AEROBIC WINDROW COMPOSTING OF MIXED DAIRY MANURE WITH RICE STRAW

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Abstract

The mixed dairy manure with rice straw can be composted in an aerobic windrow composting system for 5 weeks. The inside temperature of aerobic windrow compost pile was greatly affected by ambient temperature and over turning frequency conditions. For the peak efficiency from the rate of composting, 40-70°C was found to be most favorable temperature. On view of turning condition, once every 7 days in the late fall and 2 to 3 days in the summer and adding water to maintain optimum moisture content of 50 to 60% (w. b.) would be useful for aerobic windrow composting. Suitable aeration depth of compost pile was ranged 1.5 to 1.8 meters high.

Introduction

In the past, the agricultural wastes were used mainly as fertilizer and were important for the development of agriculture. With exploitation of an efficient fertilizer industry, obtaining plant nutrients from fertilizer became more economical than from animal wastes, because of the cost of collecting, handling and spreading the wastes. Renewed interest has been increased in the use of wastes as fertilizer in recent years because of the increased cost of fossil fuel used in manufacturing fertilizer, and the need of soil conditioners for some unproductive infertile soils may also stimulate additional interest in composting.

Cultivated crops are continually more heavily attacked by diseases and pests, despite of the increasing use of pest control agents. And the increased environmental regulations and rising fertilizer costs have made farm wastes

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utilization problems important to farmers.

Livestock wastes are renewable world resources which can play an important part in the improvement of agricultural productivity and of productivity of substances for synthetic energy. By the way, the handling of animal wastes has been a big problem on the livestock farmstead.

Windrow composting of animal and processed rural wastes has been our only economical managing method relating to utilization.

Aerobic windrow composting dose not need so much energy for operating process. In the windrow composting system, wastes are stacked in piles which can be arranged in long paralled rows or windrows. In large systems such windrows are turned at regular intervals using a mechanical equipment.

The windrows may depend on characteristics of the composting material, climatic conditions and the equipment used for turning. The windrow system has been used successfully for composting of a wide variety of organic residue. In general, windrow composting is relatively land intensive.

The importance of aerobic windrow composting arises from following aspects: 1) Shortening of the time required for satisfactory composting as a means of the utilization of the high moisture cattle manure and 2) the use of windrow composting may be done with a minimum of additional equipment and considerably less energy requirement. Consequently, windrow composting may be a practical solution for managing livestock wastes.

The specific objectives are as follows; 1) to determine the influence of physical properties such as ambient temperature, height of compost pile, moisture content and climatic conditions on the aerobic biodegradation of dairy manure mixed with rice straw and 2) to investigate the suitable conditions for wastes recycling to the land.

Literature Review

The rate microbial activity is greatly influenced by environmental factors. Most important things among these are the nature and particle size of the organic refuse, the moisture content and extent of aeration throughout the mass, the hydrogen ion concentration of the wastes and its initial C/N and the temperature of the compost pile (MERCER *et al.*[5]).

The most degradation of the wastes occurred under thermophilic condition. Temperature has been used frequently to judge efficiency and degree of stabilization of composting mass. The suitable temperature was between 40 and 70°C. The height of the windrow is critical and should be carefully managed in order to obtain good results. If piles are too high, the material will be compressed by its own weight which will destroy the spore space and cause anaerobic conditions and the height of the pile is also critical from the standpoint of controlling temperature. Shallow piles may dissipate heat too rapidly, preventing optimum conditions for thermophilic organisms to be reached (MERKEL[6]).

BELL[1], MERCER and ROSE[4] found that height of the windrow was important in preventing heat loss and maintaining high temperatures. The material to be composted is placed into windrow; heap about 1.8 to 2.4 meters high 3 meters wide and often 30 meters long.

For livestock wastes, composting is occasionally conducted in windrows with aeration furnished by frequent turning. The manure windrow depth should be 1 to 1.3 meters. The moisture content should be 45 to 55 percent since poor aeration occurs at higher moisture contents and slow digestion is encountered at lower moisture contents (SWEETEN[9]).

The most suitable height of the windrow is 1.5 to 2.0 meters.

