41 Waste Management

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Objectives

- **Discuss beneficial elements available in cattle manure.**
- **Learn how solids content affects the handling characteristics of manure.**
- **Learn how stockpiled feedlot manure can be used as fertilizer.**
- **Learn how to capture fertilizer from grazing beef cattle.**
- **Determine if a cattle operation is subject to environmental regulations.**

Manure

Food and nutrients must move through an animal's digestive tract for proper digestion to take place. When the digested material leaves the animal's body, it becomes manure. By definition, manure is a mixture of feces, urine, bedding material and added water. Feces are the semi-solid materials that exit the digestive system through the large intestine and anus. Urine is a liquid solution of waste products cleaned from the blood stream by the kidneys that exits the animal by way of the bladder and urethra.

Manure Constituents

Manure is made up of water, living and dead microorganisms, undigested food, plant nutrients, and salt. The daily production of selected manure constituents per 1,000 pounds of cattle live weight is given in Table 41.1. Definitions are given in Table 41.2. The values for confined cattle were developed using a mass balance of digestible nutrients fed, retained and excreted in a feedlot setting. The values for grazing cattle were derived experimentally in England using two sets of nearly mature (1,100 pounds to 1,250 pounds), two-year old Holstein-Simmental cross heifers and steers. Grazing intensity was determined by measuring grass height through the grazing period and limiting grazing intensity to maintain the ecological diversity of pastures. Although the study took place in a much more humid climate, the grazing intensities shown in Table 41.2 are similar to range grazing in Oklahoma.

Table 41.3 gives the distribution of plant nutrients between feces and urine. Generally speaking, the more-mobile plant nutrients (nitrogen and potassium) are found in urine and the less-mobile nutrients (phosphorus and calcium) are found in feces. A good amount of nitrogen also is found in feces, tied up as protein in microbial biomass and undigested feed. Thinking about manure as equivalent fertilizer: feces are a slow-release nitrogen and phosphorus

Table 41.1. Manure excreted per 1,000 pounds liveweight (1 AU)[1] of beef cattle.

	Confined cattle[2]		*Grazing cattle[3]*	
Manure Constituent	*Non-lactating cow*	*Growing calf 450 lbs to 750 lbs*	*Two-year-old heifers and steers moderate grazing*	*Two-year-old heifers and steers light grazing*
Weight (lbs AU^{-1} day^{-1})	104	77	51	37
Volume (ft^3 AU^{-1} day^{-1})	1.7	1.2	-	-
Fecal Total Solids Content (% wet basis)	12	12	12	12.5
Total Solids (lbs AU^{-1} day^{-1})	13	9.2	4.9	4.6
Volatile Solids (lbs AU^{-1} day^{-1})	11	7.7	-	-
N (lbs AU^{-1} day^{-1})	0.35	0.45	0.21	0.14
P (lbs AU^{-1} day^{-1})	0.08	0.08	0.02	0.015
K (lbs AU^{-1} day^{-1})	0.25	0.29	-	-
Ca (lbs AU^{-1} day^{-1})	0.16	0.135	-	-

1 1,000 pounds liveweight = 1 Animal Unit (AU)
2 ASABE, 2019 and USDA-NRCS, 2008
3 Orr et al, 2010

All Web addresses given in this chapter are subject to change. The links to these websites will be updated regularly at the Master Cattleman website at extension.okstate.edu/programs/master-cattleman.html

Table 41.2. Definition of terms.

Manure	The combination of feces, urine, bedding and added water collected from a poultry or livestock confinement area.
Feces	The solid or semi-solid materials exiting an animal's digestive system through the large intestine and anus.
Urine	The liquid solution of waste products cleaned from the blood stream by the kidneys that exits the animal by way of the bladder and urethra.
Weight	Mass of manure excreted.
Volume	Space taken up by excreted manure.
Total Solids	Sometimes written as TS, total solids are measured by measuring the wet mass of manure, weighing again after the manure has been dried for 24 hours at 215 F, and dividing the dry mass by the wet mass. Total solids can be suspended (floating particle) dissolved (salts), volatile (organic) or fixed (ash).
Volatile Solids	Sometimes written as VS, volatile solids are the portion of total solids that ignite when heated to 1,022 F. VS content is a rough measure of the organic matter content of manure.
Plant Nutrients	The major plant nutrients (sometimes called macronutrients) are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S) and magnesium (Mg). Macronutrients are elements needed in relatively large quantities for plant growth. Micronutrients include boron (B), chlorine (Cl), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo) and cobalt (Co). Small quantities of micronutrients are needed to regulate plant growth. Some micronutrients can be harmful to plants and animals in large doses.

