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Performance Characteristics of Matured Compost Biofiltration of Ammonia Gas from the Agitated Composting

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교반식 퇴비화 암모니아가스의 부숙퇴비를 이용한 탈취성능 특성

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적 요

실제 규모의 반밀폐 교반통기식 퇴비화 시스템에서 돈분과 톱밥의 혼합물을 퇴비화하는 과정에서 발생하는 암모니아가스의 탈취처리를 위하여 개방식 바이오필터 시스템을 제작하고 바이오필터로서 부숙퇴비를 이용하여 탈취시험을 수행하였다. 퇴비화 및 탈취과정에서 재료의 이화학적 특성 및 암모니아가스의 발생량을 측정하여 퇴비화의 특성 및 바이오필터 시스템의 성능을 분석하였다. 바이오필터의 암모니아가스 탈취효율은 2개월 평균 84%로 나타났으며 탈취재를 통과한 후의 암모니아가스의 농도는 최대 45ppm 이하로 나타나 허용농도(50ppm) 범위에 있었다. 부숙퇴비는 교반통기식 퇴비화 시스템에서 발생하는 암모니아가스의 탈취재로 활용할 수 있는 것으로 나타났다.

(**핵심어** : 퇴비화, 암모니아가스, 생물학적 탈취, 퇴비 바이오필터, 탈취제어)

INTRODUCTION

Composting is a process which deals with the biological decomposition and stabilization of organic substrates. Composting provides a good solution to disposal problems associated with animal wastes. Microorganisms in composting systems utilize degradable constituents to produce CO_2, H_2O, NH_3 and biological heat as major products(Hong et al., 1996). Nutrients (C, N, P.....), pH, moisture content, temperature and aeration(oxygen) affect on decomposition rates, odor generation and cost of composting.

A major problem in composting is the odor caused by the release of ammonia. Ammonia

(NH_3) 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.

Various studies have focused on ammonia control during composting. Hong(2001) and Hansen et al.(1989) stated that process conditions affected on the quantity of ammonia produced and demonstrated that the major controllable factors of C/N ratio, stirring frequency, particle size of amendment and percent recycled compost greatly affected on the nitrogen loss during poultry manure composting.

Odor emissions from an animal production site originate from the livestock waste composting facilities, animal housing and land application of manure. Livestock buildings and manure storage units emit a large number of biodegradable gases at extremely low concentrations.

Biofilters are very effective treating materials of odorous compounds at low concentrations. Biofilter system is an effective air pollution control technology that uses microorganisms to breakdown gaseous contaminants and produce innocuous end products(Nicolai and Janni, 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 all factors which influence the rate and efficiency of the biofiltration process(Rynk, 1992). Biofilters operate most efficiently at a moisture content in the range of 50 to 70% and a temperature between 15 and 35℃(Hong et al., 2002, Janni and Nicolai, 2000 ; Epstein, 1997). Biofiltration investment and operating costs are lower than that of thermal and chemical oxidation processes(Govind, 1999).

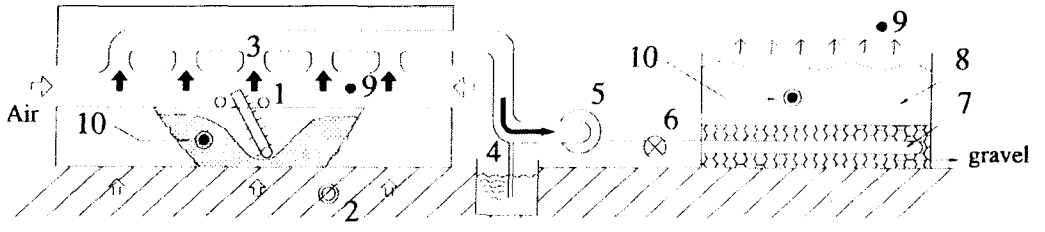
The objectives of this research was to evaluate the ammonia emission of hog manure and sawdust mixture in a continuous aeration and agitated composting system as first step in determining the best operating conditions to minimize ammonia emissions and determine the effects of compost biofilter media on odor control performance with respect to ammonia removal rate during biofiltration of ammonia emissions from the agitated bed composting system.

MATERIALS AND METHODS

This research study examined the effects of compost biofiltration on ammonia from agitated composting system. In this run, the continuous aeration mode was replicated using full scale compost reactor and open bed biofilter vessel.

