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Passively Aerated Composting of Manure Slurry

by

N.K. Patni
Research Scientist
Agriculture Canada
Ottawa, ON KIA 0C6

L. Fernandes, Assistant Professor
W. Zhan, Graduate Student
Department of Civil Engineering
University of Ottawa
Ottawa, ON K1N 6N5

P. Jui
Research Scientist
Agriculture Canada
Ottawa, ON
KIA 0C6

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SUMMARY:

Cage layer poultry manure slurry was composted at high initial moisture content in passively aerated static piles using peat and chopped straw as bulking agents. Continuous monitoring of temperature distribution at several locations per pile was used to determine process characteristics. Good quality compost was obtained in 7-10 weeks.

KEYWORDS: Static pile, poultry manure, compost

PASSIVELY AERATED COMPOSTING OF MANURE SLURRY

N.K. Patni [1], L. Fernandes[2], W. Zhan[3], P.Y. Jui[4]

ABSTRACT

Laying hen manure slurry with 89% moisture content (MC) was composted using the static pile passive aeration composting system using peat and chopped straw as bulking agents. Initial moisture contents of the compost mixtures were 73% and 80% in the peat piles and 76% in the straw pile. Each treatment was replicated in three piles. The distribution and variation of pile temperatures, monitored continuously or intermittently at up to 33 locations in each of the piles, was not uniform throughout the pile, although most of the compost attained a temperature 55°C of more. Temperature variation amongst the replicate piles, and at symmetrical locations within the piles, was very similar. The role of aeration pipes, and of direct diffusion of air into the piles, in providing pile aeration needs to be better understood. Composting time increased with increase in the initial moisture content in the peat piles. The quality of the compost product was good.

INTRODUCTION

In recent years the interest in composting liquid manure has increased in response to the concern for abatement of pollution from manures as well as for the preservation and stabilization of manure nutrients for crop production. At the present time, composting of manure slurry is not popular at most farms because of its high water content and the additional handling that is necessary to carry out this process. Composting of the traditional farmyard or "solid" manure, i.e., manure plus bedding without added water, has probably been practised by farmers for several centuries.

[1] Research Scientist, Centre for Food and Animal Research, Agriculture Canada, Ottawa, ON K1A 0C6

[2] Assistant Professor, Department of Civil Engineering, University of Ottawa, Ottawa, ON

[3] Graduate Student, Department of Civil Engineering, University of Ottawa, Ottawa, ON

[4] Research Scientist, Research Program Service, Agriculture Canada, Ottawa, ON K1A 0C6.

The feasibility of using passively aerated static piles or windrows for composting of wastes containing high moisture content such as fish wastes, crab scrap and farm animal manure slurries was recently demonstrated by Mathur *et al.* (1986, 1990). The static pile passive aeration (SPPA) composting system is operationally simple, and requires low labor and energy input because the need for turning or forced aeration of piles is eliminated (Rynk *et al.*, 1992). Although the feasibility of using the SPPA system has been demonstrated, basic information on the thermophilic temperature development and distribution in such systems is limited and inadequate. The need for such information is directly related to the estimation of the effectiveness of the passive aeration mechanism, and of its ability to destroy pathogenic organisms and weed seeds.

The objective of this study was to determine the effect of high initial moisture content of the compost mixture on temperature distribution and variation in SPPA compost piles made from poultry manure slurry with peat and straw, and to determine the physical and chemical characteristics of the compost material. The study was a collaborative effort of Agriculture Canada Research Branch and the University of Ottawa.

MATERIALS AND METHODS

Poultry manure slurry containing 89% moisture was mixed with peat to obtain two levels of moisture content, 73% and 80%, denoted as Treatment I and Treatment II. In Treatment III, barley and oat straw, chopped to 2.5 cm length, was mixed with the same poultry manure slurry to obtain an initial moisture content of 76%.

Pile preparation:

Weighed amounts of peat or straw and poultry manure were downloaded into a farm-scale feed mixer which was equipped with weighing scales and mixing augers. After thorough mixing for 30 minutes or more, compost mixtures were discharged from the side chute of the feed mixer into a small front end loader which was used to make the piles.

All compost piles were prepared in an open-front, roofed barn. The 3.35 m piles were 1 m high, and trapezoidal in cross section with a base of 3.4 m x 2.3 m, and a top of 1.4 m x 0.3 m. A wooden frame was used to have a uniform initial shape and size of the piles. Three replicate piles were used for each of the three treatments.

To prepare the piles, a base of loose peat or unchopped straw was made on level ground, and two 3.6 m long, 10 cm diameter ABS pipes were laid on it (Fig. 1). The pipes had two rows of 1.2 cm diameter perforations. They were placed such that the perforations faced upwards to allow passive movement of air upwards and sideways in the compost mixture, under the influence of convection currents induced by the heat generated in the pile. An envelope of nylon mesh was used on the pipes to prevent plugging of the perforations by the compost mixture. The compost mixture was deposited on top of the aeration pipes, and shaped into the pile configuration. It was then covered with a 5 cm layer of untreated peat or straw.

Thermocouples set in rigid plastic frames made of ducting pipe were laid at three levels in the piles while it was being prepared (Fig. 1). A total of 33 thermocouple locations were used for continuous automatic temperature monitoring in one pile under each treatment. In the two replicate piles for the treatments, temperatures were monitored manually at 23 locations corresponding to 23 locations in the piles with continuous temperature monitoring. Multi-Channel Automatic Data Logging Systems were used to log the temperature data over a 4-month period.

Compost analysis:

Compost samples were collected 13 times and analyzed for moisture content (MC), volatile solids (VS), ash, and pH according to methods described by McKeague (1978). Total carbon and total nitrogen (C and N) were determined using a LECO CHN-600 Analyzer.

RESULTS AND DISCUSSION

Temperature Distribution and Change

The change in average temperature of the piles, in which temperature was monitored continuously at 33 locations, is shown in Fig. 2 for the three treatments, namely, peat mixture with 73% initial moisture (Treatment I), peat mixture with 80% initial moisture (Treatment II), and straw mixture with 76% initial moisture (Treatment III). The temperature started rising on day 1 in all treatments (day 0 was the day the piles were made). The active composting time was about 45, 115, and 75 days in treatments I, II, and III, respectively. Reduced pore space and the greater moisture content due to the extra manure in the Treatment II pile than in the Treatment I and III piles resulted in a much longer composting period in the former. Air supply is a key factor in the composting process, and any reduction or delay in its supply would lead to increased composting time. About

