temperature at the core of compost piles was measured with a thermocouple and recorded by a recorder with an interval of two hours. The pH of the compost was determined with a digital pH meter by adding 1 g of compost sample in a 10 ml distilled water and mix thoroughly for 30 min (Sasaki et al., 2003). The moisture content was determined daily from the loss of weight after drying at 105 °C for 24 h. An adequate volume of water was added at each turning to maintain the moisture content around at 60%. In this study, the total nitrogen (TN) content was determined by the Kjeldahl method (K435, Buchi, Switzerland) and measured as total Kjeldahl nitrogen (TKN). The total organic carbon (TOC) was determined by TOC Analyzer (TOC-5000, Shimadzu, Japan) according to the manufacturer's instructions.

2.4. Maturity evaluation

In this study, five indexes of C/N ratio, GI, SOUR, DOC and DA were used for compost maturity evaluation. C/N ratio was calculated from the values of TOC and TKN (Jiménez and García, 1992), and generally the value range of C/N ratio in mature compost in China were 15 to 25, some higher than those in USA or European countries. Several reports (Helfrich et al., 1998; Chikae et al., 2006) identified GI as the most sensitive parameter for determining compost phytotoxicity, and the GI in this study was tested with each test group of 40 seeds of *Campestris brassica*, a kind of Chinese cabbage, in water extract of fresh compost as previous literatures reported (Zucconi et al., 1981; Chikae et al., 2006). SOUR test, which was proved a simple respirometric technique for assessing compost stability (Lasaridi and Stentiford, 1998; Scaglia et al., 2007), was performed as the literature (Lasaridi and Stentiford, 1998) reported and stable SOUR values around 1 were used to characterize the active composting endpoint in this study. DOC was determined with a compost extract (water to wet compost ratio of 10:1) by a TOC Analyzer (TOC-5000, Shimadzu, Japan) after centrifuging at 10,000 rpm for 10 min and filtering through a 0.45 μm membrane filter, and stable DOC values ranging from 3 to 6 were used to characterize the active composting endpoint on the basis of previous reports (Wu et al., 2000; He et al., 2001; Zmora-Nahum et al., 2005; Gomez-Brandon et al., 2008). DA was measured with the substrate of 3% of 2,3,5-triphenyltetrazolium chloride following the modified Thalmann method (Benito et al., 2003).

All results reported in the text were determined daily, and were the means and standard deviations of determinations made on three replicates. Correlation analysis of each parameter for determining the composting cycles of different runs was per-

Table 1
Characterization of the resource materials and the compost products.

	Moisture content/%	pH values	OM/g kg^{-1}	TOC/g kg^{-1}	TKN/g kg^{-1}
Resource materials	60.00 ± 1.49	6.83 ± 0.28	743.8 ± 26.3	462.5 ± 19.7	9.2 ± 0.6
Compost products					
Run A	58.60 ± 1.38	7.10 ± 0.31	315.1 ± 12.0	176.4 ± 6.2	7.8 ± 0.4
Run B-1	58.80 ± 1.24	7.22 ± 0.25	329.3 ± 10.9	180.0 ± 7.5	7.7 ± 0.3
Run B-2	58.40 ± 1.22	7.22 ± 0.27	312.2 ± 11.4	175.2 ± 8.1	7.5 ± 0.3
Run C-1	59.10 ± 1.38	7.27 ± 0.33	304.3 ± 10.1	173.4 ± 6.8	7.9 ± 0.4
Run C-2	59.70 ± 1.61	7.13 ± 0.25	291.3 ± 11.4	164.4 ± 5.8	7.6 ± 0.3

Means and standard deviations of nine replicates (each three replicates from three replicated runs) are shown. OM, TOC and TKN parameters are based on 105 °C dry weight. OM, organic matter; TOC, total organic carbon; TKN, total Kjeldahl nitrogen.

formed on the software of SPSS 16 (SPSS Inc., Chicago, IL, USA). A Dunnett *t*-test with SPSS 16 (SPSS Inc., Chicago, IL, USA) was applied to the significance analysis of the composting cycles of five different runs.