Windrows stacked too high may retain too much heat and develop temperatures above 70°C. Temperature in this range will destroy many of the microorganisms and the spore space, slowing down the process and causing anaerobic conditions. If the windrow is adequately mixed, the process will be aerobic and the composting time required is about 6 weeks. By way of contrast, anaerobic windrow composting takes 4 to 6 months. Turning the pile frequently is essential for obtaining a rapid, nuisance free composting action characteristics of the thermophilic aerobic process. In order to ensure a uniform and rapid decomposition, the compost must be thoroughly mixed. Under normal conditions when the moisture content is between 50 and 60 percent, the windrow should be turned at 3 days interval. If the moisture level exceeds 60 percent, the windrow should be turned at 2 days interval to prevent the occurrence of anaerobic conditions (MERKEL[6]).

Organic matter will not compost rapidly if the moisture content is below 40 percent (JERIS and REGAN[3]; WILEY[11]).

RODALE[8] recommends turning the windrow after 3 weeks and again after 5 weeks. This is not so different from the practice at Johnson city Tenn.

Worked by STUTZENBERGER *et al.*[10] and GABY *et al.*,[2] the composted wastes are turned over every 5 to 7 days and finished in 49 days. BELL[1] indicated that turning should be done most frequently at the early stage of decomposition when the microbial activity is most intense.

Material and Method

Sample of raw manure was taken from dairy cattle and it was manually mixed with rice straw by wet weight ratio of manure (2) to straw (1) for use in windrow composting operation. Particle size of straw was ranged 30 to 50 mm.

Periodically the heaps were turned over manually with shovel.

Compost pile remixed and turned over at 7 days intervals. Photo of the compositing site are shown in Fig. 1. The composting experiments described in this study were carried out in six piles. Two seperate investigations were conducted. The first study (Lot I) aimed at evaluating optimum composting procedure for the rectangular cross section type in the summer (R1, R2, R3) and the second (Lot II), semicircular type in the late fall (S1, S2, S3), respectively with 3 levels of aeration depth. Each compost pile was covered with sheets of vynyl.

Fig. 1. Photo of windrow composting site.

All of these compost piles were composted 6 weeks and cured 7 days.

Compost mixtures of manure and straw were stacked in piles which were arranged windrows. Fig. 2 was a schematic vertical cross section diagram of windrow compost pile, which was formed rectangular in the summer and semicircular in the late fall. Each pile was 0.8 to 2.0 meters deep, 1 to 4 meters wide and the length of the piles were uniformly one meter.

Experimental conditions for aerobic windrow composting are shown in

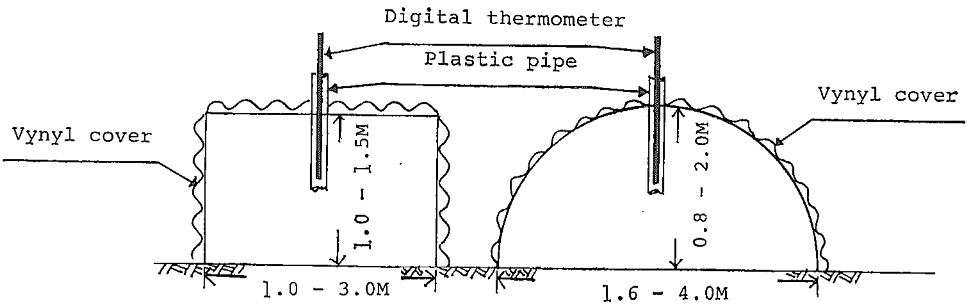

Fig. 2. Vertical cross section of windrow compost pile.

TABLE 1. Experimental conditions for aerobic window composting

Run No.	Vertical section	Experiment period	Pile size (m)	
			Height	Width
R1		June 15–July 27	1.0	1.0
R2	Rectangular	June 23–Aug. 4	1.2	2.0
R3		June 17–July 29	1.5	3.0
S1		Nov. 3–Dec. 15	0.8	1.6
S2	Semicircular	Oct. 8–Nov. 12	1.8	3.6
S3		Oct. 21–Dec. 2	2.0	4.0

Table 1. Digital thermometer (AARON, TM–200) was used to measure temperature changes in the compost pile. The temperature checking points were center of the top surface and the height in each pile. Measurements of ambient and compost pile temperature and windrow aeration depth changes were made daily at around 10 a. m. After each turning of the compost mixture, an approximate 10 grams sample was taken for laboratory determination of pH and moisture content.

