BEEF CATTLE FEEDLOTS:
WASTE MANAGEMENT AND UTILISATION

2. Solid waste storage and processing

CONTENTS

The manure stockpiling/composting area needs a durable base to withstand heavy machinery.

Manure should be stockpiled and composted on an area with good site drainage and containment.

Poor drainage creates a potential source of odour.

Introduction

An area is needed for storing and processing harvested manure, so that pens can be cleaned regularly and manure spreading can fit in with cropping cycles. Few feedlots spread manure directly after pen cleaning although some send manure off-site immediately afterwards. Stockpiling and composting manure reduces its bulk and sometimes the moisture content, concentrates some nutrients and improves handling by breaking up lumps. Space within this area may also be allocated for composting mortalities.

The main facility design considerations for the manure stockpiling/composting area are

- durable, impermeable base
- good site drainage
- sufficient area.

Durable, low permeability base

The base of manure stockpiling/composting areas must be able to handle frequent movement of heavy vehicles. If a risk assessment indicates a high risk of groundwater contamination through nutrient leaching, an impermeable barrier will be needed. Appendix C of the *National Guidelines for Beef Cattle Feedlots in Australia* details geotechnical testing to determine the suitability of soils as ‘lining materials’ for this area and provides design standards and specifications for clay soils and the constructed liner.

Clay liners should

- achieve a maximum permeability of 1 × 10-9 m/s (0.1 mm/day)
- have a minimum compacted depth of 300 mm to ensure the integrity of the structure is maintained throughout general operations. Compacting gravel over the top may help to protect the lining material.

Good site drainage

The manure stockpiling or composting area needs to sit within a controlled drainage area (CDA). This usually involves the construction of diversion banks although natural topography can be used to divert external ‘clean’ runoff away from the area. Runoff caught within the area must be directed to a holding pond.

Good drainage within the manure stockpiling or composting area prevents formation of wet patches that can destroy the integrity of the base. An even slope of 1–3% is recommended. Manure windrows need to be orientated with the long axis down the slope to promote drainage.

Area needed

The area for manure stockpiling or composting needs to be large enough to store and process the expected amount of manure, to provide an area for mortality composting and to allow for contingency storage. The required area will depend on the amount of manure harvested from the pens, the length of time the manure is stored and the management method.

The way in which manure is managed, particularly at large feedlots, is changing. In 2005, most Australian lot feeders said they preferred to age manure for at least 12 months before it was used, but strong demand for manure at that time often meant that it was being spread or sold after only a few months of aging. About a dozen large feedlots were composting their manure (FSA Consulting 2006).

By 2010, most large feedlots were stockpiling manure for less than 12 months before spreading. The number of large feedlots that were composting had increased to 18 with a cycle averaging six months (3–12 months) and with windrows being turned 7–8 times over this period (O'Keefe et al. 2011). This suggests that most feedlots need space to store at least six months of manure. Feedlots that spread manure annually need 12 months of storage space and additional space for composting mortalities.

Manure windrows should have a triangular cross-section to shed water.

Manure windrows

Manure aging or composting is best undertaken using low windrows rather than large piles. These are more manageable and less likely to catch on fire.

Forming manure windrows

Windrows are typically constructed by forming manure into a long pile with a triangular cross-section, a base width of 3–4 m and a height of 1.5–2 m. A windrow 3 m wide at the base and 2 m high has a cross-section of 3 m^2, and a 75 m long windrow will store approximately 225 m^3 of manure.

The apex and sloping sides promote water-shedding and prevent the manure from becoming too wet, which can result in significant odour. Piles that are too low will not heat up, a process which assists decomposition, pathogen deactivation and weed seed destruction. Piles that are too high may heat up excessively, particularly if they are not well compacted or contain wet manure. Manure fires are a source of odour and smoke and can be difficult to extinguish. Thus wet manure from drains and sedimentation systems should be stored separately and allowed to dry before being added to windrows.

Temperatures and moisture content are checked in windrows to monitor the process.

Windrows should be spaced at least 5 m apart with room at the ends to allow vehicle movement and turning equipment (if used). Their long axes should be perpendicular to the slope to promote drainage.

Manure stockpiling

Manure stockpiling involves forming manure into long, low windrows that are then left to age for some months. The physical properties of manure change over this time making the product more friable and easier to spread than pen manure, while there are also chemical changes. Manure stockpiling can result in environmental impacts, primarily odour from anaerobic breakdown of wet manure while dust and smoke from burning manure can also cause nuisance. These impacts can be largely avoided by restricting windrow height to less than 2 m and promoting good drainage.

Unsuitable moisture content can lead to spontaneous combustion. Stockpile fires are difficult to extinguish.

Quantity of aged manure produced

The harvested yield of manure from feedlots that retain the interface layer is around 0.40–0.42 t of TS/SCU/year (up to 2 t of TS/SCU/year for manure containing large amounts of gravel and/or soil if an interface is not retained).

