

The effects of a bulking agent and aerobic system on chicken manure composting using “Serial self-turning reactor (STR)” technology

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Abstract:

This research aims to evaluate the roles of a bulking agent as recycled compost and aerobic system in a composting technology called “serial self-turning reactors (STR)”, using chicken manure as a substrate input. Group A was composted with sawdust in the partial aeration. While group B was processed with a forced aeration at 0.5 lit/min/kg organic matter, and the recycled compost was added beside sawdust. Each group was tested at different C/N ratios caused by different mixing ratios. The temperature was recorded every 5 minutes at 3 positions: middle, bottom and wall area of each reactor. The compost with group A did not meet the pathogen requirements in any cases and the temperature simply followed ambient temperature. Conversely, the temperature in all cases of group B rose up. Only 2 in 3 cases in group B met the thermophilic phase. And the other case, which did not reach into thermophilic phase, started with the largest amount of sawdust. Recycled compost provided the suitable porosity and maintained the beneficial microorganisms by supplying oxygen from the airflow.

Keywords: Composting; STR system; chicken manure; bulking agents; aerobic system

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1. Introduction

Due to the massive increase of chicken farms in Thailand, chicken manure has caused heavily polluted environment, such as, fly control, odors, urban encroachment and limited land for manure disposal. The untreated chicken manure has the long-term potential to rise human and animal health risks, odors, also leach nitrates and other toxic pollutants into groundwater. However, composted chicken manure increases the N, P, K, Ca and Mg concentration as a good fertilizer (Duncan 2005). The composting process is one of the best-known process for the biological stabilization of solid organic wastes by transforming them into a safer and more stabilized material, which can be used as a source of nutrients and soil conditioners in agricultural applications (Haga 1999). Thus composting chicken manure is the suitable way to turn untreated chicken manure to an applicable soil amendment. Bulking agents and aerobic system are major keys to control the composting factors. Bulking agents are the very effective to control the air supply, moisture and other composting parameters (Haug 1993). Moreover, the efficiency and usefulness of suitable bulking agents are the great prominence, which results in pollution control and economically sound (Batham, Gupta et al. 2013). Chang and Chen (2010) also reported that bulking agents like rice husk, sawdust, peanut shells and straw increased the degradation and resulted a very good quality compost and food waste. Therefore, environmental conditions as bulking agents and oxygen supplies that maximize microbial activity will maximize the rate of composting.

Thammasat University (TU) has been the pioneer in organic waste disposal technology for small communities by using the STR technology since 2005. Due to the over odor control of chicken manure at chicken farms, STR technology is considered as the suitable solution (Sungsomboon, Chaisomphob et al. 2013). Chicken manure is the next step to approve the effective of the STR composting to small communities in term of the odor control. The STR technology requires low fixed cost and low operating cost because of using the gravity. Interestingly, only two unskilled workers can control the whole system. The STR operation process, which is demonstrated in Fig. , had some potential changes to be the safest, simplest and easiest method to handle. The aim of the present study was to investigate the role of a bulking agent (recycled compost) and aerobic system, which was tested in the STR system at different mixing ratios through two experiments.

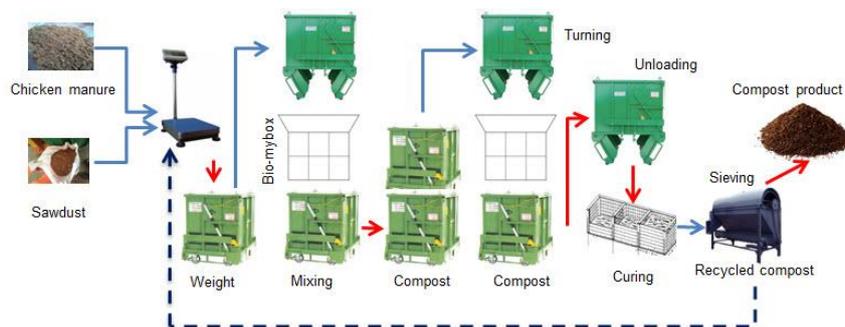


Fig. 1 STR operation process of the chicken manure.

2. Materials and methods

2.1 Composting materials

Chicken manure (CM) was taken from a chicken farm of Laemthong cooperation group. All chicken manure was collected on the same day with the experiment. Sawdust (SD) as a carbon resource was obtained from sawmills in Pathumthani. The recycled compost (RC) was used as a bulking agent and a main factor to increase the porosity to allow the air to go through inside the reactor. The C/N ratio is the mainly concerned factor of the substrates and bulking agent shown in Table

Table 1 Properties of mixing materials

Parameter	Chicken manure	Sawdust	Recycled compost
C/N ratio	5.96	309.99	13.05
Moisture content [%]	65.00	11.54	30.19
Total Nitrogen ^(a) [%]	1.79	0.13	0.76
Total Organic Carbon ^(a) [%]	10.66	40.30	9.92

^(a) = Dry weight basis.

