Producing Quality Compost From Livestock Manure

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Introduction

Composting is the aerobic (oxygen requiring) decomposition of manure or other organic materials in the thermophilic temperature range of 104 – 149° F (40 - 65° C). Nature provides an extensive, native population of microorganisms that are generally attached to all organic wastes. When conditions are right, these microbes grow and multiply by decomposing the material to which they are attached. From a scientific viewpoint, the composting process is started and managed under controlled environmental conditions rather than accepting the results of natural, uncontrolled decomposition. The composted material is odourless, fine-textured, and low-moisture and can be used for non-agricultural and agricultural purposes with little odour or fly breeding potential. When managed properly, composting improves the handling characteristics of any organic residue by reducing its moisture content, volume and weight. The process increases the value of raw manures by destroying pathogens and weed seeds and creating a media for the production and proliferation of beneficial organisms.

The Composting Process – Creating the Right Conditions

The composting process is a biological one that compares somewhat to the raising of plants or animals. The rate of composting, like the rate of plant or animal growth, can be affected by a number of factors.

Four keys factors are:
1. nutrient balance
2. moisture content
3. temperature
4. aeration

Nutrient balance is determined primarily by the ratio of carbon to nitrogen in the compost mixture. The microorganisms require carbon and nitrogen for growth since these elements are the main components of carbohydrates and protein. If nitrogen is in excess, large amounts of ammonia will be released to the atmosphere, if carbon is in excess the composting rate will decrease. The moisture content should ideally be 60 percent after organic wastes have been mixed. Maintaining the correct moisture level during the thermophilic (high temperature) phase of composting can be difficult in an open-air windrow system due to dry or wet climatic conditions.   When the moisture content exceeds 60 %, the windrows subside and lose porosity thereby becoming anaerobic. Fermentation will set in and odours will be emitted from the material. If the moisture content decreases below 50 %, the rate of decomposition decreases because nutrients must be in solution to be utilized by microorganisms. As the microorganisms decompose organic matter, heat is generated and the temperature of the compost rises. Decomposition is a dynamic process, accomplished by a succession of microorganisms, each group reaching its peak population when conditions are optimum to support that particular group.

When one group of microorganisms dies, another group populates the composting material until the next incremental change in nutrition and temperature occurs. Since the release of heat is directly related to the microbial activity, temperature is a good process indicator. The temperatures of composting materials typically follow a pattern of a rapid increase to 120 – 140° F (49 - 60° C) which is maintained for several weeks, a gradual temperature decrease to 100° F (38° C) as active composting slows due to nutrient consumption, and a final leveling off at ambient air temperature. The temperature pattern is generally described in Figure 1. During the

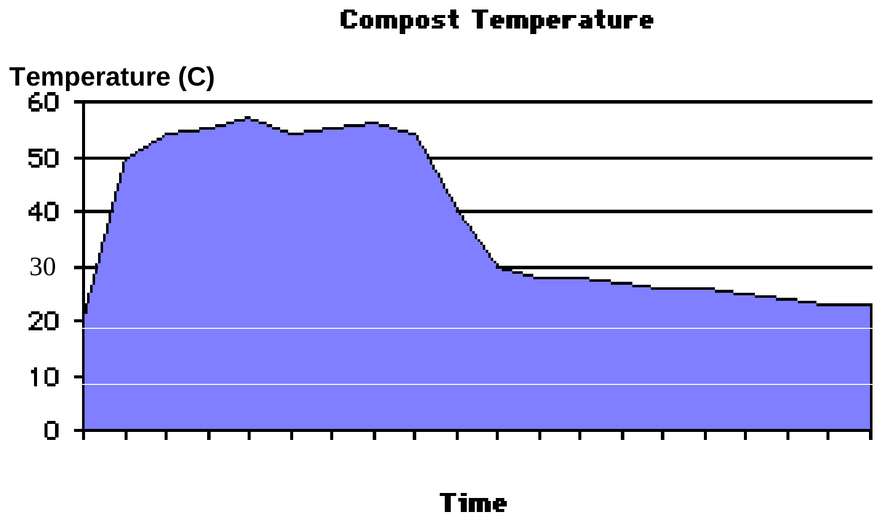

Figure 1. General time-temperature pattern for composting.

initial days of composting, readily degradable components of the raw material are rapidly metabolized, therefore the need for oxygen is greatest at the early stages and decreases as the process continues. Without sufficient oxygen, the materials become anaerobic. Anaerobic processes are generally slower and less efficient than aerobic processes. Little heat is generated under anaerobic conditions and intermediate compounds such as methane, organic acids, hydrogen sulfide and other odourous compounds are generated. Aeration also removes heat, water vapour and other gases trapped within the composting materials. Livestock manures will compost rapidly under the conditions listed in Table 1.

