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Evaluation of the biodegradability of animal carcasses in passively aerated bio-secure composting system

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Abstract

Composting livestock carcasses is a viable method for on-site treatment and disposal. Properly estimated carcass biodegradability is valuable for designing and controlling animal mortality composting systems. However, it is still difficult to assess the biodegradability inside composts. In this study, approximately 250kg of swine carcasses were composted in each of nine 2m X 2m weighable composting test units using three different envelope materials: corn silage, ground cornstalks, and ground oat straw. Total weight of compost material was measured monthly to observe the carcass decomposition trend with composting time. The most significant weight loss occurred during the first 6 weeks of composting. Biodegradability of the swine carcasses was estimated by comparing the mass of carcass remains after 16 weeks composting with the total carcass weight placed in the pile during the time of construction. Based on these results the influence of envelope material type on the biodegradability of swine carcasses was evaluated. The carcass decomposition within silage test units was only 66% of the initial carcass mass, while carcasses in cornstalk and oat straw test units decomposed 86% and 79% respectively.

Keywords

Livestock carcass, biodegradability, cover materials, mortality composting

Disciplines

Bioresource and Agricultural Engineering

Comments

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Abstract. *Composting livestock carcasses is a viable method for on-site treatment and disposal. Properly estimated carcass biodegradability is valuable for designing and controlling animal mortality composting systems. However, it is still difficult to assess the biodegradability inside composts. In this study, approximately 250kg of swine carcasses were composted in each of nine 2m X 2m weighable composting test units using three different envelope materials: corn silage, ground cornstalks, and ground oat straw. Total weight of compost material was measured monthly to observe the carcass decomposition trend with composting time. The most significant weight loss occurred during the first 6 weeks of composting. Biodegradability of the swine carcasses was estimated by comparing the mass of carcass remains after 16 weeks composting with the total carcass weight placed in the pile during the time of construction. Based on these results the influence of envelope material type on the biodegradability of swine carcasses was evaluated. The carcass decomposition within silage test units was only 66% of the initial carcass mass, while carcasses in cornstalk and oat straw test units decomposed 86% and 79% respectively.*

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Introduction

Rendering, incineration, burial, and composting are the main methods used for livestock mortality disposal. Due to bio-security concerns and increasing costs associated with rendering, livestock producers are showing increasing interest in on-farm disposal methods. Incineration is commonly used for small carcasses, but is less practical for larger carcasses as it requires substantial amounts of fuel and can cause air pollution. Although burial is the most common on-farm mortality disposal method, its use is declining due to groundwater and soil contamination concerns. Increasingly, composting is being adopted as a viable method for on-site treatment of livestock carcasses. Due to successful use in the poultry and swine industry, it is perceived to be an economical and environmentally friendly process. The high temperature acquired through microbial metabolism has potential to inactivate pathogens. Therefore it has been used for pathogen related carcasses disposal in USA and Canada. Glanville et al. (2006) reported excellent viral pathogen inactivation and animal tissue decomposition using a windrow type cattle composting system.

Previous researchers reported animal tissues (internal organ and soft tissues) were fully decomposed within 4-10 months in windrow type composting systems (Glanville et al., 2006; Sander et al., 2002). They observed and determined animal tissues decay extent during excavating composting piles. Properly estimated carcass decomposition rate is valuable for designing and controlling animal mortality composting systems. However, it is still difficult to evaluate the decomposition rate inside of field scale compost piles. In this study, about 250kg of swine carcasses were composted in nine compost boxes with three different cover materials: corn silage, ground cornstalks, and ground oat straw. Total weight of compost material was measured monthly to observe carcass decomposition trends with composting time. Biodegradability of the swine carcasses was estimated by comparing the mass of carcass remains with the total carcass weight at the time of construction. Based on these results, the influence of cover material type on the biodegradability of swine carcasses will be discussed.

