RESEARCH REPORT

ENVIRONMENT

Title: Minimizing Cost while Safely Composting Swine Mortality in Roofed and Unroofed Compost Systems – An Evaluation of Type and Amount of Amendments on the Compost Process – **NPB #97-1756**

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ABSTRACT

Proper disposal of carcasses occurring due to mortality in animal production is necessary for protection of the environment and prevention of the spread of disease organisms. Mortality disposal laws and regulations vary from state to state with regard to the legality of composting swine mortality and in many states where mortality composting is legal, restrictions on the system can limit the extensive use of the procedure by swine producers. A common restriction on mortality composting operations in many states has been the requirement that sawdust be utilized as the bulking agent in the compost operation. Because producer access to sawdust is limited in many areas of the United States, research was initiated to determine the effectiveness of alternative bulking agents on the effectiveness of the compost process.

Tests were undertaken to compare swine composting in sawdust with that in ground wheat straw and with that in ground corn stover. Initial tests were begun early in July, 1997, with two 200 kg (450 lb) sows placed in each of three 2.4x2.4x1.2 m deep (8'x8'x4') bins containing these three amendment materials (45 cm (18") of material under the carcasses). Thermocouples were placed around the carcasses to measure temperatures, and a hand held oxygen meter was attached to an insertable probe to measure oxygen levels at various locations within the bins. Early in October, 1997, the first set of bins was turned into secondary bins and a second set of three essentially identical bins was started. In all cases, the temperatures around the carcasses rose rapidly to above 60 ^{o}C and high temperatures were maintained for several weeks. Oxygen levels near and above the carcasses dropped to close to zero, but values laterally from the carcasses remained elevated suggesting good convective circulation in all materials. Leachate was observed shortly after composting began, and further leachate from the ground materials was observed when rewetting of the bins was done. Composting of these large animals was not entirely complete at turning after three months but was reasonably similar for the three materials. The results indicate that in bin compost systems with a roof, the composting process can be effectively completed using either straw or corn stover as an alternative to sawdust. The results also indicate the common recommendation of turning the compost at 90-day intervals may not be long enough for satisfactory degradation of large, mature animals and that consideration of extended composting times is necessary for large animals. Work is continuing on windrow and static pile systems to determine the effectiveness of alternative bulking agents in outdoor compost systems.

INTRODUCTION

A growing concern in animal agriculture is disposal of carcasses resulting from mortality during production. Such disposal is constrained by concerns for protection of the environment and prevention of the spread of disease. Producers across the United States have traditionally been limited to three legal methods of dead animal disposal including, incineration, burial, and rendering; but these methods have been becoming either less acceptable or less available. Composting dead animals is now another option available to producers in many states as appropriate regulations are put in place. As this process becomes more common in the swine industry, research on improving procedures and practices to assure composting of mortality offers protection of ground and surface water from pollution, reduces the risk of disease transmission, prevents nuisances such as flies, vermin and scavenging animals, and maintains air quality are needed.

Much of the important, primary work on composting dead swine has been done in Missouri (Fulhage and Ellis, 1994), and this work indicates that sawdust is the ideal amendment material but that straw has been used less successfully. An extensive study by Morris et al. (1995) characterized composting of market size pigs and sows in sawdust or chopped straw under two different management strategies. They also concluded that sawdust was a better substrate than straw. A recent pork industry publication (NPPC, 1997) reiterates that sawdust is the ideal bulking agent for outside composting of swine mortality, but it also indicated that other materials can work effectively in roofed bin systems. Other important references are cited in this last publication. In the work reported here, ground wheat straw and ground corn stover were compared to sawdust for use as amendments in bins under Ohio conditions. Further work is planned, with the aim being to determine the conditions under which materials that are more readily available to swine producers can be recommended for composting swine mortality.

OBJECTIVES

The objectives of the experiment included: 1) Determine the effectiveness of three alternative carbon sources for use in composting swine mortality, and 2) Determine the time requirement necessary for complete decomposition of mature swine commonly disposed of in production units and establish guidelines for sizing composting facilities based on these findings.

