UNDERSTANDING MANURE: DIFFERENCES IN MANURE TYPES AND NUTRIENT CHARACTERISTICS

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Introduction

The nutrient credits from applied manure vary by animal species and the manure management system in place on the farm. Traditionally, the most common approaches have been liquid handling systems (minimal bedding) and solid manure systems, which is a more highly bedded management strategy. In more recent years, practices such as running the manure through a digester or composting process as well as liquid-solid separation have become more common. These actions can have a significant impact on total nutrient content and potential availability of the nutrients when field applied. The use of sand bedding has replaced wood products as a bedding source on many farms as well.

With any change in management there is the potential for a significant shift in the manure characteristics and nutrient content. The best way to track these changes is though a comprehensive manure sampling and testing program. In cases where this is not practical, book values exist to give an estimate of the typical nutrient content for a specific manure type. This can be an effective strategy but only if the manure on the farm is relatively normal or typical.

Manure analysis results summarized in this paper were provided by the following laboratories. The cooperation of these laboratories in providing their data for these tables is greatly appreciated.

AgSource Laboratory
Dairyland Laboratory
Rock River Laboratory
UW Soil and Forage Laboratory

Nitrogen

First-year nitrogen (N) availability varies with animal species and management system as well as whether or not the manure is incorporated and how much time has elapsed between application and incorporation (Table 1). This is because nitrogen in manure is in both inorganic (immediately available) and organic (not immediately available) forms. Nearly all the inorganic form is present as ammonium. Ammonium is easily volatilized to ammonia and lost if manure lays on the soil surface. Research now shows that after 1 hour, a large portion of the ammonium is assumed to have volatilized unless significant rainfall has occurred. This volatilization loss may continue at a lower rate for several more days unless the manure is incorporated. For this reason, the N credits for surface-applied, unincorporated manure are less than when manure is incorporated or injected. Also, manure with higher dry matter content typically has a lower percentage of the readily available ammonium N than lower dry matter (liquid) manures. For this reason higher dry matter (solid manure) will have a lower first year available N credit than liquid manure from the same animal species.

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Phosphorus and Potassium

Phosphorus (P) in manure is present in both inorganic and organic forms. For most animal species, the inorganic P forms are dominant. Wisconsin research has demonstrated that first-year availability of manure P is equivalent to the availability of commercial fertilizer applied at the same rate of total P_2O_5. Potassium (K) in manures is largely in the inorganic form and is readily available to plants. Because there is some inherent variability in spreading manure evenly across the field and also variability with the nutrient content of each load of manure, the first-year availability of P and K is assumed to be 80% of the total. No second- or third-year credit is given for manure P or K (Table 1). Any manure P or K applied, but not credited in the first year, is best accounted for by subsequent soil testing.

Table 1. Estimated nutrient availability for various manures.

	N					
	Time to incorporation					
Species	> 72 hours or not incorporated	1 to 72 hours	< 1 hour or injected	P_2O_5	K_2O	S
First-year availability	**% of total**					
Beef: liquid (≤ 11.0% DM)[a]	30	40	50	80	80	55
Beef: solid (> 11.0% DM)	25	30	35	80	80	55
Dairy: liquid (≤ 11.0% DM)[a]	30	40	50	80	80	55
Dairy: solid (> 11.0% DM)	25	30	35	80	80	55
Goat	25	30	35	80	80	55
Horse	25	30	35	80	80	55
Poultry[b]	50	55	60	80	80	55
Sheep	25	30	35	80	80	55
Swine	40	50	65	80	80	55
Veal calf	30	40	50	80	80	55
Second-year availability						
All species	10	10	10	0	0	10
Third-year availability						
All species	5	5	5	0	0	5

[a] If dry matter (DM) is < 2.0% and NH_4-N is > 75% of total N, the following equation for first-year N availability may be used in an effort to better account for the high concentration of NH_4-N found in these manures: first-year available N = NH_4-N + [0.25 x (Total N – NH_4-N)], assuming manure is injected or incorporated in < 1 hour.

