COMPOSTING GREENHOUSE USING THE FORCED AERATION METHOD

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ABSTRACT

Recent research in composting greenhouse has focused on some of the fundamental properties during the process such as temperature, carbon dioxide content and odors which change as the composting progresses. The composting greenhouse of cattle manure with rice hulls by a forced aeration method without turning is available for the practical proposition. The control of a predetermined temperature range(45 - 65 ℃) is possible if intermittent aeration is used. The carbon dioxide concentration was maintained in the range from 400 to 2650 ppm by the intermittent aeration. The ammonia emission rose rapidly leading to a temperature increase of composting material up to more than 60 ℃ for six days. Ammonia emission declined quickly and could hardly be detected after 10 days of running period.
Keywords: Compost, Aeration, Ammonia emission, Carbon dioxide, Greenhouse, Animal wastes

INTRODUCTION

Agricultural wastes are serious problems, particularly cattle manures. We propose to utilize part of these waste resources as compost and to use CO_2 and heat which are produced in the process of composting. CO_2 and heat, by-products of composting of agricultural waste, are potentially inexpensive sources for protected cultivation.

The majority of composting systems are aerobic and the aeration is essential for optimum microbial activity. A forced aerobic decomposition unit is utilized in which heat and CO_2 can be delivered to the crops. The aerated static pile composting system without turning for livestock manure mixed with rice hulls has been developed in the last ten years and has been considered to be both practically and economically viable.

The aims of this research are as follows:

1) to develop a practical system for the utilization of the output products from composting process, namely the biothermal energy and the carbon dioxide in a greenhouse cultivation.

2) to investigate the effect of an intermittent mode of aeration on the efficiency of the composting process.

3) to analyze the quality of the compost produced.

MATERIALS AND METHODS

Samples of raw cattle manure were mixed with rice hulls in a volumetric ratio of 2 : 1.

The quality and maturity of compost are ascertained by examining the characteristics and composition of the compost. Moisture content, C/N ratio, pH level and volatile solids and nutrient content are the criteria commonly used for the analyses of the compost.

Admixture of raw material was composted in the composting greenhouse for 42 days from Jan. 13 to Feb. 23, 1996. Composting greenhouse was constructed with a dimension of 12.5 m long and 4.37 m wide(54.6 m^2) as shown in Fig. 1. Tomato was produced while composting was processed in the greenhouse.

Static pile was made by inputting the raw material into the 3 lines of concrete ditch(60 cm H × 60 cm W × 8 m L). A plastic pipe of 4 cm of inner diameter was installed above the bottom of the ditch floor to supply air into the compost. The static pile composting unit(45 cm H × 60 cm W × 8 m L) of 3 lines had a loading capacity of around 2.5 tons(6.5 m^3).

Forced air with continuous or intermittent aeration was supplied to the compost mass through the aerated pipe by the turbo blower(1ps) of a positive pressure mode. Aeration rate was 87 L/min./m^3. From the beginning of composting, air was supplied by continuous aeration for 11 days except one period of no aeration at 8th day. After 11 days of continuous aeration, intermittent aeration was performed to the end of composting process. To maintain the moisture content of compost material to the level of 50%, 1.7 L/m^3 of water was supplied every day for the period from 23rd to 42th day of composting.

Ammonia gases appeared for early 5 days of composting were eliminated towards the outside of the composting house through the vinyl duct installed over the concrete ditch, and discharge pipe. As the NH_3 gas did not appear practically from the 10th day, tomatoes were planted on the soil bed of composting house on the 14th day.

Temperatures of compost and CO_2 concentration inside composting greenhouse were measured and monitored at the interval of one hour. Temperature sensor for compost material was placed at a depth of 30 cm below surface and at the center line along the length of the pile and CO_2 concentration was measured at the height of 35 cm from the ground in the middle position of the greenhouse. Air heater(20,000 Kcal/h) was used to control the inside temperature of the greenhouse at 4 stages of temperature a day.

