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Evaluation of Rotary Composting Technique for Animal Wastes

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Abstract: In order to investigate the compost process and the evaporating phenomenon, a rotary reversing compost system has been tested in a swine farm. During the summer season, the compost temperature was varied in the range of 50~60 ℃ and the ash content was increased by 12.8 % with the average of 24.7 % at the end of phase. In the winter season, the compost temperature was varied in the range of 40~57 ℃ and the ash content was increased to 8.5 % showing the average of 18 % at the end of phase. In summer, the compost facility could handle all of the animal waste, but it could not handle 1/4~1/3 of the animal excrement during the winter. The required amount of sawdust by this method could be reduced to 1/3 than that of the mixing method at the beginning of compost process.
Keywords: Animal Wastes, Composting, Rotary Composting Technique

Introduction

The management of animal wastes gets more meaning in the animal production because of its environmental effect. The number of pig farms in Korea has been radically reduced from 133 thousand farms in 1990 to 24 thousand in 1999. The main reason is the increased cost to meet the environmental regulation. Generally, the manure is treated separately as dung and urine in pig production. However, for the mixed manure, a slurry method is widely applied to the swine farms since it can save the labor. This method is premised on spreading in the land after storage period. In case of the swine farms, they separate the slurry with a separator and the solid part is composted, the liquid purified since they have hardly a spreadable land themselves. However, this treatment requires a high maintenance cost so that a normal farm can not easily perform. Another composting technique utilizes fermentation of the slurry and partial evaporation of the moisture. The advantage in this method is that there is no discharge of waste water. The composting technique is usually used to ferment the dung only, but a slurry with high moisture content also used by mixing with sawdust as a bulking agent. It needs so much sawdust because of high moisture content of slurry and in case of lesser use of sawdust it is not fully composted. Therefore, it is investigated to examine the composting process according to the seasons and to find a way of saving the sawdust.

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Materials and Methods

The test is done in a pig farm located in Anseong, Kyunggi province. This farm is raising 2200 heads of swine. In the fattening stall, the animal waste is treated as a slurry and in the other stalls for sows and piggys, the manure was treated separately with scraper. After the urine and the waste water are gathered in a storage tank, they are spread on the composting pit to evaporate the moisture during the summer and spread on the land during the winter. The farm possesses land of 3 ha. It is also spread on the grassland of neighborhood. The capacity of underground pit of slurry stall is about 190 m^3 and there are 3 tanks for urine and waste water and each has a capacity of 54 m^3.

The composting machine is consisted of rotary, forward removal and turning equipment, and tank for slurry spreading. The rotary turns the material out. For forward and turn, each has 2 motors connected with 2 reduction gear. The tank and discharger on the machine rotate very slowly to spread the slurry uniformly. As the outside temperature decreases at November, a blower works and stops for one hour by turns to evaporate the moisture. The motor of blower has 7.5 horse power and there is no extra warming facility.

If the rotary rotates 1 revolution by moving forward of machine, the materials removes about 70cm backwardly. The tank mounted on the machine has a capacity of 4 m^3. The machine turns 5 times in a week and it spreads 40 m^3 with one turn. The sample is taken from the middle part in 6 sites with an interval of a week (fig. 1, 2).

The sample is dried by using a dry oven at 104℃ for 24 hours to measure a dry matter content and the sample is burned in electric furnace at 700℃ for 3 hours to measure the ash content. Total organic carbon is calculated by the following equation (University of California at Berkeley, 1953).

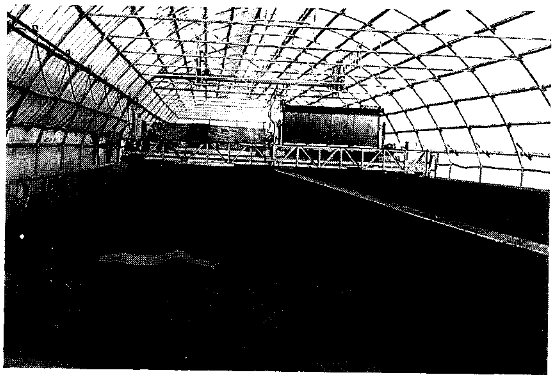

Fig. 1 View of the composting facility.

