2.9 Composting

The management of manure by composting does not simply consist of placing the accumulated manure in a pile and leaving it to rot down. The process relies upon control of temperature, moisture and feedstock and on supplementation of the manure with straw, sawdust or hay to serve as a source of carbon. Information on standards for composting for soil conditioners and mulches is provided in Standards Australia (2003). Further information is presented in Recycled Organics Unit (2007). The Recycled Organics Unit website is particularly valuable if the compost is to be marketed.

The composting process

Composting is the breakdown of relatively dry manure by microorganisms and fungi under aerobic, moist conditions. The naturally elevated temperatures foster microbial growth, kill weed seeds, encourage pathogen die off, kill helminths and cysts, and avoid generation of noxious gases. During composting, the readily biodegradable component of the waste is oxidised (converted to carbon dioxide, water and heat), leaving an organic residue (humus).

The metabolic heat generated by the microorganisms elevates the temperature of the mixture. The heat, if not too high (<60 °C), promotes rapid decomposition as a result of the build-up of microbial biomass. Temperatures in excess of 55 °C for 3 days are effective in killing weed seeds.

Success with composting depends on providing conditions conducive to the preferential growth of desirable microbes. It is not an *ad hoc* process but needs careful management for success; viable large-scale operations are uncommon. Anaerobic conditions and noxious odours are common problems, particularly at the larger scale. In addition, contaminants in the manure such as antibiotics and disinfectants, and changes in pH, moisture content, temperature and feedstock, can hamper microbial activity.

Generally the main objective of composting is to increase the nutrient density and nutrient availability of manure with minimal mechanical processing and odour via the control of a biological process. This process assists storage, transport and reuse. The advantages and disadvantages of composting and related manure treatment processes are discussed in Pittaway *et al*. (2001).

Advantages of composting

- Composting and sale of the product will be more cost effective and environmentally friendly than some other management options, including storage and landfill.
- Composting can have less impact on the environment than most alternatives. Current research aims to reduce greenhouse gas emissions.
- A biologically stable compost does not generate noxious odours during land application and can be stored without being a nuisance because it forms a water repellent crust.
- Stable compost does not provide a medium for the breeding of flies.
- Unlike some organic wastes (including sludge, barley, sawdust, green waste and food processing waste), mature manure compost does not contain or produce phytotoxic substances (which inhibit plant growth and seed germination).
- The heat generated during composting promotes moisture removal, with the result that it is less costly to store and transport the composted material than the raw manure.

- Heat and other factors generated during composting destroy pathogens and most common weed seeds.
- Plant nutrients in the organic material become more concentrated as the readily biodegradable carbon compounds are removed and the manure volume is reduced.
- Compost contains both macro- and micronutrients.
- Compost has a higher nutrient density and availability than raw manure, thereby improving the cost-effectiveness of reuse.
- The structure and appearance of the organic material is improved, making it easier to reuse or sell.
- The product is more homogeneous, i.e. less lumpy and easier to handle and spread.
- There is likely to be more community support for the transport and application of compost than of manure.
- The manure to be composted can be mixed with other sources of waste organic material such as garden refuse, sawdust, straw, food scraps and forest prunings to provide a value-added resource.
- Well managed compost generates less greenhouse gas than stockpiled manure.
- The result is a higher-value product suitable for use in high-return industries such as horticulture and urban landscaping.

Disadvantages of composting

- The effectiveness of the composting operation is usually dictated by atmospheric conditions, and quality suffers during wet, cold or dry weather.
- A high degree of control of moisture and temperature is required to achieve a satisfactory product.
- The material must have a relatively high void ratio, warranting the use of low-density blending agents.
- The markets for compost are not as well defined as those for commercial fertiliser or animal manure, and the characteristics of the bulking agent can affect the quality of the compost.
- High application rates are required to meet crop nutrient requirements.
- Cartage costs are higher than for fertilisers.
- Composting is more demanding than the direct application of manure to land.
- The high capital and operating costs of the required turning machinery.
- Labour costs extra.
- There is a risk of odour generation during the composting process.

Composting methods

Methods of composting vary. Some proprietary systems require licences to operate. The windrow system, with little process control and a long stabilisation period, is common. The totally enclosed composting reactor, with a high capital cost, complex design and high level of process control, is not commonly used for dairy manure. Dairy manure can, however, be added to regional facilities (if available) to enhance the process. The selection of the type of composting method depends on the scale of the enterprise, age and source of the manure, site and landscape characteristics, climate, proximity of neighbours, availability of expertise, funding and a source of cheap blending agent.

Windrows

Windrow composting relies on turning and passive aeration, whereas forced aeration composting uses mechanical systems for process control. The suitability of each method is dictated by waste characteristics such as porosity and content of readily biodegradable material, and by site factors, including proximity of neighbours, access to carbon sources (blending agents) and power availability. Windrow composting is favoured for manure processed in a rural setting. Forced aeration is used to yield-higher quality compost for application in urban and urban-fringe situations, particularly at nurseries and in mushroom culture. Apart from simple stockpiling, the windrow method is the most common method used for stabilising dairy manure with bulking agents or carbon sources such as straw, sawdust or rice hulls. Two types of windrow are used: one relies on static stockpiles, the other on turned stockpiles; both can be watered. Temporary covers can be used to preserve moisture or shroud stockpiles from rain..