3. Results

3.1. pH and moisture content

In conventional composting processes, a decline of pH value was generally detected in the initial several days, and was considered as the result of acids produced by some mesophilic microbes. Though the same phenomenon occurred in the four CTC runs, the pH value only declined in the first day in runs B-1 and B-2 and in the first two days in runs C-1 and C-2 while the pH decline lasted 4 days in run A. And much higher peak pH values were detected in the four CTC runs. However, pH values in the five runs shared a similar changing trend and finally decreased to the steady values of 7–7.3, in the range of satisfactory pH values of 7–8.5 that Masó (Masó and Blasi, 2008) claimed.

Moisture content of 15–30% in mature bio-compost is the usual value established in Chinese regulations. However, the moisture content was maintained at about 60% to provide a suitable environment for growing microbes in the present study. According to the regulations, the products may need a drying before packed.

3.2. Temperature

Temperature is deemed to one of the most important factors affecting the microbial growth and the composting progress, and 50 °C was usually considered as the demarcation of thermophilic phase or mesophilic phase in composting process, as well as the mesophile and the thermophile (Williams, 1975). In this study, the temperature was under strict control and showed the main difference in physicochemical properties between the five runs (Fig. 1). The conventional high-temperature aerobic composting process of run A was set as a control group, and the incubator temperature was maintained at 30 °C, a similar value to local summer room temperature. The peak temperature in run A was only 56.6 °C due to the bench-scale pile. However, the T phase of run A still lasted 82 h, and the composting cycle of 28 days matched with our previous studies. The CTC method was applied to the remaining four runs with different control modes because of the needs of experimental contrast. Though runs B-1 and B-2 was placed in an incubator under constant temperature of 50 °C at the beginning of composting, temperature in run B-1 changed naturally without further control and temperature in run B-2 was controlled under 60 °C by increasing the amount of ventilation. The incubator temperature of runs C-1 and C-2 was set at 40 °C based on the consideration that a reasonable buffering time should be given to the thermophilic microorganisms for switching from a low activity at room temperature to a high activity at high temperature. Run C-1 was operated as run B-1 sequentially, and run C-2 as run B-2. To investigate the stability of mature compost at room temperature, the authors brought the temperature in the four CTC runs down from 50 °C to 30 °C in the last 30 days, and observed no obvious changes in temperature.

3.3. TOC, TKN and C/N ratio

A high initial TOC value of about 45.3 g kg^{-1} (dry weight) in resource materials (dry weight) was measured in this study. TOC values descended quickly in the first ten days and stabilized at about 17 g kg^{-1} (dry weight) at the end of the processes. However, the five runs presented different speed of TOC drop (Fig. 2a) as it decreased the fastest to the stable values in run B-1 while it was the slowest in pile A. And run B-1 possessed the highest TOC value after having decreased to the stable value while pile C-2 had the lowest value and the others reserved a similar TOC value.

Low TKN value of 9.2 g kg^{-1} (dry weight) was detected in resource materials, and decreased slowly to stable values between

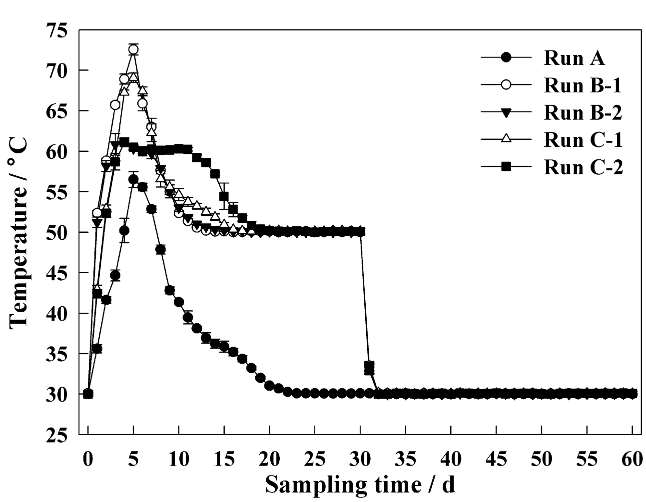

Fig. 1. Curving lines of average temperature in the five triplicated runs.