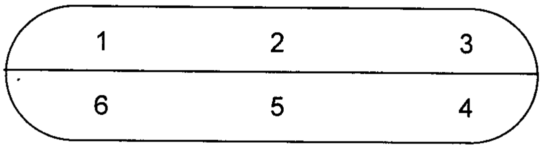

Fig. 2 Sampling sites in composting facility.

TOC (total organic carbon) % C
= (100 − % Ash) / 1.8

Because the material is on moving, the composting temperature is measured momentarily with the thermometer (Testo 452) in the middle part. The compost process is analyzed according to the seasons, hot and cold time. To calculate the amount of animal waste from the stall, the number of spreading time and the amount of discharge are examined.

Results and Discussion

1. Compost Process in Summer

The summer composting period continues from July to November. The sawdust was set down already in the pit and the slurry was mixed gradually. The sampling is started from the middle of August. The slurry, which was spread in the pit, has a moisture content of 85% and the sawdust has 24% moisture content. Although the measurement from 6 sites shows a wide variation, they could be regarded as a repetition. The moisture content of materials was 40~57% when the composting process was ended (fig. 3).

At the beginning of composting, the slurry is not fully mixed so that the variation of moisture content is big. The composting temperature, which implies the process of compost, reaches to maximum 70℃, but it shows 40~60℃ in all cases (fig. 4). During the test period, the composting process is going on smoothly. These curves were different from the generally known curve of composting temperature, which shows a trend

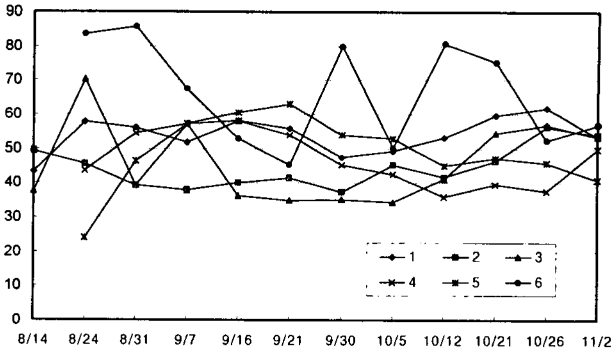

Fig. 3 Variation of moisture contents in summer (%).

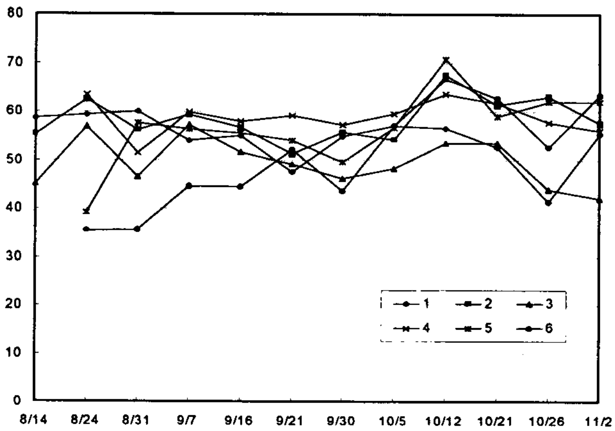

Fig. 4 Variation of composting temperature in summer (C).

of increasing temperature in the beginning, maximum temperature after 3~4 weeks and then decrease. The reason is that the composting is artificially prolonged because of periodical spread of a certain amount of slurry. The ash content shows a lower level and a significant variation because of great ratio of sawdust. But this content is gradually increased up to 20~30% as increasing the mixed slurry (fig. 5). From this fact, it is known that the organic matter is uniformly fermented through the microorganism. The decomposition of organic matter can be assumed by the TOC content, which was 43~56% at the beginning and narrows to 38~46% at the end period of composting (fig. 6).