The analogue signals from the temperature and the CO_2 sensors were transferred to signal conditioner, multiplexor and A/D converter to convert to the digital values. The average value of 100 times of conversion data for each sensor was recorded in the memory of personal computer.

RESULTS AND DISCUSSION

TEMPERATURE IN COMPOST

Compost temperature curves(TM5) for the various aeration levels to maintain optimum temperature during composting were shown in Fig. 2 (a) to (c). The temperature of the compost rose rapidly after mixture was placed in the concrete ditch, reaching a peak value of 60°C after 5 days of continuous aeration mode. A rapid drop of temperature from 6th to 10th day of continuous aeration indicated that the compost had a cooling effect by supplied air. Temperature frequently has been used to judge efficiency and degree of stabilization of a composting mass(Stentiford and Leton, 1990; Miller, 1991). With an intermittent aeration mode after 10th day, the temperature rose rapidly again to the optimum range of 40-63°C at the 22th day. While the temperature maintained in the range of 55-60°C during more than 3 days, the majority of pathogenic organism can be inactivated. It is clear from the figure that the intermittent aeration is necessary for composting process.

CHANGES IN CO_2 CONCENTRATION

Carbon dioxide concentration(CB) was greatly affected by aeration mode as shown in Fig. 2 (a) to (c). The rise in carbon dioxide concentration and ammonia emission at the initial stage seemed to be due to the increase of microbial activity by aeration. Ammonia odor did not exhibit any marked increase and also a disagreeable odor was not noticed after 10 days. The carbon dioxide concentration was maintained in the range from 400 to 2650 ppm with intermittent aeration. The combination of high carbon dioxide level(1500 ppm), increased day temperature and optimum light level will reduce the time between germination and harvest by as much as 50% for some crops. Increases in carbon dioxide over normal amounts improve plant quality, increase yields and result in more rapid plant development(Esmay and Dixon, 1986). The average level of carbon dioxide concentration amounted to 820 ppm during composting process. Carbon dioxide is the basic material, along with water, required for photosynthesis and is the factor most often limited in greenhouse environments. The carbon dioxide concentration had a very strong effect on the growth speed of tomato.

CHANGES IN CHEMICAL PROPERTIES

The chemical properties of the initial admixture and finished compost was shown in Table 1. The moisture content, pH value, total carbon, C/N ratio, NH_4^+-N decreased generally, however total nitrogen and NO_3^--N increased. The characteristics and composition of final compost are very similar to those of products made from the same types of substrates in ordinary composting system. The C/N ratio, moisture content and pH value are usually used to estimate the maturity of produced compost.

The pH value went down from 8.7 to 7.3, moisture content went down from 67.8 to 53.6 percent, volatile solids went down from 81.1 to 66.3 percent, carbon content decreased from 45.1 to 35.1 percent, C/N ratio went down from 25.3 to 19.5 percent and nitrogen levels for compost went up from 1.78 to 1.83 percent during composting.

The level of P_2O_5, K_2O, CaO, MgO, Na_2O was 1.81, 2.94, 2.20, 1.12, 0.70 percent at the start of the process, 2.14, 3.28, 2.43, 1.29, 0.79 percent respectively at the end of composting. From the results, it was also possible to use this compost as soil conditioner. By applying this compost, the nutrient content in the soil would increase resulting in the improvement of the physical properties of soil.

Table 1. The chemical analysis of the admixture and finished compost.