Table 2 Mixing proportions of cases

Description	Experiment 1			Experiment 2		
	[F-1]	[F-2]	[F-3]	[S-1]	[S-2]	[S-3]
CM : SD : RC	1:0.5:0	1:0.75:0	1:1:0	1:0.5:0.5	1:0.75:0.5	1:1:0.5
Moisture [%][mass based]	65.00	65.00	65.00	65.00	65.00	65.00
Aeration rate [lit/min/OM]	0.00	0.00	0.00	0.50	0.50	0.50
Organic matter ^(a) [%]	55.55	65.32	72.66	46.62	55.22	62.09
Total nitrogen ^(a) [%]	1.26	1.11	0.99	1.13	1.03	0.95
C/N ratio	22.06	29.48	36.54	20.55	26.79	32.77
Chicken manure ^(b) [kg]	709.62	655.49	609.04	586.81	549.30	516.30
Sawdust ^(b) [kg]	140.38	194.51	240.96	116.08	163.00	204.27
Recycled compost ^(b) [kg]	0.00	0.00	0.00	147.10	137.70	129.43
Water should be added [kg]	214.43	297.11	368.08	323.63	385.93	440.75

^(a) = dry weight basis

^(b) = wet weight basis

2.2 Composting set-up

Two groups were tested following the principle of the STR process. Group A was composted with sawdust as a bulking agent in the partial aeration, which was not supported by any forced aeration. Conversely, group B was processed with the appearance of sawdust, recycled compost and air systems. Each group was checked at three different mixing ratios among chicken manure (CM), sawdust (SD) and recycled compost (RC) in term of dry weight. With the high level of carbon,

sawdust was the controller to change C/N ratios. Three cases of group A are named F-1, F-2 and F-3, corresponding to the mixings of CM, SD as 1:0.5, 1:0.75 and 1:1. Similarly, three mixings of CM, SD and RC as 1:0.5:0.5, 1:0.75:0.5, 1:1:0.5 were labeled S-1, S-2 and S-3 respectively in group B. Details of mixing proportions are shown in Table 2. The composting temperature and also ambient were recorded by data logger and thermal copper. Three positions inside reactors were observed: Bottom: 20 cm to the bottom of reactors, wall: 20 cm to the bottom near dead wall zone and middle: the middle of the reactors.

3. Results and discussion

The activity of microbes is governed by the rise and fall in temperature. For this reason, temperature has become the most important factors in the composting process. Fig. a, b and c show the recorded temperature in group A without supports from air systems and the recycled compost in the first period. Also Fig. d, e and f indicate the temperature result in the second test by adding the recycled compost in the aerobic composting system.