Table 41.3 Distribution of plant nutrients between feces and urine.

	Feces	*Urine*
Source material	*Intestinal bacteria and undigested feed*	*Waste products cleaned from the blood stream by kidneys*
Fertilizer Analogy	Slow release N-P-Ca fertilizer	Liquid urea-potash fertilizer
Distribution of nitrogen	30%	70%
Distribution of phosphorus	100%	0%
Distribution of potassium	10%	90%
Distribution of calcium	95%	5%

fertilizer with some liming capacity; urine is liquid urea-potash fertilizer.

Environmental Effect of Manure

Manure constituents can be either good or bad depending on how they end up in the environment. Fecal bacteria can render water undrinkable and unswimmable. Organic matter (represented by VS in Tables 41.1 and 41.2) adds tilth and moisture-holding capacity to the soil. But if it ends up in streams and ponds, organic matter is a strong pollutant. Microorganisms living in water eat organic matter, grow and remove dissolved oxygen fish need to live in the water. Plant nutrients (N, P, K) help crops to grow, but if the same nutrients run off into water, they can cause aquatic plants and algae to grow, which also removes oxygen dissolved in the water.

Manure Consistency

Consistency defines the physical properties of manure. Unfrozen manure can exist as liquid, slurry, semi-solid or solid depending on the concentration and shape of manure particles (Figure 41.1). The main difference between liquids and slurries is that slurries contain suspended particles. Semi-solids can act as either a liquid or a solid, depending on how much pressure is applied. Most of the time, semi-solid manure acts like a solid. It stacks and can be moved with a shovel. But, stepping on a fresh cow pie might cause it to squirt like a liquid.

Figure 41.2 shows how consistency relates to solids content for swine, poultry and cattle manure. Notice that this figure does not have bars for liquids. This is because manure, being a mixture of feces and urine, always contains solid particles associated with the feces. The dotted line in the figure gives the solids content and consistency at which feces are excreted. Cattle manure is excreted at around 12% total solids. In this concentration range, cattle feces are a semi-solid (cow patties usually stack up in the pasture). Care must be taken, because changing an animal's diet may change the consistency of its manure. Changing cattle from a high-forage to a high-grain diet usually makes their manure more liquid. Another thing to remember is the 'as excreted' line in Figure 41.2 only shows consistency as the feces are excreted. Adding bedding absorbs urine and increases the solids concentration of feces. This makes manure more solid and easier to handle with shovels, bucket loaders and conveyers. Adding water makes manure more liquid, which makes it easier to transport in channels and pipelines.

Using Feedlot Manure as Fertilizer

Manure that has been laying in a feedlot, or stored in a stockpile is not the same as excreted manure. After lying exposed, wetting and drying, freezing and thawing, feedlot manure loses most of the nutrients it had when