Carbon sources were chosen based upon availability, cost effectiveness, physical properties including: carbon:nitrogen ratio, porosity, moisture and surface area achievable without significant modification of the physical form

PROCEDURES

This composting trial took place in very simple bins placed on a concrete pad under the extended roof of the south side of the new OARDC Composting Research Building. For Run 1 of the trial, three abutting 2.4x2.4x1.2 m deep (8'x8'x4') bins were constructed from ten uncut sheets of 2 cm (3/4") thick plywood which were screwed to 5x5 cm (2"x2") supports down each corner of the three square structures, and which had 1.6 mm (14 gauge) galvanized wire stretched side-to-side, both ways across the squares at 30 cm (1') above the concrete floor. For Run 2 of the trial, an additional set of three adjoining bins of the same design was constructed from seven uncut sheets of plywood.

Run 1 began on July 8, 1997. Sawdust (SD), ground wheat straw (STW), and ground corn stover (CS) were used as the amendment materials. These materials were wetted to bring them to an estimated 50% moisture, and a 45 cm (18") deep base of each was laid down in one of the three bins. Then, two, roughly 200 kg (450 lb), freshly killed sows were laid on the base in each bin and centered relative to the sides of the bins. Six thermocouples were placed in each bin; one under each head, belly and rump. The bins were then filled with the amendment materials. One additional thermocouple was used to monitor ambient conditions. Temperatures were recorded twice a day initially and then less often as time progressed. Further amounts of amendment were added to level off the bins as material sagged due to composting, and water was added when materials seemed too dry. Samples of the amendment materials were taken and analyzed for moisture content and other properties. Qualitative observations on odor and leachate were recorded.

The second stage of Run 1 began on October 7, 1997. The composted materials from the first set of bins were turned into each of the adjacent new bins, and two thermocouples were placed about half way down in these materials at locations to either side of the middle of the bins. Then, to start Run 2, the old bins were filled with fresh materials as before, except that 60 cm (24") of base was laid down in each case. On January 8, 1998, the first trial materials were removed to a separate site for curing, and the second set of materials was turned into the new bins on January 22.

Oxygen levels were recorded using a portable oxygen analyzer (Teledyne Brown Instruments) connected to a 1.2 m (4') long probe. Three readings were taken about half way down in each bin; two along two opposite sides and one in the center of the bin. Readings were obtained twice a week for the first two weeks and then weekly for the remainder of the first stage of Run 1. Only one set of readings, for both the newly placed sows and for the turned composted materials, was obtained at one week into the second stage of the trial.

RESULTS

Various initial properties of the amendment materials are given in Table 1. Temperatures for replicate 1 and 2 are presented in Figures 1 through 4. Average temperatures for the first phase (day 0 to 90) of replicate one (Run 1) are depicted in Fig. 1 and the second phase (day 91-180) following turning and mixing are depicted in Fig. 2. The results indicate that temperatures rose quickly in corn stover and straw amendments when compared to sawdust, but temperatures were sustained at a higher level in sawdust for the first 90 days and following turning and mixing. This is an indication that the compost process was continuing at a more rapid rate and for a longer time in the sawdust as compared to straw and corn stover. Similar results are indicated for replicate 2 (Run 2) as shown in Fig. 3 and 4, respectively. Note that air temperature (T Air) for Run 2 (day 0 to 90) are the same as Run 1 (day 90 to 180), and note further that air temperatures were generally read early to mid morning and are not daily means. Both replicates reached temperatures above 55 ^{o}C or 131 F (T 55) (using USEPA 503 regulations for biosolids as a guideline temperature for pathogen destruction) for a minimum of six days.