Table 1. Recommended conditions for rapid composting[a].

Condition	***Reasonable Range***	***Preferred Range***
Carbon/Nitrogen ratio	20:1 – 40:1	25:1 – 30:1
Water content	40 – 65 %	50 – 60 %
Oxygen concentration	5 %	5-15 %
Particle size (diameter)	1/8 – 1/2 inch	varies[b]
pH	5.5 – 9.0	6.5 – 8.0
Temperature	110 – 150° F(43 – 65° C)	130 – 140° F (54 – 60° C)

[a] from Rynk et al. 1992
[b] depends on materials used

Composting Alternatives – Selecting the Right Method

Open-windrow composting using some form of mechanized turner is frequently the method of choice for intensive beef production operations (Figure 2a). Other methods commonly used for composting include: passive composting piles (also referred to as static pile composting), passively aerated windrow (supplying air at ambient pressure through perforated pipes embedded in the windrow), active aerated windrow (forced air through perforated pipes [Figure 2b]), turned bins, rectangular agitated beds, silos, rotating drums, and vermi-composting (using worms to degrade organic material). The method selected depends on the type of livestock, size of the operation, climatic conditions and available capital. Plastic covers have recently been made commercially available to cover open-air windrows, protecting the material from changing climatic conditions, yet allowing free gas-exchange.

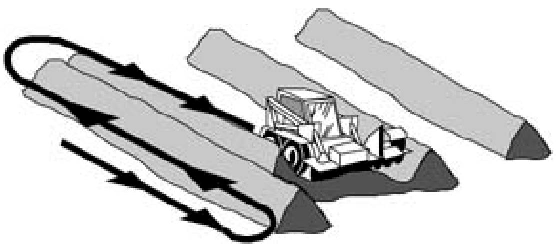

Figure 2a. Open windrows with mechanical turning. From Rynk, R. et al. 1992.

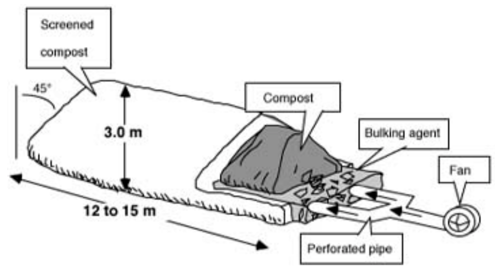

Figure 2b. Active aerated windrow. From Rynk, R. et al. 1992.

Nutrient Content of Compost Ingredients – Getting the Right Mix

Manure nutrient contents vary according to species, diet, and handling systems for animal wastes. The bulking agent used as a source of carbon or amendment to increase porosity of the mixture varies according to preference and availability. Chemical characteristics of livestock manure and common bulking agents are given in Table 2 and 3. Depending on the bulking

Table 2. Range of manure characteristics from several livestock species[a].

Characteristics	N	P	Water content	C:N	pH
	--------------------------%---------------------				
Beef feedlot[b]	0.2 – 3.0	0.1 – 1.2	20 – 80	10:1 – 20:1	6 – 8
Swine	0.1 – 0.5	0.1 – 0.2	80 – 99	15:1 – 21:1	7 – 8
Dairy	0.3 – 0.6	0.1 – 0.2	75 – 90	8:1 – 30:1	6 – 8
Chicken manure	0.8 – 2.5	0.3 – 0.7	50 – 85	4:1 – 18:1	6.2 – 7.5
Broiler litter[b]	1.7 – 6.8	0.8 – 2.6	22 – 29	6:1 – 24:1	6.5 – 8.5
Turkey	1.2 – 1.8	0.3 – 0.9	50 - 85	4:1 – 18:1	6.2 – 7.5

[a] from Eghball and Zhang 1998.
[b] beef feedlot manure and broiler litter as collected, others on a fresh manure basis.

agent used in the mixture solid manure or separated liquid manures can be composted in 60 – 120 days using windrow composting and mechanical turning. Chicken manure, broiler litter and turkey manure mixtures frequently require the addition of water to achieve the desired moisture content. Temperatures in these composts have been known to exceed the maximum recommended temperature levels and require close monitoring to produce a quality product. High carbon amendments are known to reduce nitrogen loss from high nitrogen manures (Mahimairaja et al 1994, Eghball et al 1997).

Table 3. Carbon content and C:N ratios of bulking materials[a].