Space between rows allows for turning.

Truck delivering manure to the stockpile area

After six months, aged manure can be transferred to stockpiles.

Space for windrows

A feedlot that retains the interface layer during pen cleaning will need to provide about 150 m of windrow length per 1,000 SCU capacity. This assumes the manure windrows are 3 m wide at the base and 2 m high, and space is needed to store six months manure production.

If the pens are cleaned back to the pad, up to 750 m of windrow length might be needed, although this will depend greatly on how much soil and gravel is harvested with the manure.

If additional materials are added to the manure for composting, these need to be considered when planning the size of the composting area.

With at least 5 m of space around each windrow for vehicle movements and turning equipment, each windrow with a footprint 75 m long and 3 m wide requires 85 m × 8 m of space plus an additional 5 m of width on the pad overall.

In a feedlot with an interface layer, twenty windrows 75 m long would provide for at least six months storage for every 10,000 SCU on feed. This provides some buffer since the manure decomposes during aging or composting and it may be possible to combine some windrows after three months. Assuming the windrows are stored in a single row parallel to one another, the area needed is 165 m × 85 m (Figure 2.1).

Storage space

Space should be provided for contingency storage of manure that has been through the aging or composting process. Aged or composted manure can be stored in large piles. For a 10,000 SCU feedlot, space for two large piles with a triangular cross section, a base width of 10 m, a height of 4 m and a length of 60 m is suggested. The footprint needed for each of these would be 70 m × 30 m.

Lengthy stockpiling or composting reduces the total dry matter content of the manure by about 35%. For a feedlot with an interface layer, the aged material production would be around 0.26 t TS/SCU/ year which equates to 0.35 t/SCU/yr (total mass) or about 0.6 m3/ SCU/ year at a moisture content of 25% and bulk density of 0.6 t/ m3. The yield from a feedlot that does not retain an interface layer would depend on the rock content and how much material was removed during screening.

Properties of aged (stockpiled) manure

Stockpiling reduces the total mass of manure dry matter, volatile nutrients like nitrogen and often the moisture content, but stable nutrients such as P can become more concentrated. The drop in manure N content with aging or composting is shown in Table 2.1.

Typical analysis results for pen, aged and composted manures from Australian feedlots are presented in Tables 2.5, 2.6 and 2.7. Since the results can vary considerably, lot feeders should analyse their own manure for important agronomic properties just before it is used.

