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A Low Maintenance Approach to Large Carcass Composting

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Abstract. *In recent years, costs of animal mortality pick-up have increased substantially due to reduction in demand for rendered products. Carcass disposal by burial has been the most common method while incineration of poultry and swine carcasses is also practiced in several states. These methods raise concerns over groundwater contamination at burial sites, and odor, air pollution, and unsuitability of disposing large carcasses by incineration. As the cost of dealing with mortalities and environmental concerns increase, the animal feeding operation's (AFO) use and/or acceptance of on-farm mortality composting could very easily make it a preferred method of handling livestock losses. This paper presents results of a large- carcass (horse and cow mortalities) composting study using an in-bin, static pile composting system. Bins were created using large hay bales and spent horse bedding was used as a co-composting material. In one case, the carcass compost piles were turned at 3 and 6-month intervals after the start of composting. In the other case, the compost piles were built by placing the carcass above wooden pallets and turning the pile only once in a 6-month period. This was a low maintenance composting system because no pre processing of mortalities (cleaving, grinding etc.) was performed, no extra moisture other than that from the natural precipitation was added to the compost pile, and piles were turned no more than twice during the nine-month trial period. Within a few days after composting began, all piles achieved temperatures above 55 ^{O}C and remained at or above this temperature for several days or weeks. Turning piles without the wooden pallets after 3 months of composting resulted in a much greater temperature increase for the larger carcass (cow carcass weighing 909 Kg) than that for the smaller (horse carcass weighing 500 Kg) carcass. After six months of composting with and without the wooden pallets, similar carcass conditions in terms of faint odors and a high degree of large bone biodegradation were observed. After 9 months of composting, the C:N ratios of all compost piles were nearly one half of the horse bedding used as a co-composting material. Pathogenic evaluation of 9-month old carcass compost piles indicated low counts of salmonella and fecal coliform bacteria. The final product was ready to be land applied without the need to screen out large bones as they shattered and disintegrated easily. Based upon these results and observations, it was concluded that an in-bin, low maintenance carcass and horse bedding composting operation for the disposal of cow and horse mortalities can be carried out successfully in temperate climates during seasons of normal precipitation.*

Keywords. Compost, Carcass, Mortality, Carbon-nitrogen ratio, Temperature, Pathogens

Introduction

In recent years, cost of animal mortality pick-up has increased substantially due to a reduction in demand for rendered products and closing of rendering plants at some locations in the USA (Keener et al., 2000). In 2001, Hereford Bi-Products, a large rendering outfit in the panhandle of Texas, picked-up and processed more than 114 thousand metric tons (250 million pounds) of mortality from feed lots, farmers, packing houses and dairies in Texas, New Mexico, Oklahoma and Kansas (Merrick, 2002). According to Merrick (2002) lack of demand for beef in pet food, closing and consolidation of pet food canneries, and restrictions on meat and bone meal use for cattle feed have caused a steady decline in pick-up and rendering of animal mortalities. According to a seven-county survey in west Texas, closing of a rendering plant coupled with unavailability of carcass pick-up services in the vicinity of dairies, beef feed lots, and suburban horse grooming facilities have raised the dead animal pick-up costs to as high as $150 per mortality (Personal communications, 2000). This trend is imposing new financial hardship on small and large producers alike, who are looking for disposal alternatives for their dead animals.

Carcass disposal by burial has been the most common method while incineration of poultry and swine carcasses is also practiced in several states. Concerns over groundwater contamination at burial sites, and odor, air pollution, and unsuitability of disposing large carcasses by incineration (Langston et al., 1997) have resulted in increased interest in composting poultry and livestock mortalities. Generally, composting of carcasses using windrows, static piles, and bins or vessels has been described in the literature for swine and poultry (Fulhage and Ellis, 1994, Glanville, 1995, Keener et al., 1997, Langston et al., 1997). Others have reported composting whole carcasses such as cow mortality in static piles using saw dust (Looper, 2002), or grinding cow carcasses prior to composting in windrows (Kube, 2002). While dissecting or grinding mortality enhances carcass biodegradation during composting, it may be a less attractive option for individuals maintaining an on-farm large-carcass composting operation. In practice, a successful composting operation that requires minimum amount of labor and inputs including cleaving or grinding of carcasses, additional moisture, forced aeration or frequent turning will be more attractive for adoption at the farm level. This paper presents results of a low maintenance, static pile composting of cow and horse carcasses using spent horse bedding as a source of carbon and bulking material.