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 beds. 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 Sunchon-si are 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 shows the general layout of the rectangular agitated bed composter and the



1. Turning machine
2. Blower
3. Exhaust gas loaded
4. Condensed water tanke
5. Turbo fan
6. Control valve
7. Oder duct
8. Biofilter media
9. Ammonia gas detectors
10. Temperature sensors

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

open type biofilter system. Blower(27m^3/min.) was connected to provide air to compost reactor. The full scale rectangular agitated bed composting(left side) vessel was 75m in length. 5m in width and 1.4m depth. The turning machine(6kW) moves the composting materials by 1.5m at each turning and the bed is 75m long. As the turning machine works twice a day, so one run is required 25 days for complete composting. The decomposition composting was performed during the first 8 days in 25m length of composting reactor. Odorous gases from the composting reactor were captured by the turbofan through the five ports of the discharge pipe(150 mm ID) installed in the decomposition composting area zone of 25m length. This exhaust gases passed through the biofilter media. The odorous air was exhausted from composting manure through the turbofan.

Turbofan(2kW) moves the odorous air through a duct to a gravel zone beneath the biofilter media. An open biofilter media(right side) was a rectangular type(1.4m H × 5m W × 5m L) with 0.6m thickness gravel base material. The distribution 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(7mm) in the bottom area of biofilter to supply the odorous air uniformly to the biofilter media.

Temperature of the material in the core of the compost reactor and biofilter vessel was monitored using K-type thermocouples. Temperature in compost, biofilter media and ambient air were measured and recorded on field book twice every day through a thermo-recorder(TR-72). Ammonia concentrations of exhaust gas from the composting and the biofiltration process in each run were obtained for each compost and biofilter vessels 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 as shown in Fig. 1.

Approximately 0.8 kg samples were collected from six arbitrarily selected points for each compost and biofilter vessel at the start and at the end of this study. The samples were analyzed for pH, total nitrogen(T-N), total carbon(T-C), C/N ratio and moisture content

Table 1. Physicochemical properties of the composting and biofilter materials

Item	Compost		Biofilter	
	Decomposition phase	Curing phase	Initial	Final
MC(%)	66.7	42.1	42.2	37.9
pH	7.2	6.6	6.8	6.5
T-C(%)	47.26	44.64	42.04	41.32
T-N(%)	1.26	1.69	1.72	1.87
C/N	37.5	26.4	24.4	22.1

(MC) by a standard methods for soil chemical properties according to the Office of Rural Development(ORD, 1988). The results of the material properties are shown in Table 1.

RESULTS AND DISCUSSION

1. Ammonia reduction

Average ammonia concentrations before and after biofiltration of the decomposition phase in agitated composting are shown in Fig. 2. Mean ammonia concentration in the decomposition phase was 109 ppm and mean ammonia concentration was 18 ppm after biofiltration process. The outlet NH_3 concentrations from biofilter increased in the higher temperature area ranged from 58 to 65℃ of biofilter between 01-11-20 and 01-12-12. The maximum ammonia concentration after filtering was 45 ppm at 01-12-12 showing lower than allowable value of 50ppm(Esmay and Dixon, 1986). It

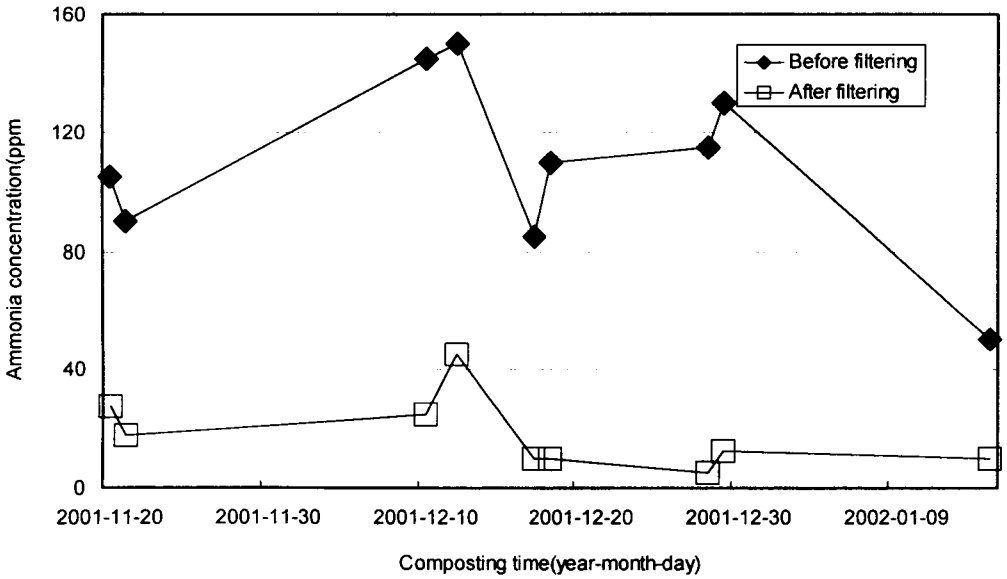


Fig. 2. Ammonia concentration before and after biofiltration in agitated composting process.

was concluded that compost can be used as a biofilter materials.