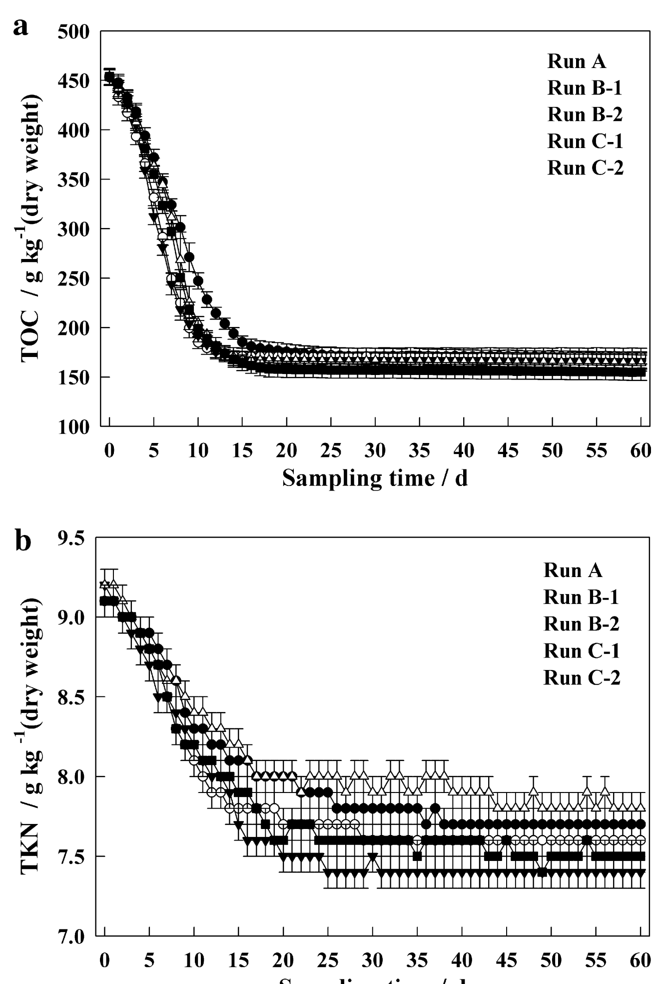

Fig. 2. Daily changes of total organic carbon (TOC) (a) and total Kjeldahl nitrogen (TKN) (b) in the five triplicated runs.

7.5 g kg^{-1} and 8 g kg^{-1} (dry weight) in about 20 days in the five runs (Fig. 2b). At the end of composting, run C-1 reserved the most TKN in compost and run A reserved the second-most TKN while run C-2 reserved the second-least TKN and run B-2 reserved the least TKN. Because of the similar stable values of TOC and the low TKN values with small differences in the five runs, the C/N ratio of the five runs formed similar curves the TOC and stabilized at 21–24 in 20 days. In China, the general value of C/N ratio in mature compost is within the range of 20–25 because of the unique liestyle, higher than those in western countries.

3.4. Germination index

Though some researchers (Paredes et al., 2005; Cunha-Queda et al., 2007) have reported that the compost with GI values greater than 80%, even as low as 60%, is phytotoxin-free and completely mature, the authors considered it a mature compost with a higher GI value of 90% that Ko (Ko et al., 2008) recommended. GI of cabbage increased from about 10% in the non-composted MSW to higher than 90% in the MSW composted for 26 days in run A, 16 days in run B-1, 17 days in run B-2, 19 days in run C-1 and 21 days in run C-2, respectively (Fig. 3). No significant changes of GI values were detected after 40 days of composting in the five runs. That all samples have a GI greater than 98% at the end of composting indicates phytotoxin-free compost and, as a consequence, its application would not injure plants.