Methods and Materials

Three bins, 3-m W x 6-m L (10’ x 20’) each, were built using large hay bales of coastal Bermuda grass at a ranch in central Texas. Two bins were used for carcass composting (henceforth called the compost bins) and the third stored spent horse bedding (Pine wood shavings and horse manure), as a co-composting material used in this study. As shown in figure 1, a compacted gravel sub-base was prepared before bin establishment to restrict any seepage from the carcasses into the soil. Each compost bin was filled with nearly a 0.46 -m (18”) thick layer of horse bedding above the compacted sub-base. Then, in the rear half of each compost bin, two wooden pallets were placed above the bedding (figure 2). It was assumed that the air spaces between the pallets and the bedding layer underneath will continue to aerate the static pile, requiring the pile turning only once after 6 months of carcass composting. All bins were fenced with cattle panels to keep the livestock out of the composting facility.

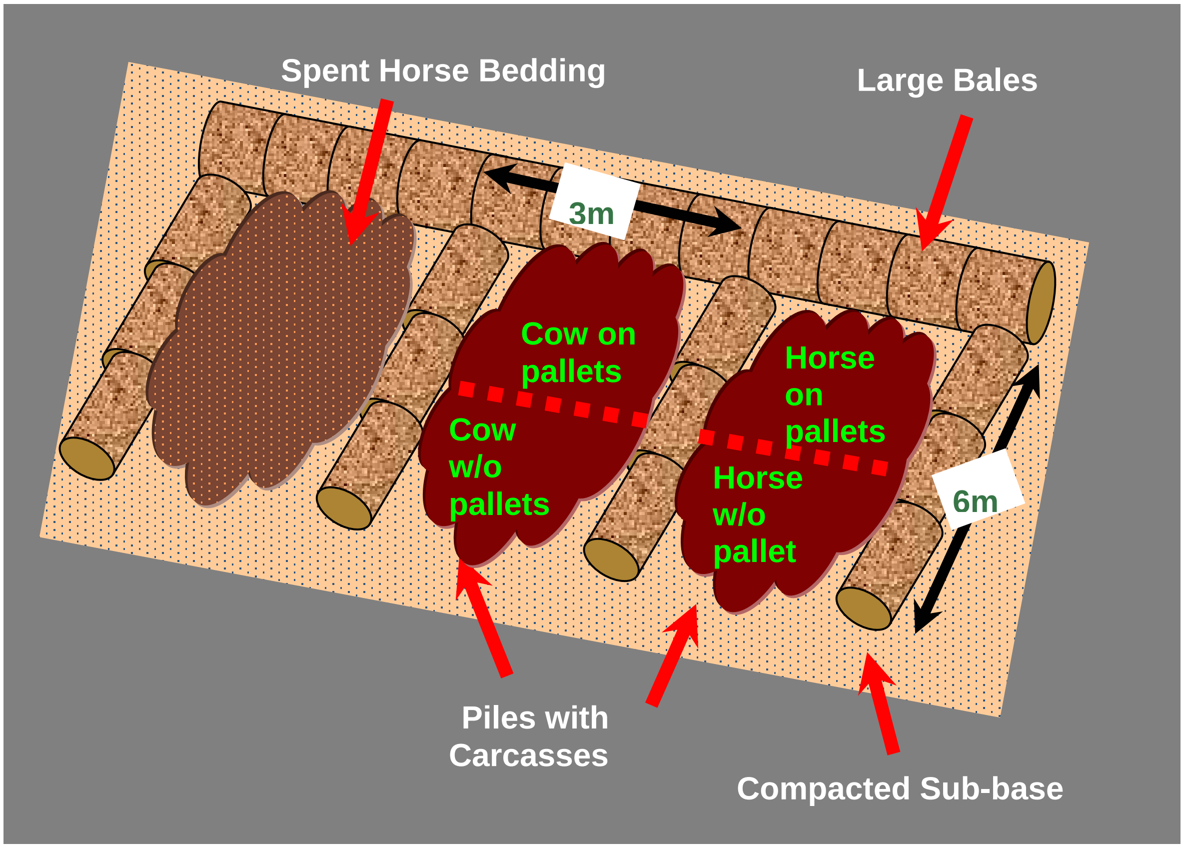

Figure 1. A three-bin large-carcass composting set-up built with large hay bales.