[b] Poultry includes chicken, duck, and turkey.

Second- and Third-year Credits

Manure nutrients are available to crops the second and third years after application. For all nutrients other than P and K, second- and third-year availabilities are estimated at 10% and 5%, respectively, of the total amount applied in the first year. The sum of the first-, second-, and third-year availabilities for a nutrient does not equal 100%. This is because some losses will occur, particularly with N, and because manure applications are not always uniform in rate and composition across a field. These estimates of nutrient availability are agronomically conservative to ensure that adequate nutrients are available for the crop.

Laboratory vs. Book Value

To calculate the nutrient credits from manure, it is necessary to know the application rate and total nutrient content of the manure. Total nutrient content can be measured on a manure sample sent to most soil testing laboratories. Where specific nutrient analysis for a manure is unknown, typical nutrient contents (also called book values) based on animal species and management can be used. In Table 2, the typical total nutrient content of samples analyzed by Wisconsin based laboratories between 1998 and 2012 are summarized. These values probably give an acceptable estimate for the "typical" producers, especially if sampling methods do not represent the pit, pack or gutter adequately. However, an analysis of a well-sampled system may give a better estimate of nutrient value for individual farms especially if herd and manure management is not "typical". Because manure nutrient content can vary greatly from farm to farm, and book values represent an average nutrient content, it is preferable to occasionally have all manure types on a farm analyzed.

Table 2. Typical total nutrient content of manures tested in Wisconsin (1998–2012).

	DM[a]	N	P_2O_5	K_2O	S
Solid manure	lb/ton				
Beef	29	13	8	12	1.9
Dairy: semi-solid (11.1–20.0% DM)	15	8	4	6	0.8
Dairy: solid (> 20.0% DM)	33	9	4	7	1.2
Goat	43	13	7	10	2.0
Horse	33	10	6	8	1.3
Poultry: chicken	57	49	44	33	3.0
Poultry: duck	36	12	10	9	1.8
Poultry: turkey	59	51	44	31	3.8
Sheep	34	19	9	24	2.2
Swine	19	18	13	10	2.0
Liquid manure	lb/1,000 gal				
Beef	3	16	7	15	1.6
Dairy: liquid (< 4.0% DM)	2	14	4	14	1.1
Dairy: slurry (4.1–11.0% DM)	6	24	8	21	2.2
Goat	4	17	8	19	1.7
Poultry	2	12	7	9	1.3
Swine: finish (indoor pit)	5	43	18	28	3.2
Swine: finish (outdoor pit)	2	18	7	10	1.0
Swine: (farrow-nursery, indoor pit)	2	21	8	13	1.0
Veal calf	1	9	3	16	0.6

[a] DM = dry matter

Even though on average the actual farm values compare well to established Wisconsin book values in many cases, the actual analysis values can range widely from the book value estimates (Table 3). This could be the result of different management practices on farms or other on farm differences, or improper sampling techniques. Taking multiple samples over time and averaging these values will help reduce the potential for using a single anomalous laboratory result as the basis for crediting nutrients on a farm.

Table 3. Variability in analyzed manure total nutrient values, WI 1998-2012.

Solid manure

Animal type	Nutrient	Total samples	Wisconsin Median	Std. dev.	Min.	Max.
			--lbs/ton--			
Dairy	N	10743	8.8	8.2	0.2	189
	P_2O_5		3.8	9.2	0.1	266
	K_2O		7.0	21.3	0.1	1090
Beef	N	1083	13.1	7.1	1.0	62
	P_2O_5		7.8	13.5	1.3	219
	K_2O		11.5	12.4	0.2	162
Chicken	N	532	49.1	27.5	12.5	226
	P_2O_5		44.4	30.1	5.2	132
	K_2O		32.7	17.7	1.8	104
Turkey	N	1657	51.4	15.8	1.3	558
	P_2O_5		44.4	11.7	2.1	113
	K_2O		31.2	6.6	2.9	59
Poultry	N	1312	45.0	18.8	0.7	145
(all others)	P_2O_5		47.9	29.5	1.4	223
	K_2O		34.9	19.2	0.7	151