Samples for laboratory analysis of the compost mixtures consisted of grab samples taken from several different locations in the mass.

The acidity or alkalinity of the various samples was determined with pH test paper on samples blended with distilled water.

Approximately 10 grams of sample was placed into sampling can weighed and dried overnight at 105°C in electric drying oven for determination of the moisture content and dry weight.

The bulk weight is expressed in the wet weight of material per unit volume. Each value was the average of three samples.

Results and Discussion

The temperature fluctuations for the two lots of windrow compost pile respectively, with 3 levels of the aeration depth are shown in Fig. 3–1 to 4–3. At the first day after placing of the compost mixtures, elevations in temperature occurred. The temperature of the compost mass began to increase up to levels between 56 and 69°C and gradual declining temperature followed as shown in Fig. 3 and 4. The cause for the decline in the temperature was due to ambient temperature and the moisture content being below 40% (w. b.).

Organic matter will not compost rapidly if the moisture contents is below 40% (Table 2; JERIS and REGAN[3]; WILEY[11]). These conditions should be corrected by over turning the pile more frequently to aerate and adding water during hot summer composting (Fig. 3; MERKEL[6]).

It can be seen that in this results, the temperature within the compost heaps rose readily to the thermophilic levels for the first three weeks and then gradually decreased to ambient after the fifth week.

These fluctuations are about the same as those reported by POINCELOT.[7]

In either case the temperature stabilizes at thermophilic range, followed by a gradual cooling to ambient. The temperature dropped after turning and within a day rapidly rose to levels usually above those measured prior to turning. The rise in temperature after turning must have been due to an increase in microbial activity resulting from aeration. This fact suggests

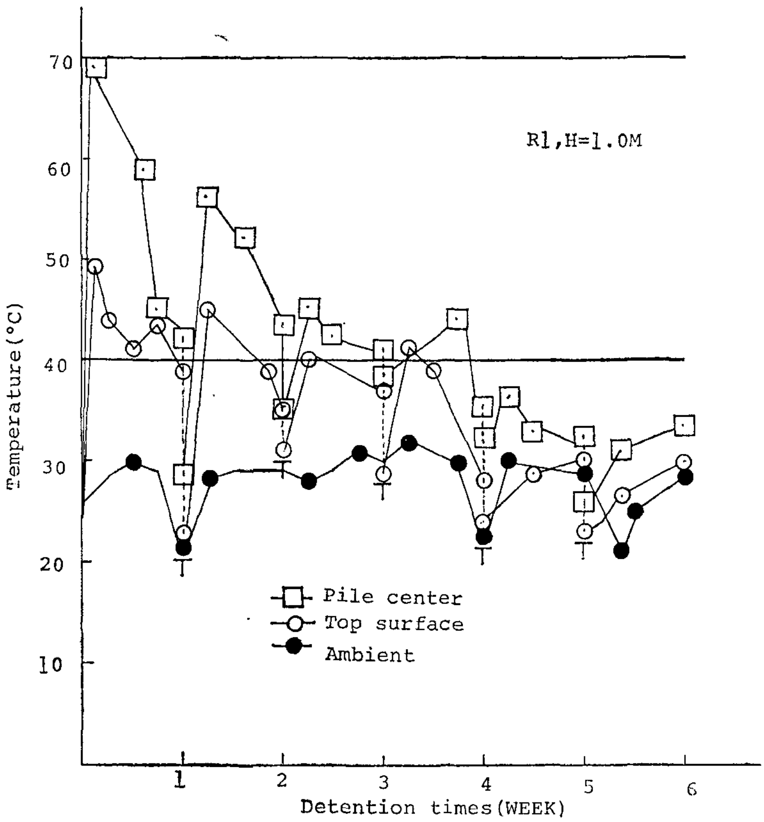

Fig. 3-1. Relationship between temperature and aeration depth while windrow composting (T: Turning).