Two horse and two cow mortalities were received from a large animal hospital in the area. At first, a horse carcass was brought on site in February, 2002 and placed on its side, above the wooden pallets. The carcass was completely covered with a 0.46-0.61 m (18-24”) thick layer of horse bedding (figure 3) and the pile was left to compost without turning for 6 months. This carcass was partially opened at the belly for postmortem evaluation. Temperatures of this horse on pallet (HOP) compost pile were measured at 0.61-m (2’) depth using a 1.22 m (4’) long stem and dial type temperature probe (Reotemp Instrument Corp., San Diego, CA) on 21 occasions between February 20 and April 7, 2002. In April, 2002, compost piles for one horse carcass and two cow carcasses were established. These carcasses were completely intact. A procedure similar to the HOP compost pile construction was used for one of the two cows except that two temperature data loggers (Onset Computer Corporation, Pocasset, MA); one under and one above the cow on pallets (COP) were installed to measure temperatures every 6 hours for 6-months from the start of composting (figure 4). Prior to installation data loggers were encased in a rugged, waterproof plastic enclosure (Onset Computer Corporation, Pocasset, MA). As shown in figure 1, the COP compost pile was established in the rear of the center bin.

The compost pile for the second horse carcass was built next to the HOP pile but separated by at least 0.61-m of the bedding used as a co-composting material. The horse carcass was placed on its side above the bedding and covered with a 0.46-0.61 m thick layer of horse bedding. No pallets were used for this pile and only one data logger, above the carcass was installed to measure temperature every 6 hours for 6 months since beginning of composting. A similar procedure was used for the construction of the second cow carcass compost pile (figure 5). This pile was built in the center compost bin adjacent to the COP compost pile.

Figure 2. A compost bin showing wooden pallets above a layer of horse bedding.

Figure 3. Partially (left) and fully covered (right) horse carcass on wooden pallets.

Figure 4. Data logger located under (left, between pallets) and above(right) the cow carcass.

Figure 5. Cow carcass without pallets (left) and the data logger location (right) for this carcass.

The compost piles without the pallets were turned at 3 and 6 months after establishment. After the first turning of each compost pile without pallets, additional horse bedding was used to cover any exposed and non-degraded parts of the carcass. A tractor with a front end loader bucket was used to construct the compost bins, carcass compost piles, and for turning the compost piles. After 6 months of composting, all the April, 2002 mortalities (COP, horse, and cow without pallets) were combined into one pile (large pile), while the February, 2002 mortality (HOP) was left in its own pile (small pile) till the end of the study in January 2003. All composting bins were exposed to weather conditions. Throughout the composting and curing process, no additional water other than the natural precipitation was added to any piles.

Sampling of the co-composting material (spent horse bedding), was conducted to determine total carbon (C), nitrogen (N), phosphorous (P) potassium (K), pH, and moisture content. Nine months after composting of each carcass, the finished large and small piles were sampled for C, N, P, K, pH, moisture content, fecal coliform, and salmonella. In each case, five randomly collected composite samples (composites from 15 randomly collected sub samples) were used. Analyses for chemical constituents and pathogens were conducted at the Texas A&M University's Analytical Laboratory in El Paso (C and N), and Soil, Water and Forage Testing laboratory (P, K, pH, moisture content) and Food Safety and Microbiology laboratory (Salmonella and fecal coliform) in College Station. Total C and N were determined using an elemental analyzer (NCHS-O Analyzer). Phosphorous and K were determined through elemental analysis by ICP (Angel and Feagley, 1987). The pH for solid samples was measured with a probe from 2:1 water to solid paste. Tests for moisture content, salmonella and fecal coliform were performed using test methods 4540 B, 8030 B and 9221 E (Standard Methods, 1995), respectively. Bulk density of the co-composting material was also determined from several depths by weighing known volumes of 10 composite samples of the stored material (third bin in figure 1). Average daily temperatures and monthly precipitation data were obtained from the National Climatic Data Center (NCDC, 2003) for a station near the compost site. Compost pile establishment, turning and sampling schedules, carcass weights, and volume and weight of co-composting material needed for each carcass, are presented in table 1.

Results and Discussion

Physical, Chemical and Pathogenic Properties of Carcass Compost Piles

The co-composting material (bedding) needed for carcasses varied from 8.8 m^3 for the horse on pallets (HOP) to 12.1 m^3 for the cow without pallets (table 1). These volumes included the layer of bedding under and on top of the carcass. With an average bedding density of 369 kg/ m^3, these volumes translated into the bedding to carcass weight ratios of 6.2:1, 7.8:1, 7:8.1, and 4.9:1 for HOP, horse without pallets, cow on pallets (COP), and cow without pallets, respectively.