3.5. DOC and SOUR

The growth of microorganisms requires soluble substrates, and the index of DOC reflects how much substrate left in the composting pile for microbes growth, therefore, a stable low value of DOC is usually used as indication of a mature compost (Gomez-Brandon et al., 2008) since little usable organic matter (or DOC) left in the mature compost pile will significantly reduce the growth and the activity of heterotrophic microbes. In this study, the initial DOC concentration in the compost materials was as high as 46.5 g kg^{-1} (wet weight) but the manner how the DOC changes during the composting process was similar to each other for the five runs examined (Fig. 4a). DOC decreased sharply in the initial stage to below 10 g kg^{-1} (wet weight) within 15 days in five runs and, consistent with previous reports (Wu et al., 2000; He et al., 2001), reached a level below 5 g kg^{-1} (wet weight) towards the end of maturation, proving the feasibility of DOC standard of 5 g kg^{-1} (wet weight) for mature compost.

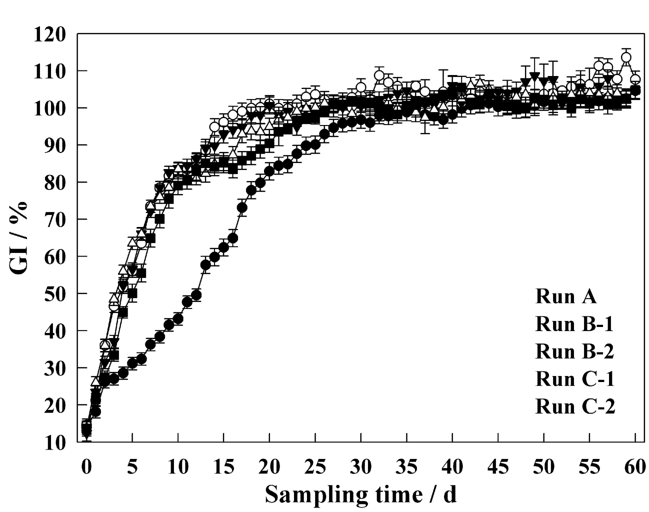

Fig. 3. Daily changes of germination index (GI) in the five triplicated runs.

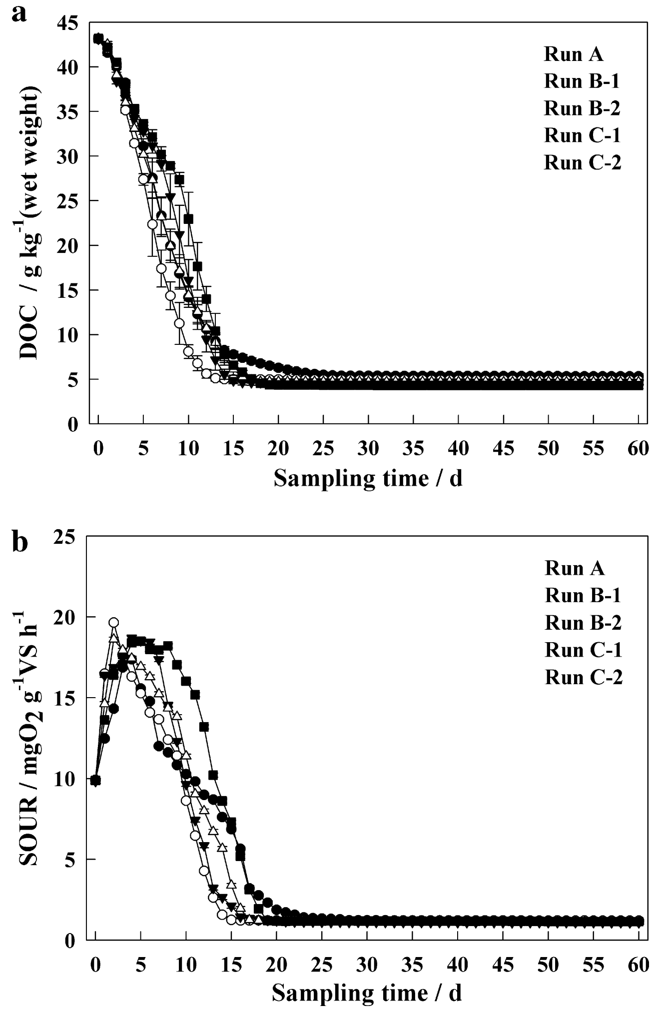

Fig. 4. Daily changes of dissolved organic carbon (DOC) (a) and specific oxygen uptake rate (SOUR) (b) in the five triplicated runs.