Fig. 3 shows the average efficiencies of the ammonia reduction through the manure compost biofilter media. The overall average efficiency of the ammonia reduction was 84%. Average daily efficiency of the ammonia reduction ranged from 74% to 96%.

2. Temperature variations

Changes of temperatures in decomposition composting, curing, biofiltration and ambient during experiment are shown in Fig. 4. Composting process can be divided into two stages such as the decomposition composting stage and the curing stage. The temperature of the decomposition composting stage rose rapidly within 5 days after the mixtures were placed in the composters and reached between 69 and 75℃. The temperature of curing stage in the agitated bed on the 3rd and 4th weeks of composting with continuous aeration and turning was in the ranges of 12 to 56℃.

As shown in Fig. 4, the curve pattern of the biofilter temperature in biofiltration process was greatly affected by the ambient temperature. The biofilter temperature in the biofiltration reached 65.2℃ on the first day and 25℃ on the 30th day during biofiltration process. The temperature decrease which took place in the biofilter could be due to low ambient air temperatures(6.4 to -0.5℃), these factor did not affect biofiltration performance as shown in Fig. 3. The ambient temperature outside the biofilter went down from 15 to -0.5℃. Though there was great fluctuation in ambient temperature according to the weather conditions, the biofilter media temperatures changed rapidly over the experiment. This means the biofilter media temperature was influenced greatly by the ambient air.

3. Changes of pH, moisture and C/N

The results of physicochemical analysis of

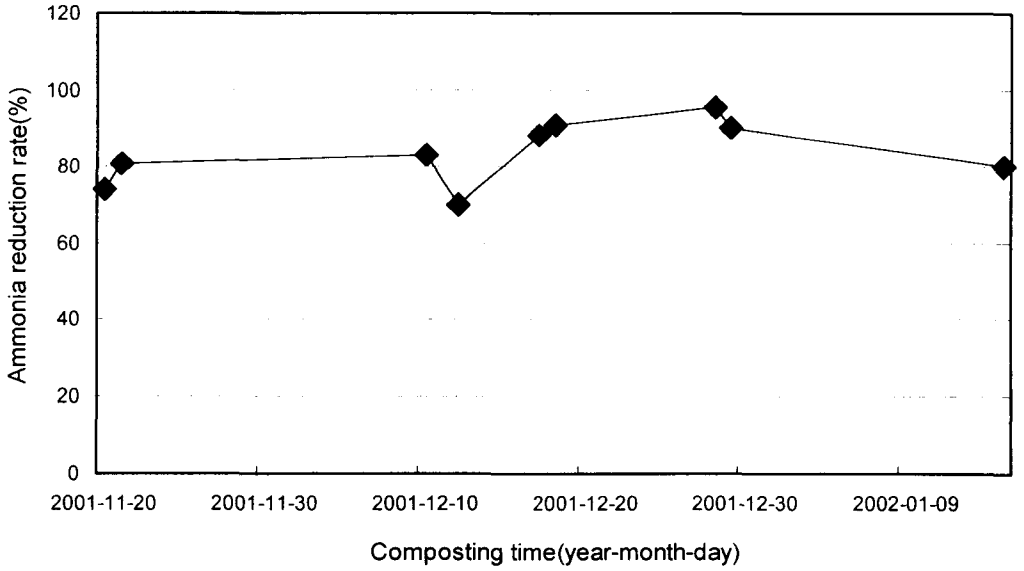


Fig. 3. Ammonia reduction rate during biofiltration.