Table1. Large - carcass composting activities, carcass and co-composting material information.

Date	Activity	Animal weight, kg *	Co-composting material per animal m^3 (kg)**	Weight ratio of co-composting material to animal kg/kg***
February, 2002	Site preparation and compost and storage bin construction.			
February, 2002	Horse on pallet (HOP) compost pile construction	523 (1150 lb)	8.8 (3247)	6.2:1
April, 2002	Horse without pallet compost pile construction	500 (1100 lb)	10.6 (3911)	7.8:1
	Cow on Pallet (COP) compost pile construction	455 (1000 lb)	10.6 (3911)	7.8:1
	Cow without pallet pile constructed	909(2000 lb)	12.1 (4465)	4.9:1
	Co-composting material sampled for chemical analysis			
July, 2002	Piles with horse and cow without pallets turned after 3 months of composting and temperatures from data logger were down loaded from each pile.			
August , 2002	Pile with HOP turned after 6 months of composting.			
October, 2002	Piles with horse and cow without pallets turned the second time after 6 months of composting and temperatures from data loggers were down loaded from each pile. Pile with COP turned after 6 months of composting and pile samples taken for chemical and pathogen evaluation. Combined all but the HOP piles into one large pile.			
November, 2002	Pile with HOP sampled for physical, chemical and pathogenic evaluation after 9 months of composting.			
January, 2003	Samples taken from the combined large pile for physical, chemical and pathogenic evaluation after 9 months of composting.			

*Animal weights are estimates provided by the veterinary clinic.
**Based on number and volume of the front end loader buckets used per animal. Weights calculated from estimates of field measured bulk density (369 kg/ m^3) of the stored co-composting material.
***Total weight of horse bedding to construct bottom and top of each compost pile and material used to cover piles after turning.

Even though the cow without pallets required most bedding, it had the least bedding to carcass weight ratio. This cow carcass, though heaviest of all carcasses, was stocky and had a foot print smaller than those of the horse carcasses. Compost piles with carcasses on pallets required less additional bedding to cover any exposed non-degraded parts as they were turned only once as compared to the carcasses without pallets that were turned twice during the 9-month composting period.

The chemical, physical and pathogenic properties of bedding only and carcass piles after 9 months of composting are presented in table 2. The small pile refers to the HOP pile and the large pile refers to the pile that was built by combining the rest of the piles after 6 months of composting.

Table 2. Chemical and physical properties of co-composting material and carcass compost piles.

Parameter (as is basis)	Co-composting material	Small compost pile *	Large compost pile**
C (mg/kg)	167,781 (±16,844)[1]	123,258 (±35,161)	96,292 (±10,886)
N (mg/kg)	3,431 (±414)	6,669 (±2,479)	4,000 (±611)
C:N	49.1 (±4.8)	19.3 (±4.4)	24.4 (±3.5)
P(mg/kg)	1,313 (±119)	1,659 (±623)	1,247 (±450)
K(mg/kg)	3,806 (±697)	4,512 (±677)	3,220 (±859)
pH	7.7 (±0.13)	7.8 (±0.07)	7.7 (±0.44)
MC (%)	41.4 (±2.6)	42.7 (±11.5)	51.5 (±5.4)
Salmonella[2]	NA	not detected	≤2
Fecal coliform[3]	NA	55 (±26.2)	227 (±388)

* Refers to horse on pallets compost pile
**Refers to combined compost pile of horse and cow without pallet and cow with pallet.
[1]Mean values with standard deviations in parentheses. n=5.
[2]Maximum probable number (MPN) per 10 gram of material on as is basis.
[3]Colony Forming Units (CFU) per 10 gram of material on as is basis.

The carbon to nitrogen ratio (C:N) of the bedding was 49.1. The C:N for carcasses was not known but was estimated to be low, at about 5.0 (Keener et al, 2000). Based on C:N estimates for the carcasses and that measured for the bedding, and bedding to carcass weight ratios, it was calculated that the C:N ratio of the piles ranged from 42-46 at the start of composting. After 9 months of composting, C:N for both small and large piles reduced to nearly one half of the original mix. This was mainly due to the reduced carbon and increased nitrogen contents for both piles (table 2). Phosphorus and K concentrations for the small pile were slightly higher than bedding while P and K concentrations for the large pile were lower than bedding and small pile. The pH of bedding and small and large piles remained essentially the same. The moisture content of both piles was higher after 9 months of composting as compared to the bedding. For each pile, the samples for moisture determination were taken 9 months after composting, during much colder pile and ambient temperatures, and greater amounts of precipitation (49.6 cm of rain between October 2002-January, 2003) than in the summer and early fall when both piles were actively composting at much higher temperatures and lesser amounts of precipitation (40.6 cm of rain between April-September, 2002) fell on the piles.