The aim of the SOUR test is to measure the maximum oxygen consumption rate that may be exhibited by the sample under ideal conditions, when the only limiting factor is the amount of assimilable carbon. And many previous reports (Lasaridi and Stentiford, 1998; Said-Pullicino et al., 2007) have proved it a useful index for compost stability assessment by evaluating the amount of readily degradable organic matter still present in the sample. In the study, the SOUR of compost materials rose quickly from the initial about 10 $mgO_2\ g^{-1}$ VS h^{-1} to the peak value of 17.40 in run A (4th day), 19.68 in run B-1 (2nd day), 18.72 in run B-2 (4th day), 18.64 in run C-1 (2nd day) and 18.52 in run C-2 (5th day), thereafter the SOUR decreased fast to a low level of below 2 $mgO_2\ g^{-1}$ VS h^{-1} in runs A, B-1 and C-1 in 20 days while it stayed at a high level (SOUR value above 16 after the peak) for more than 3 days (run B-2) or 5 days (run C-2) (Fig. 4b). No obvious change of SOUR was detected in the four CTC runs after the temperature of the incubator was adjusted from 50 °C to 30 °C. At the end of composting, the final SOUR values in the five runs varied from 1.12 $mgO_2\ g^{-1}$ VS h^{-1} (run B-2) to 1.23 $mgO_2\ g^{-1}$ VS h^{-1} (run B-1), in accord with the low SOUR level of about 1 $mgO_2\ g^{-1}$ VS h^{-1} that Lasaridi (Lasaridi and Stentiford, 1998) claimed.

3.6. Dehydrogenase activity

Previous reports (Benito et al., 2003; Tiquia, 2005a; Barrena et al., 2008) have demonstrated that DA is an easy and rapid parameter to monitor compost maturity. The decrease of DA to low levels towards the end of composting indicates that less active decomposition is going on within the composting windrow and the compost is getting mature. The DA in the five runs increased rapidly from about 0.75 to the maximum of 2.87 (run A, 6th day), 3.59 (run B-1, 3rd day), 3.38 (run B-2, 4th day), 3.42 (run C-1, 3rd day) and 3.29 (run C-2, 3rd day) mgTPF g^{-1} (dry wight) d^{-1}, respectively (Fig. 5). And then, the DA declined gradually in runs A, B-2 and C-2. However, about 30% of the DA lost in runs B-1 and C-1 when the temperature was above 60 °C, and some of the DA recovered as the temperature decreased to about 60 °C, before its rapidly decline. A relatively high DA was detected in runs B-2 and C-2 while the windrow temperature was controlled around 60 °C. During the decline of DA in run A, a phenomenon somewhat anomalous appeared that was, the DA almost maintained at a stable level when the temperature dropped to the range of 41–35 °C. The DA declined to 0.4–0.5 mgTPF g^{-1} (dry wight) d^{-1} in less than 20 days in the four CTC runs while it took about 30 days in run A.

3.7. Composting cycles

In the study, the compost maturity was evaluated with five indexes of C/N ratio, GI, DOC, SOUR and DA, and the mean composting cycles with standard deviations of the five triplicated runs were sequentially determined by comparing the index values in this study with those previously reported (Table 2). The Dunnett *t*-test of the composting cycles of five different runs showed that the four CTC methods differed from the conventional composting method significantly at a significant level of 0.01 while they differed from each other significantly at a significant level of 0.05. The correlation analysis of the five indexes showed that the SOUR, GI, DA and DOC shared high correlation coefficiences (>0.97) at the significant level of 0.01 in determining composting cycles while they were under 0.9 for index of C/N ratio, which suggested C/N ratio an inaccurated index for evaluating compost maturity or determining composting cycle. That the highest correlation coefficiences (>0.98) of SOUR in determining composting cycle indicated SOUR test a precise method for compost maturity determination.