Material	% N (dry wt.)	C:N
Corn stalk	0.6 – 0.8	60 – 73
Straw	0.3 – 1.1	48 – 150
Bark, hard woods	0.1 – 0.4	116 – 436
Bark, soft woods	0.04 – 0.39	131 – 1285
Newsprint	0.06 – 0.14	398 – 852
Sawdust	0.06 – 0.8	200 – 750
Wood chips	0.04 – 0.23	212 – 1313
Leaves	0.5 – 0.13	40 – 80

[a] from Rynk et al. 1992

It is necessary to determine the chemical composition of the ingredients for the compost mix but, provided that major changes in diet and manure management do not occur, the chemical composition of the manure should not change significantly from year to year. Spreadsheets for calculation of composting mixtures to obtain the correct C:N ratio are available on the internet at http://www.cfe.cornell.edu/compost/download.html. Front end loaders, skid steers with buckets, conventional solid manure spreaders, tub grinders or mixing wagons are among the equipment used to mix the compost ingredients and deposit the material in windrows.

Compost Quality – Getting the Right Stuff

The three factors described by Jim Wimberly (Director of the Foundation for Organic Resource Management, Fayetteville, FL) that define compost quality are consistency, absence of pathogens and fine texture. The nitrogen, phosphorus and potassium in the composted manures are not the components of highest value (Table 4). The greatest benefit is probably in the microbiology and the organic matter of the material. Currently there is no value attached to these components and, until this value is established through research, the margin of return for composted manure products will remain low. According to Bess (1999), microbiological methods used to evaluate soil microbiology may be used in the future as standard analytical methods to determine compost quality. Compost quality could be determined, in part, by the concentration of six functional groups of microorganisms: aerobic bacteria, anaerobic bacteria, fungi, actinomycetes, pseudomonads and nitrogen-fixing bacteria. There is evidence that specific organisms that inhibit the growth of plant pathogens can be isolated from compost and compost extracts. It has been suggested that composts could be tailored to suppress specific plant diseases prevalent in horticultural and agricultural production (De Ceuster and Hoitink 1999) and to clean-up environmental contamination (Alexander 1999). Another indicator of compost quality is compost maturity, which is determined by an assay for the presence of phytotoxic compounds, and measurement of pH, sodium content and electrical conductivity.

Table 4. Composition of raw manure/straw mixture (dry matter basis) prior to and following compost treatment at Brandon Research Centre*

Chemical Constituent (kg/Mg)	Raw Manure	Compost
Total N	15.9	12.5
Organic N	15.8	12.1
Ammonia N	0.14	0.05
C:N ratio	19:1	13:1
Phosphate	10.9	10.2
Potassium (K_2O)	11.62	9.56
Sulfur	1.65	1.48
Calcium[a]	30.9	28.0
Magnesium[a]	10.7	8.0
Sodium	1.9	1.3
Physical Properties		
pH	8.6	8.5
EC (mS cm^{-1})	6.54	7.70
Moisture (%)	75	42

* Because of the heterogeneous nature of the raw manure/straw mixture, sample variability is high for nitrogen and phosphorus.

Composting – Summary of Pros and Cons

Benefits

- production of an excellent soil conditioner that adds organic matter, improves soil structure, improves water-holding capacity, reduces fertilizer requirements and reduces potential of soil erosion.
- potential market for the composted product ie. home gardeners, landscapers, vegetable farmers, turf growers, golf courses and ornamental growers. Compost can also be used as bedding for poultry.
- reduction in weight and mass, and improvement in handling characteristics.
- product can be stored and applied at convenient times of the year since organic N is less susceptible to leaching and further ammonia losses
- reduction of the C/N ratio to levels that are more suitable for land application compared to raw manure mixed with straw.
- destruction of pathogens and weed seeds.
- elimination of odours and flies.
- reduction of soilborne pathogens without the use of chemical controls
- potential income from tipping fees for organic waste. Note: composting off-farm wastes must be considered cautiously.

Disadvantages

- a suitable site must be developed for composting activities to prevent runoff and leaching of nutrients. The composting site, storage of raw materials and finished compost can occupy a considerable area of land.
- cost of equipment, labour and management.
- potential odours from stockpiled materials collected for composting.
- climatic limitations may require a higher capital investment.

- development of a marketing plan for excess compost.
- diversion of nutrients from agricultural land to other uses.
- potential loss of nitrogen (however, the total losses from raw manure compared to composting have not been determined scientifically).
- slow release of nutrients due to the higher concentrations of organic nitrogen in compost compared to manure.

Figure 3. Photograph of the 5 acre composting site at Brandon Research Centre which can accommodate 8000 tonnes of raw manure for composting.

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