No samples for salmonella or fecal coliform were taken from the bedding but these pathogens were analyzed from samples of small and large piles after 9 months of composting. As shown in table 2, salmonella was not detected in the small pile but large pile had a salmonella count of two or less maximum probable number (MPN) per 10 grams of sample. Both small and large piles had an average of 55 and 227 colony forming units (CFU) of fecal coliform (FC) bacteria, respectively. In fact, the large pile varied highly (4-900 MPN per 10 grams of sample) for FC concentrations. These pathogenic concentrations are well within the limits (less than 1,000 CFU and less than 3 MPN per 4 grams of solids for FC and salmonella, respectively) of pathogenic standards for a high quality compost product standards established by the Texas Commission on Environmental Quality (TCEQ, 1995).

Temperature and Qualitative Assessment of Carcass Compost Piles.

Pile and ambient temperature and rainfall data for HOP, COP, and horse and cow without pallets pile are presented in figures 6-8. The solid straight horizontal line on all plots is the 55 ^{O}C (131 ^{O}F) temperature line. Regulations are set at this temperature for killing most human and plant pathogens (NRAES, 1992). Temperatures for the HOP compost pile were measures intermittently and hence the data points were not interconnected (figure 6). Within three days of pile construction, the HOP temperatures reached above 55 ^{O}C and remained above this temperature for the next twelve days. The highest temperature observed for this pile was 71 ^{O}C and for the entire measurement period, the temperatures remained above 40 ^{O}C (104 ^{O}F). A more than 2 cm rainfall in March, 2002 added some moisture to the top of the pile, slightly increasing the pile temperature for a few days. Throughout the measurement period, average ambient temperatures remained much lower than the pile temperatures.