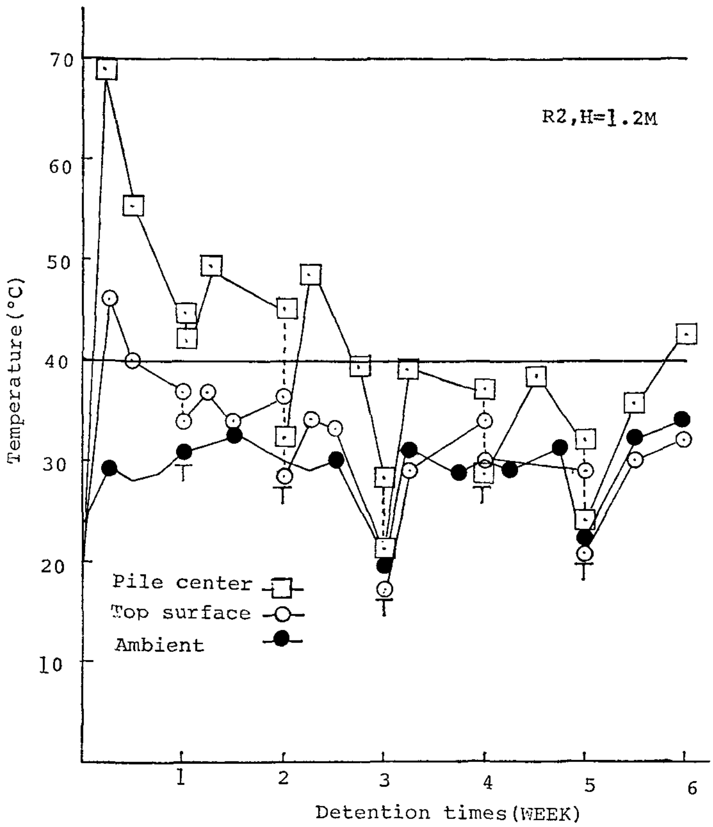

Fig. 3-2. Relationship between temperature and aeration depth while windrow composting (T: Turning).

TABLE 2. Variations of the parameters duringthe composting

Run No.	Aeration depth	Weeks	pile height: height (m)	pile height: reduction (%)	M.C. % (w.b.)	pH
R1	1.0	1	0.68	32	59.1	7.9
		2	0.63	37	57.4	7.8
		3	0.50	50	53.1	7.7
		4	0.44	56	28.9	7.8
		5	0.40	60	25.1	7.8
R2	1.2	1	0.54	55	65.2	7.8
		2	0.45	62	61.9	7.6
		3	0.40	67	42.7	6.8
		4	0.38	68	35.8	7.9
		5	0.34	72	31.1	7.7
R3	1.5	1	1.20	20	67.0	7.8
		2	0.84	44	58.8	8.2
		3	0.54	64	56.5	7.9
		4	0.50	67	43.3	8.0
		5	0.48	68	34.4	7.9

Table 2. Continued

Run No.	Aeration depth	Weeks	Pile height		M.C. % (w.b.)	pH
			height (m)	reduction (%)		
S1	0.8	1	0.65	19	70.3	7.8
		2	0.45	44	63.8	7.9
		3	0.40	50	54.8	7.8
		4	0.30	63	38.4	7.8
		5	0.30	63	33.0	8.0
S2	1.8	1	1.20	33	64.2	7.7
		2	0.85	53	56.7	7.6
		3	0.60	67	49.6	7.7
		4	0.45	75	40.8	7.6
		5	0.45	75	32.0	7.7
S3	2.0	1	1.25	38	62.7	7.8
		2	0.85	58	55.4	7.9
		3	0.65	68	44.8	8.0
		4	0.55	73	42.6	7.8
		5	0.48	76	30.4	7.7