Materials and Methods

Construction and loading of the test platform

Each test unit consisted of a 2m X 2m platform with 1.2 m high sidewalls. The interior of the test unit was lined with a 45 mil synthetic rubber liner to capture and retain leachate. The exterior of the test unit was insulated with a 5.0 cm Styrofoam insulation board. Three passive aeration tubes were installed beneath the swine carcasses. Corn silage, cornstalks and oat straw were used as the envelope material. About 30cm depth of envelope material was placed beneath the carcasses, and approximately 60cm of the same material (Figure 1) was placed over them. Approximately 250 kg of swine carcasses were placed in each test unit (Table 1). Three replications were performed for each envelope material (3 replications X 3 envelope materials).

Table 1. Mass of compost material and pigs in each test unit at the time of construction (N=3).

	Corn stalks	Silage	Oat straw
Cover material (kg)	694±64	2431±89	539±58
Pig weight (kg)	259±24	256±29	241±18
# of pigs	4.7±0.6	5.0±0.0	4.3±0.6
Total weight (kg)	953±42	2687±65	780±64

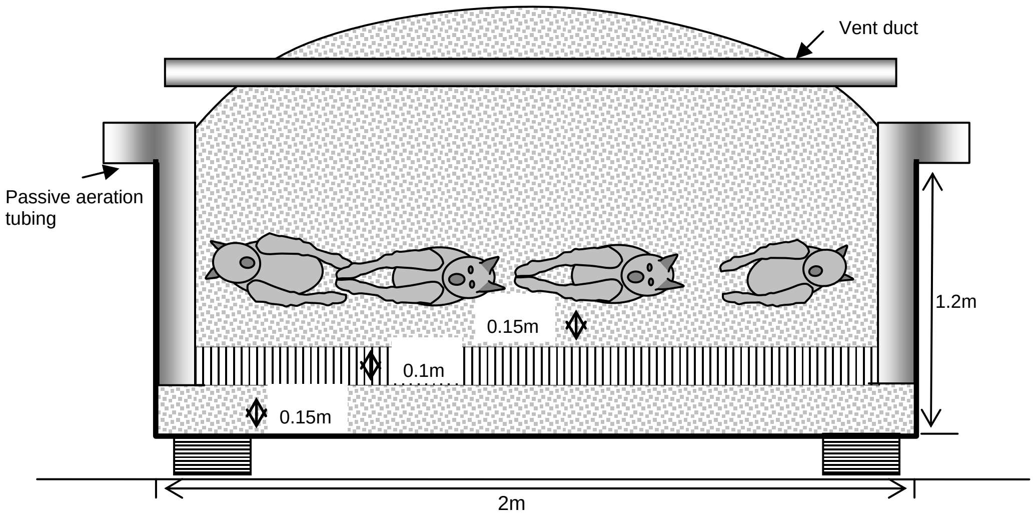

Figure 1. Cross-section of loaded test unit.

Weighing of total compost materials during composting

Total weight of compost material was measured monthly using portable platform scales as shown in Figure 2.

The loaded platform was lifted with four 2-ton hydraulic jacks supported on the scale platforms.

Figure 2. Test platform weight measurement.

Weighing of envelope material and carcass remains during post-trial excavation

Total final envelope material weight was acquired by subtracting the weight of carcass remains from the total compost materials following 16 weeks of composting. This was accomplished by carefully excavating the finished compost layer by layer (0.4m depth) and recording the subsequent changes in platform weight. This procedure also permitted calculation of the bulk density of the envelope material at various depths within the compost pile. The location of the decomposed carcasses remains in the compost box was carefully observed during excavation of each test unit and they were separated from envelope materials and weighed to quantify carcass biodegradation.

Moisture content (MC) and bulk density of envelope materials

Moisture contents of envelope materials were measured by drying samples at 105°C for approximately 24 hours (TMECC, 2001). Bulk density of each layer was calculated by dividing the weight of the material by the volume of each layer.

Results and Discussion

Weight variation of total compost materials

Figure 3 and Table 2 show the weight variation of each test unit during the 16 weeks of composting. The most significant weight loss occurred during the first 6 weeks of composting while a slight loss was observed during the rest of the composting period. The weight differences were caused by a combination of carcass and envelope materials decomposition, and water evaporation.