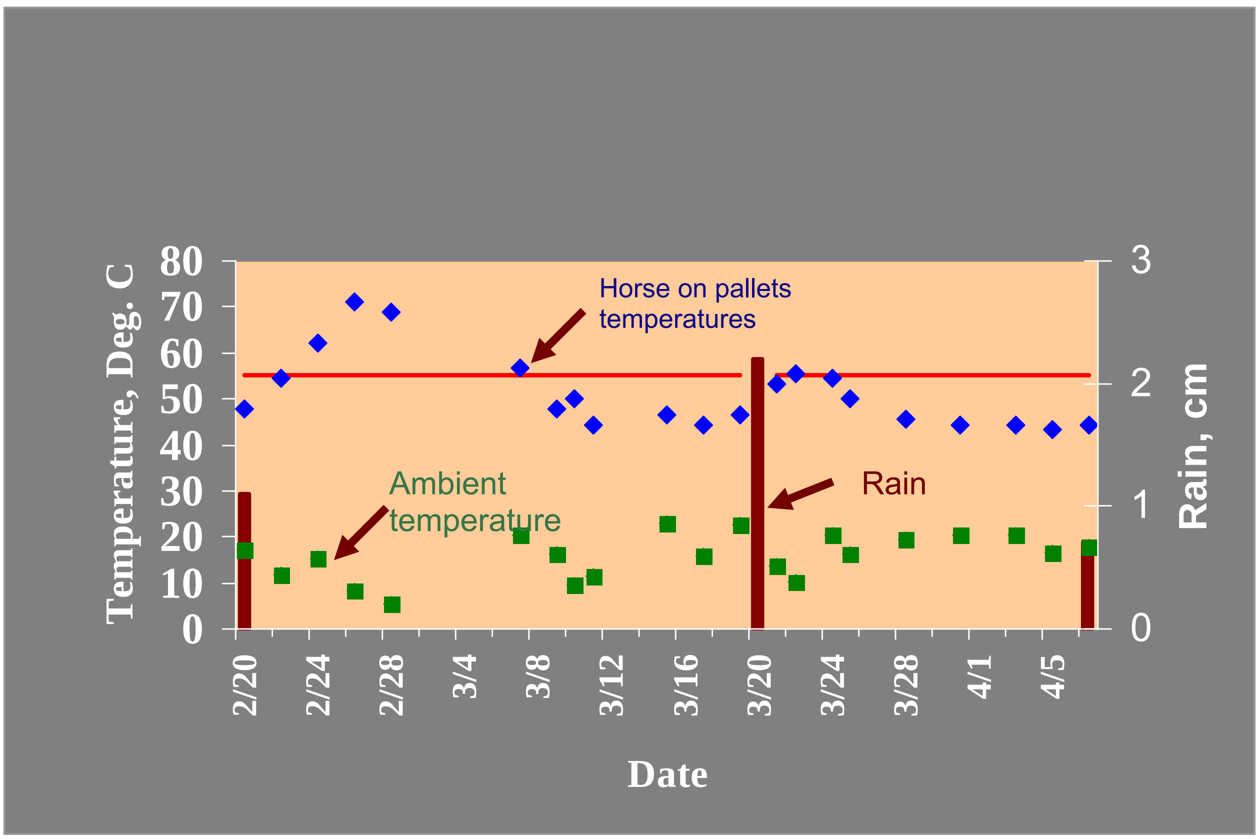

Figure 6. Horse on pallets (HOP) pile and ambient temperatures, and rainfall data

This HOP pile was turned only once after 6 months of composting. A faint odor was observed upon pile turning. Several large bones, still intact, were found. No flesh or soft tissue remained and no pieces of hide could be distinguished. This pile was uncovered again after 9 months of composting. A drier pile with earthy smell and several fully or partially decomposed bones was observed.

Figure 7 presents temperature and rain data for the COP compost pile. Pile temperatures were measured at two depths, below (bottom) and above (top) the carcass. Within a few days of the pile construction, both temperatures reached above 55 ^{O}C and the bottom temperature remained 5 to 10 ^{O}C higher than the top temperature for nearly five months into composting of this pile. Initially, the top temperature reached a few degrees higher than the bottom but remained less than the bottom temperature for most of the duration of temperature measurement (6 months). This was due to excessive drying out of the pile top than the bottom. During the first three and a half months of composting, the top temperature increased in response to moisture added to the pile from rainfall. The bottom temperature (below the carcass), although remained higher than top, did not show this response during the same time period. It seemed that over time, the moisture released from the carcass may have continued to provide favorable conditions for active biodegradation and hence higher and steadier temperatures for the bottom. Average ambient temperatures remained much lower than the compost pile temperatures during 6 months of measurements.

