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Reduction of Ammonia Emissions by Compost Biofilter from the Agitated Bed Composting of Hog Manure

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Abstract □ Manure compost biofilter for reducing ammonia emissions at the active stage of a semi air tight and agitated bed composting of hog manure amended with sawdust were evaluated in the practical composting plant(75 m× 5 m× 1.4 m deep). During 55 days of composting and biofiltration process, the manure compost biofilter had a ammonia reduction of 91 to 98%. Results showed that the active stage of composting maintained temperatures between 40 and 70℃ and fluctuated greatly the ammonia concentrations between 100 and 300 ppm. Ammonia concentrations in manure compost biofiltration reached within a moderate range (2~18 ppm).

Keywords □ High rapid composting, Manure compost biofiltration, Ammonia emissions.

I. Introduction

As the scale of livestock farms enlarged, the management of wastes became a serious problem. To prevent surface and underground water pollution, composting and waste water treatment are essential in Korea. But during these treatments, the harmful effect gases such as ammonia, methane and nitrous oxide are emitted. Methane and nitrous oxide emission are not so high and can be controlled with adequate treatment. A major problem in manure composting is the odor caused by the release of ammonia. Ammonia is a byproduct of aerobic composting of low C/N material. Ammonia gas is not only an example of an intense on site odor, but also represents a valuable nutrients loss of N from compost to be used for crop production (Kuroda et al., 1997).

Various studies have focused on ammonia control during manure composting. Elwell et al .(2002), Hong et al.(2000), Matsuda & Maeda (1997), and Hansen et al.(1989) stated that process conditions affected on the quantity of ammonia emission and demonstrated that the major controllable factors of C/N ratio, stirring frequency, aeration rate, particle size of amendment and recycled compost percentage greatly affected on the nitrogen loss during manure composting.

Ammonia emission was high at the early stage of composting till the 8th day and about 10 to 20% of the influent nitrogen was lost as NH_3 gas during swine feces composting (Osada et al., 1997).

Low-cost, open-bed agricultural biofilters that use mature compost and wood chips as a filter medium have been shown to reduce odor emissions from swine production facilities with minimal management control (Nicolai and Janni, 1999). Biofiltration investment and operating costs are lower than that of thermal and chemical oxidation processes (Govind,1999).

In the biofiltration process, live bacteria biodegrade organic contaminants from odor gas into carbon dioxide and water. In biofiltration, a number of factors are controlled so that microorganisms may absorb and decompose the ammonia efficiently. Temperature, moisture content, pH level, flow rate and surface loading rate and the physical structure of the biofilter are factors which influence the rate and efficiency of the biofiltration process. Biofilters operate most efficiently at a media depth range in the range of 40 to 60 cm for ammonia odor removal from composting (Hong et al., 2002), a moisture content in the range of 30 to 60% (w.b.) for compost biofilter to 40 to 70% (w.b.) for peat biofilters, and a temperature between 15 and 35℃ (Janni et al., 2000; Epstein, 1997).

Most previous research (Elwell et al, 2002; Hong et al, 2000) on control of ammonia emissions has been conducted with a bin composting manure system. Reducing ammonia emissions has received little attention in the rectangular agitated bed composting system.

The purpose of this research was to investigate the ability of manure compost biofilter to reduce ammonia emissions from the semi tight and agitated bed system at the early stage of composting within a period of 8 days.

The specific objectives of this research were:

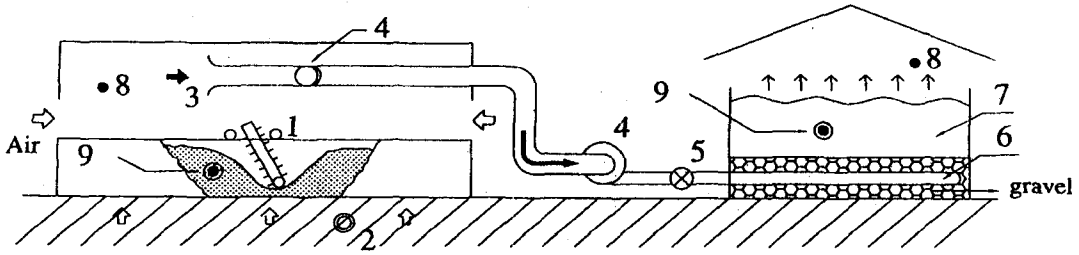
1. to evaluate the ammonia emissions of hog manure and sawdust combinations at the active stage of composting by day 8 in a continuous aeration and periodic turning.

2. to determine the effects of manure compost biofilter on ammonia control performance with respect to ammonia removal during biofiltration of ammonia emissions from the semi tight and agitated bed composting system.

Ⅱ. Materials and Methods

The agitated bed system combines controlled aeration and periodic turning. In this system, composting takes place between walls which form long, narrow channels referred to as a bed. A channel on top of each wall supports and guides a compost-turning machine. Raw materials as a fresh hog manure amended with sawdust was supplied from a N pig house at Suncheon-si were placed at the front end of the bed by a loader. As the turning machine moves forward on the rails, it mixes the compost and discharges the compost behind itself.