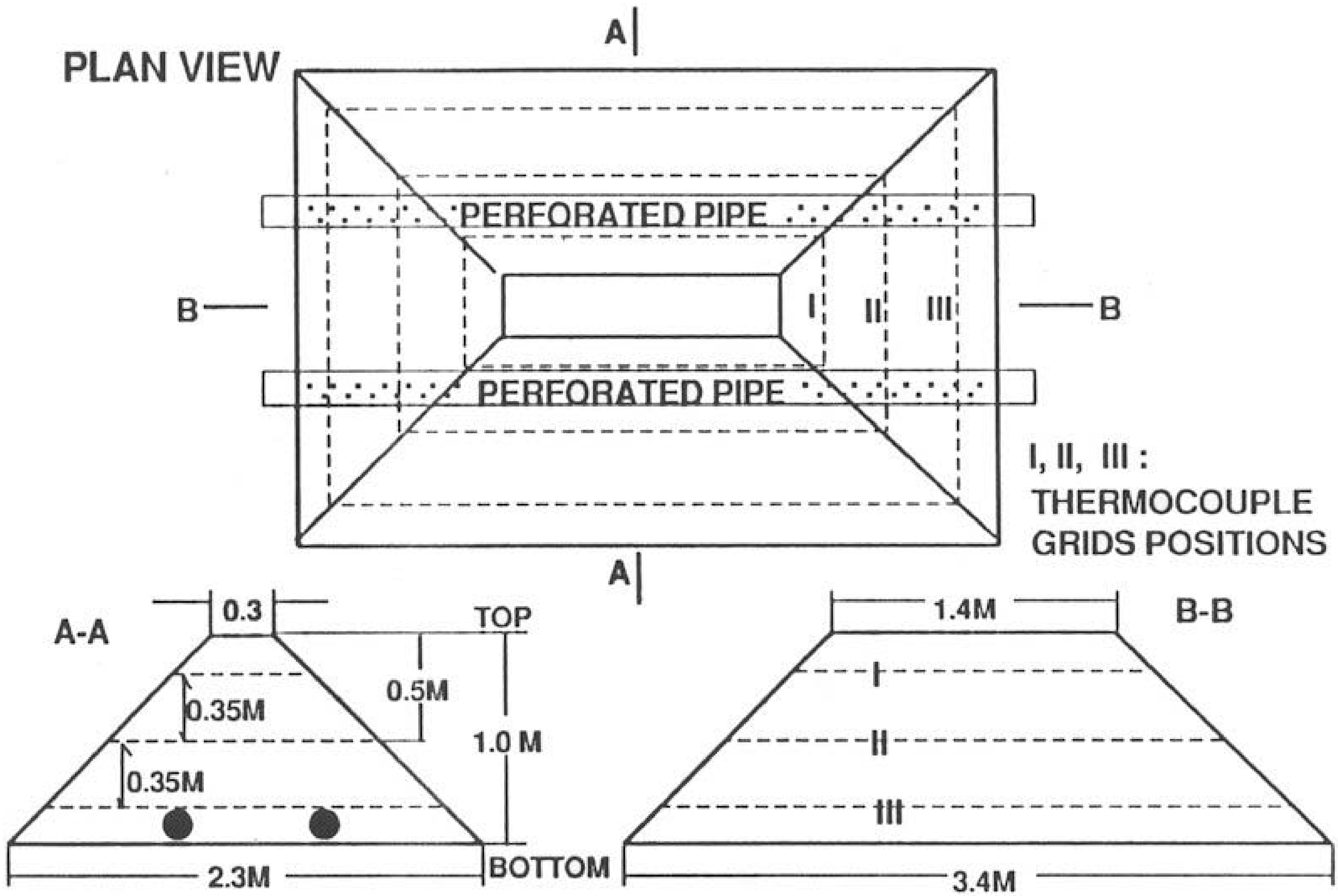

Fig. 1. Compost Pile Configuration.

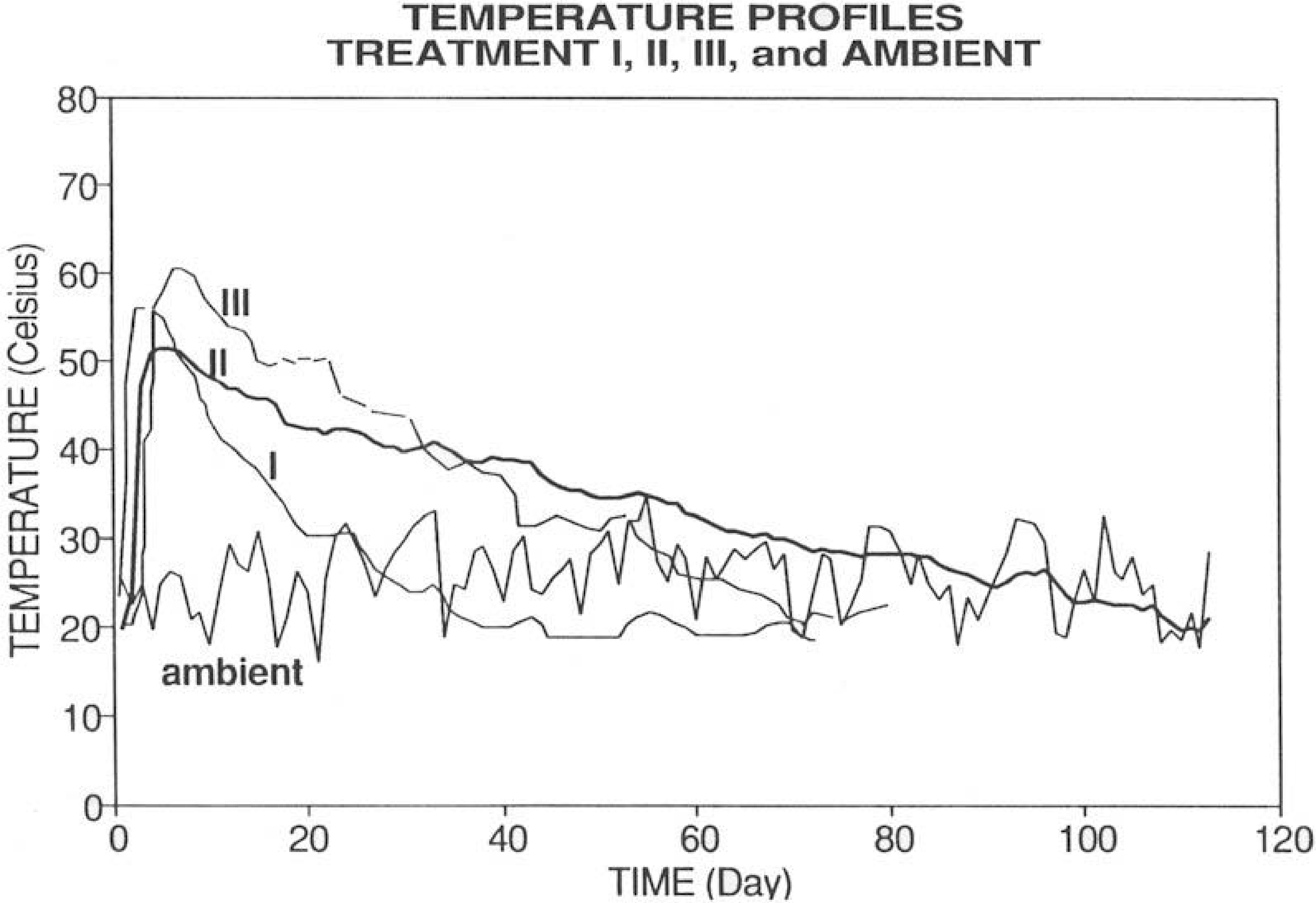

Fig. 2. Average temperature variation in piles with 33 temperature measurement locations.

twice the manure was contained in Treatment II piles (initial bulk density 530 kg/m^3) than in the Treatment I pile (initial bulk density 325 kg/m^3).