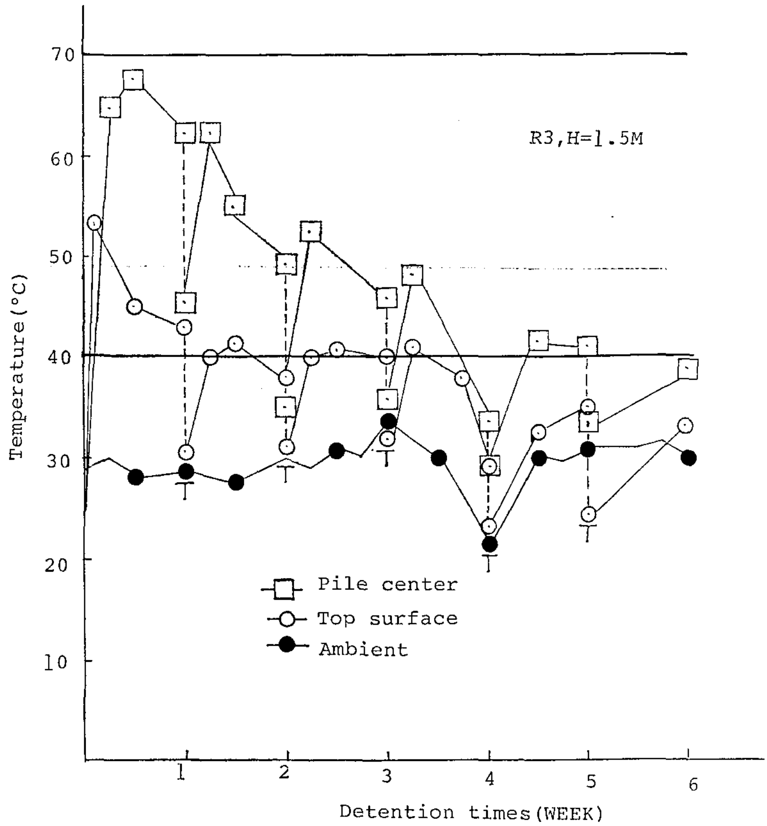

Fig. 3-3. Relationship between temperature and aeration depth while windrow composting (T: Turning).

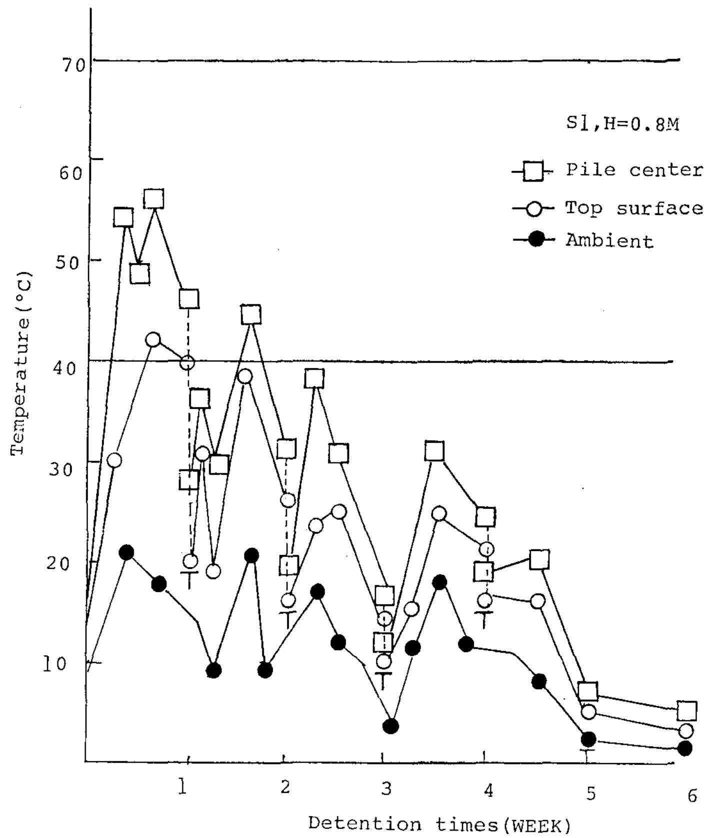

Fig. 4-1. Relationship between temperature and aeration depth while windrow composting (T: Turning).