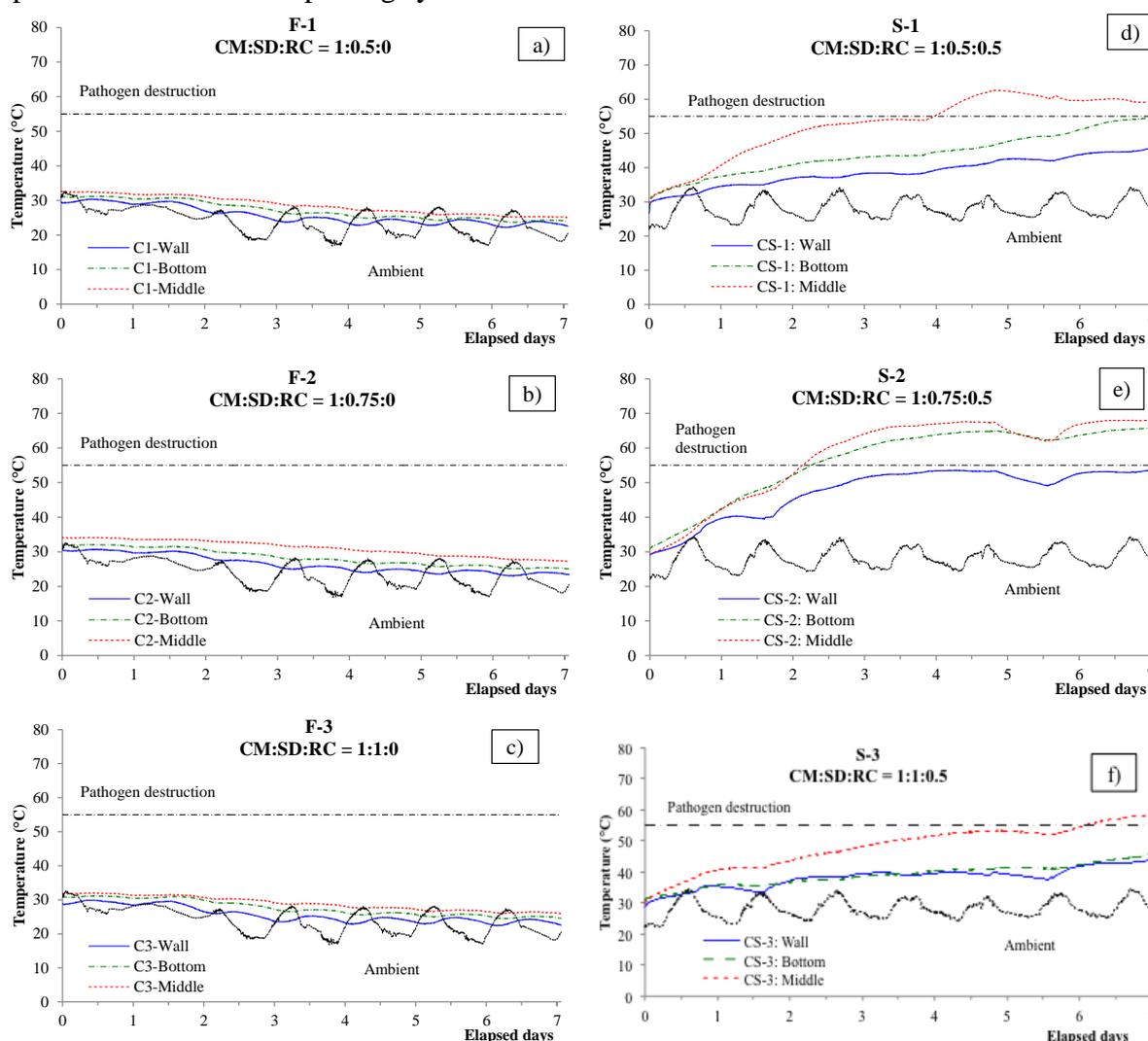


Fig. 2 Temperature profiles in the first period.

The general trend in group A is the fluctuation in temperature of all cases (F-1, F-2 and F-3) following the ambient temperature. The ambient temperature was about 30°C at daytime and 20°C nighttime. Furthermore, there was no difference in temperature at all mixings between CM and SD. The temperature seemed to fall down slowly during the first 7 days of composting. The gap between recorded temperature and pathogen destruction level was large range. However, the

materials were dry on the top of each compost mixtures and helped to avoid the odors. The other areas did not change the properties. Meanwhile, the helpful microorganisms were not active in the environment without the support of the recycled compost and aerobic system. As far as the recycled compost and the aerobic system were concerned during the second experiment of the first period, the composting materials went through the three typical degradation phases: Mesophilic, thermophilic and curing. The mixings of 1:0.5:0.5 and 1:0.75:0.5 (CM:SD:RC) as is shown in Fig. d and Fig. e indicated the significant increase in temperature. The compost mixtures were treated in the thermophilic phase and remained long time enough to kill the harmful pathogen. The other case, 1:1:0.5 (CM:SD:RC) as Fig. f, did not reach the pathogen destruction level (55°C) at the wall bottom area, neither maintained in thermophilic phase long time enough to meet the pathogen requirement. This is mainly because of the absence of microbes so that the substrate could not be broken out. Obviously, these microbes were supplied oxygen by the air system, and recycled compost provides the air space to allow the movement of oxygen.

To find the best mixing in chicken manure composting, group B showed that the best mixing ratio among CM:SD:RC should be 1:0.75:0.5. The temperature profile from Fig. f indicated the satisfaction in pathogen requirement at the bottom and middle layers. The temperature reached the thermophilic phase at the day 2 and kept remains during the last 5 days before turning. The other positions did not reach the pathogen destruction. The recycled compost contains a high percentage of microbes and becomes the key factor to speed up the composting process. Furthermore, this STR technology proved advantages itself, such as, producing the well mixing materials, using less energy and human resources.

4. Conclusion

The temperature in all three cases in group B (F-1, F-2 and F-3) went up and maintain in thermophilic regime. But, the first batch (S-1, S-2 and S-3) without the appearance of recycled compost and air system did not show the increase in temperature. Thus, aerobic system plays the important role to help microbes survive. Also, bulking agents plays the support role to make the reasonable space for air movement.

The recycled compost has the neutral C/N ratio. Therefore, the amount of recycled compost does not affect the initial C/N ratio of compost mixtures. From two experiments, the role of recycled compost is to provide the suitable air space at all positions and accompany well to the aerobic system to create the best environment for activities of microorganisms. Also, this combination has sped up the rate of composting process. STR has proved the advantages itself when creating the well-mixing mixtures and proceeding long time enough for the final composting product.

5. References

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