Results in Figure 2 show that although it is feasible to compost poultry manure/peat at the high initial MC of 80%, a cost in terms of a long composting period is involved. The straw compost mixture (Treatment III) was slow to heat up, but it attained the highest temperatures amongst the treatments.

There was good agreement for temperature change among the three replicate piles for each treatment. The average temperature, for the 23 measurement locations in the three replicate piles for Treatment II is shown in Fig. 3. The good agreement among the three piles indicates that the compost mixture was well-mixed initially, and that similar average temperature can be expected in piles with similar geometry. This is supported by the observation that symmetrically positioned locations in different parts of the pile exhibited similar temperature variation. A typical example is shown in Fig. 4 for Treatment II.

Temperatures differed at various locations in the piles during the composting process. This difference was more pronounced at the start than at the end of the composting period. The location of the aeration pipes and the pile initial moisture content also appeared to influence the temperature variation. The temperature variation at four similar locations at the bottom of the pile are shown in Figs. 5, 6 and 7 for Treatments I, II and III, respectively. The relative location of the four measurement sites 2, 5, 7 and 11 are also shown. Figures 5, 6 and 7 show that the rise and fall of temperature occurred earliest at the periphery location 2, followed by the interior location 5, and then 7. This appears to indicate that more air for biochemical oxidation and heat generation was available initially at the periphery (location 2) of the piles than at the interior locations (5, 7, 11). Thus diffusion of air into the compost mass may also have had a role in the composting process. The relative amount of air supplied by diffusion through the porous compost mass and by passive aeration through the pipes needs to be established. It is also possible that movement of passive aeration air at sites 5 and 7 was hindered by compression of the compost mass at these sites due to the weight of the increasing amount of material above these sites. The role of the aeration pipes in supplying air is illustrated somewhat by the temperature distribution at location 11 in Figs. 5, 6 and 7. The temperature at site 11 rose earlier than at site 7 in all three treatments presumably in response to a greater availability of air at Site 11 than at site 7.

It should be noted that in Treatment II (Fig. 6), the temperature at sites 5 and 7 did not increase much above 45°C. This has implications with respect to possibly incomplete

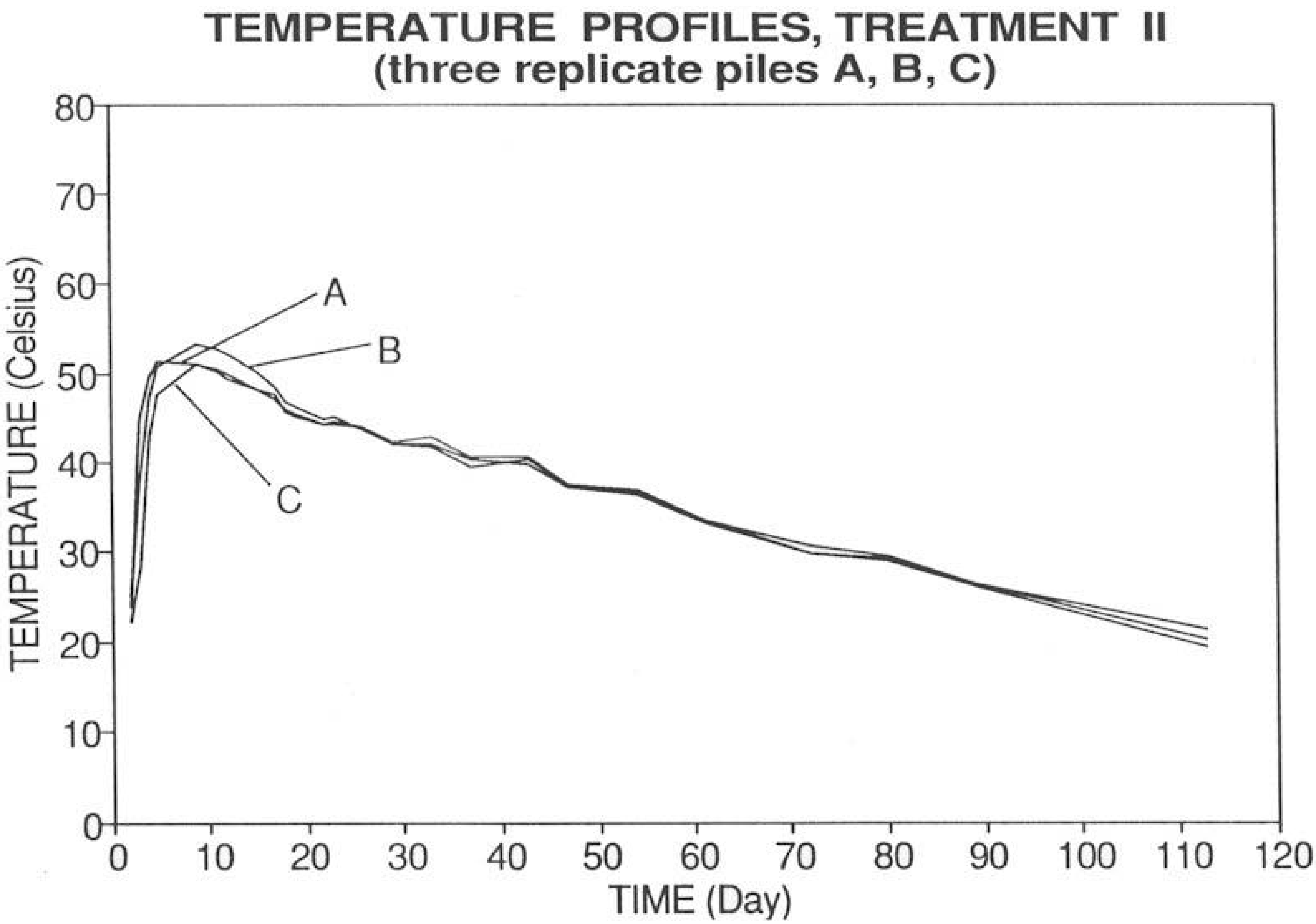

Fig. 3. The average temperature profile in three replicate piles of Treatment II (peat & manure at 80% initial MC).