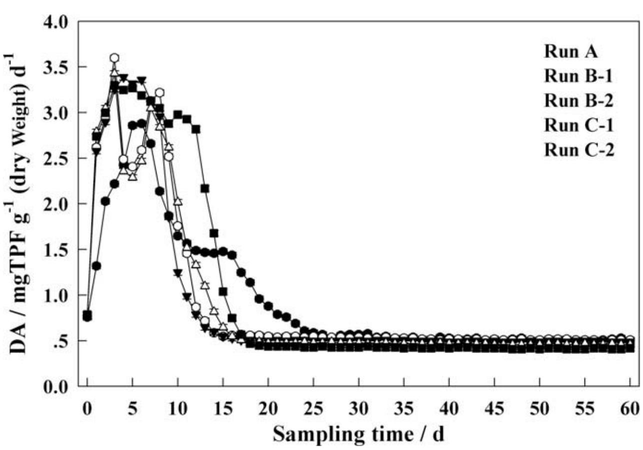

Fig. 5. Daily changes of dehydrogenase activities (DA) in the five triplicated runs.

Table 2
Composting cycles (*d*) of the five triplicated runs determined by C/N ratio, germination index (GI), specific oxygen uptake rate (SOUR), dissolved organic carbon (DOC) and dehydrogenase activity (DA).

	A	B-1	B-2	C-1	C-2
C/N ratio	20 ± 1.4	14 ± 0	16 ± 0	17 ± 0.5	18 ± 0.5
GI	27 ± 1.4	14 ± 0	16 ± 0.8	17 ± 0.5	19 ± 0.5
SOUR	27 ± 0.5	15 ± 0	17 ± 0.5	18 ± 0	19 ± 0
DOC	28 ± 0.9	14 ± 0.5	15 ± 0.5	17 ± 0	18 ± 0.5
DA	32 ± 0	13 ± 0.5	16 ± 0	18 ± 0.5	19 ± 0
Composting cycle	28 ± 0.9	14 ± 0	16 ± 0	18 ± 0.5	19 ± 0

Means and standard deviations of the composting cycles of each replicated run are shown.

4. Discussion

Some reports indicated that, following by increasing temperature, bacterial activities would grow continuously until 58 °C, and the diversity of bacteria increased even when temperature was higher than 60 °C (McKinley and Vestal, 1985; Tiquia, 2005b). Unpublished study in our laboratory detected abundant bacterial diversity when the temperature was as high as 64 °C, and also found that most of bacteria growing under the condition belonged to the genus of *Bacillus*. Some studies showed that microbes in the T phase played a major role in organic substrates degradation and degraded more than 2/3 of lignin degraded during the composting process while the mesophilic microbes mainly degraded those readily degradable materials in the S phase or humified materials left in the C or M phase (Tuomela et al., 2000; Mayende et al., 2006; Wang et al., 2007; Yu et al., 2007). Based on the comprehension of previous reports, the authors deduced that the thermophilic microbes could metabolize most of organic materials as the mesophilics did in the S or C or M phase. The authors also summarized that the S, C and M phase might not be necessary parts of a composting process, and the composting cycle could be shorten if a compost windrow was heated artificially to make a suitable condition for the growth of the thermophilics.

In this study, the authors compared the composting cycles and the compost quality of five different processes (run A, B-1, B-2, C-1 and C-2) to exploit more effective composting techniques by controlling the temperature in the forced aeration system. Meanwhile, the authors applied five frequently used indexes of C/N ratio, DOC, SOUR, GI and DA to monitor the composting process of MSW since no standard could unify the compost maturity and stability, and the authors defined the composting cycles of the five runs by comparing the values of the five indexes in this study with those recommended by previous reports, respectively. The C/N ratio was not taken to evaluate the cycle in run A since it provided too short a cycle, which indicated the risk of evaluating the compost maturity with the only index.