Fig. 1 illustrates the construction and mode of operation of the composting material on the agitated bed composting manure (left) and the matured hog manure compost/sawdust biofilter on the open bed biofilter (right). The full scale rectangular agitated bed composting vessel was 75m in long 5m in width and 1.4m deep. Blower (27㎥/min.) was connected to provide air to



1. Turning machine
2. Blower
3. Exhaust gas inlet
4. Turbo fan
5. Control valve
6. Exhaust gas distributer
7. Biofilter medium
8. Ammonia gas detector
9. Temperature sensor

Fig. 1 General layout of rectangular agitated bed composting (left) and open bed compost biofiltration (right) system

compost reactor. Exhaust gases from the agitated composting reactor were captured through the inlet of the discharge pipe (160 mm ID) by the turbofan. This exhaust gases pass through the control valve and biofilter media. The turning machine (6 kW) moves the materials 1.5m at each turning and the bed is 75 m long.

One run lasted 28 days for composting, about 75 m of the bed daily twice turning. The high rapid decomposition period is eight days and 25 m in length after composting. The odorous air is exhausted from composting manure through the two turbofan as shown in Fig. 1. Two turbo fan (2kW) moves the odorous air through a duct to a gravel zone beneath the biofilter media. The operating gas flow rate and surface loading rate of manure compost biofilter were about 0.84 m^3 /hr and 11.9 $m^3/(m^2 \cdot hr)$, respectively. An open biofilter media (right side) was a rectangular type (1.4m H× 5m W ×5m L) with 0.9 m thickness gravel base material. The distribution odor pipe to the biofilter media is 150 mm in diameter. A 150 mm (ID) pipe was divided into seven 80 mm (ID) pipes with small perforated hole (7 mm) in the bottom area of biofilter media to supply the odorous gas uniformly to the biofilter media.

This study examined the effects of manure compost mixed with sawdust biofiltration on ammonia from decomposition phase on the semi tight and agitated composting system. The data reported here are from this run begun on April 5, 2002 for 55 days. Fifty five days were conducted using manure compost biofilter. In each days, the controlled aeration and periodic turning mode was replicated using a full scale agitated compost reactor and an open bed biofilter.

Composting materials were made by turning machine mixing raw hog manure and sawdust. The resulting initial C/N ratio and moisture level were shown in Table 1.

The active stage of composting and biofiltration were performed within the first 8 days and 25 m in length (both side are closed wall by galvanized steel sheet) after composting, respectively.

Temperature of the material in the core of the

compost reactor and biofilter vessel was monitored using K-type thermocouples. Temperatures in compost, biofilter media and measured ambient air temperature were stored in note book twice every day through a thermo-recorder (TR-72).

Table 1 Characteristics of composting material and biofilter

	Compost	Biofilter
Moisture content,% w.b.	63.2-64.2	48.2-49.4
Carbon content, % d.b.	40.1-44.9	41.3-42.0
Total nitrogen, % d.b.	1.63-2.32	1.78-1.95
Carbon to nitrogen ratio	19.4-24.6	21.5-23.2
pH	6.4- 6.5	6.0-6.1

Ammonia concentrations of exhaust gas from the composting decomposition and the biofiltration process in each day were obtained for each compost reactor and biofilter vessel using a gas detector (GASTEC 801) at intervals of 12 hours. Ammonia concentration was measured at the center line of the 20 cm above from the top of compost and biofilter surface material.

The ammonia removal rate was determined by:

$$R = (I-O)/I \times 100(\%) \quad (1)$$

where,

R = ammonia gas removal rate (%)

I = inlet ammonia gas concentration (ppm)

O = outlet ammonia gas concentration (ppm)

Cumulative ammonia gas concentrations during composting and biofiltration in this study are not presented. Approximately 0.8 kg samples were collected from six arbitrarily selected points for each compost and biofilter vessel during the active stage of composting and biofiltration study. The samples were analyzed for pH, total nitrogen (T-N), total carbon (T-C), C/N ratio, and moisture content (MC) by a standard methods for soil chemical properties according to the Office of Rural Development (ORD, 1988). All analyses were carried out in triple.

Ⅲ. Results and Discussion

1. Temperature and Ammonia Concentration

Figures 2 and 3 show temperature and ammonia concentration during the active stage of composting and biofiltration process, respectively. Temperatures and ammonia emissions as shown in these Figures were monitored during

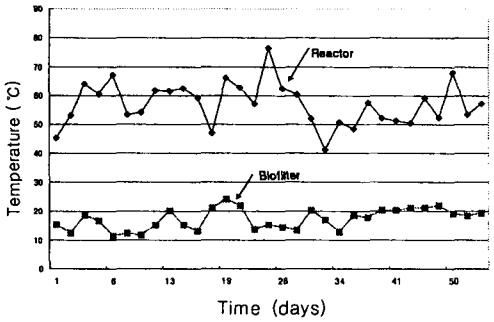


Fig. 2 Temperature in compost and biofilter (Each data point is the mean of three replications)