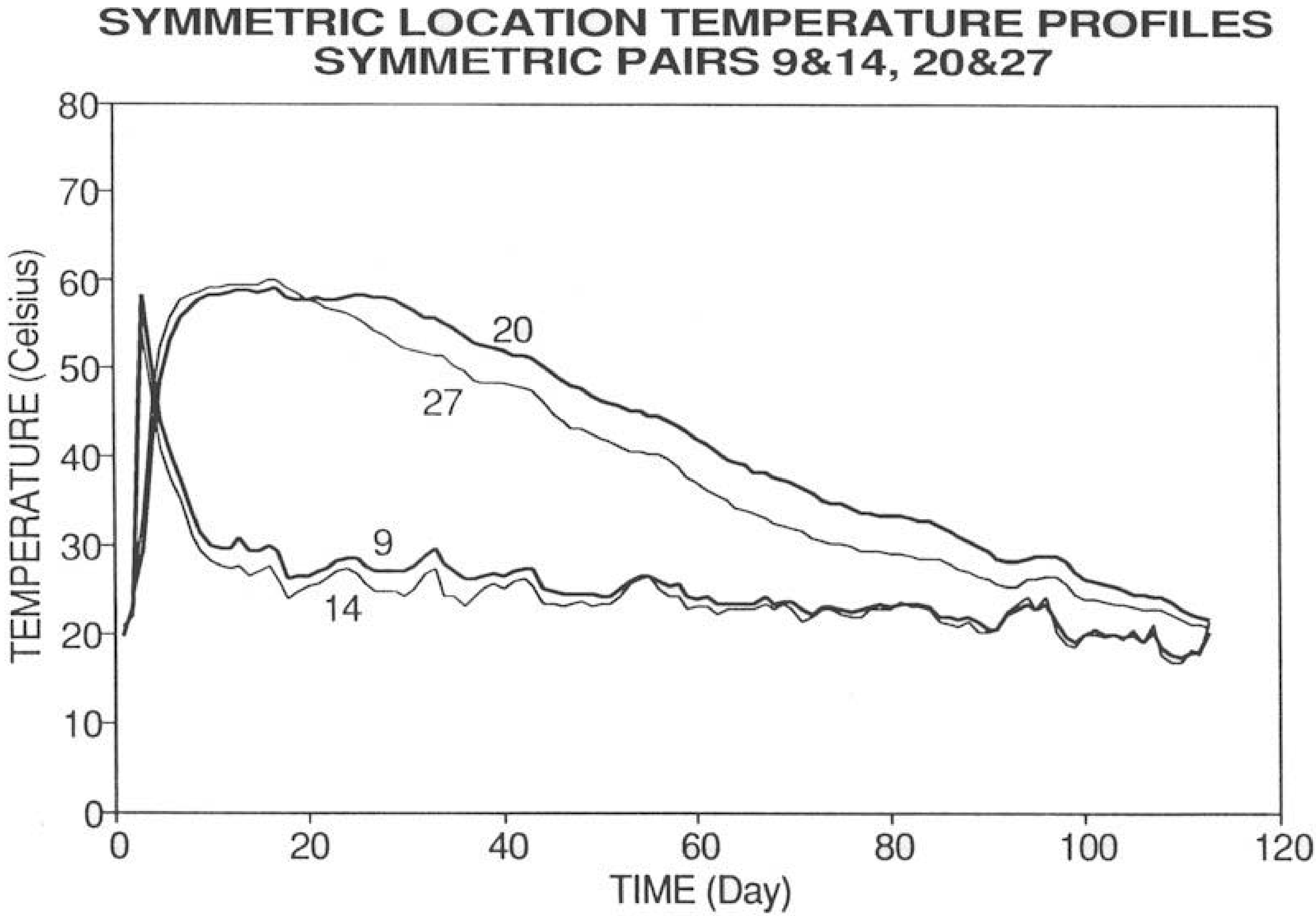

Fig. 4. Temperature similarity at symmetrically positioned locations in the pile under Treatment II.

