Dairy Manure Nutrients: Variable, But Valuable

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Nutrient management planning for a dairy farm is important to maximize utilization of manure nutrients for crop production, as well as to avoid excessive application rates and adverse water quality impacts. The nutrients in manure have recently become even more valuable with dramatic increases in fertilizer prices.

What is the content of various nutrients in dairy manure? How much is it worth as fertilizer replacement? How variable is the nutrient content from different farms? Have there been changes over time with shifts in feeding or other management practices? Recent summaries of manure analyses run by laboratories in Wisconsin and Vermont help to answer these questions (Jokela and Peters, 2009).

Manure Nutrient Content: Laboratory vs. Book Values. Most state extension programs publish "book values" of manure nitrogen (N), phosphorus (P), and potassium (K) content for use in nutrient management planning when nutrient lab analyses from individual farm samples are not available. Book values for Wisconsin are published in UW-Extension publication A2809 (Laboski et al., 2006). Another commonly used source for book values in the Midwest is the Livestock Waste Facilities Handbook (MWPS, 2007).

Comparisons of these book values to average values from laboratory analyses of dairy manure N, P, and K content from recent long-term summaries in Wisconsin and Vermont are shown in Table 1. The book values from UW-Extension publication A2809 agree quite well with average numbers from both Wisconsin and Vermont summaries, whereas the MWPS book values vary in some cases.

What is the Fertilizer Value of Manure? Using average NPK values from the long-term Wisconsin summary, nutrient availability factors from UW-Extension publication A2809, and current fertilizer prices (as of Jan. 2009), estimates can be made of the dollar value of dairy manure (Figure 1). It is important to recognize that only a portion of the total nutrient content, especially of N, is available to the crop in the first year, the remainder being either lost or tied up in the soil (and some becoming available in future years). These availability factors are estimates, and actual availability can vary considerably depending on manure properties and soil and weather conditions.

An average liquid dairy manure has first-year fertilizer value of about $17/1,000 gal. If the manure were applied to a field with high soil test P and K (and, therefore, no additional P or K need), the value of the nitrogen alone would be more than $5/1,000 gal. The comparable numbers for solid manure are close to $10/ton for NPK and $2.65 for N only. Assuming an application rate of 10,000 gal/ac of liquid manure or 20 tons/ac solid manure (typical for corn production), the fertilizer value would be more than $50/ac for N and about $180 for NPK (Figure 1). Last fall the dollar value of manure was 30-40% higher because of higher fertilizer prices and, given the recent volatility of fertilizer prices, these estimates may change again over the next few months.

Variability of Nutrients in Manure. The calculations of dairy manure nutrient content and dollar value were based on average nutrient content. The nutrient content of manure on an individual farm, however, may vary considerably from the average. Variability of N and P content of over 1,600 liquid dairy manure samples analyzed by the University of Vermont Agricultural and Environmental Testing Lab over a 15-year period is shown in Figure 2.

Table 1. *Dairy manure nutrient content: lab analysis averages vs. book values.*

System	Nutrient	Lab Analysis		Book Values	
		WI[1]	VT[2]	A2809[3]	MWPS[4]
		lb/1,000 gal			
Liquid	N	22	24	24	31
	P_2O_5	8	9	9	15
	K_2O	19	21	20	19
	DM%	7	7	6	--
		lb/ton			
Solid	N	11	10	10	10
	P_2O_5	6	6	5	3
	K_2O	10	9	9	6
	DM%	33	29	24	--

[1]*Averages of 4,691 solid/semi-solid dairy and 10,144 liquid dairy manure samples analyzed by four Wisconsin-based laboratories 1998-2008 (Peters, 2008).*
[2]*Averages of 1,623 liquid and 743 solid/semi-solid dairy manure samples analyzed by Univ. of Vermont Agricultural & Environmental Lab 1992-2006 (Jokela et al., 2005).*
[3]*UW-Extension Publication A2809 (Laboski et al., 2006)*
[4]*Livestock Waste Facilities Handbook (MWPS, 2007)*