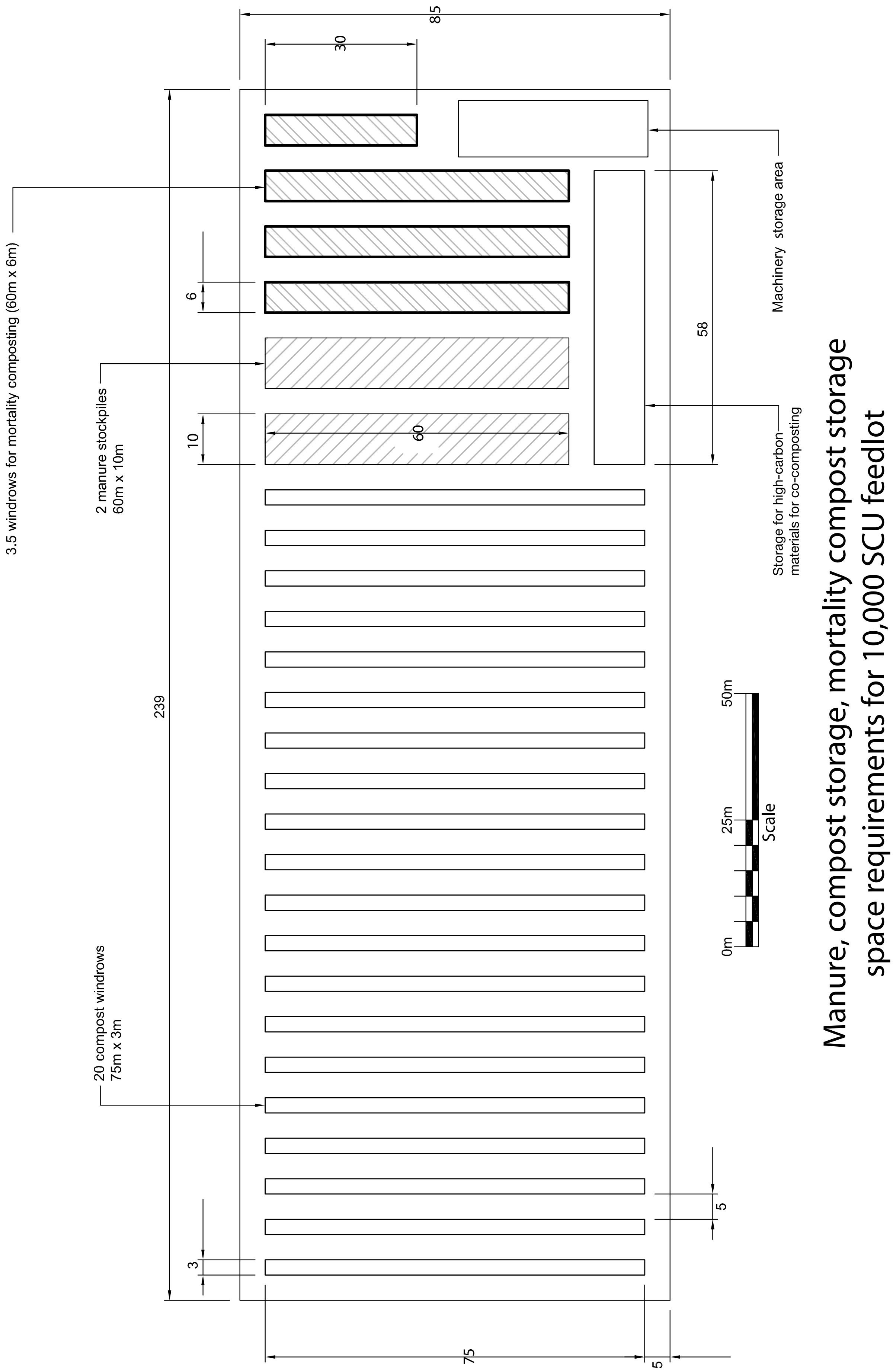

Figure 2.1 Example of space required for composting and storage of manure for a 10,000 SCU feedlot

Table 2.1 Nitrogen content of Australian feedlot manure at different management stages (Davis et al. 2010)

Feedlot	Nitrogen content (%)*		
	Pen manure	Aged manure	Composted manure
Feedlot A	1.7–2.0	0.8–1.0	-
Feedlot D	2.5–3.3	1.9–2.5	-
Feedlot F	1.8–4.5	1.9–2.5	0.7–2.0

Other materials can be blended with manure during the composting process.

Feedstuffs may unintentionally introduce weed seeds into the feedlot diets and ultimately to the manure. Manure may also contain seeds introduced in bedding.

Weed seeds in grain may be sterilised if it is steam flaked. They may be destroyed by the heat generated during aging, although this depends on the temperatures achieved, whether all seeds are exposed to that temperature, the length of time of exposure to that temperature and the weed species.

The risk of weed seeds being present in aged manure can be reduced by using practices that expose all manure to temperatures exceeding 55°C for at least three days, which requires thorough mixing and turning of the windrow, generally at least three times. However, it is difficult to guarantee that the final manure product is free of viable weed seeds.

A range of pathogens can be found in aged feedlot manure. Very low concentrations of parasiticides and steroids may also be present. Full details are provided in *Appendix 2: Managing human exposure to contaminants*.

A probe can be used to measure temperature in the compost windrow.

Manure composting

Composting is the microbiological breakdown of organic matter into compost or humus. Aerobic windrow composting uses organisms that need oxygen to function and is preferred over anaerobic composting because it minimises odour emissions, emits carbon dioxide rather than methane (lower net GHG emissions) and produces heat.

Composting is a more labour and capital intensive process than simply aging manure in static windrows.

Benefits of composting manure

The benefits of composting manure include

- reduced bulk and moisture content of the manure
- more friable and consistent manure which is more easily handled and spread
- possibilities of value adding on or off site
- reduced viable weed seeds and pathogens
- nutrients stabilised into a slow-release form
- reduction in temporary nutrient draw-down that can occur when raw manure is spread on soil
- reduced nitrogen losses on spreading
- increased concentration of phosphorus
- less odour release during aerobic composting

- more predictable nutrients for application to agricultural land or for further processing.

The composting process

Composting consists of an active stage and a curing stage. In the early part of the active stage, readily digestible sugars and starches are rapidly broken down and the temperature within the pile rises to over 40°C (typically 50–60°C). The temperature stays high for several weeks providing there is sufficient nitrogen. Next, the more resistant materials such as lignin are broken down and pathogens are suppressed. Finally, the decomposed organic matter is converted into humus. Once the temperature within the pile drops, the compost can be cured for several weeks. Curing is important since immature compost may have high organic acid levels, a high carbon:nitrogen (C:N) ratio and other properties that can be detrimental to crops.