TABLE 3. Physical characteristics of compost

Run No.	Before composting			After composting		
	Weight, kg	Volume, m^3	Bulk weight g/cm^3	Weight (loss), kg (%)	Volume (loss), m^3 (%)	B.W.* g/cm^3
R1	240	1.0	0.24	198 (17.5)	0.4 (60.0)	0.50
R2	298	2.4	0.12	236 (20.8)	0.9 (62.5)	0.26
R3	384	4.5	0.09	272 (29.2)	1.3 (71.1)	0.21
S1	259	1.0	0.26	195 (24.5)	0.5 (50.0)	0.29
S2	592	5.1	0.12	428 (27.7)	1.2 (76.5)	0.39
S3	665	6.3	0.11	476 (28.4)	1.3 (79.4)	0.37

* Bulk Weight.

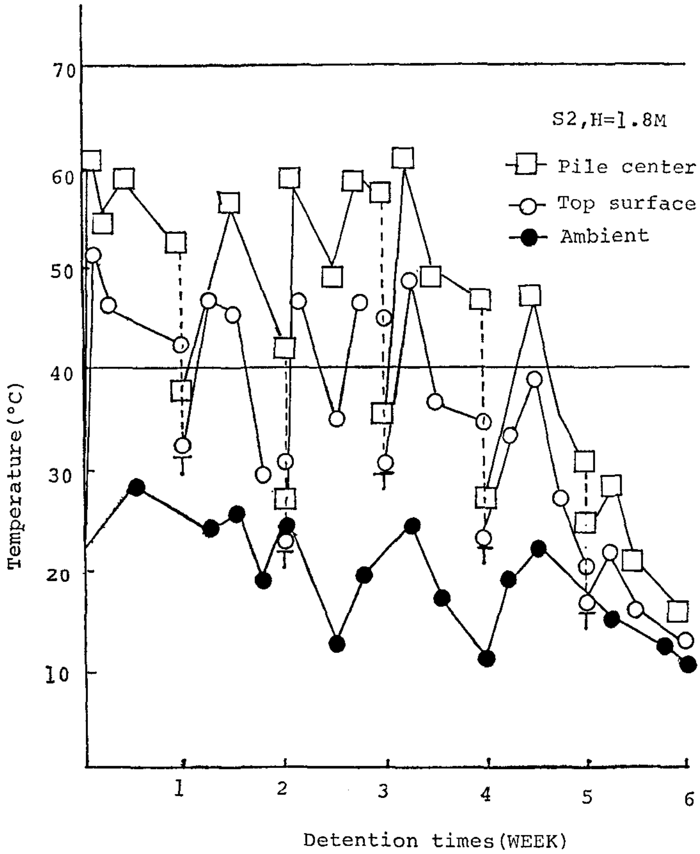

Fig. 4-2. Relationship between temperature and aeration depth while windrow composting (T: Turning).

that turning is necessary for preventing offensive odor from anaerobic conditions and shortening of the time required for windrow composting.

It was noted that the temperature at the center of the compost was approximately 20°C above the ambient temperature. The maximum temperature of the compost mass occurred near the center of the heap rather than at the top surface. The maximum temperature difference between center and top surface was around 22 to 34°C after placing for a few days (Fig. 3 and 4).

The speed of the composting process increases with increasing temperature from ambient to thermophilic. According to the Fig. 3 and Fig. 4, the process was at its peak efficiency between 40 and 70°C. For peak efficiency from the standpoint of the rate of composting, the suitable height