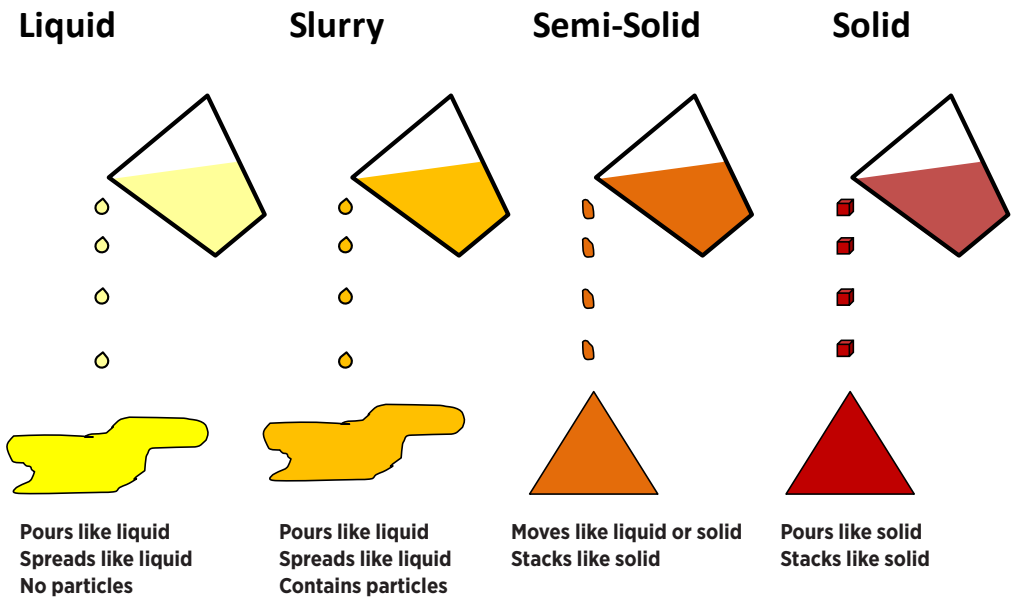

Figure 41.1. Consistency of manure.

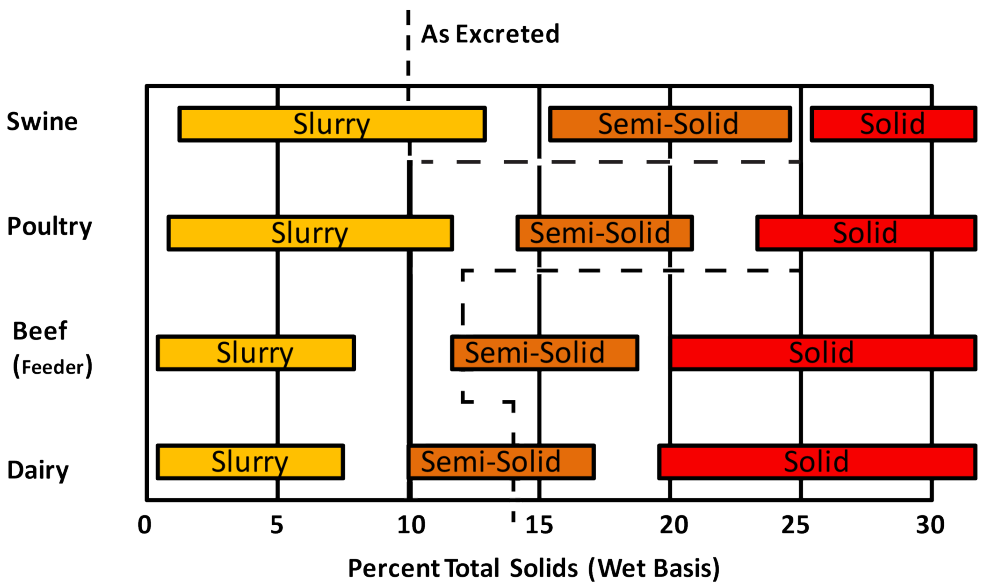

Figure 41.2. Relationship between manure solids content and consistency. Source: USDA-NRCS.

it was excreted. That does not mean feedlot manure is bad fertilizer, however. Some typical fertilizer values of stockpiled feedlot manure analyzed by the OSU Soil, Water and Forage Analytical Laboratory are given in Table 41.4. Overall, feedlot manure is similar to a 1-1-1 fertilizer. Also, it provides organic matter to the soil and has some liming value. To capture the most benefit from land application, follow these steps:

1. Take a representative sample of the manure and have it analyzed for plant nutrients (see OSU Extension fact sheet PSS 4288, *Sampling Animal Manure*).

Table 41.4. Fertilizer value of typical feedlot manure in Oklahoma on an "as is" basis (from PSS-2250, Using Stockpiled Feedlot Manure as Fertilizer).

	Percent Composition (%)	*Average Concentration on a Mass Basis (lb/ton)*
Total Solids	20 to 55	-
Total N	1.7 to 2.4	24
Organic N	1.3 to 1.9	20
Phosphate (P_2O_5)	1.5 to 2.1	21
Potash (K_2O)	1.7 to 2.3	25

2. Multiply the fertilizer value by the availability factors in Table 41.5 to determine the long-term plant-available fertilizer value of the manure.
3. Take a representative sample of the soil in the field you want to spread manure (See OSU Extension fact sheet PSS 2207, *How To Get A Good Soil Sample*).
4. Calculate manure application rate using the plant available nutrients in the manure and the most limiting nutrient (usually, but not always phosphorus) in the soil test recommendation for the yield goal and the crop to be grown.
5. Use commercial fertilizer to supplement manure nutrients.