2. Composting Process in Winter

The composting period in winter continues from the middle of November to February and sampling began from the middle of October. During the test period, the compost is going on, but it is not active as in summer. When the composting is ended, the moisture content of material was 56~59%. It was 3~5% higher than that of summer period and it means lesser

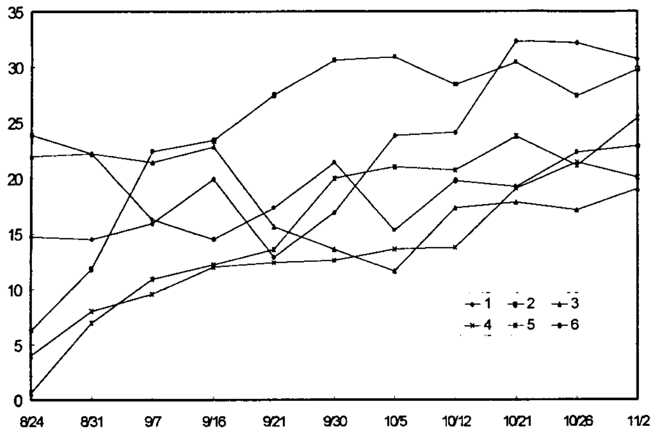

Fig. 5 Variation of ash contents in summer (%).

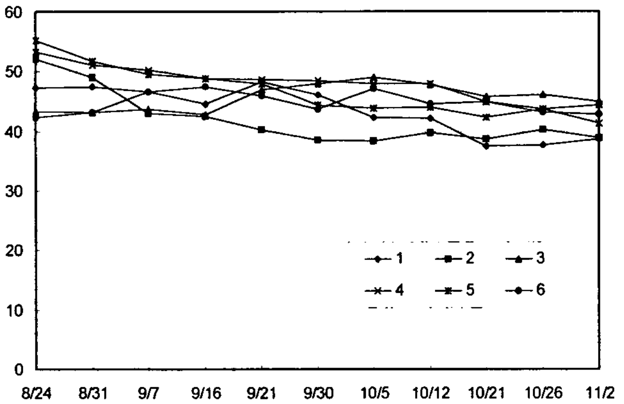

Fig. 6 Variation of total organic carbon in summer (%).

evaporation (fig. 7). The composting temperature shows 40∼57℃ and the increase of temperature is not significant. While the average temperature increases by 3.3℃ at the end of process during the summer, the temperature in winter decreases (fig. 8). Ikeda et al. (1990) reported that the composting temperature in winter was 7∼8℃ lower than that of summer. While the ash content in summer increases 12.8% and curve is steep, the increase in winter was only 8.5% due to the lower activity of microorganism. The organic decomposition was not done well (fig. 9). The curve of TOC content shows a slow decrease (fig. 10). The outside temperature in winter comes down so that the temperature of slurry was low. These are the factors to affect the process, which has not been supplied a sufficient energy. That is the reason why the composting process in winter is generally diminished than in summer. The variation of ash content shows a similar result from Kwak et al. (1996), who tested broiler dung and at the beginning the ash content was 19.1%, after 8 weeks it went to 26∼29%.

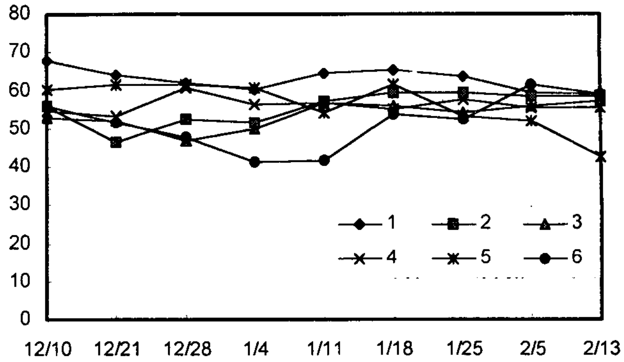

Fig. 7 Variation of moisture contents in winter (%).