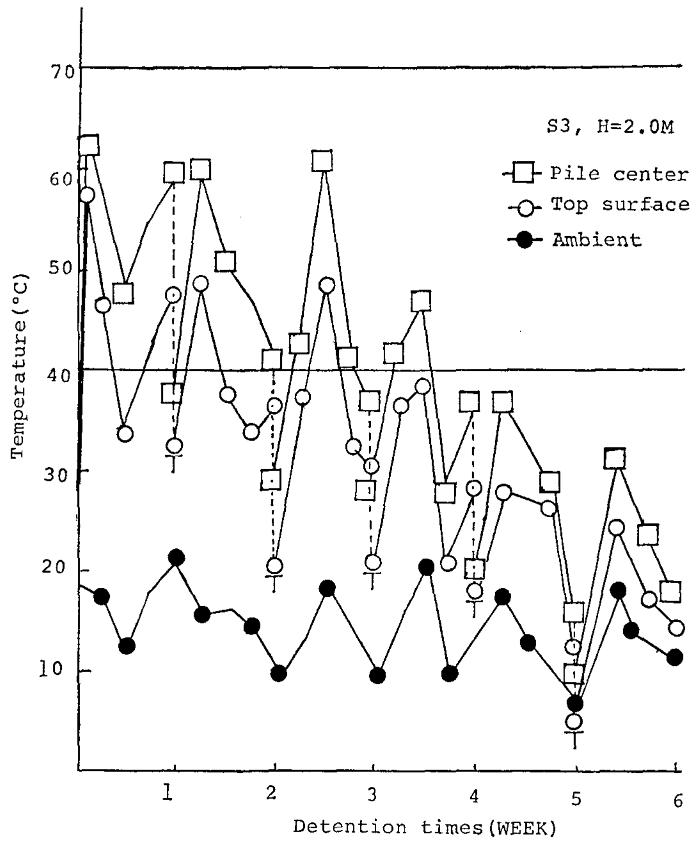

Fig. 4-3. Relationship between temperature and aeration depth while windrow composting (T: Turning).

of the compost pile was ranged 1.5 to 1.8 meters (Run No. R3, S2). Shallow piles (Run No. R1, S1) dissipates heat too rapidly, preventing optimum conditions for thermophilic organisms to be reached. Detention times of peak efficiency were shown as Table 2. Required time for peak efficiency zone from the standpoint of the rate of composting was ranged from 4 to 5 weeks. These results were similar to the reports worked by GABY *et al.*[2], MERKEL[6] and STUTZENBERGER *et al.*[10]

Loss of moisture content due to the hot weather may also be excessive, causing the retardation of the composting speed.

Ambient temperature and over turning the compost mass affected greatly to the speed of composting process (Fig. 3 and 4). Therefore, over turning once every 2 to 4 days and adding water to maintain suitable moisture content of 50–60% (w. b.) would be useful for too hot pile during warm weather conditions.

Table 2 showed the changes in the aeration depth of compost pile, the percent of the height reduction, the moisture content and the pH value of the compost mass. The rate of reduction in aeration depth of compost pile during composting was ranged from 60 to 72 percent for the first lot and 63 to 76 percent for the second lot. Temperature of the compost mass was developed below 70°C and majority of the decomposition during the composting process took place in the 40 to 70°C range. Consequently, the good results in the summer were obtained under the height of the pile No. R3 (H=1.5 m). To the contrary, the height of 1.8 meters for the compost No. S2 was ranged from 35 to 60°C in the late fall.

The final moisture content of each compost mass was generally about 30% (w. b.). When the moisture content was below around 40 percent as shown in Table 2, the composting process would not compost rapidly (Fig. 3 and 4; JERIS and REGAN[3]; WILEY[11]).

Generally, the pH was above the natural value of 7.0 and peaked around 8.2. The pH value of the produced compost remained consistently close 8.

Physical analyses of the compost mass before and after composting process were presented in Table 3. The average value of weight loss during composting was approximately 24.7 percent and the reduction in volume was around 0.9 percent. The loss in weight and volume were resulted from evaporation at the elevated temperature during composting and microbial activity on carbohydrates to give carbon dioxide and water.

The average value of the final bulk weight of each compost was generally about 2 times higher than that of initial conditions. Increases in bulk weight during the composting process might be due to decreases of moisture content and pile height. The compost did not have offensive odor and it might be suitable for improving soil properties.

Summary

The prupose of this study is to investigate aerobic windrow composting of mixed dairy manure with rice straw systems and discuss the engineering physical parameters which govern their operation.

The results of the study are as follows:

1. Complete aerobic windrow composting of mixed dairy manure with rice straw required 5 weeks.

2. Suitable height of the aerobic windrow compost pile was ranged 1.5 to 1.8 meters.

3. Turning once every 2 to 4 days and adding water to maintain optimum moisture content of 50 to 60% (w. b.) would be useful for too hot pile during composting in the summer.

4. The temperature within aerobic windrow compost pile was greatly affected by turing frequency and ambient temperature.

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