High temperatures of compost materials were observed during the initial period of composting and subsequently decreased to ambient air temperatures (Glanville et al., 2007). Compost material temperature reflects biological activity of microbes. Microbes broke down organic material actively in the early stage of composting and the raised temperature caused by their metabolism accelerated the water evaporation from the compost matrices.

Unfavorable factors such as low moisture, low readily degradable organic material, low oxygen, and low ambient temperature, retarded microbial degradation after 6 weeks. Therefore, trivial weight variation was observed.

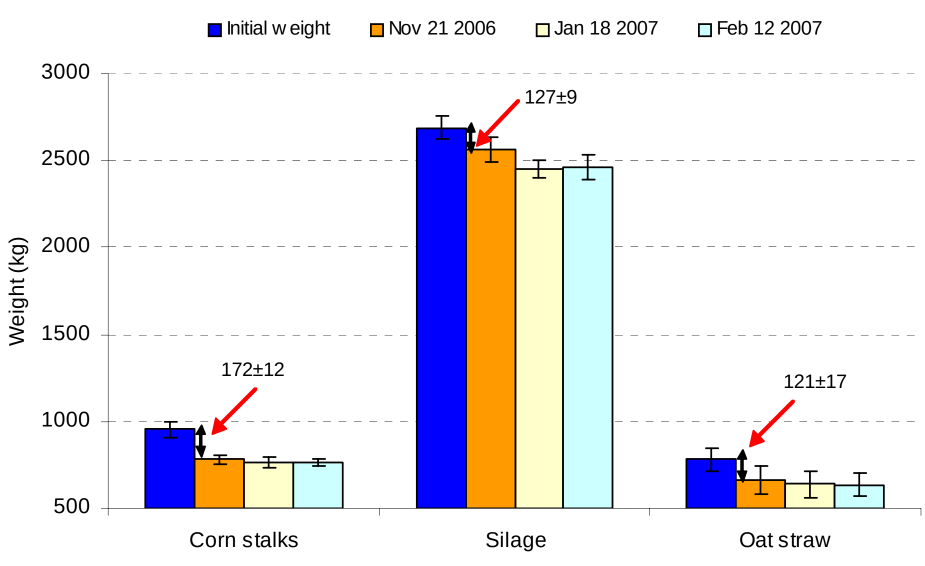

Figure 3. Test unit weight changes during composting process

Table 2. Summary of test unit weight changes during the composting process (N=3).

	Cornstalks	Corn silage	Oat straw
Total weight (kg) @ Oct 5	953±42	2687±65	780±64
Total weight (kg) @ Nov 21	780±30	2560±72	659±81
Total weight (kg) @ Jan 18	768±30	2452±53	638±79
Total weight (kg) @ Feb 12	767±20	2461±70	637±69
Total difference (kg): Initial-Final	186±25	225±23	144±11

Moisture content and bulk density

The carcasses were located in the middle layer (0.4-0.8m above the bottom of the pile) when the compost pile was built, but settling during the composting process caused the carcasses to be re-located into the bottom layer (0-0.4m above the bottom of the pile). Table 3 shows the MC and bulk density of envelope materials collected from the bottom layer. The carcass decomposition environmental conditions can be predicted by estimating the characteristics of envelope material around the carcasses.

Due to the lack of moisture in cornstalks and oat straw test units, carcass decomposition appeared to have been inhibited. As shown in Figure 4, all desiccated carcass remains were observed from cornstalks and oat straw test units. Since they are very porous materials, fresh air can penetrate their matrices easily and the moisture can be evaporated through their big pore space.