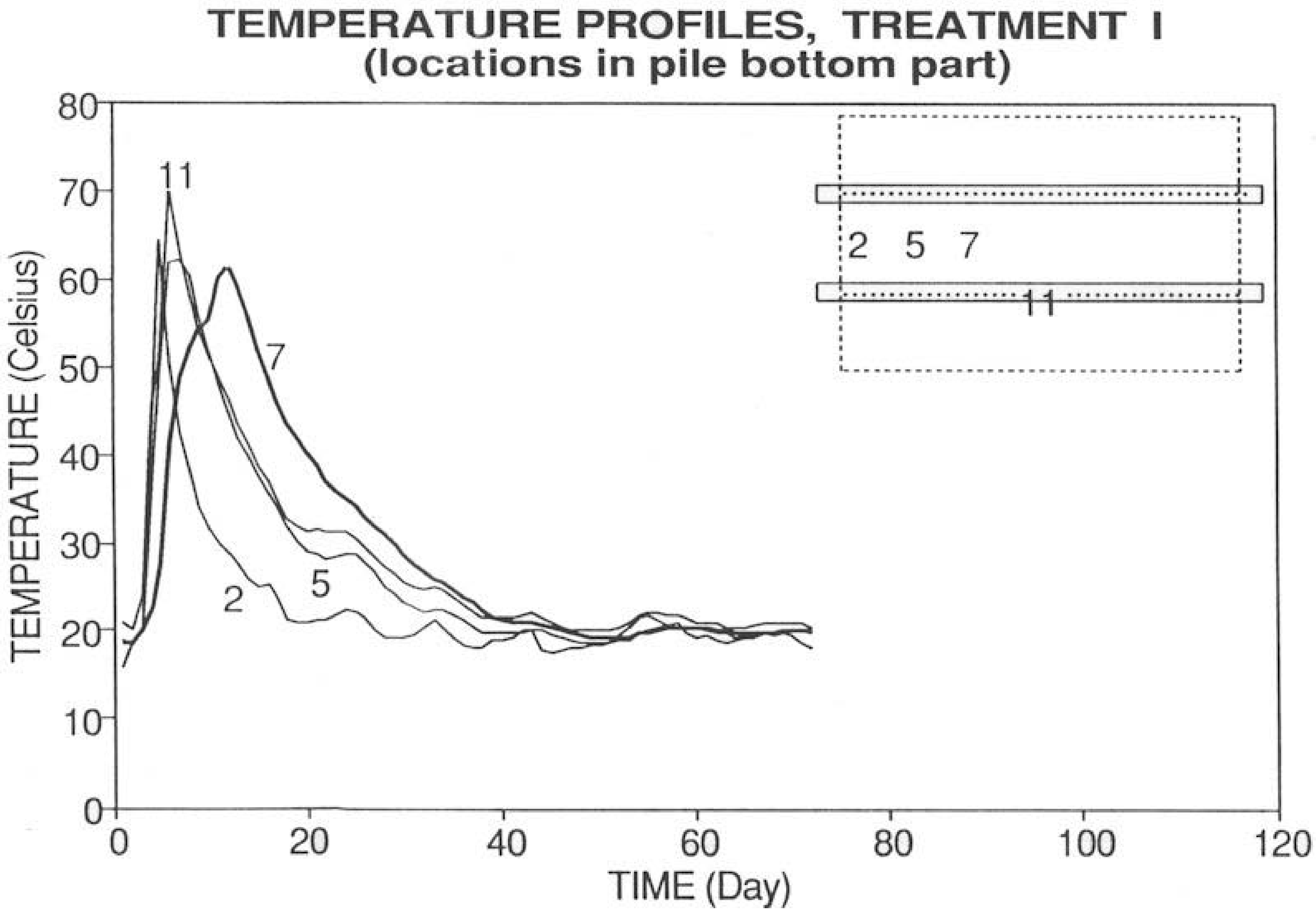

Fig. 5. Temperature profiles at different locations at the bottom of the pile in Treatment I.

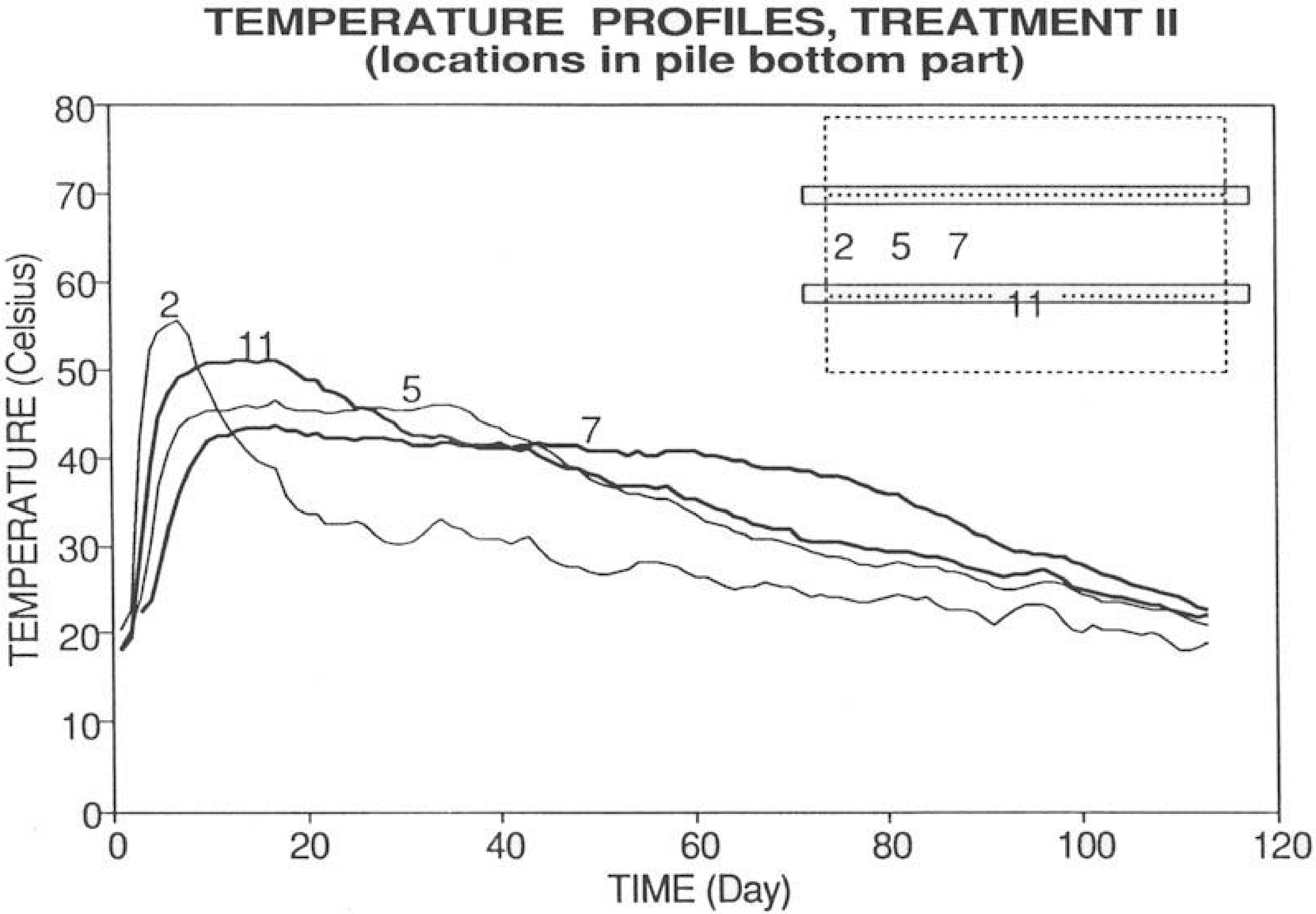

Fig.6. Temperature profiles at different locations at the bottom of the pile in Treatment II.