Static windrows

The static windrow method relies on passive aeration to provide oxygen. Oxygen enters the pile through a combination of diffusion and convection (caused by heating within the pile). Moisture can be added by sprinklers or spray carts.

The aspect and size of the windrow and the porosity of the material affect how well passive aeration works; these factors also affect heat loss, and thus the internal pile temperatures. Stabilisation is enhanced by controlling the size and porosity of the windrow so that it is both small enough (in cross-sectional area) and ‘fluffed up’ enough to allow adequate oxygen transfer, yet large enough by critical mass to retain some heat.

Static composting is suitable only for manure with a low content of readily biodegradable substrate and an open structure achieved by mixing with straw, sawdust, rice hulls or leaves. Manure with greater oxygen demand may be composted by this technique when diluted with coarse, porous, inert blending material. The addition of a blending (or bulking) material also produces an open structure in the mixture. Anaerobic conditions and suboptimal temperatures and moisture levels are unavoidable with static stockpiles. Accordingly, stabilisation periods may range from 6 months to years depending on prevailing atmospheric conditions. Siting of static windrows is critical to facilitating airflow and to taking advantage of sunlight and exposure. Shade should be avoided. To ensure the homogeneity of product and uniformity of process time, the static stockpiles should be subject to the same conditions of exposure; this usually dictates a north–south alignment.

Turned windrows

Turned windrows are similar to static windrows, except the material is turned or agitated to introduce air into the stockpile and bulk it to facilitate homogeneity, passive aeration and heat removal.

A front-end loader or specialised turning machine is commonly used. With turned windrows, fresh manure with a higher oxygen demand can be composted more rapidly, and larger windrows can be used than with static windrows. However, mechanical turning cannot control compost temperatures precisely, and unless the material is turned frequently, anaerobic conditions are unavoidable. Water is often added to promote effective biological activity in the summer, via either overhead irrigation or a water cart and side sprinkler system.

The frequency of turning required to prevent nuisance odours and achieve rapid stabilisation will depend on the manure's oxygen demand and porosity and on the type and amount of blending agent and carbon source. Stabilisation periods of less than 3 months are achievable. Avoid areas prone to katabatic wind drift, as odour generated under cooler temperatures during the night can flow downhill. Labour and site access can be limiting, and neighbours can encounter odour.

Management and quality control

Given appropriate initial feedstock, the most important factors influencing the rate and efficiency of composting are oxygen supply, temperature control and availability of water in the blend. Oxygen is required by the composting microorganisms to oxidise biodegradable material. The higher the content of readily biodegradable material, the greater the potential oxygen demand. If insufficient oxygen is supplied, anaerobic conditions will result, reducing quality, producing noxious gases and generating more greenhouse gases. The aim of composting should be to yield consistent product quality. To achieve this, the process must be monitored. In particular, the finished product should be analysed for pH, moisture and nitrogen, especially if it is to be sold.

Bulking and blending agents and carbon sources

The structure and moisture content of a solid waste determines how easily it can be aerated, and on the type and quantity of blending and bulking agents or carbon sources required (if any) to enhance porosity and absorb excess moisture. The method of mixing the manure and bulking agent will also be determined to some extent by the structure of the manure. Blending and bulking agents must maintain their structural integrity during the composting process to provide air voids. Commonly used agents and sources of carbon for dairy manure are:

- rice hulls
- food processing by-products (orange peel, pips, husks)
- woodchips
- sawdust
- crushed pine bark or other bark with a granular structure when crushed
- organic wastes with structural integrity such as leaves, grass and straw
- recycled compost
- dried dairy manure or sludge.

Recycled compost can be used as a bulking agent for compost, although Pecchia *et al*. (2002) indicate that there is little benefit in this practice.

Approach local industries which produce waste material suitable for use as bulking agents for access to feedstock. Blending and bulking agents can be used in combination, and if coarse bulking agents such as woodchips are used, the bulking agent can be screened from the compost and reused. Degradable agents are generally preferred to those which simply provide structure to a pile.

Pittaway *et al.* (2001) discuss regional solutions to waste disposal by composting. This type of solution is favoured if the amount of material generated from farms is significant enough to justify investment. Urban garden waste is frequently used as the main carbon source, and operations are now common on the fringes of many cities. Factors other than the structure of the waste that affect the selection of a blending or bulking agent are:

- availability and cost

- product quality requirements (e.g. crushed pine bark normally produces a compost with a better appearance than do sawdust or rice hulls)
- product volume constraints; recycling the compost or bulking agent (after separation by screening) reduces the volume of product
- consistency of supply
- colour
- risk of contaminants.