Parameter(Unit)	Mean value of six samples	
	Admixture	Finished compost
pH(-)	8.7	7.3
Moisture content(%, w.b)	67.8	53.6
Volatile solids(%, d.b)	81.3	66.3
T-C(%, d.b)	45.1	35.1
T-N(%, d.b)	1.78	1.83
C/N ratio	25.3	19.5
P_2O_5(%)	1.81	2.14
K_2O(%)	2.94	3.28
CaO(%)	2.20	2.43
MgO(%)	1.12	1.29
Na_2O(%)	0.70	0.79
NH_4^+(ppm)	2,223	773
NO_3^-(ppm)	7	354
Fe(ppm)	23.2	16.1
Zn(ppm)	33.1	40.3
Cu(ppm)	14.3	2.2
Mn(ppm)	13.1	15.9

CONCLUSIONS

Composting greenhouse was constructed to make compost with cattle manure and rice hulls while cultivating the tomato plant. Intermittent aeration method was used to supply the air into the compost materials of static pile system. Compost material temperature and carbon dioxide concentration were measured at the interval of one hour while composting was processed. Chemical analysis was performed before and after the composting process. The results of this study are as follows:

1. Composting greenhouse is a possible system to make compost while growing some crops in the house in winter.
2. The combination of continuous and intermittent aeration mode in the static pile system was useful to maintain the compost temperature of optimum range.
3. CO_2 concentration inside the greenhouse was enhanced during composting process resulting in the beneficial effect on the plant growth.
4. Tomato was cultivated from the 14th day of composting when ammonia emission did not appear almost, and the plant did not get any harm from ammonia gas.
5. The characteristics and composition of final compost are very similar to those of products made from the same types of substrates in ordinary composting system.

ACKNOWLEDGEMENTS
This work has been funded by the Ministry of Agriculture, Forestry and Fisheries, Korea.