The average N and P values for liquid manure (24 lb N/1,000 gal and 9 lb P_2O_5/1,000 gal; Table 1) match well with the peaks of the histograms, and 30-40% fall within about 20% of the mean. However, over ⅓ of the samples are more than 8 lb N and 4 lb P_2O_5 above or below the mean, which would result in large errors in N or P application rates if average values were used. The large variability could be the result of a number of factors such as differences in diets and bedding, amount of water entering the storage facility, degree of agitation, and sampling technique. This emphasizes the importance of sampling and analysis of manure from individual farms rather than relying on book values in order to have reliable nutrient content values for nutrient management planning.

Trends Over Time. The long-term summaries of dairy manure nutrient analysis from Wisconsin (10-year) and Vermont (15-year) provide an opportunity to examine changes in nutrient content over time as a result of shifts in animal diets or other management practices. While there is considerable year-to-year variation and specific farms sampled are not the same each year, some general trends over time can still be observed.

Nitrogen content of dairy manure showed only small trends, with a slight decline in Wisconsin and increase in Vermont (data not shown). Potassium content of liquid and/or solid increased slightly over time in samples from both states (data not shown). However, phosphorus is the nutrient of primary interest due to concern about excess manure P application contributing to runoff water quality problems. Phosphorus content of liquid manure decreased by about 30% over the 10-year period in Wisconsin (Figure 3) and for the 1992-2004 period in Vermont.

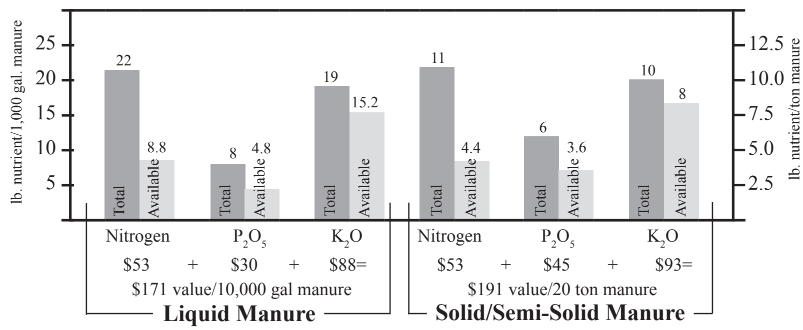
Solid/semi-solid manure showed a similar trend in the Vermont data but little change over time in Wisconsin (data not shown). The most likely cause of the decline in liquid manure P content is a shift to lower P diets. Research results and extension education efforts in the past ten or more years have emphasized the economic and environmental importance of feeding dairy rations that meet but do not exceed the animal P requirement, which has led to less P supplementation of feed. This phenomenon is supported by a decreasing trend in P content of total mixed rations (TMRs) in Wisconsin since 2002 (Figure 3).

Manure also contains a variety of micronutrients that are beneficial to crops. The Wisconsin lab data do not include micronutrients, and the Vermont data show only slight, if any, trends for most micronutrients. An exception was copper (Cu). The copper content of solid/semi-solid dairy manure in Vermont showed large year-to-year variation and also no consistent trend over time. But the copper content of liquid manure increased somewhat over the first seven years, and then increased dramatically in the post-1998 period, reaching values of over 500 mg/kg (DM basis) compared to averages under 100 mg/kg at the beginning of the period (Figure 4). These results reflect increased use of copper sulfate in foot baths to treat hairy heel warts and disposal of waste foot bath solution into liquid manure.

Summary. Summaries of over 14,000 dairy manure samples from Wisconsin and 2,300 from Vermont over a 10-15 year period showed average values that were consistent with UW-Extension book values but differed from those for some nutrients in the Livestock Waste Facilities Handbook. High variability, however, indicates that the average values are not reliable for nutrient management planning purposes, emphasizing the need for farm-specific sampling and analysis of manure to determine application rates.