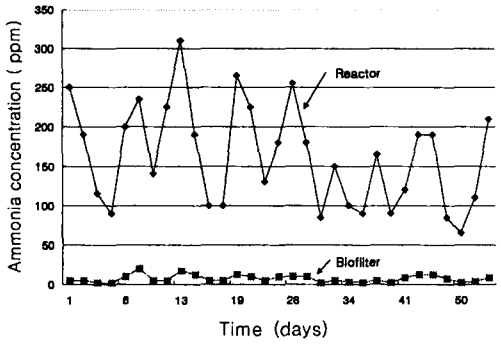


Fig. 3 Daily ammonia concentration from compost reactor and biofilter. Each data point is the mean of three replications

the active stage of composting (Reactor) and bio filtration (Biofilter) process everyday through thermo-recorder and gas detector, respectively.

The temperature of compost reactor was ranged from 41 to 68℃. From these Figures, it appears that optimal decomposition and biofiltration take place in the thermophilic range of 50 to 60℃ and 10 to 20℃, respectively. Temperature at 55℃ or above for at least 3 days is important in the destruction of pathogens in the compost materials.

The ammonia concentration in the compost reactor ranged from 65 to 310 ppm during the active stage of composting. Ammonia concentration levels in the exhaust gas from biofilter remained within a moderate range (2-20 ppm) and very low until around day 55.

Judging from the ammonia concentrations and the transition of temperature of the fresh compost reactor and matured manure compost biofilter during the biological process, it was found that there are no significant differences and nearly the same pattern in ammonia concentration and temperature during the composting decomposition and biofiltration process.

Fig. 4 shows ammonia removal rate during the manure compost biofiltration process, The

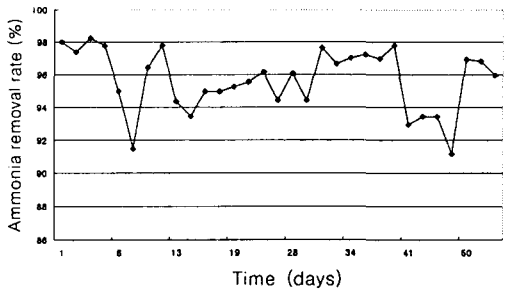


Fig. 4 Daily ammonia removal rate of open bed compost biofiltration system

efficiency of the manure compost biofiltration process can also be evaluated by determining the ammonia removal rate.

The ammonia removal rate during the manure compost biofiltration for 55 days were nearly the same trend as the previous runs between 91 and 98% as shown in Fig. 4. The results show that the manure compost biofilter is attributed to the effectiveness of the biofiltration.

2. Chemical Properties of Compost and Biofilter

The results of chemical analysis of the active stage of composting material are shown in Table 1. After 8 days of active composting, the mixes were transferred for curing stage at least 3 weeks. The composition of compost and biofilter are very similar to those of products made from the same types of substrates in ordinary composting systems (Hong et al., 2002).

The quality of compost is ascertained by examining the composition of the compost. Moisture content, C/N ratio, and pH are the criteria commonly used. The moisture content of this compost was in the narrow range of 63.2 to 64.2 % after 8 days of composting. No apparent trend could be found in the various days.

The compost contained 1.63 to 2.32 nitrogen (%, d.b.). Upon examining the change in nitrogen content over time, it was realized that total nitrogen increased during the first 8 days composting. The carbon content was generally above 40% (d.b.). The mixed sawdust compost was in the range of 40.1 to 44.9% (d.b.) carbon. The C/N ratio was between 19.4 and 24.6. The compost was in the range of pH 6.4 to 6.5.

Based on the temperature in compost and

compost chemical properties, it may be concluded that the fresh composts after 8 days composting made with sawdust as bulking agent best met the stability criteria suggested by Hong et al (2000).

The biochemical properties of matured manure compost used for biofilters treating exhaust air from the active stage of composting are shown in Table 1. The moisture content of manure compost biofilter was in the range of 48.2 to 49.4 %, w.b., while the pH of the biofilter was between 6.0 and 6.1 at the end of the biofiltration process. Generally, moisture content in the range of 50 to 70 % and pH between 7.0 and 8.5 are recommended for biofiltration process (Toffey, 1997). Recommended moisture contents for biofilters range from 30 to 60% for compost biofilters (Ottengraf, 1987). Microbial activity is best if biofilter media pH is maintained between 6 and 9 (Janni and Nicolai, 2000).

Results for the final manure compost biofilter chemical properties in experimental work showed slight differences throughout the biofiltration process.

Ⅳ. Conclusions

Ammonia removal rate from the active stage of composting of hog manure mixed with sawdust were studied in the semi air tight and agitated bed composting with an open bed manure compost biofilter under practical conditions.

Average ammonia removal rate varied from 91 % to 98 % at the active stage of composting using manure compost biofilter.

Judging from the transition of temperature and ammonia concentration of the compost reactor and biofilter media, it was concluded that the manure compost biofilter was good for compost odor control during the active stage of composting.

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