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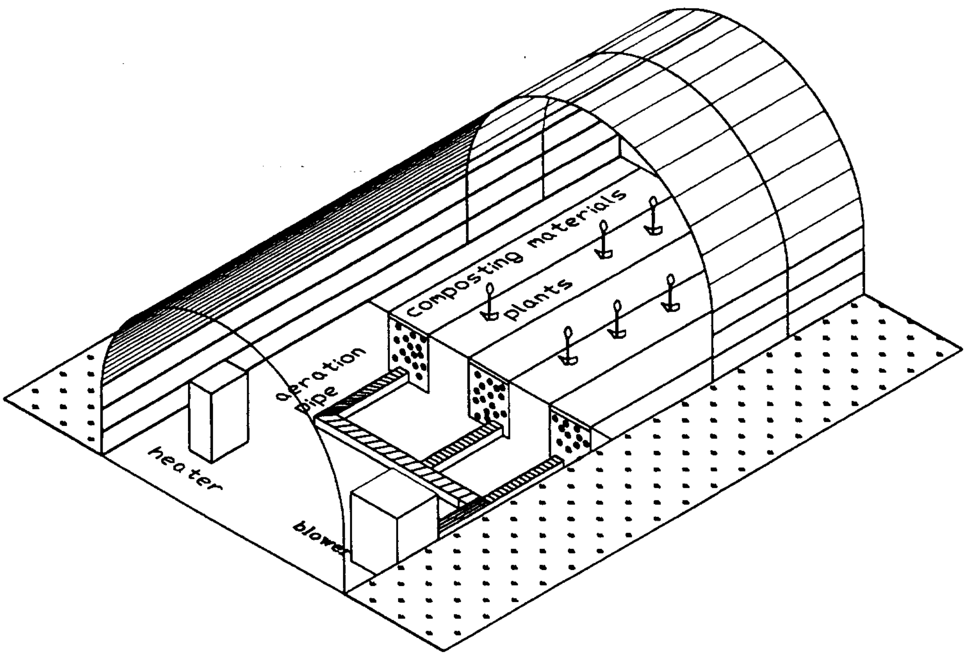
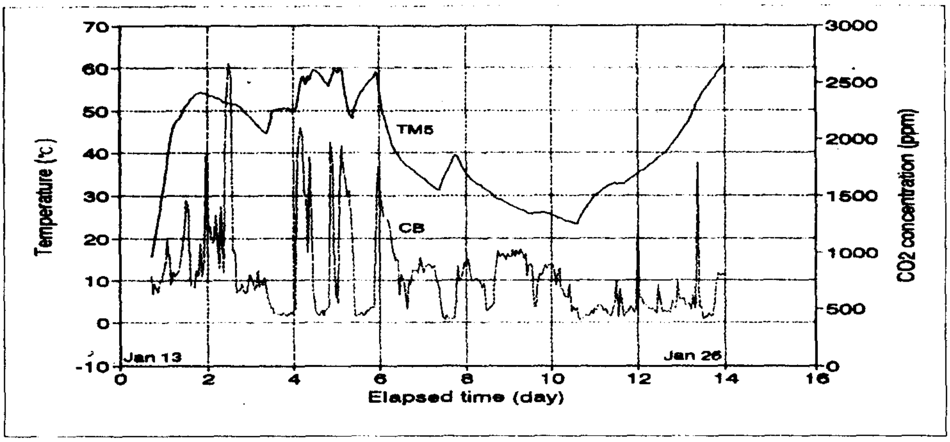
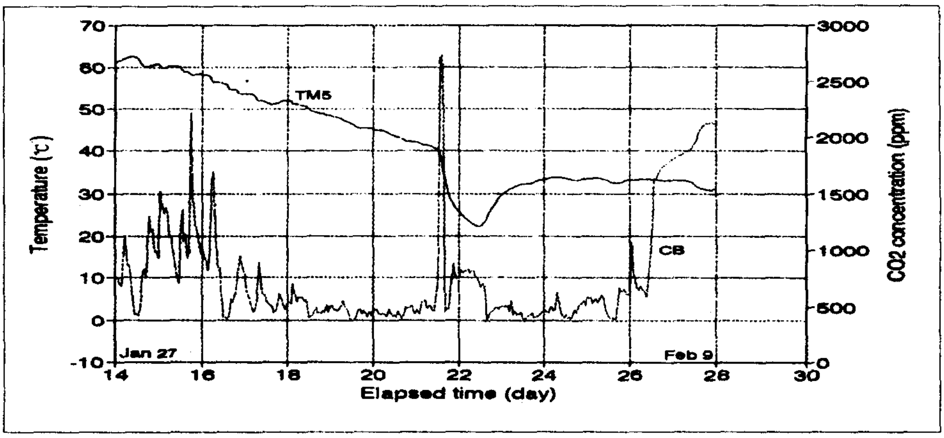


Fig. 1. General layout of composting greenhouse.



(a)



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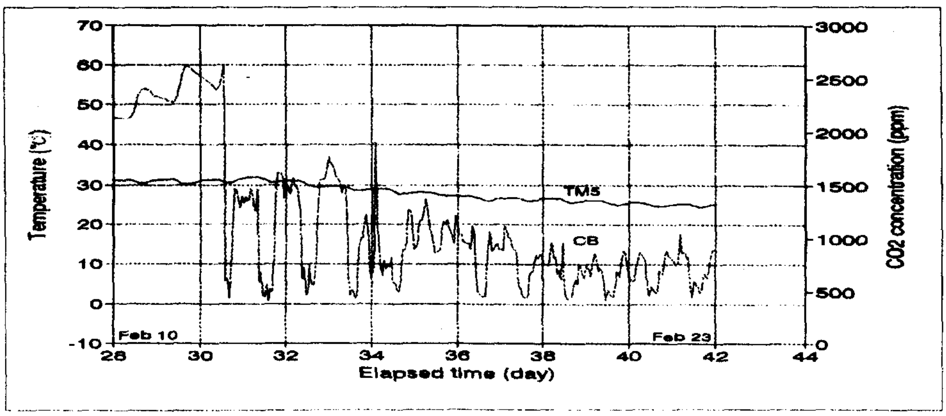

(c)

Fig. 2. Changes in composting temperature and CO_2 concentration.