Oxygen levels generally supported a pattern of air being drawn in from the sides of the bins and rising in the middle. This was seen as oxygen levels along the walls of a bin being high, at least 15% and typically around 20% (nearly atmospheric), while the oxygen level in the center of the bin was low, no more than 5% and usually less than 1%. In the corn stover, this pattern was established by day 3 of

Run 1 and lasted through day 21, with high values being observed at all points on day 28 and thereafter. In the straw, the pattern was only fully established by day 6 and had begun to break up by day 21. In the sawdust, only the outer wall showed high oxygen values while the inner wall (i.e. next to the straw bin) and middle showed low readings, but this pattern lasted from day 6 through day 45 and was not fully gone by the time turning took place. At day 4 after turning, the composted material showed high oxygen values at all but one location, and the newly composting Run 2 materials showed patterns entirely consistent with Run 1 values.

Table 1. Amounts of amendment materials, moisture contents before and after water addition at start of runs, and carbon/nitrogen ratio at start of Run 1. No C/N is available for Run 2.

	Run 1					Run 2			
	weight		MC(%,wb)			weight		MC(%,wb)	
	(kg)	(lb)	bef.	aft.	C/N	(kg)	(lb)	bef.	aft.
Sawdust	1980	(4365)	39	55	221:1	1680	(3710)	37	61
Straw	455	(1000)	13	42	32:1	590	(1300)	12	58
Corn Stover	510	(1160)	33	57	44:1	590	(1300)	15	63

The pen arrangement did not allow for clearly distinguishing sources of leachate or odor. Modest amounts of leachate were observed from about three days after carcasses were newly placed in pens and for about a week thereafter. Flies and distinct odors were associated with this leachate until it was cleaned up. The leachate did seem to be more prominent next to the straw and corn stover bins. It also seemed to be less in Run 2 where a deeper base was used. Further leachate was observed from the corn stover and, to a lesser extent, the straw bins when materials were wetted down in the middle of Run 1. Odors, other than as just noted, were mild and smelled mostly like amendment materials.

At the end of three months of composting, that is at turning of the material for both Runs 1 and 2, samples indicated that the sawdust moisture had been kept adequate (55%, 51%; Runs 1, 2) but that the corn stover and especially the straw had dried out (30%, 34% and 22%, 23%). At the same times, qualitative observations were that most of the large bones and some flesh/skin of the animals were still present in the compost. The sawdust did appear to have less flesh/skin present. At the end of six months (Run 1 only) moisture levels were similar, somewhat less flesh/skin was present, and in the sawdust (pH for first part of Run 1 only was 5.2) the bones were easily broken while in the other materials (pH's of 7.1 and 7.3) they remained difficult to damage.

Slower temperature rise in the sawdust bins indicates that the carcasses were less rapidly composted in this material. Oxygen availability may be the critical factor in this. Severe oxygen depletion was more extensive in the sawdust and lasted much longer than in the other materials. This suggests that air movement was more restricted in the sawdust, which would be entirely consistent with its greater density and less open structure. Because of this, convective movement would be limited, and both oxygen supply and heat loss would be reduced. Better heat retention in sawdust is consistent with the temperature declines seen in Figs. 1 and 3, and so straw and, particularly, corn stover may not adequately sustain composting in cold areas.

While three months has generally been accepted as adequate for composting swine carcasses, this trial indicated that this period is not long enough to fully decompose large, mature animals. All three materials had reasonably similar success in the three month periods used, but sawdust appeared to do a marginally better job, particularly on mature bones. This may have been the result of better heat and moisture retention as well as more acidic conditions. The poorer water retention of the ground materials also resulted in more leachate, and indicates that open (rain exposed) piles will be harder to manage properly. Further trials on smaller, younger carcasses and in open conditions are planned.

The immediate implications of the research for swine producers are that alternative carbon sources must be managed properly in roofed compost systems to control leachate and sustain appropriate moisture levels for adequate composting. All three amendments evaluated reached temperatures above 55 C for a minimum of 6 days resulting in destruction of pathogens as indicated by generally accepted guidelines for compost operations. The generally accepted guidelines for time requirements for large, mature swine will need to be extended beyond the normal 90 day cycle to complete the degradation process in the primary stage (first 90 days) and secondary stages (second 90 days). Research on the effectiveness of alternative compost materials in open, unroofed facilites is ongoing and promises to answer more questions about the mortality composting process.

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