To read about land application of feedlot manure in greater detail, consult OSU Extension fact sheet PSS-2250, *Using Stockpiled Feedlot Manure as Fertilizer*. It is always best to test manure before applying. But, if you have a rough idea of the tons of manure to spread, you can use the typical values of Table 41.5 to estimate nutrients available, combined with soil testing and yield estimates to determine land needed to spread.

Table 41.5 Long term availability of manure fertilizer elements after application.

Nutrient	*Amount of nutrient available for plant growth over several growing seasons (%)*
Nitrogen (N)	70
Phosphorus (P)	80
Potassium (K)	80
Calcium (Ca)	80

Nutrient Recycling in Grazing Systems

Grazing beef cows, calves and stockers are under-appreciated fertilizer dispensers. Plant nutrients are directly deposited on pasture free of charge. The long-term plant availability values given in Table 41.5 apply to the "as excreted" manure. In addition, half of manure nitrogen is available in the first year after deposit.

One big difference between spreading stockpiled manure and manure spread by grazing is, with grazing, feces and urine are applied separately. Although cattle generally defecate and urinate shortly after one another, the nutrients are applied in separate locations. So, cattle deposit aqueous urea fertilizer in one spot, and slow-release organic nitrogen in another. Stocking rate has a large impact on nutrient distribution. With light stocking density, cattle tend to concentrate nutrients in shady areas, near water and near feeders. Also, cattle tend to not eat grass near a fresh (or even an old) cow pie. By skipping spots covered with feces and eating grass where cow pies are less common, cattle move nutrients away from heavily grazed areas and deposit it in heavily manured areas, reducing overall pasture fertility.

Distribution of plant nutrients by cattle is maximized under rotational grazing with stocking density matched to forage growth. It is also a good idea to drag pastures with a chain harrow after rotating cattle through a paddock. Dragging distributes fecal nutrients and reduces selective grazing. Dragging also helps to control parasites and distributes perennial seeds throughout the pasture.

Since most of the nutrients deposited by cattle stay on the pasture, grazing is a good way to maintain fertility in already fertile fields. Once a field has reached an adequate soil test phosphorus index, grazing maintains the phosphorus fertility of the soil almost indefinitely. You cannot expect grazing to increase the fertility level of a poorly fertilized field, however. Without supplemental fertilization, forage production tends to follow stocking rate. If the soil cannot grow much forage, cattle do not eat much forage. If cattle do not eat much forage, they do not deposit much fertilizer. If other factors for forage growth (deep soil, adequate moisture, adequate organic matter) are sufficient, adding supplemental fertilizer to a pasture for a few years can boost forage production. Afterwards, grazing maintains the soil fertility level and reduces the need for supplemental fertilizer.

The values of Table 41.1 should be used as a starting point to manage soil and forage resources. Use soil and forage testing to constantly monitor a field's condition and adjust stocking density and fertilizer application rates to maximize production while taking advantage of the free nutrients cattle are applying to the pasture.

Regulations Covering Use of Manure in Grazing Systems

In most situations, cattle managed in pasture systems will not fall under state or federal environmental regulations. Use good pasture and soil fertility management, and limit cattle access to streams to control water pollution. There are three cases, however, under which a permit may be required:

1. The operation has more than 1,000 head of cattle and the animals are confined in an area without growing vegetation for more than 45 days in a 12-month period.
2. The operation has more than 300 head of cattle, the animals are confined in an area without growing vegetation for more than 45 days in a 12-month period and a stream or other liquid conveyance drains the confinement area.
3. An agent of the federal or state regulatory agency has inspected the operation and determined that it is causing water quality degradation.

If an operation falls under any of these conditions, contact the Oklahoma Department of Agriculture, Food and Forestry - Division of Agricultural Environmental Management.

References

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Woolsey, C. (2016) Dragging pastures: are the benefits worth the cost? Progressive Forage. Jerome, ID: Progressive Publishing.

Zhang, H. and D.W. Hamilton (1998) Using Stockpiled Feedlot Manure as Fertilizer. OSU Extension Fact Sheet PSS-2250. Stillwater, OK: Oklahoma Cooperative Extension Service.

Websites with Regulation Information

U.S. EPA, Division of Water Pollution Control (Washington, DC).

U.S. EPA, National Agricultural Compliance Assistance Center (Kansas City, MO) epa.gov/agriculture/

U.S. EPA, Region 6 (Dallas, TX) epa.gov/region6/

Oklahoma Department of Agriculture, Food and Forestry – Division of Agricultural Environmental Management (OKC, OK) ag.ok.gov