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On-farm Composting of Livestock Manure

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Introduction

The management of on-farm-generated livestock manures has consistently been a challenging issue for livestock producers throughout Arkansas. Historically, livestock manures have been applied as slurry or as solids to provide a source of fertilizer for crops or grazing lands. Although manure slurry or solids, such as poultry litter, are easily land applied, the storage and handling of farm-generated manures are comparatively less efficient. In addition, transporting slurry or high-moisture solids over long distances to other agricultural regions throughout Arkansas has posed logistical and economic barriers as well. Consequently, producers have investigated various methods to effectively maintain and manage on-farm-derived livestock manures. One of the methods involves the composting of on-farm manure.

Composting Livestock Manure

Livestock manure is regarded as having significant amounts of nutrients, such as phosphorus (P) and nitrogen (N) (Dougherty, 1999), which are beneficial factors for effective plant growth and development. However, the P and N content of livestock manures in compost can vary from farm to farm depending on the type of production system used, animal feeding habits, and composting management (Chastain et al., 2006). Production systems that can significantly influence the nutritional content of livestock manures and resultant compost mixtures include livestock and dairy operations through their respective feeding methods (Kenna, 2022).

Livestock manure management often entails the mixing of manure with a variety of organic materials for composting purposes (Figure 1). Examples of organic materials can include crop residues, such as chaff and corn stalks, along with wood remnants (Schott et al., 2022). Other sources of organic materials that can be used in the composting process are plant leaves, eggshells, and corn cobs (Hirrel et al., 2004) . Organic residues can absorb the liquid-manure fraction and create a stable and coagulated product that can be used at a later date. Mixing animal manures with organic materials also relieves the necessity of creating on-farm storage lagoons and ponds, in which liquified manures are typically stored and retrieved by pumping systems into mechanized spreaders for field application. The most vital aspect of composting management is knowledge of the carbon (C) to nitrogen (N) ratio of a specific organic material (Figure 2). A good C:N ratio for effective composting is in the range of 25 to 30:1 (Hashemi and Herbert, 2011).

A benefit of mixing livestock manure with organic materials is the increased potential to stimulate chemical and biological activity within the mixture (Figure 3), where the

Carbon & Nitrogen Sources for Compost

Carbon Materials		Nitrogen Materials	
Aged hay	Cardboard Egg Cartons	Vegetable Trimmings	Algae
Cardboard	Paper Towels	Green Leaves	Grass Clippings
Sawdust	Toilet Paper Rolls	Kelp or Seaweed	Green Shrub Prunings
Newspaper	Dried Grass	Tea Bags	Alfalfa Meal/Hay
Wrapping Paper	100% Cotton Fabrics	Coffee Grounds/Filter	Animal Manure (herbivores only)
Straw		Houseplants	Weeds (without seed heads)
Wood Ash (not coal)		Old Flower Bouquets	Human/Animal Hair
Shredded Paper		Aquarium Water (freshwater)	
Oat Hay			
Dry, Shredded Leaves			
Chipped Wood			

Figure 1. Image displaying common organic materials used in composting with respect to their abilities to provide carbon and nitrogen. Image adapted from (Murphy, 2019).

stimulation is typically associated with increases in temperature and the proliferation of microbial organisms brought on by a surplus of readily decomposable organic C (Schott et al., 2022). The enhancement of biological and chemical processes within the mixture ensures that the mixture will remain a viable fertilizer source for a sustained period of time. Maintaining livestock manures with additions of organic materials also serves to reduce unpleasant odors characteristically linked to the storage of raw, unrefined effluent (Dougherty, 1999). Not only does a livestock manure/organic material mixture alleviate manual and/or mechanical handling, but this mixture can also decrease the presence of surrounding insects that may be attracted by the aroma of untreated manure.

Another major advantage of composting on-farm-generated livestock manures is the enhancement in handling and storage efficiency (Burke et al., 2023). When a compost mixture is ready to be land-applied, it can be accomplished by broadcasting on the ground surface, similar to applications of a variety of commercial fertilizers. Because of the thickened nature of the compost mixture, field applications can be made prior to a rainfall event to ensure that the remaining liquid fraction, and some solids, can effectively infiltrate into the soil. As with any on-farm nutrient management plan, livestock manure applications should be avoided in areas with soil-test-P levels in the "optimum" or "above optimum" categories.

Food scraps	15:1	Green
Grass clippings	19:1	
Coffee grounds	20:1	
Rotted manure	25:1	
	30:1	Ideal
Corn stalks	60:1	Brown
Leaves	40-80:1	
Straw	80:1	
Paper	170:1	
Sawdust, wood chips	500:1	

Actual content may vary.

Figure 2. Image displaying average carbon to nitrogen ratios of materials commonly used for composting. Color column represents materials abundant in nitrogen "Green" and materials rich in carbon "Brown." Image adapted from Saunders (2020).