Although the moisture content of corn silage seems to be appropriate for bio-decomposition, a lot of un-decomposed carcass remnants were observed as shown in Figure 4. Bulk density of corn silage in the bottom layer is about 3 times those in the top layer while cornstalks and oat straw is around 2 times. This confirms significant compaction occurred in corn silage compost piles during the composting process (Glanville et al., 2007). The compaction is closely related to air-filled porosity of compost matrices. The air-filled porosity is generally decreased with increasing compaction (Ahn et al., 2007). Glanville et al. (2007) reported air-filled porosity of corn silage in the bottom layer was only 18% which is considerably lower than the minimum value (30%) required by the researchers to lead an appropriate aerobic composting process.

Table 3. Average moisture content and bulk density of envelope material collected from bottom layer where carcass remains were located (N=9).

	Moisture content* (%, w.b)	Bulk density (kg/m^3)
Cornstalks	25.8±1.5	225.7±5.4
Oat straw	23.3±2.3	163.1±5.9
Corn silage	75.1±6.1	918.2±62.0

*Sample collected when the experiment was terminated

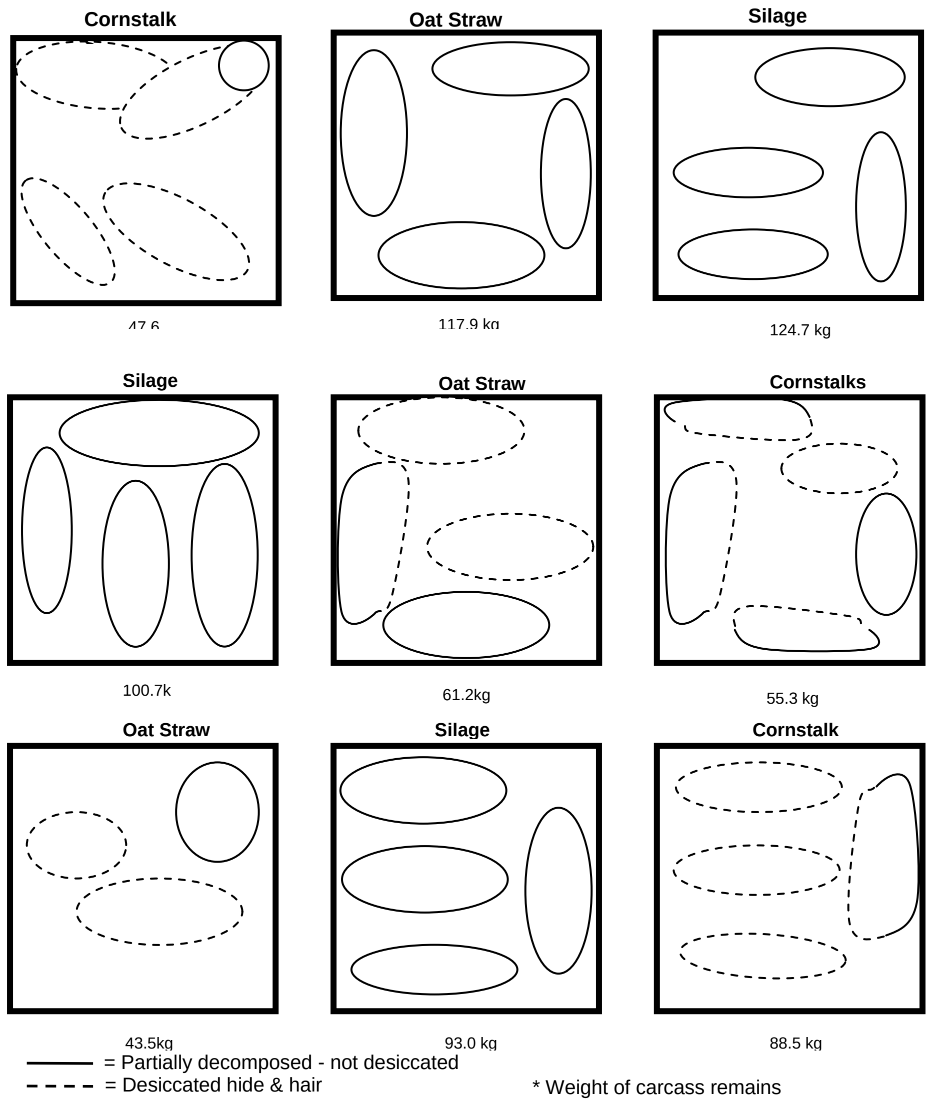

Figure 4. Location, moisture characterization, and approximate weight of un-decomposed carcass remains (fully decomposed carcasses not shown due to inability to accurately identify them).