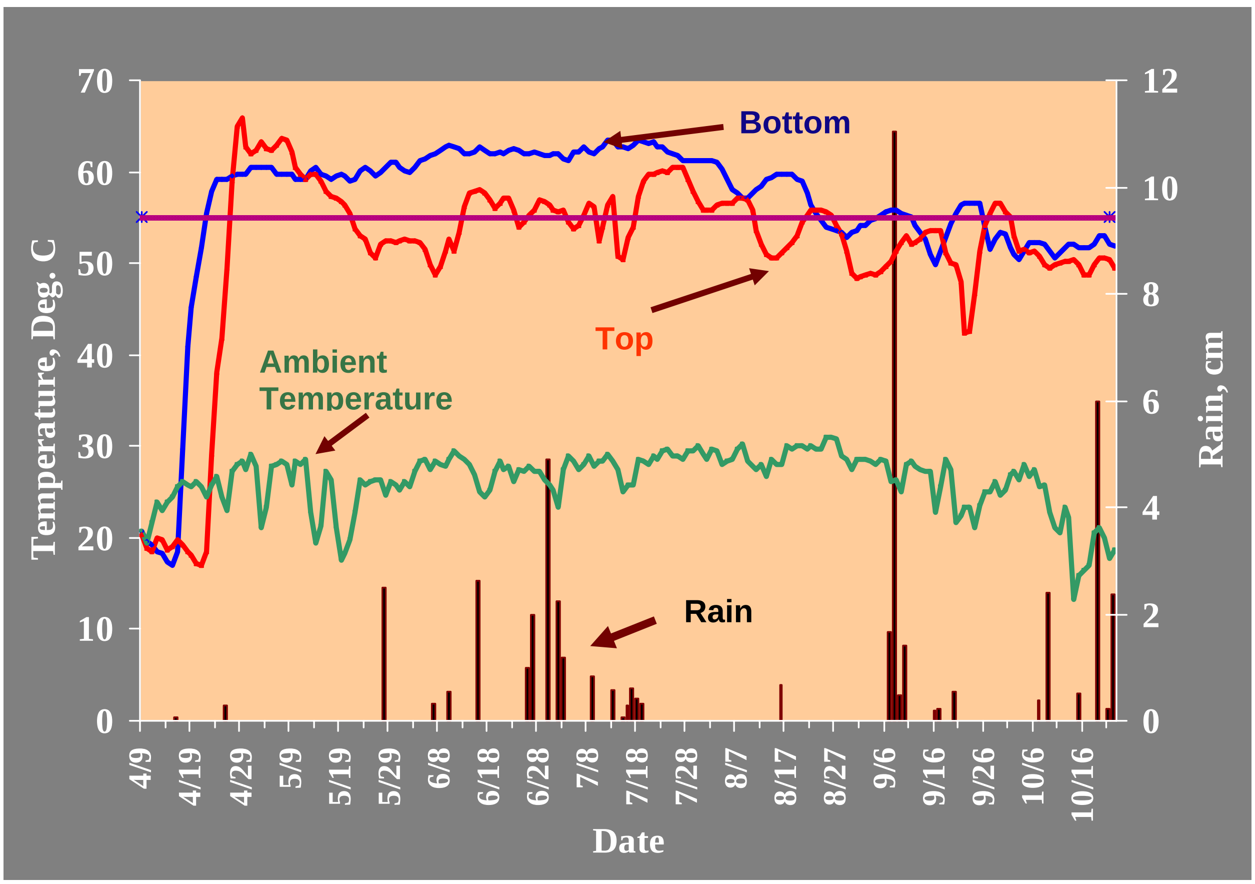

Figure 7. Cow on pallets (COP)Top and bottom pile and ambient temperatures, and rainfall data

After 6 months of composting, the COP pile was turned and its contents were examined. Other than a few large intact bones, most of the cow carcass was biodegraded leaving no flesh or soft tissue. A faint odor was observed upon uncovering the pile.

Temperatures and rainfall data for cow and horse compost piles without pallets are presented in figure 8. Within 6 days, temperatures for both piles reached above 55 ^{O}C and remained above this temperature for 22 and 38 days for cow and horse without pallets composts pile, respectively. A series of rainfall events and the larger size (hence more moisture) of the cow carcass helped raise the temperature of the cow compost pile higher than the horse compost pile. Both piles were turned after three months. This aeration coupled with another series of rainfall events preceding aeration, caused a significant increase in the cow compost pile, indicating enhanced microbial activity. In fact, the highest temperature (74.1 ^{O}C) for the cow compost pile was achieved within 5 days of aeration. For the next three months after aeration of both piles, the cow compost pile temperatures remained above or near 55 ^{O}C while the horse compost pile temperatures continued to decrease with occasional upward swings due to rainfall events. Throughout the temperature measurement period, average ambient temperatures remained significantly lower than the pile temperature.