The steps in windrow composting are

1. Blend the materials for composting. Check that there is sufficient carbon in the manure; it should be in the range of 15–40:1 (ideally 15–25:1). Freshly harvested pen manure may be suitable for composting without amendment or may need additional carbon. Sawdust or wood shavings are ideal for this as they have a C:N ratio of 200–500:1, depending on the timber species. If other materials are to be composted with the manure their carbon and nitrogen content must be determined and the materials thoroughly blended to achieve a suitable C:N ratio.
2. Form the manure into windrows 1.5–2 m high and 3–4 m wide at the base with an apex at the top to shed water. The windrows should be oriented with the long axes perpendicular to the slope to promote drainage. Leave enough space between windrows (at least 5 m) to provide access for turning.
3. Check the moisture content of the material in the newly formed windrow. The composting material has the ideal moisture content if it appears moist but little water can be squeezed from a handful. If it appears dry and no water is released, it is classed as 'dry'; if the compost has water leaking from it without being squeezed, it is classed as 'wet'.
4. If the material is too dry, water the windrow using high pressure jets along the sides. Effluent can be used on this initial watering only; pathogens in effluent make it unsuitable for watering later in the process. If micro-sprinklers are used, the pile must be checked at least every hour during watering to ensure there is no runoff. If the material is too wet, it needs to be turned every couple of days or dry co-composting materials incorporated into the pile until the moisture content is optimal.
5. Monitor the pile temperature and moisture content weekly. The temperature should reach 50–60°C within a week or two. A temperature exceeding 60°C poses the risk of spontaneous combustion. Measure the temperature using a long probe thermometer or thermistors inserted deep into the windrow at ten separate spots along the length of the windrow. Monitor the moisture content by applying the squeeze test to handfuls of compost from an arm-length depth at ten sites along the windrow.

High temperatures during composting will destroy weed seeds.

Compost is turned after at least three days at high temperature.

Effluent being applied by self-propelled windrow turner to raise moisture content

6. If water is available, water material that is 'dry', taking care not to over-water.
7. Turn the compost pile only after at least three consecutive days of high temperatures (>55°C). To kill pathogens and weed seeds, the pile should be turned at least three times during the active phase which may take three months or more. Fortnightly turning will minimise labour while creating good quality compost but the pile can be turned more frequently if it has heated sufficiently and equipment and labour are available. A strong temperature rise after turning indicates that active composting is still occurring; if the temperature does not rise markedly, the material is approaching maturity.
8. The active phase is considered complete when manure with a suitable moisture content no longer heats up to >55°C after turning.
9. After completion of the active phase, the compost can be kept in a windrow or formed into a stockpile where it can cure for at least a month.

Tractor-drawn compost turner

Table 2.2 summarises the conditions that promote efficient composting while Table 2.3 provides troubleshooting for common composting problems.

A number of feedlots have differentiated their compost by ensuring their process meets the requirements of *AS 4454: 2012 Composts, soil conditioners and mulches* (Standards Australia Limited 2012). This is necessary to market material as compost and may also attract a premium price, particularly in niche markets.

Composting equipment

Equipment options include
- front-end loaders
- tractor-drawn PTO-driven compost turners
- tractor-drawn self-powered compost turners
- self-propelled straddle turners.

Factors to consider when assessing compost turners include
- *Windrow dimensions* – tractor-drawn PTO-driven, tractor-drawn self-powered and self-propelled compost turners are more suitable for large windrows and can handle larger amounts of compost. Check the amount of space needed between windrows for different types of turners.

Good quality finished compost

Table 2.2 Recommended conditions for efficient composting (FLIAC 2012b)

Parameter	Acceptable range	Optimum range
C:N ratio	15–40:1	25–30:1
Moisture content (%)	45–65	50–60
Oxygen content (%)	>5	>5
pH	5.5–8.0	5.5–8.0
Core temperature (°C)	40–65	55–60
Particle size diameter (mm)	5–50	5–25

Table 2.3 Troubleshooting for common composting problems

Problem	Cause	Solution
Strong odour	Excess moisture	Turn window
	Windrow too large	Make window smaller
	Temperature <60°c	Turn window
	Leaf compaction	Turn/reduce window size; eliminate ponding
	Surface ponding	Apply odour masking agent (addresses symptom only)
Low windrow temperature	Windrow too small	Combine windrows
	Insufficient moisture	Add water while turning
	Poor aeration	Turn window
High windrow temperature	Windrow too large	Reduce window size
	Leaf compaction	Turn window
Surface ponding	Depression or ruts	Fill depression and/or regrade
	Inadequate slope	Grade site to recommended slope design
Vectors (rats, mosquitoes)	Presence of garbage (food etc)	Remove garbage or use rat bait
	Presence of stagnant water	Eliminate ponding
Fires/spontaneous combustion	Excessive temperature	Make window smaller
	Inadequate moisture	Add water
	Stray sparks, cigarettes etc	Keep potential fire sources away from windrows
		If fire does start, break windrows apart and extinguish completely

(Biocycle & Composting Equipment Pty Ltd ND)

- *Turning rates* – three-point linkage models can generally turn 200–400 m³/hr, tractor-pulled units 400–800 m³/hour and self-propelled turners 1,200–6,500 m³/hour.
- *Power requirements* – tractor power required depends on turner size. Tractors of 35–45 kW will generally be needed for three-point linkage turners, while a PTO-driven unit might need 60–100 kW. The tractor will need a creeper gear for slow-speed travel or hydraulic assist on the turner.
- *Turning method* – straddle turners turn the windrow in a single pass so the windrow width must match the drum length. Auger turners that lift and move the compost to one side using paddles are well suited to composting in small areas as less tractor space is needed beside the windrow.
- *Watering* – turners that can add water using a trailing hose system are suited to medium to large operations and improve operating efficiency. Turners that can tow a water tanker that applies water during turning may suit small operations.
- *Amount of manure* – front-end loaders are suitable at small operations because they may already be available on-farm and have a range of uses. However, they are generally too slow for larger quantities of manure and may not thoroughly mix the pile. Three-point linkage units suit small to medium scale composting. Purpose-built compost turners that mix the compost using an auger, rotary drum with flails or an elevating conveyer are best for large-scale operations.