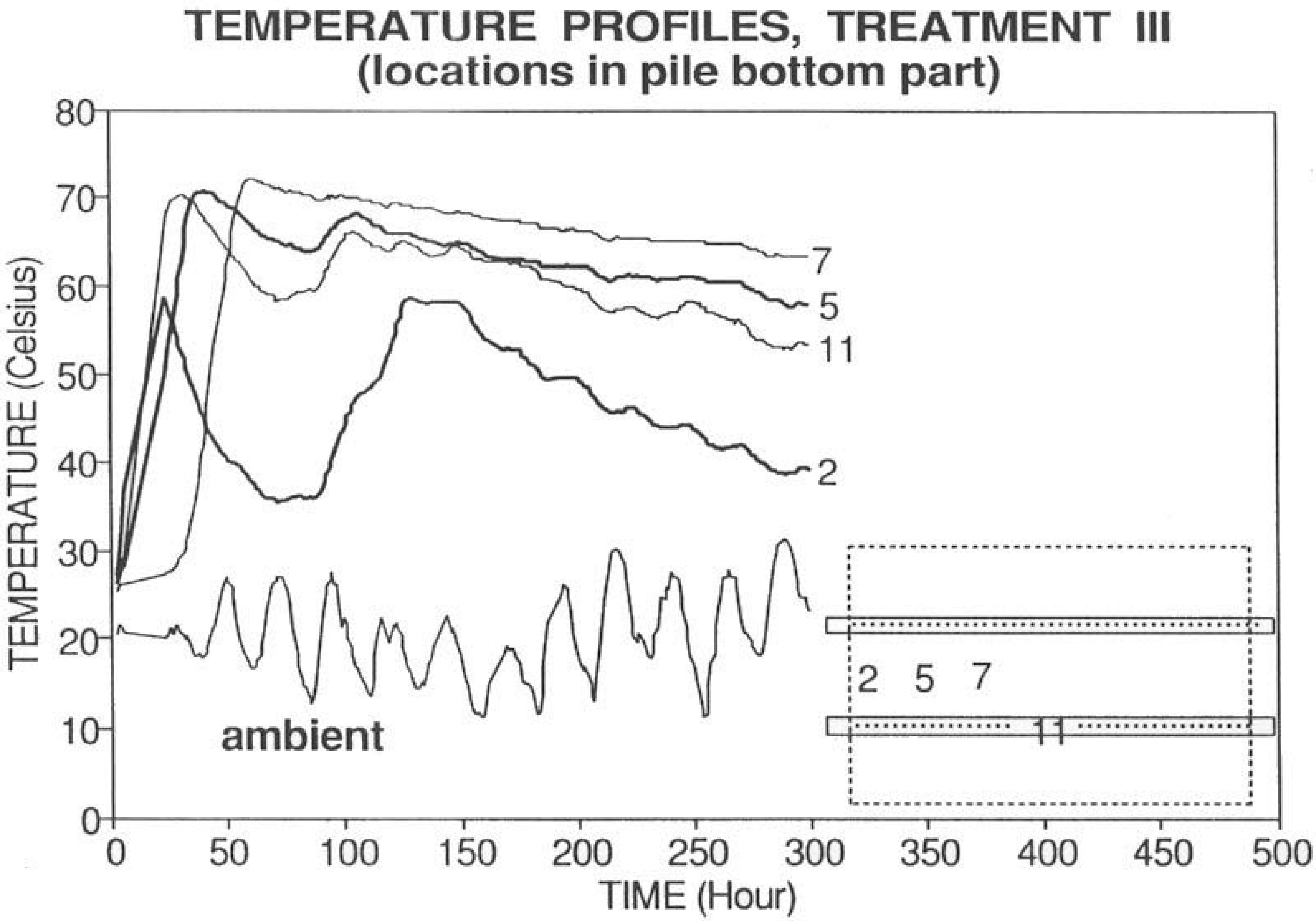

Fig. 7. Temperature profiles at different locations at the bottom of the pile in Treatment III.

destruction of pathogens under Treatment II conditions. Figure 7 shows two temperature peaks at some locations. The reason for this is not clear at this time.

From the large data base of continuous temperature measurements at the 33 locations within the piles, it was possible to establish temperature distribution profiles under the three treatments (Figs. 8, 9 and 10). In Treatment I, temperature distribution at days 5, 10 and 30 (Fig. 8) suggests that heating in the pile started at the periphery initially and then progressed to the pile interior. Most of the pile reached temperatures of 50°C or more. In Treatment II (Fig. 9), heating again appears to have started initially at the periphery and then in the interior. However, as also noted above (Fig. 6), the temperature in some parts of the interior of the pile did not reach more than 45°C. In Treatment III (Fig. 10), temperatures rose earlier, and to higher values, than in the peat piles. However, it appears that temperatures near the periphery at the bottom did not increase beyond 40°C. Temperature distribution in Treatment II on day 70 was similar to that in Treatment III on day 60. The results in Figs. 8, 9 and 10 seem to suggest that direct diffusion of air into the compost piles may play a significant role in the initial stages of the composting process.

Compost Quality

The initial and final values of the compost mixture properties are shown in Table 1. The initial C/N ratios in the two peat treatments were much lower than the usually recommended values of 25 to 30. Low C/N ratios are supposed to promote ammonia losses. However, much higher concentrations of ammonia gas were measured under Treatment III than the other two treatments (Fig. 11). This shows that acidic peat was quite effective in controlling loss of nitrogen, as ammonia gas, from the compost piles. Most of the ammonia evolution from the piles was over in the initial three weeks.

The compost product from all three treatments had good nutrient and fertilizer value. The product had dark brown colour, loose structure, and earthy smell, which are characteristics of good quality compost.

CONCLUSIONS

1. It is feasible to use SPPA systems to compost high moisture content manure slurries with suitable bulking agents.

2. The relative role of air supply via aeration pipes and by diffusion through the pile surface needs to be better understood for improved design of the SPPA systems.