With high current fertilizer prices, the available nutrients in manure can be worth more than $50 for N and ~$180 for N, P, and K/ac at typical application rates for corn production. Two long-term trends were especially noteworthy. Manure content of P decreased significantly over most of the time period, presumably reflecting lowered P in dairy diets. And copper content of liquid manure in Vermont samples increased dramatically after 1998, reflecting increased use of copper sulfate foot baths and raising concerns about long-term soil loading and potentially increased plant levels.

Figure 1. *Average total and available N, P and K content and dollar value[1] of dairy manure based on average nutrient analyses of 14,855 samples by Wisconsin labs.*



[1]N as urea $0.60/lb; P_2O_5 as DAP is $0.63/lb; and K_2O as potash is $0.58/lb.

Figure 2. *Variability of liquid manure nitrogen (top) and phosphorus (bottom) in Vermont samples.*

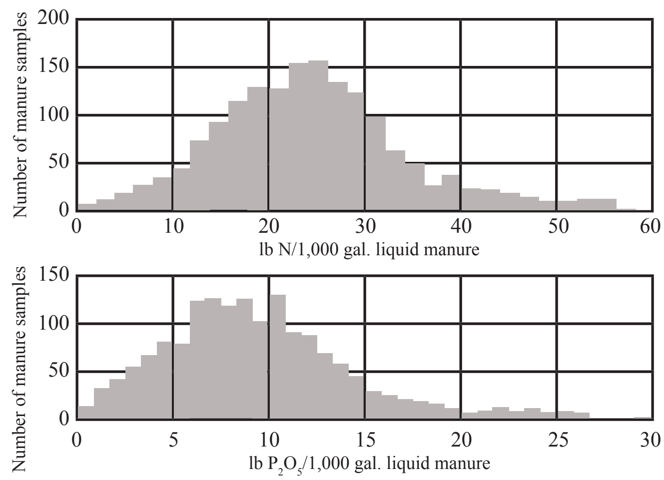


Figure 3. *Long term trends in P content of liquid dairy manure and TMRs in WI.*

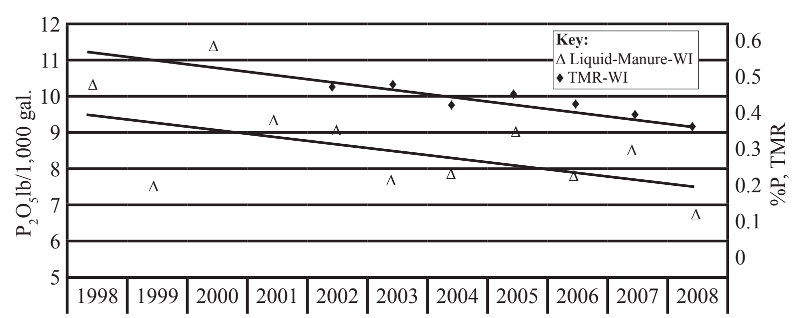
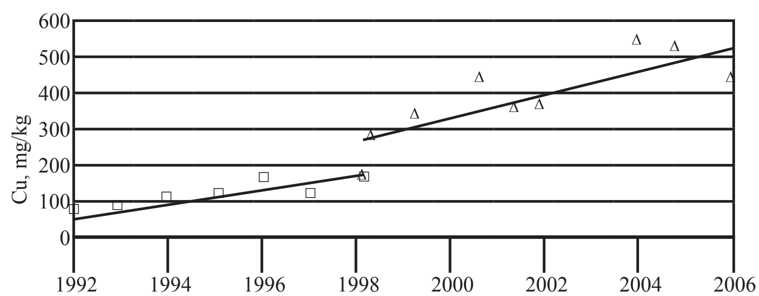


Figure 4. *Long term trends in copper content (DM basis) of liquid manure in VT.*



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