Windrow turned with a front-end loader

Composted manure has a fine, even structure.

Finished manure or compost can be stored in large stockpiles.

Quantities of manure compost produced

The rate of compost production depends on whether other materials are added (co-composting). Composting generally reduces the initial volume of material by 60–70%.

To optimise the composting process, the initial moisture content of the manure should be 40–65%. Assuming no additional materials are added, there is about 0.8 t/SCU/year of manure for composting (at a moisture content of 50%). At a bulk density of 0.6 t/m^3, this gives some 1.3 m^3/SCU/year of material initially.

If 35% of the TS is lost in the process and the moisture content drops to 25%, the final yield of compost is 0.35 t/SCU/year (or 0.46 m^3/SCU/year at a bulk density of 0.75 t/m^3).

Properties of manure compost

Typical analyses of manures and compost (Tables 2.5, 2.6 and 2.7) are presented on pages 16 and 17. Since results can vary considerably, particularly if co-composting is practiced, lot feeders should analyse their own compost to ascertain its properties.

While composting may well destroy weed seeds by heating, the effective loss of viability depends on a range of factors. While most weed seeds are likely to be destroyed, feedlot compost cannot be guaranteed weed-free.

Similarly, after two to three months of composting, most pathogens should have been substantially reduced in numbers but some pathogens may still be present in the finished compost. Very low concentrations of parasiticides and steroidal hormones may also be present. Full details are provided in *Appendix 2. Managing human exposure to contaminants*.

Composting will not remove harmful inorganic metals or strong acids or alkalis (which are likely to impede the process) and may produce small amounts of some plant and animal toxins, although this is more likely in poorly managed systems

Composting feedlot cattle mortalities

Mortalities have to be removed quickly from the pen, and most large Australian feedlots use windrow composting for managing them.

Windrow systems are

- readily adaptable to any number and size of carcases
- easily formed with typical farm equipment
- low maintenance.

Mortalities can also be composted in bins or piles. Bin composting involves the use of separate bays for each stage of composting (primary, secondary and curing) but this method is often impractical because the large bodies of cattle are difficult to place in the bins. Composting piles consist of layers of carbon source and carcases formed into a cone or hemisphere shape. Piles are not recommended because the large surface area promotes heat loss and rapid drying and it is difficult to turn the pile.

For and against composting mortalities

Advantages and disadvantages of composting are summarised by Animal Health Australia (2010):

Advantages

- can be done on-site
- commercial operators exist
- most feedlot operators are familiar with the composting process
- produces a useful, biologically stable, saleable product that is safe for the environment
- reduces odour and attracts few insects
- leachate is absorbed
- quick response possible for a medium-scale incident
- kills most disease agents if properly implemented and managed.

Disadvantages (especially if applying to mass disposal)

- can be difficult to implement in the event of emergency animal disease involving large numbers of mortalities
- needs a large land area
- needs heavy machinery to construct and manage the pile
- needs suitable mortality transport
- requires large amounts of high carbon material
- needs regular turning after the first 3–4 months
- need to control runoff and run on
- need to consider soil type and water table
- may need to manage pests (birds, insects, foxes, feral pigs)
- potential odour risk if not well managed
- needs good control and monitoring
- possible biosecurity risk if high temperatures are not reached
- process takes time and may affect release from quarantine
- unsuitable for destroying spore-forming organisms or animals affected by transmissible spongiform encephalopathies.

Mortalities can be composted in piles.

Some feedlots compost mortalities in bays.

Design principles for mortalities composting areas

The design principles for a mortalities composting area match those for a manure stockpiling or composting area. Thus, mortalities are often composted in this area.

The main facility design considerations are

- durable, low permeability base
- good site drainage
- sufficient area.

The area needed depends on the method of composting: bin, pile or windrow.

Windrows with a trapezoidal cross section are most commonly used for mortality composting. At least 2.5 m of windrow length is needed for each tonne of carcases. The mass of mortalities depends on the size of the feedlot, the mortality rate and the average weight of individual mortalities. Sufficient space should be provided between windrows to allow for construction and maintenance.

Areas for composting mortalities need a well-compacted base.

Runoff and leachate from the mortality composting area must be controlled.