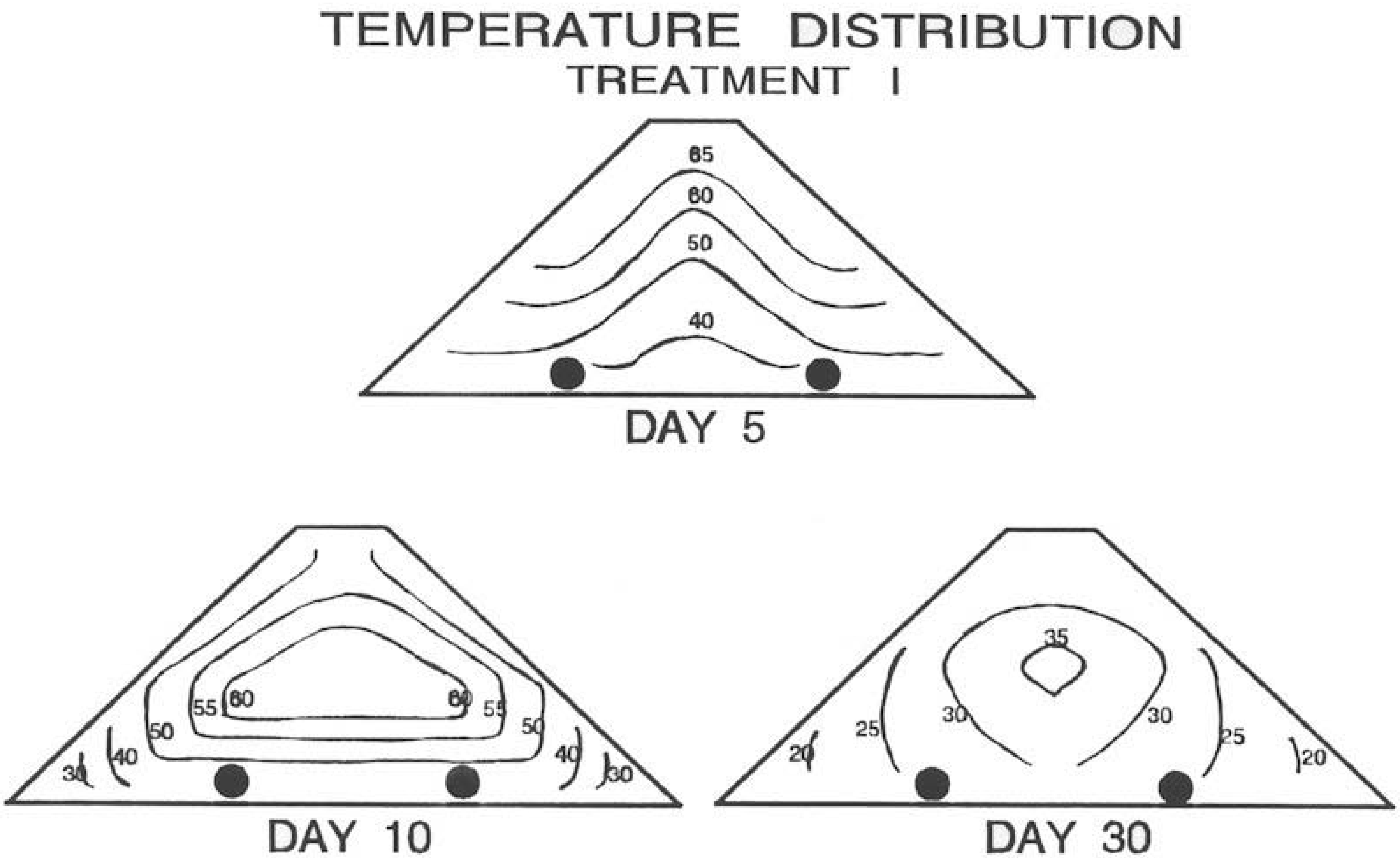

Fig. 8. Temperature distribution profile for Treatment I piles (peat & manure at 73% initial MC).

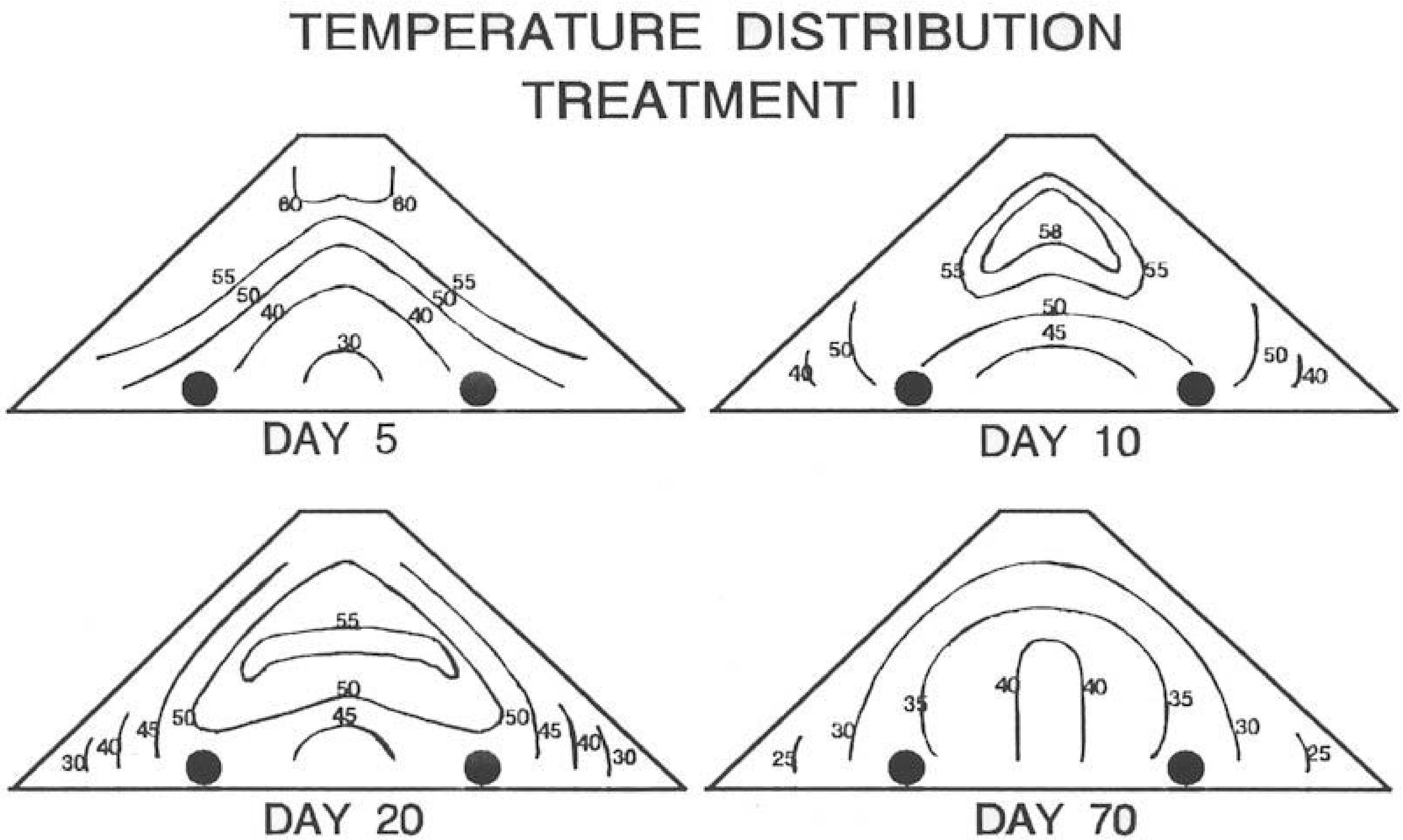

Fig. 9. Temperature distribution profile for Treatment 11 piles (peat & manure at 80% initial MC).