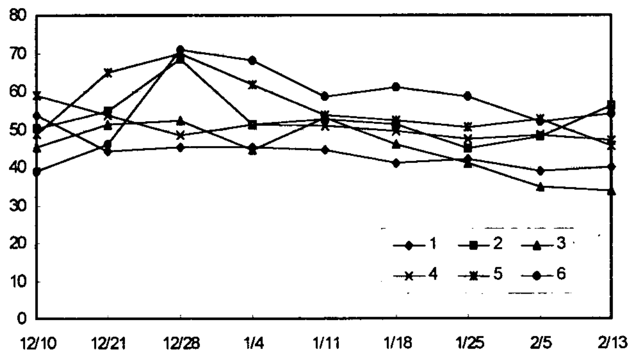

Fig. 8 Variation of composting temperature in winter (℃).

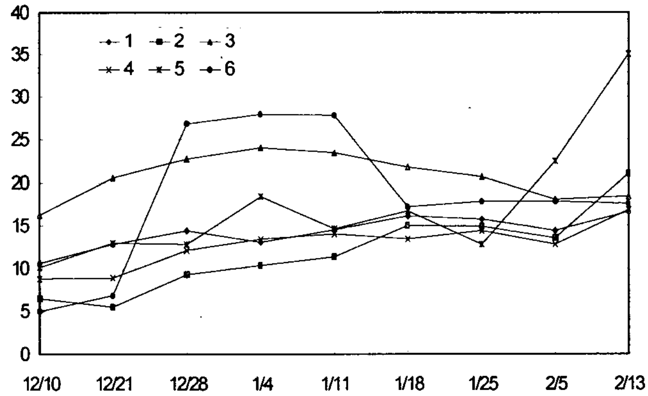

Fig. 9 Variation of ash contents in winter (%).

3. Moisture Evaporation and Required Amount of Sawdust

The amount of materials which composted in a pit differs somewhat in summer and winter. While the evaporation in summer has a surplus through the intensive sunshine, an additional blower has to be used to evaporate the moisture in winter. The urine and waste water couldn't be spread over the pit as well as some slurry in the winter time. With the low

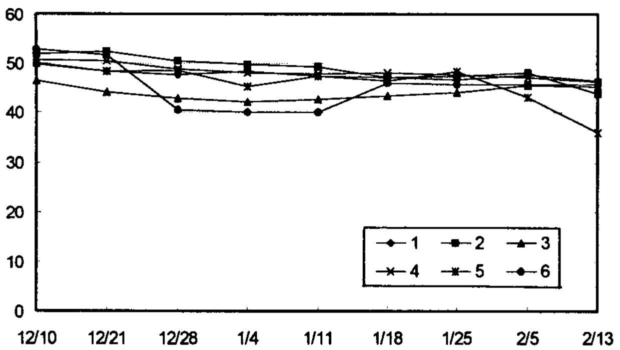

Fig. 10 Variation of total organic carbon in winter (%).

temperature, the addition of more waste water might cause a negative effect to the compost process. In the test period, there are variation of raising animal number and amount of feed intake, so that the precise calculation of produced manure and evaporation of moisture was not easily done. Thereafter by the analysis of data available, the capacity of facility couldn't be able to compost 1/4~1/3 of produced slurry in winter. The countermeasure for this farm in winter are followings: making sure of a tank with an enough capacity, which can storage the extra manure in winter and the tank content can be spread in spring, establishing an extra composting pit or heating system which supplies heat to the composting pit in winter.