Compost mixing

Mix the manure and added material (e.g. by front-end loader) in a ratio that ensures that the blend is homogeneous and has an open structure to facilitate complete aeration of the composting pile while conferring a stable but loose structure to the finished product. The mixture should generally have a moisture content of about 50% to 60%, which can be maintained by rainfall, sprinklers or temporary covers.

Dairy manure does not produce unacceptable levels of odour during short periods of storage. Mixing and pile formation may be done once a week, but other wastes need daily incorporation. Spoilt feed and silage leachate have different characteristics. If week-long storage in uncovered stockpiles proves unsatisfactory, the stockpiles may be covered with a layer of bulking agent or mixed with the bulking agent and placed onto the composting pad daily.

pH

Compost should have a pH within the range of 5.0 to 8.0 to be compatible with plant growth and to avoid odour. A pH within the range of 5.5 to 6.5 is desirable if the compost is to be used as the sole component in a general potting medium, because within this range nutrients are most available to plants. Both saline and acidic conditions are not conducive to good composting, and ameliorants such as sulphur and lime are occasionally added to correct pH.

Moisture

Moisture loss is a good indicator of process activity, because evaporative cooling removes excess heat generated during the aerated stage of the composting process. In addition, moisture reduction is a common objective, because raw manure contains excess moisture, and a drier product is easier to handle, store and apply.

Temperature

The metabolic heat generated by the microorganisms elevates the temperature of the compost, so the control of temperature is an important aspect of composting. The temperature of the compost is a good indicator of the composting process activity; temperatures within 40 to 60 °C promote maximum biological activity. If moisture drops below 50%, the temperature will fall even if the composting process is incomplete. An elevated temperature (<60 °C) promotes rapid decomposition rates, and temperatures in excess of 55 °C for 3 days are effective in killing weed seeds. However, excessive temperatures can occur, and temperatures can exceed 60 °C, limiting microbial activity, delaying stabilisation and presenting a risk of spontaneous combustion. In the absence of heat removal via a decline in ambient temperature or good ventilation, and if oxygen is not limiting, composting temperatures can exceed 60 to 65 °C (and may reach 80 °C). Inadequate moisture can reduce efficiency in winter and generate excessive heat in summer, so water often needs to be applied, especially to avoid spontaneous internal combustion of a stockpile.

Nitrogen

Nitrogen is required by microorganisms for the breakdown of carbonaceous substrates. Insufficient N impairs the composting process, whereas excess N results in loss of N to the atmosphere by volatilisation of ammonia, which may cause noxious odours. An ‘ideal’ C:N ratio of 25–30:1 for the raw waste is acceptable. However, the nutrient status of compost is determined by the availability (to microorganisms) of the N and C, and therefore the required N content may different between manures generated by grazing animals and those from animals fed supplements.

The compost produced from dairy manure usually has a total N level of 1.0% to 1.5% by dry weight. This can be increased to around 3.0% by the addition of fertilisers and high-N wastes such as raw effluent. The increased N level in the waste will aid breakdown of plant fibres, so if they are available, add these wastes when composting manure. Under aerobic conditions, ammonia may be oxidised to nitrate and nitrite by nitrifying microorganisms. Oxidised N normally increases in concentration as a result of composting and is therefore sometimes used as an indicator of the success of the process.

Odour and appearance

A good indicator of compost maturity is the odour and appearance. A mature compost should be dark in colour and have a friable structure with an earthy odour. The presence of mycelium (fungal growth) is evidence of a poor composting process.

Other management techniques

Alternative techniques for managing the process are described in Keener *et al*. (2002); these include the use of temporary covers and aeration for quality control. The blending agents evaluated in this study were straw and sawdust. Although covers and aeration improved the quality of both straw and sawdust composts, researchers found little difference in the performance of the two blending agents, as further confirmed by Frederick *et al*. (2004).

The composting of dairy manure, with a high oxygen demand and a high potential for heat generation, requires management of both temperature and oxygen supply to promote rapid stabilisation, the selection of appropriate blending material, and a site that does not introduce undesirable organisms to the mix. Non-biodegradable materials like clay, silt and sand can impede the process by increasing the density and reducing the void ratio. The process can be further limited by the presence of disinfectants, antibiotics, herbicides and insecticides and by elevated levels of copper, zinc and chlorine.

Composting can be used as a way of disposing of animal carcasses. Murphy et al. (2004) successfully evaluated techniques for reducing carcasses into humus. This is now an accepted feedlot practice in Australia.

Compost use

Before use or sale, the compost can be passed through a screen to remove foreign objects. Depending on the structure and properties of the final product, it can be marketed as a soil conditioner, an ingredient for a potting mix or a complete potting mix or plant growth medium. The finished product can be sold in bulk to wholesalers or direct to the public as long as the source is specified. Although materials sold as soil conditioners or fertilisers must be registered and tested for quality and consistency, composts and mulches do not have this requirement. However, all marketed products need to comply with the Australian Standard for composts, soil conditioners and mulches (Standards Australia 2003).

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