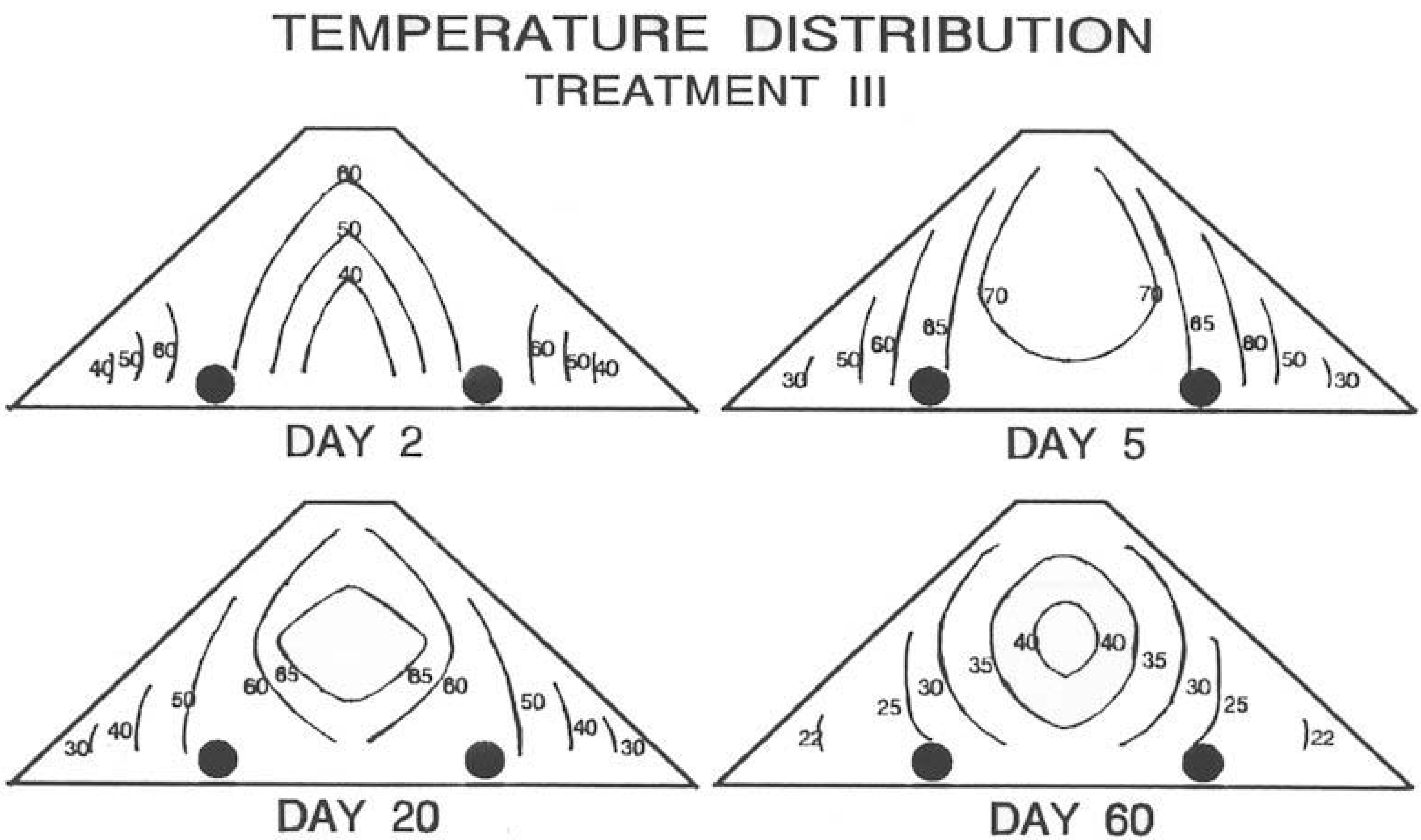

Fig. 10. Temperature distribution profile for Treatment III piles (chopped straw & manure at 76% initial MC).

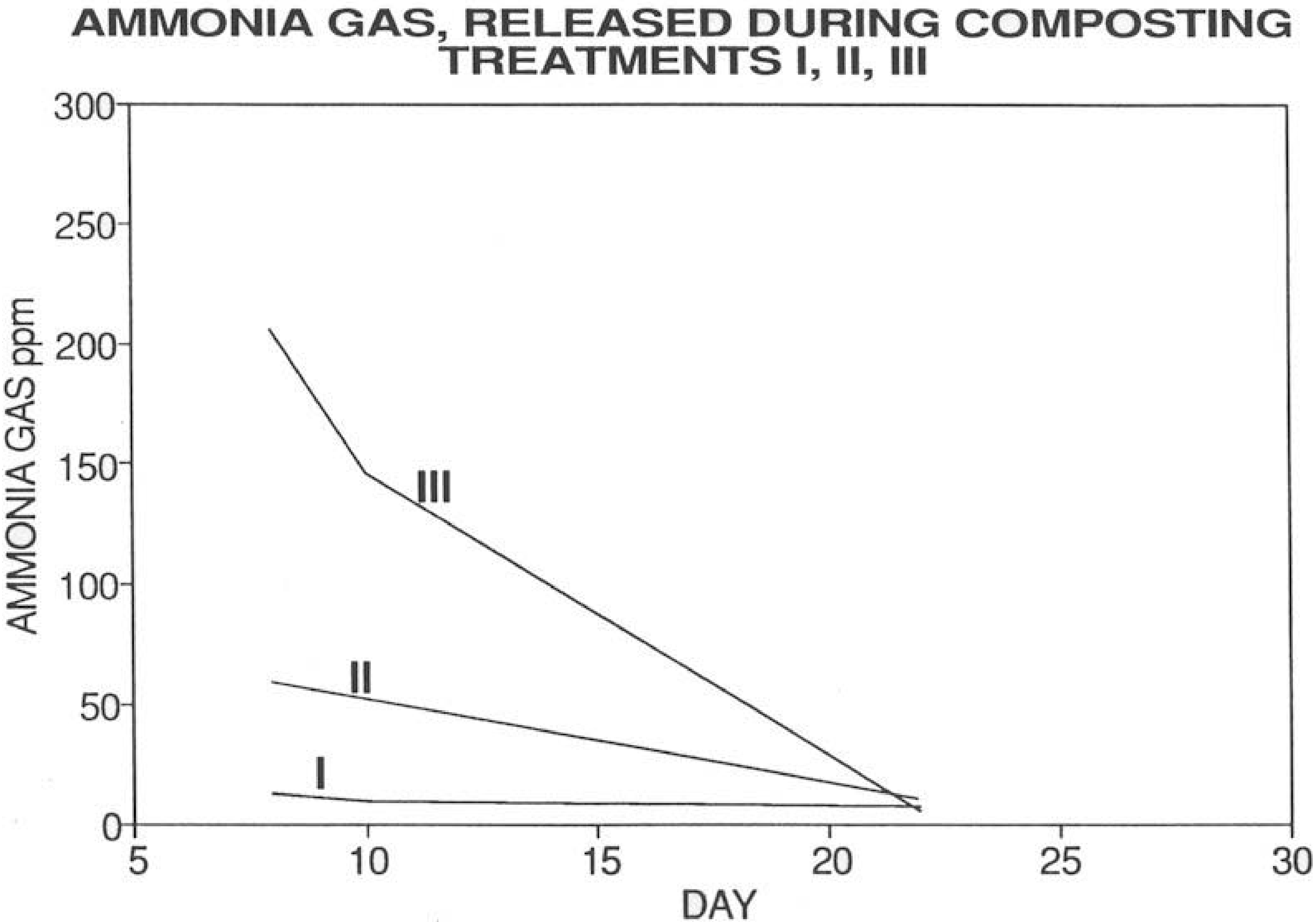

Fig. 11. Ammonia gas concentrations on pile surfaces.

Table 1. Initial and final properties and composition of the compost mixtures.

Property	Treatments*					
	I		II		III	
	Initial	Final	Initial	Final	Initial	Final
Moisture Content %	73	66	80	73	76	48
Volatile Solids % DM	87	86	81	79	82	69
Ash %DM	12	13	18	20	17	30
pH	6.2	7.6	7.2	7.3	7.9	9.4
C/N ratio	16	15	13	10	23	12

* Treatments I, II, and III consisted of 73, 80 and 76% initial moisture content mixtures of poultry manure slurry with peat, peat and chopped straw, respectively.

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