Liquid manure

Animal type	Nutrient	Total samples	Wisconsin Median	Std. dev.	Min.	Max.
			--lbs/1000gal--			
Dairy	N	19085	19.5	9.5	0.1	354
	P_2O_5		6.9	14.5	0.1	1078
	K_2O		17.8	10.1	0.1	737
Beef	N	480	15.8	61.6	0.1	1303
	P_2O_5		7.0	8.3	0.1	46
	K_2O		15.2	9.8	0.1	56
Swine	N	1787	43.2	63.1	0.8	2266
-finish	P_2O_5		18.0	11.5	0.1	127
(indoor pit)	K_2O		28.0	11.2	0.3	88
Swine	N	159	18.2	18.4	0.9	73
-finish	P_2O_5		7.2	14.7	0.2	82
(outdoor pit)	K_2O		10.5	10.1	0.3	43
Poultry	N	612	12.2	12.4	0.1	91
	P_2O_5		7.1	12.2	0.1	96
	K_2O		9.0	6.4	0.1	66

Changes in Dairy Manure Nutrient Content by Digestion

Passing liquid dairy manure through an anaerobic digester has become increasingly popular. The process has the potential to change the dry matter and nutrient content, which could affect its performance as a nutrient source when applied to cropland. A study is currently looking at a comparison of raw vs. digested liquid dairy manure as a nutrient source when applied to crop fields. As a part of this study, the manure was tested both before digestion (raw) and following passing through an anaerobic digester. The raw manure had a higher dry matter content, which resulted in a lower ash content (Table 4). The digested manure had a much higher C:N ratio and a somewhat higher ratio of ammonium-N to total N. The field study is ongoing to address what affect digestion has on liquid dairy manure as a nutrient source.

Table 4. Effect of anaerobic digestion on characteristics of liquid dairy manure.

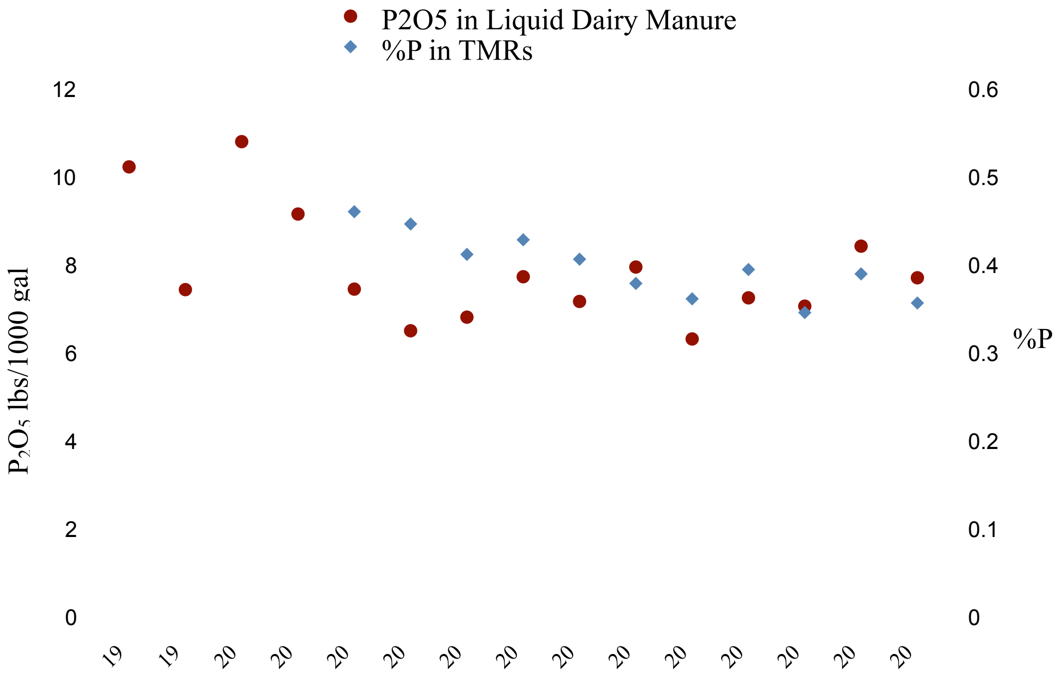
Source	Manure type	Year	%DM	% ash	Total N	Total P_2O_5	Total K_2O	C:N	NH_4-N
					---------lbs/1000 gal--------				% of TN
Site 1	raw	2011	5.9	22.5	22.3	10.0	18.2	8.8	49
Site 2	raw	2011	10.4	17.2	26.6	10.8	23.4	13.4	45
Site 1	raw	2012	6.3	17.5	20.8	8.7	17.0	10.7	45
Site 2	raw	2012	8.5	16.9	23.5	9.7	21.9	13.0	48
Average			7.8	18.5	23.3	9.8	20.1	11.5	47
Site 1	digested	2011	5.3	32.1	25.0	12.9	21.2	6.3	57
Site 2	digested	2011	3.2	32.2	19.3	6.1	18.8	4.9	51
Site 1	digested	2012	3.4	30.2	24.7	7.9	20.6	4.1	60
Site 2	digested	2012	5.5	23.8	20.8	7.1	20.3	8.2	54
Average			4.4	29.6	22.5	8.5	20.2	5.9	56