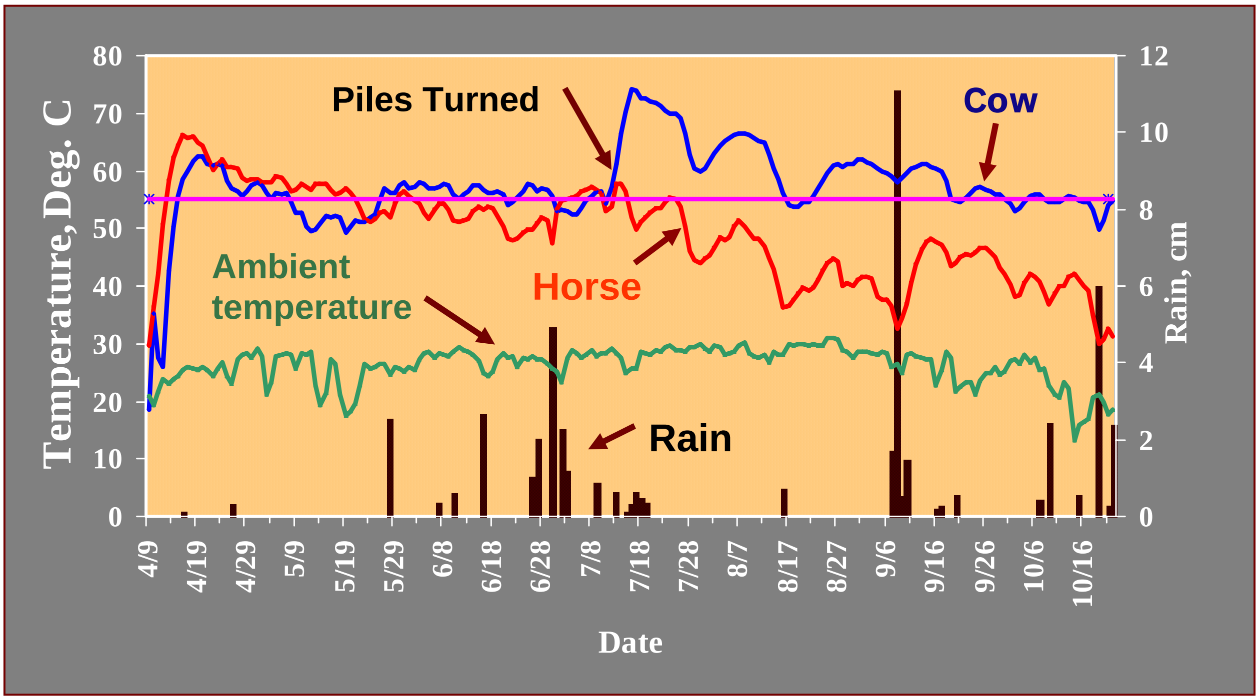

Figure 8. Cow and horse without pallets piles and ambient temperatures, and rainfall data.

Three months after the construction of cow and horse carcass compost piles without pallets, they were turned for the first time. All soft tissue, hide and smaller bones were biodegraded but a faint odor and several large intact bones from the horse carcass pile were observed. Upon uncovering the cow carcass pile, a strong odor was observed, several large bones were intact, some soft tissue and rumen contents were still present and the pile around the remains of this heaviest of all carcasses was still wet. After 6 months of pile construction these two piles were turned again. The cow carcass pile had a faint odor and only large semi degraded bones were left in the pile. The horse carcass pile had a faint odor, and with the exception of few large bones, most of the carcass was biodegraded.

In January, 2003 after 9 (large pile, a combined pile of two cows and horse carcass after 6 months of composting in individual piles) and 11 (small pile, HOP compost pile) months of composting these mortalities the piles were uncovered and the contents were reexamined. Most of the mortalities were completely biodegraded over this time period. Very few large bones remained but were easily disintegrated (figure 9) reducing the need for screening or mechanical crushing of bones prior to land application of this composted material.

Figure 9. Condition of large bones at the end of carcass composting trials.

Conclusions

The objective of this study was to demonstrate that large-carcasses totally enveloped in spent horse bedding, can be composted without processing of the carcass (cleaving or grinding) frequent turning, and addition of moisture, other than the natural precipitation to the carcass compost pile. Two approaches were used. In one case, the carcass compost piles were built using horse bedding and turned at 3 and 6-months intervals after the start of composting. In the other case, the horse bedding and carcass compost piles were built by placing the carcass above wooden pallets and turning the pile only once in a 6-month period. This also reduced the need to add additional bedding that was needed after turning other piles at the 3 and 6-month intervals. Within a few days after composting began, all piles achieved temperatures above 55 ^{O}C (the critical temperature where most human and plant pathogens may be killed) and remained at or above this temperature for several days or weeks. Turning piles without the wooden pallets after 3 months of composting resulted in a much greater temperature increase for the larger carcass (cow carcass weighing 909 Kg) than that for the smaller (horse carcass weighing 500 Kg) carcass. This sustained high temperature was due to high C:N ratio of the bedding material used as a co-compost and very high moisture content of the large carcass. Temperatures measured below the relatively dry pile top increased as moisture to the pile was added due to rainfall events.

After six months of composting with and without the wooden pallets, similar carcass conditions in terms of faint odors and a high degree of large bone biodegradation were observed. After 9 months of composting, the C:N ratios of all compost piles were nearly one half of the horse bedding used as a co-composting material. Pathogenic evaluation of 9-month old carcass compost piles indicated low counts of salmonella and fecal coliform bacteria. The final product was ready to be land applied without the need to screen large bones as they shattered and disintegrated easily. Based upon these results and observations, it was concluded that an in-bin, low maintenance carcass and horse bedding composting operation for the disposal of cow and horse mortalities can be carried out successfully. *Finally, the success of this composting study depended upon the availability of suitable initial moisture of the mix (whole carcass and co-composting material) and the C:N ratio of the co-composting material. Additionally, this method may also be more suitable to temperate climates during years with normal precipitation.*

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