Mortalities composting process

In conventional composting processes, raw materials are typically mixed to provide an optimal C:N ratio, a moisture content of 50–60% and good porosity. The materials are then regularly turned. However, the mixture is inconsistent with mortality composting. Cattle bodies have a large mass, a high moisture content, a low C:N ratio and almost no porosity. Consequently in the initial stage, the decomposition process close to the carcass is anaerobic. The fluids and gases released then move into an aerobic zone.

The recommended process for windrow composting of mortalities involves

- Using a front-end loader bucket, spread a 0.3-0.6 m-deep base of absorptive material such as sawdust or waste straw that will contain fluids released during decomposition. The base should be about 5–5.5 m wide as this will allow two carcases to be lain side-by-side. Increase the width to 7 m if mortalities will be stacked two high.
- Promptly transporting mortalities to the composting area to reduce the risk of disease transfer. Mortalities that may be infected should be lifted and carried from the pens if possible. Dragging looks bad and may release body fluids that could pose a biosecurity risk to workers and other stock. Do not use equipment used for feed processing (e.g. front-end loaders) to transport mortalities or to handle compost.
- Place carcases in a single layer on top of the absorptive layer. If the windrow will be two carcases wide, place the spines of the animals in the centre of the pile and legs on the outer edges as this exposes the bulk of the body to the highest temperatures. Generally, the thoracic cavity is opened and the rumen punctured, but not if the likely cause of death is an infectious disease.
- Cover the bodies completely with at least 0.5 m of manure or sawdust. A second layer of carcasses can be added on top and surrounded with a further mimimum of 0.5 m of cover material. It is important to maintain good cover continuously to promote composting and prevent access by insects and birds that could transmit disease vectors. Allow at least 2.5 m of windrow length for each tonne of carcasses.

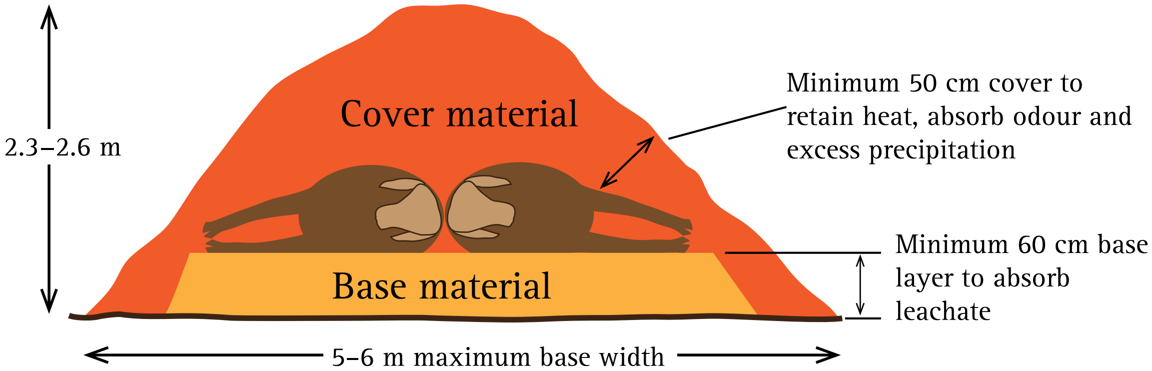

Figure 2.2 Placement of carcasses side-by-side for composting

- Ideally, the cover material will have an initial moisture content of 50– 60% and will feel moist. If the cover material is too dry, adding moisture by applying effluent through micro-sprinklers running along the top of the windrow. High pressure jets may also introduce micro-organisms that are beneficial to the process. Otherwise water can be used.
- Monitor core temperatures weekly during the active stage using a long-stemmed thermometer or thermistors at 10 spots along the windrow. Temperatures should reach 50–60°C within 2–3 days and remain high for at least two weeks.
- The carcase windrow should be turned and watered (if required) but only after the organic material has broken down into mall particles and the bones partially softened (typically 4–6 months).
- The active stage is completed when the pile no longer heats above about 30°C after turning, and the material is low in odour, a dark brown to black colour and humus-like. This typically takes at least 6-8 months. Turning is recommended at this point.
- Curing can then occur. The material can be formed into a pile for this purpose. Microbial activity during curing will remove plant inhibitors from the compost. Allow 12 months in total for active composting plus curing. To prevent regrowth of pathogens, composted material should be kept separate from uncured material.
- The finished material can be screened to remove any remaining bones.

Yield of carcase compost

Assuming carcases are composted in a 1:1 ratio by weight with manure and the combined moisture content of the manure and carcases is 60%, there will initially be 0.4 t TS/t. If 50% of the TS is lost by decomposition throughout the process, there will be about 0.2 t TS on completion. At a moisture content of 25% and a bulk density of 0.7 m^3/t, there will be about 0.54 t or 0.76 m^3 of compost for every tonne of carcases.