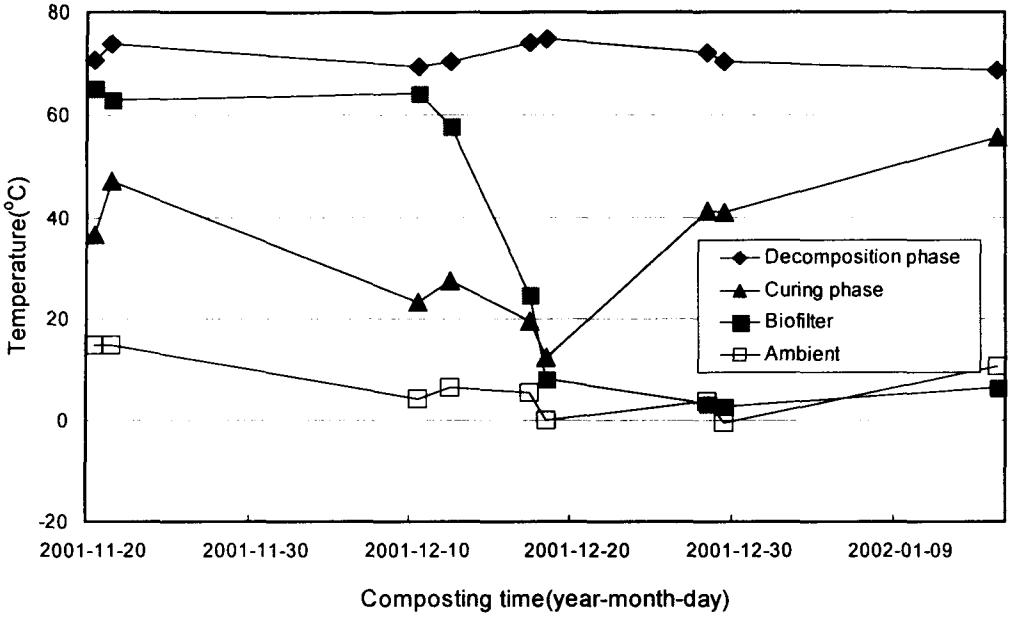


Fig. 4. Temperature variance of compost (decomposition and curing phase), biofilter and ambient in agitated composting process.

the initial admixture, fresh compost and biofilter are shown in Table 1. The characteristics and composition of fresh compost are very similar to those of products made from the same types of substrates in ordinary composting and biofiltration systems. The pH went down from 7.2 to 6.6, and moisture content went down from 66.7% to 42.1%, and C/N ratio went down from 37.5 to 26.4 during composting. In all the compost mixtures, the C/N ratio decreased due to the mineralization of the organic matter.

During a composting process, nitrogen compounds are immobilized by microorganisms but are also lost as ammonia volatilization. These nitrogen losses not only reduce the agronomic value of the end products, but also contribute to environmental pollution. It would be necessary to reduce nitrogen losses during composting, controlling those parameters that are known to affect ammonia formation and losses during composting, such as C/N ratio and nitrogen contents as well as pH(Kissel et al., 1992; Martins & Dewes, 1992).

Moisture contents of compost biofilter were in the range from 42.2 to 37.9(wb) with no discernible pattern, while the pH value varied from 6.8 to 6.5. These alkaline pH values could contribute to nitrogen losses and ammonia odors during the biofiltration process.

CONCLUSIONS

The open bed type biofiltration process for ammonia reduction from composting manure in winter was characterized by determinations of such parameters as changes in temperature, pH, moisture content, and C/N ratio.

Composting using turning equipment generally involves odorous emissions, large capital

investments and operating cost that many farmers are reluctant to incur. However, in open bed biofiltration with composting facility, the biofilter media was not turned nor was large capital investments and operating cost needed.

Short-term measurements were carried out in agitated composting ammonia gas on open bed type manure compost biofilter media under practical conditions to test it reduction potential for ammonia emissions. The average efficiency of the ammonia reduction was about 84%. The efficiency of ammonia reduction was mainly influenced by the temperature of biofilter media. The maximum ammonia concentration after filtering was 45ppm lower than allowable value of 50ppm. It was concluded that compost can be used as a biofilter materials.

SUMMARY

Real sized open type biofilter system was manufactured to control the odor generated from the agitated composting system which composted swine manure and sawdust mixtures. The aim of this research was to develop a biofilter system using matured compost and to evaluate the performance of the biofilter system. Average ammonia reduction rate through the biofilter was 84% during about two month period of composting. The maximum ammonia concentration after filtering was 45ppm lower than allowable value of 50ppm. It was concluded that compost can be used as a biofilter materials.

(**Keywords** : Composting, Ammonia gas, Biofiltration, Compost biofilter, Odor control)

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