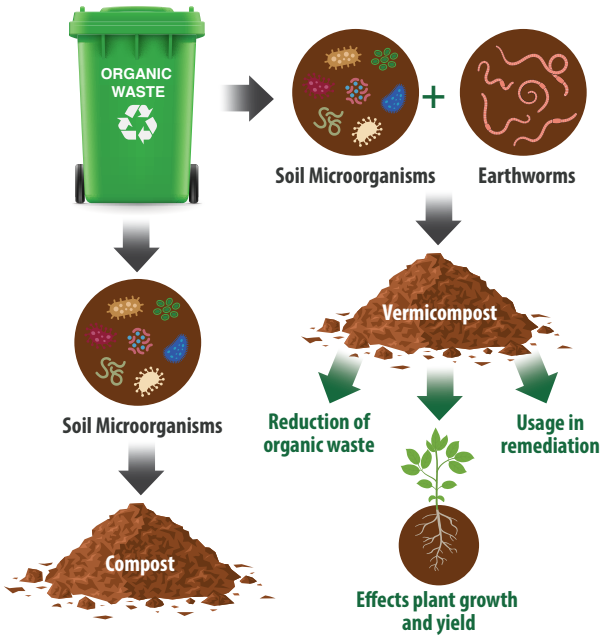

Figure 3. Image showing microbial activity and stimulation in the composting process. Image adapted from Vukovic et al. (2021).

Case Study: Composting Livestock Manure with Sawdust at an Arkansas Discovery Farm Dairy Operation

Research conducted at an Arkansas Discovery Farm dairy operation near Decatur, Arkansas from 2020 to 2021 investigated the effects of composting on-farm-generated livestock manure with sawdust (Burke et al., 2023). The use of sawdust in manure management is similar to that of other organic materials. At this dairy farm, sawdust is lain in an area where livestock congregate, usually for feeding purposes (Figure 4). While congregating, the manure deposited by the livestock drops to the sawdust-covered surface. After the livestock has been left, the resultant manure/sawdust mixture is either manually dry scraped or mechanically shoveled out of the congregating area into an open-air storage facility (Figure 5) where the mixture can be held for future field application or for transport to other farms. The average storage time of this mixture prior to field-application is 45 days and the mixing frequency is once every other day (Bill Haak, personal communication). The ratio of sawdust to manure in the mixture can vary according to a producer's preference, but a 30%/70% sawdust-to-manure ratio is usually sufficient for handling and storage objectives.

A major benefit for composting livestock manure with sawdust is that sawdust particles have a larger surface area per particle compared to other composted organic materials . The increase in surface area allows sawdust particles to absorb the liquid manure fraction at a rapid rate, creating a more solidified product conducive to on-farm relocation and containment. Furthermore, the storage of the mixture can be prolonged by the continuous absorption properties of individual sawdust particles. Because of the prevalence of forests and wooded areas across Arkansas, sawdust is readily available and can be attained by agricultural producers throughout the state. According to Hull Forest Products, sawdust prices for 2024 range from $14.50-$42 per yard (yd) depending on the amount purchased along with options for loading and delivery. Sawdust can be obtained at regional sawmills or at retailers such as Tractor Supply Company and Walmart. The accessibility of sawdust can alleviate many economic and logistical concerns about transportation and shipping issues. Sawdust is manageable and can be easily stored on the farm until it is ready to be used in composting with on-farm produced livestock manures.

To illustrate the effect of mixing sawdust with livestock manure at this Arkansas Discovery Farm dairy operation on the resulting nutrient content, livestock manure samples were collected in 2020 and 2021. Samples were collected from a pile composed of a livestock manure/sawdust mixture. In 2015, a sample of raw, untreated dairy manure was collected and analyzed for N, P, and potassium (K). Both sets of samples were analyzed for the same constituents and means were calculated and reported (Table 1).

Figure 4. Sawdust on the floor of a milking holding pen prior to manure addition and mixing. Image courtesy of Arkansas Discovery Farms.

Figure 5. On-farm storage facility containing a sawdust/manure mixture. Image courtesy of Arkansas Discovery Farms.

Table 1. Comparison of nutrient content from untreated and sawdust-treated manure from an Arkansas Discovery Farm dairy operation (data from the Arkansas Discovery Farm Program).

	Nutrients (lbs./ton)		
Manure Type	**N**	**P_2O5**	**K_2O**
Untreated¥	33.0	5.0	26.2
Sawdust¥¥	16.9	3.6	9.3

¥Sample collected in 2015.

¥¥Samples collected from 2020-2021. Values represent averages from 2020-2021.

At the dairy farm, mixing deposited livestock manure with sawdust has reduced the N, P and K contents. Except for N, the P and K content of the sawdust manure mixture is consistent with values reported for the average composition of dairy manure in a solid system (11-5-11; N-P2O5-K2O) (Pennington et al., 2018). While the nutrient levels are lower in the compost, the nutrients, especially N, are in a more stable organic form and will behave much like a slow-release fertilizer dependent on soil mineralization rates, which are dependent on environmental conditions, such as soil temperature and moisture. The other advantage of amending soil with composted manure rather than raw manure is that composted manure will more readily build the soil's organic matter, which, in turn, can increase microbial activity and nutrient cycling and improve water-holding capacity (Goldan et al., 2023).

Conclusions

On-farm livestock manure management is to be an evolving area in which researchers and producers are searching for efficient approaches to ensure that livestock manure management is mutually beneficial to environmental stewardship as well as agricultural productivity. The addition of a potential variety of organic materials to on-farm-generated livestock manure can enhance handling and storage capabilities, as well as provide a sustainable nutrient source. Due to the abundance of organic materials, especially forests and woody plant species in Arkansas, forest products, like sawdust, have the potential to be financially and logistically viable options as organic materials to mix with raw livestock manure.

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