*Laboratory data from Carrie Laboski, personal communication

Changes in Phosphorus Content of Liquid Dairy Manure over Time

For the past 11 years, the UW Soil and Forage Analysis Laboratory has been conducing a program to thoroughly evaluate TMRs for dairies. One of the outcomes of this has been the ability to monitor total P levels in these TMR rations. During this same time period there has been a tremendous amount of extension effort put into getting information to dairy farmers as to the appropriate levels of total dietary P in rations. In general, most dairy rations originally contained significantly more P than was necessary for herd health and proper milk production. Over this period of time there has been a steady decline in the average total P content of dairy TMRs. There has been a similar downward trend in liquid dairy manure P levels over this same time period (Fig. 1). This is another example of a changing farm management strategy having a direct influence on the nutrient content of manure generated by that farm.

Fig. 1. Long term trends in P levels in liquid/slurry dairy manure vs. TMRs.



Summary

The use of manure analysis as a tool in on farm nutrient management has increased greatly in the past 15 years. During this same time period, there has been a lot of innovation in technology and changes in farm management practices that have also affected manure nutrient content. Changes in bedding materials, housing and manure handling facilities have occurred as well as treating manure by digestion, composting or liquid-solid separation. Using book values has traditionally been one way to attempt to properly credit applied nutrients from manure. However, if manure varies from the old established norms, as is often the case when a farm management strategy is changed, using a standard value may be inappropriate. By following recommended sampling guidelines and keeping long-term records, the appropriate manure nutrient content values can be obtained for a farm that reflects the management system in place.

References

Laboski, C.A.M., and J.B. Peters. 2012. "Nutrient Application Guidelines for Field, Vegetable and Fruit Crops in Wisconsin." University of Wisconsin-Extension Publication A2809. University of Wisconsin-Madison, Madison, WI.

Peters, J.B., editor. “Recommended Methods of Manure Analysis.” Feb. 2003. University of Wisconsin-Extension Publication A3769 (web based), Cooperative Extension Publishing Operations, Madison, WI. http://uwlab.soils.wisc.edu/pubs/A3769.pdf

MWPS Livestock waste facilities handbook. Handbook #18, 2nd ed. Midwest Plan Service. Ames, Iowa, 2007.