The required capacity of composting pit is considered 0.28 m^3 per head to meet a condition of the moisture content of slurry, 90% and moisture of compost, 50% (Oh, 1994). In a farm scale of 2000 swine, a capacity of composting pit becomes 560 m^3. Therefore, the capacity is sufficient in summer, but in winter, it is necessary to have an extra capacity of about 20~30%. In the viewpoint of sawdust necessity, there are two cases to be considered. The first thing is that the slurry is mixed with the sawdust and then feeding the mixture into the pit. Another method is that the sawdust is set at first up in the pit and the slurry is mixed gradually with it as in this farm. When the moisture contents of slurry and sawdust are 90% and 25%, respectively, and 70% of moisture content of mixture is required, it is needed 17.8 ton of sawdust with composting of 40 m^3 slurry. When the density of sawdust is 0.25 ton/m^3, it becomes 71.2 m^3 per week. When the compost period is 4 months or 18 weeks, it needs totally 1,280 m^3 of sawdust. By the method, the sawdust is put down in the pit at first and then mixed with slurry, the area of composting pit is 530 m^2 with 0.8 m of height, the capacity becomes 424 m^3. In this way, the need of sawdust can be reduced to 1/3 of the first method.

In the composting of high moisture slurry, the high price of sawdust is the weak point. The model like this farm needs less amount of sawdust and results in economical management and improves the quality of compost. A dealer gives the sawdust to the farm and takes the compost for compensation.

4. Analysis of Compost Component

The chemical composition of slurry and compost for fertilizer are shown in table 1.

The sample of slurry is taken from the intermediate tank before throwing to the composting pit and has a moisture content of 80.4%. It is lower than the other cases because the capacity of the intermediate tank is small and sampling is limited.

The organic matter content of compost is more than 30% and is more than official standard. The ratio of organic matter versus nitrogen is also less than 50, the official standard. In comparing the 3 fertilizer component, N, P_2O_5, K_2O, P_2O_5 is somewhat higher than the general value. The official standard determines that the content of copper is less than 500 mg/kg, but the 435 mg/kg of compost 1 is relatively high though it is sufficient. The concentration of ammonia gas from the pit was 20~50ppm by a intermittently measurement, but it needs a more precise test. To maintain a proper moisture content is important in the composting. Composting the mixture of slurry with higher moisture content and insufficient amount of sawdust may not be successful. In other viewpoint, it should be considered the hygiene of compost product. To become extinct pathogenic microorganism, the composting temperature should be kept over 60℃ for several days. But in this case, the fresh slurry is spreaded continually, it is not fully composted and guaranteed for the safety of

Table 1 Chemical composition of slurry and compost for fertilizer

	H_2O (%)	pH	OM (%)	OM/N	N (%)	P_2O_5 (%)	K_2O (%)	Cu (mg/kg)
Slurry	80.4	9.3	15.3	11.3	1.35	0.96	0.63	199
Compost 1	52.4	9.1	34.6	23.7	1.46	3.39	2.07	435
Compost 2	57.2	9.2	31.1	22.2	1.40	2.79	1.47	345
Standard			>25.0	<50.0	>1.0*	1.5-2.0*	0.8-1.0*	<500

* Content range of compost.

hygiene. Therefore, before carrying out the compost materials, spreading the slurry should be avoided in 1~2 weeks.

Conclusions

This study was undertaken to examine the composting process according to season and evaporation effects with the slurry in composting facility.

1) The composting temperature was shown in range of 50~60℃ and the moisture content 43~59% in summer. The ash content was 24.7% in average which is increased 12.8% compared with that of beginning of composting.

2) In winter, the temperature at the end of composting was in range of 40~57℃ and the moisture content 43~59%. The ash content was in average of 18%, which was an increase of 8.5% than at the beginning.

3) In summer, all of the slurry which are produced could be composted in the pit, but in winter 1/4~1/3 of the slurry couldn't be treated.

4) The amount of sawdust necessity could be saved maximum 2/3 by the gradually mixing method than the mixing before the throwing the slurry into the pit.

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