The foregoing results clearly showed that the cycle of conventional high-temperature aerobic composting, run A, was 28 days, matching the results of many previous studies conducted in or out of our lab, and the four CTC processes had shortened the composting cycle from 8 days (run C-2) to 13 days (run B-1). This indicated that the different curving lines of temperature in the five runs varied the microbial diversity and activity in the piles, and consequently the rate and degree of the materials degradation. The mechanisms how the CTC method accelerated the degradation of organic materials and promoted the compost maturing could be investigated by analyzing the differences on the changes of various indexes in different runs.

The authors summarized that pH values in a CTC process must be more suitable for the growth of microbes since Sundberg (Sundberg et al., 2004) reported that most aerobic microbes in compost grew better in an alkalescent pH condition. Most thermophilic microbes propagated quickly in a CTC process as the temperature was rapidly increased to 50 °C artificially, which consequently restrained the growth of mesophilic anaerobic microbes and reduced the yields of organic acids, avoiding a pH value drop. Many studies also have showed that alkalescent pH values are advantageous to activity expression of some important enzymes, such as cellulase and ligninase. So, the CTC method can speed up the degradation of cellulose and some other organic materials to achieve better effect on carbons mineralization in very short time than a conventional composting does, which has been confirmed with similar TOC content in mature compost in the five runs.

The microbial activity might have increased continuously along with the temperature rising in the compost windrow, and the maximum temperature for activity increase would be higher than 58 °C or 60 °C that reported before. In this study, DAs in the four CTC runs increased faster than that in the conventional one, along with the temperature rising, and the highest DA in a CTC process was also higher than that in a conventional run, which indicated the contribution of high temperature to improve the microbial activity. Though DAs significantly decreased in runs B-1 and C-1 when the temperature exceeded 60 °C and high DA was maintained in runs B-2 and C-2 where the temperature was controlled at about 60 °C, the authors still believed that a composting process, without temperature control, might embody higher microbial activity since TOC contents in runs B-1 and C-1 were similar to the other runs and runs B-1 and C-1 matured faster comparing to runs B-2 and C-2, respectively, which also suggested us that the index of DA was not suitable for monitoring the activity of the thermophilics under room temperature with underestimate of microbial activity.

In addition, most of the thermophilic microbes may possess a strong temperature tolerance and can recover its higher activity under high temperature from lower activity under room temperature. In the present study, the authors set the incubator temperature in runs C-1 and C-2 at 40 °C for one day before raising it to 50 °C for the consideration of giving some buffer time to the thermophiles. However, it was proved to be unnecessary since that higher SOUR values and DAs was detected in runs B-1 and B-2 comparing to runs C-1 and C-2, respectively, and less days were required for compost maturation in runs B-1 and B-2. Thus, the authors conclude that many mesophiles have propagated during the buffering time, interfered the thermophiles rapid recovery and thus prolonged the cycles.

Based on the fact that no obvious changes in physicochemical properties and DA were detected after the temperature in the incubators of the four CTC runs had been set at 30 °C from the 31th day, the authors presumed that the thermophiles would be the potential replacer of the mesophiles for organic matter degradation and compost maturation.

5. Conclusion

Based on the research results, the authors concluded that a CTC method could apparently shorten the composting cycle without a compost product quality degradation and suggested a method for rapid degradation and maturation of MSW as follows: rapidly heat the composting materials to 50 °C and maintain the surrounding at that temperature point during the whole composting process, provide suitable amount of air and water and turn over the pile daily. Applying the method for composting, a cycle could be shortened to 14 days and better products could be expected, except for lower TKN. In addition, the SOUR test was recommended as a precise method for compost maturity evaluation. However, further work should be conducted to analysis the mechanisms of microbiograms and optimize the techniques to reduce the energy consumption in the process.

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