Properties of carcase compost

Since animal bodies have a high nutrient content, carcase compost has a greater nutrient density than manure compost. It could be expected to contain around 1.6% N, 0.6% P and 1.1% K on a wet basis; and 2.1% N, 0.8% P and 1.5% K on a dry basis. However, the composition of compost at a given feedlot will depend on the type and amount of covering material. Chemical analysis of finished compost is recommended.

The pathogen content of cured carcase compost has been found to pose a risk similar to that of manure compost. Thus, this method of mortalities management is acceptable provided high temperatures are achieved.

Placing waste straw under the carcass helps to aerate the pile.

Composting carcasses must be kept covered.

Jawbones and teeth often remain after composting is completed.

The rumen is commonly punctured before composting, but not if death was possibly caused by an infectious disease.

Windrows are the most suitable for composting large numbers of mortalities.

Mortality compost can be put in a stockpile to cure.

How much windrow space for composting mortalities?

Carcases of lighter (short-fed) cattle need less space for composting. Assuming an average weight of 350 kg, every 10 mortalities would weigh 3.5 t and so would need about 9 m of windrow length to be provided for composting.

Carcases of heavier (long-fed) cattle need more space for composting. Assuming an average weight of 450 kg, 10 mortalities would weigh 4.5 t and would need about 11.5 m of windrow length to be provided for composting.

The total space needed will depend on the number of mortalities each year, their weight and the length of time the compost is kept in windrows.

Emergency composting of large numbers of mortalities

Composting is a suitable method for disposal of cattle mortalities of all sizes. However, it may be difficult to implement as an emergency disposal response where there are large numbers because of the amount of carbonaceous material needed, the time taken to complete the process and difficulties in ensuring a uniform process. Even if approval has been obtained for mass disposal by composting on-site, the relevant environment protection agency should be involved and provide a representative for the disposal team.

In general, follow the process previously described. If an infectious disease is the cause of death, additional precautions should be taken when composting. The following will help to reduce the risks of pathogen survival and disease transmission

- Do not puncture the rumen or open the body.
- To achieve high temperatures that are able to kill pathogens as quickly as possible, cover the carcases with silage or a 0.15–0.30 m layer of moist manure that is then covered with ground straw for a total depth of at least 0.6 m. For every 450 kg animal, about 9 m^3 of high carbon material will be needed.
- Do not turn the pile during carcase decomposition as this can increase the risk of pathogen release into the wind.
- Do not excavate and spread compost until approved by the Chief Veterinary Officer. In emergencies involving highly contagious diseases, the Chief Veterinary Officer may require burial or incineration of the finished compost.

Where the livestock deaths are not the result of disease, the following apply

- Dry, porous materials that do not necessarily produce high temperatures as quickly can be used as cover material – feedlot manure is often suitable.
- The compost pile can be turned after 60–90 days, although this is not necessarily needed.
- Excavation and spreading of compost can occur once the soft tissues and internal organs are fully decayed (usually 8–12 months after commencement of the process).

Emergency composting of mass mortalities

In response to the outbreak of foot and mouth disease in Great Britain in 2001, the Iowa Department of Natural Resources funded a three-year project into emergency disposal of livestock mortalities. The project produced draft guidelines for emergency composting of cattle mortalities (Iowa State University 2002). The following recommendations are based on those guidelines.

The composting site should

- avoid unnecessary transport of mortalities that might spread disease
- be accessible by large trucks if cover materials will need to come from off-farm
- be well separated from receptors and public use areas
- be situated on well-drained land that is not subject to runoff or ponding and is outside the 1-in-100 year flood line
- be well separated from bores, streams and areas of exposed bedrock
- be close to agricultural land where compost can be utilised on crops that are not consumed directly by humans or grazing livestock.

Composting is appealing for emergency disposal of mortalities as it provides for rapid, on-farm containment of mortalities. The high temperatures generated during composting help to destroy pathogens. Most feedlots have the equipment and materials needed to undertake composting.

Compost and manure screening

Screening is used to remove rocks and other debris from manure and bone fragments from carcase compost. These are removed to avoid damage to spreading equipment and the distribution of physical contaminants onto utilisation areas. Screening also converts lumpy manure into a loose, friable product that can be spread more evenly. However, screening is costly.

Maintaining an interface layer when pen cleaning minimises the amount of rock in the manure and consequently the screening costs.

Most large Australian feedlots screen manure and carcase compost as part of their standard practice, usually just before spreading or on-selling. Some feedlots screen manure before composting to avoid damage to the turning equipment.

Trommel screens, or rotating cylinder screens, can be constructed as portable stand-alone units or smaller units that can be attached to excavators and front-end loaders.

Managing waste feed

In well-run feedlots, feed wastage through spillage or spoilage is generally low. If a significant quantity of feed is spilled along the front of the feed bunks, it should be collected and taken to the manure storage or composting area — a bobcat is useful for this task. If some feed becomes wet and unpalatable in rainy weather or if cattle go off their feed under wet or hot conditions, it needs to be

The finished material can be screened to remove any remaining bones.

Compost passing through a gravel screen

Screening converts lumpy compost into a loose, friable product that can be spread more evenly.