Carcasses and envelope material weight loss

While temperatures in silage units were higher than in cornstalks and oat straw test units, and moisture levels also were more favorable in silage (Glanville et al., 2007), the carcass weight loss in silage (58%) was significantly lower than in cornstalks (76%) and oat straw (70%).

The envelope material weight loss includes both water and organic material loss (Table 4). The percentage of envelope material loss was relatively small compared with carcass weight losses. As mentioned before, lack of moisture in cornstalks and oat straw test units, and low air-filled porosity in silage test units are the major reasons for the low envelope material weight losses.

Table 4. Average carcass and cover material weight change and % weight loss during composting processes (N=3).

	Initial carcasses (kg)	Initial cover material (kg)	Final carcasses (kg)	Final cover material (kg)	Carcasses loss (%)	Cover material loss (%)
Corn stalks	259±24	694±64	64±22	640±33	75.7±5.9	7.5±5.6
Oat straw	241±18	539±58	74±39	488±32	69.8±13.7	9.1±5.3
Silage	256±29	2431±89	106±17	2263±41	58.2±7.2	6.9±2.3

Carcasses decomposition

In general, bone weight is about 12% of swine body weight (Kuhn et al., 1997). Bone fraction was subtracted from the total swine carcasses weight to get the mass of biodegradable organic material because it is not a readily biodegradable material.

The average decomposition of readily decomposable animal tissues in silage test units was only 66% of the initial carcass mass while cornstalks and oat straw test units decomposed 86% and 79% respectively (Table 5).

Table 5. Average decomposition of readily decomposable animal tissues during composting process (N=3).

	A Initial carcasses (kg)	B Bone in initial carcasses[1] (kg)	C Final carcasses (kg)	Carcasses decomposition[2] (%)
Corn stalks	259±24	31±2.8	64±22	86.0±6.8
Oat straw	241±18	31±3.5	74±39	79.3±15.5
Silage	256±29	29±2.1	106±17	66.1±8.1

[1] Bone content: about 12% of body weight (Kuhn et al., 1997)
[2] Carcass decomposition rate (%) = {(A-C)/(A-B)} * 100

Conclusions

The following conclusions can be drawn from this investigation of biodegradability of animal carcasses in passively aerated bio-secure composting systems.

The observation of carcass decomposition and compost material weight loss trends associated with composting time was possible by weighing compost test units using portable platform scales. The compost material weight loss was caused by organic material decomposition and water evaporation during the composting process. Significant weight loss during the early weeks of the trial reflects active biological activity of microbes since they break down organic material and produce heat to evaporate moisture from compost materials. The most significant weight loss was observed during the first 6 weeks of composting processes. This shows that the major organic material decomposition occurred in the early stage of composting when the composting environment was favorable.

The extent of bio-decomposition of the readily degradable portion of the swine carcasses was calculated by subtracting the mass of carcass remains from the total carcass weight placed when piles were built. The carcass decomposition in silage, cornstalk, and oat straw test units were 66%, 86%, and 79% respectively. Moisture content of envelope materials around the carcasses in cornstalks and oat straw test units ranged from 23 to 26% on a wet basis. It appears that low moisture content impaired decomposition of swine carcasses during the later phase of the composting process in both types of test units. Silage test units showed more favorable moisture content (75%) than cornstalks and oat straw test units but significantly compacted envelope material around the carcasses impeded their decomposition.

The development of moisture control strategies to keep appropriate levels for cornstalks and oat straw test units may improve carcass decay rate. Modification of the passive aeration system to supply more fresh air to carcasses or adjustment of envelop material combinations to prevent significant compaction of envelope material around carcasses could improve decomposition rates in silage test units.

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