Manure Basics

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Manure is a nutrient rich byproduct of animal agriculture. It is composed of animal feces and urine, as well as bedding, wasted feed, and added water from stock tanks, evaporative cooling systems, and sanitation processes. Manure has been considered a waste product due to its odor and potential pathogens. Odor can be a nuisance but utilizing good management this can be minimized. While there are potential pathogens most are species specific. Good management can minimize the potential for pathogen contamination. Manure can be a significant benefit when land applied in providing nutrients as well as augmenting the soil with organic matter.

Manure contains a broad range of nutrients including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), copper (Cu), manganese (Mn), and zinc (Zn), just to name a few. As such it can be utilized to support most of the nutrient needs of growing crops, replacing a significant portion of purchased fertilizers. As evidenced by Table 1, the general amount and composition of excreted manure varies by age, size, level of performance and life stage. This may be even further complicated by the diet that is fed, feed quality and digestibility, bedding type, added water, type of manure storage, the duration of the storage, and precipitation and evaporation during storage. Cattle retain some of the feed nutrients to produce milk, and meat, and to maintain their metabolism. The efficiency is highly variable and 50% to 90% of the consumed nutrients may be excreted. There are things that can be done to minimize the excretion:

1. Feed a diet balanced to the nutritional requirements of the animal. Feeding to excess results in excretion of the excess. Conversely, because of the interplay among nutrients, feeding too little of one nutrient may have the same result as feeding too much of another.
2. The quality and availability of feed nutrients affects the total amount of feed needed to meet nutritional requirements. Poor quality feed requires that more be fed to meet requirements, but also could result in more excretion but in less available forms.
3. Similarly, feeding highly digestible feeds reduces the amount required to be fed.

Manure composition

N, P, and K are the major nutrients of manure. Knowing the concentration of these components is crucial for calculating proper land application (right time, right form, right rate, right method) and determining appropriate treatment techniques.

Table 1. Daily manure production and analysis.

Animal	Body Weight (lbs.)	Total Manure (lbs.) [a]	Nutrient Content (lbs.) [a]		
			N	P_2O_5	K_2O
Dairy					
Calf	250	20	0.11	0.02	0.09
Heifer	1000	60	0.30	0.10	0.31
Lactating Cow:					
75 lbs. milk/day	1400	143	0.93	0.48	0.53
100 lbs. milk/day	1400	160	1.04	0.54	0.59
125 lbs. milk/day	1400	177	1.15	0.60	0.65
Dry cow	1700	87	0.51	0.18	0.40
Veal	250	6.6	0.03	0.02	0.05
Beef					
Calf	450	48	0.20	0.09	0.16
Finishing	1100	54	0.40	0.12	0.25
Cow	1000	92	0.35	0.18	0.29

[a] per head per day, as excreted

These nutrients can be categorized as soluble and insoluble. Soluble nutrients (solubles) are readily available for plant usage, while insoluble nutrients (insolubles) may not be available for a year or more. Generally, solubles are found in urine and insolubles, along with some solubles, are found in feces.

Usually N is evenly distributed between the two phases: 50% in the liquid and 50% in the solids. Much of the P (80%) is found in the settled solids and is insoluble. K is the opposite with as much as 80% is found in the liquid phase and is soluble.

Nitrogen (N)

N comprises about 78% of the earth's atmosphere, and is an essential component of amino acids, the building block of proteins. Unfortunately, even at this concentration, it can be a limiting factor in agricultural soils. Even though they may have the same total N content, not all manures are equal in terms of fertility value because some of the N may not be immediately available for crop use. N exists in two forms: organic and inorganic. N must be in an inorganic form to be utilized by plants.

Ammonium (NH_4^+-N) / Ammonia (NH_3-N) are the main inorganic forms of N in manure, and are the result of the conversion of urea in urine and the breakdown of organic-N in the feces. Liquid manures tend to have a greater portion of N in these forms than solid manures.

Nitrate-N (NO_3^--N) is another inorganic form. Even though a heavily manured field may be very high in nitrate-N, liquid manures tend to have very little nitrate-N. This is because ammonia-N in the liquid manure is converted to nitrite and then nitrate by soil bacteria, *Nitrosomonas* and *Nitrobacter*, respectively. Unfortunately, this presents an environmental problem when manure is excessively applied. Nitrous oxide can be formed and is a potent GHG. Nitrate-N has a negative charge, as do the soil particles. The like charges repel each other and the nitrate-N leaches into the groundwater or runs off into streams, rivers, and lakes leading to high nitrate levels in drinking water.

Organic-N is estimated as the difference between total-N and inorganic-N. It is the N that is bonded to carbon typically contained in undigested feed particles and bedding. This must be converted to an inorganic form, usually from bacterial degradation, before it is available to plants.

Phosphorus (P)

P in manure is in organic and inorganic forms that also determines its availability. Inorganic-P exists as a soluble form as well as a precipitate (solid) with calcium and/or magnesium. Only the soluble form is available to plants.

Like N, the organic-P is bonded to carbon structures, and it too must be converted to an inorganic form before it can be used by plants. The principle organic forms are phytates, orthophosphates, and phospholipids. These are the primary contributors to P pollution during high sediment load runoff events leading to algal blooms.

Potassium (K)

K is required by every living cell. In animals it helps to regulate fluid balance, muscle contractions, and nerve signals. In plants it regulates the opening and closing of stomata for intake of CO_2 for photosynthesis, and activates enzymes necessary for energy production, among other functions.

As shown in Table 1, there is no shortage of K in manure. Moreover, most of this is inorganic and water soluble, so there is no microbial transformation required to make it available to the plant. Excess K can be bad for cows close to freshening.

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