Spilt feed should be collected and taken to the manure storage or composting area.

Rotating brush cleaners can be used for feedbunk cleaning.

Screening is used to remove rocks and other debris from manure and bone fragments from carcass compost.

removed from the bunk, often manually using brooms and shovels, before the next feed delivery. The spoilt feed is generally thrown onto the pen surface where it mixes with the manure and is removed at pen cleaning. Rotating brush cleaners are available for feedbunk cleaning, and should throw the waste feed into the yard rather than onto the road.

Grain screenings and spoilt silage can be removed from the milling or feed preparation area to the manure storage or composting area for management with the manure.

Using boiler ash

Coal-fired boilers produce ash that must be managed. Coal ash is mainly carbon with oxides of aluminium and iron but has virtually nil nutrient value.

Table 2.4 Composition of ash from a coal-fired boiler

Parameter	Content
Carbon (% db)	31.7
Silicon in plant tissue (% db)	7.4
Sulfate (mg/kg db)	1,800
Aluminium (mg/kg db)	1,900
Iron (mg/kg db)	5,700

Coal ash mixed with soil may be useful for filling potholes and patching high use areas (e.g. behind aprons) of the feedlot pad or roads. Fly ash mixed with soil yields a product with good engineering properties for feedlot surfacing.

Table 2.5 Typical composition of Australian feedlot pen manure (dry matter)

Parameter	Average level	Minimum level	Maximum level	No. of samples
Dry matter (%)	66.0	19.6	95.6	161
Total nitrogen (% db)	2.5	0.95	4.1	85
Total phosphorus (% db)	0.96	0.75	1.21	21
Potassium (% db)	1.86	0.73	2.92	21
Sodium (% db)	0.33	0.08	0.50	27
Sulfur (% db)	0.44	0.31	0.56	26
EC1:5 (dS/m)	14.7	9.1	18.8	21
Ammonia-N (mg/kg db)	1,797	130	6,430	53
Nitrate-N (mg/kg db)	120	1	390	38
Copper (mg/kg db)	43.8	11.0	68.0	23
Iron (mg/kg db)	11,783	1900	27,000	23
Zinc (mg/kg db)	280	79	430	23

Table 2.6 Typical composition of Australian feedlot aged (stockpiled) manure

Parameter	Average level	Minimum level	Maximum level	No of samples
Dry matter (%)	63.2	37.2	89.0	22
Total nitrogen (% db)	2.18	1.10	3.30	71
Total phosphorus (% db)	0.80	0.52	1.10	63
Potassium (% db)	1.86	0.75	3.2	71
Sodium (% db)	0.30	0.04	0.70	65
Sulfur (% db)	0.45	0.18	0.77	62
Calcium (% db)	2.22	0.77	3.80	66
Magnesium (%db)	0.86	0.24	1.58	65
EC1:5 (dS/m)	8.26	0.16	17.2	59
pH	7.22	6.3	8.66	62
Ammonia-N (mg/kg db)	1,431	0	3,800	45
Nitrate-N (mg/kg db)	307	1	1,115	26
Boron (mg/kg db)	21.5	1.9	54	37
Cobalt (mg/kg db)	7.0	2.3	15.0	13
Copper (mg/kg db)	34.5	3.9	59.0	41
Iron (mg/kg db)	11,717	200	27,000	34
Manganese (mg/kg db)	387	53	870	41
Molybdenum (mg/kg db)	4.28	0.80	12.00	25
Ortho-phosphate (mg/kg db)	944	4	2,909	15
Zinc (mg/kg db)	221	70	420	64

Table 2.7 Typical composition of Australian feedlot composted (windrowed) manure

Parameter	Average level	Minimum level	Maximum level	No. of samples
Dry matter (%)	74.0	53.6	94.4	27
Total nitrogen (% db)	2.11	1.30	2.80	30
Total phosphorus (% db)	1.31	0.49	2.61	22
Potassium (% db)	2.49	0.96	3.40	20
Sodium (% db)	0.43	0.07	0.99	21
Sulfur (% db)	0.52	0.02	0.89	18
Calcium (% db)	2.47	0.50	5.56	22
Magnesium (%db)	0.93	0.24	1.77	21
EC1:5 (dS/m)	16.1	2.8	24.8	8
pH	7.3	7.0	7.8	9
Ammonia-N (mg/kg db)	1,016	17	2,200	16
Nitrate-N (mg/kg db)	588	0	1,700	14
Boron (mg/kg db)	22.8	2.8	42.0	14
Copper (mg/kg db)	36.9	3.0	70.0	20
Iron (mg/kg db)	5,266	100	12,000	18
Manganese (mg/kg db)	351	30	630	19
Molybdenum (mg/kg db)	5.67	2.40	13.00	5
Ortho-phosphate (mg/kg db)	3,115	11	7,521	8
Zinc (mg/kg db)	254	89	410	19

Further reading

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