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Manure

Nutrient Content of Dairy Manure from Three Handling Systems

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Animal manure is often used as a source of crop nutrients. Unfortunately the nutrient content of manure is quite variable. The objectives of this study were to: (i) evaluate the nutrient content of dairy manure from different handling systems and determine if published nutrient credits are outdated, (ii) determine if the nutrient content could be estimated from the solid content of the manure, and (iii) determine the seasonal variation of the nutrient content of manure. Three dairy-manure handling systems, dairy feedlots, dairy barn cleaners, and dairy bedded packs, were sampled sequentially from June 1990 to April 1992. Manure was sampled by handling system at 13 farms located in northeastern Iowa. Samples were analyzed for total Kjeldahl N (TKN), ammonium-N, P_2O_5, K_2O, and solid content. The nutrient values found in this study were higher than values previously reported in Iowa and other midwest states. For dairy feedlot manure, solid content of the manure was correlated with the nutrient content of the manure. A correlation between solid content and nutrient content was not evident for dairy barn cleaner manure or dairy bedded pack manure. Dairy feedlot manure nutrient values were higher in summer and fall than in spring and winter. Seasonal variation was not evident for the dairy bedded pack manure or the dairy barn cleaner manure. The use of manure in a nutrient management program is dependent on accurate nutrient recommendations based on thorough and timely manure sampling.

THIS PROJECT was designed to create a database of nutrient analyses of manure from several handling systems in widespread practice throughout northeastern Iowa. The first objective of this study was to evaluate the nutrient content of dairy manure from different handling systems. The second objective was to determine if an easy method of estimating nutrient content could be derived from measuring the solid content of the manure. The third objective was to determine if the nutrient content of the manure changed seasonally.

The nutrient content of liquid dairy manure is documented (Sutton et al., 1983). However, the information concerning the nutrient content of manure from dairy bedded packs and dairy scrape-and-haul systems from both dairy feedlots and gutters is limited and, because of changes in feeding and manure handling systems, may have to be updated. Values used today in making nutrient recommendations are usually based on data that are 10 to 15 yr old or older. These data have been republished so often that it is often difficult to ascertain the original source, to determine how the samples were analyzed, or the solid content of the manure.

Many of the soils of northeastern Iowa are shallow to bedrock, and karst features are abundant. In addition, many livestock holding areas and feedlots are adjacent to streams; in some situations a stream flows through the area. These factors give rise to the risk of groundwater and surface water contamination. Consequently, proper manure handling, storage, and disposal provide an opportunity to reduce potential contamination while effectively using manure as a nutrient resource in a nutrient management program. Case studies indicate that producers generally apply manure to the land as a fertilizer or simply to dispose of a waste (Nicholas Rolling, 1991, personal communication). To achieve full nutrient credit for manure applied as a fertilizer, it is important that accurate information concerning nutrient analyses be available.

Nutrient values of manure have been published by Midwest Plan Service (1985), Safely et al. (1984), Van Dyne and Gilbertson (1978), and Sutton et al. (1983). Midwest Plan Service reports the nutrient content of the manure from a 1000-lb dairy cow to be 0.41, 0.17, and 0.33 lb/day of N, P_2O_5, and K_2O, respectively. These average values are useful in estimating nutrient content of manures, but actual values are found to be highly variable. Lindley et al (1988) reported that nutrient values in manure can range from 50 to 100% of the published values. In a review of nutrient composition of manures, Powers et al. (1975), found the range of nutrient concentrations reported for beef manure to be 0.60 to 4.9% for N, 0.11 to 1.6% for total P, and 0.05 to 4.0% for K. Safely et al (1984) reported that fresh dairy cattle manure had approximately 30% more N than mean values previously reported in ASAE D384 (1982). Values are dependent on such factors as feed inputs, species, age of the animal, age of the manure, environmental conditions, and how the manure is handled, stored, and land applied (Bulley and Holbeck, 1982; Burton and Beauchamp, 1986; Lindley et al., 1988; Clanton et al., 1991).

MATERIALS AND METHODS

Manure was sampled from several farms for each handling system to obtain an average nutrient value for a given

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Abbreviation: TKN, total Kjeldahl N.

ficients of variations, and number of samples of dairy feedlot manure averaged over sampling dates for each producer.*

Producer	TKN	NH_3	P_2O_5	K_2O	Solids
SC					
Mean†	15.0a	4.2b	7.8bc	12.2b	25.30a
C.V.	24.9	27.9	34.3	33.8	32.6
n	62	60	62	62	62
LM					
Mean	15.4a	5.6a	9.6a	11.6b	21.68b
C.V.	23.7	31.5	48.7	38.8	21.3
n	62	62	62	62	62
LK					
Mean	14.6a	4.8b	8.6ab	11.8b	21.20b
C.V.	18.5	38.4	40.4	39.0	21.8
n	62	60	62	62	62
RP					
Mean	14.8a	4.6b	7.0c	15.0a	21.06b
C.V.	28.9	31.7	39.8	43.3	27.4
n	62	62	62	62	62

* Means with the same letter within columns are not significantly different at P > 0.05.

† Nutrient means expressed in pounds per ton, solids in percentage.

handling system. Subsamples were taken at each location on each sampling date. Samples were frozen within 2 h of collection to reduce loss of nutrients.

Four dairy feedlot daily scrape-and-haul systems were sampled. In this system the cows were on the feedlot for several hours a day prior to milking and for a short time after milking. The lots were not roofed, and were subject to the existing weather. Manure was usually scraped from the lot once a day, usually after the morning milking, and hauled directly to the field.

In this study, the samples were collected by scraping manure from one area of the lot into a pile. The manure in the pile was mixed with a shovel. A sample of manure was taken from the pile by wearing a plastic 1-gal freezer bag turned inside out over one hand and pulling the bag right-side-out over the sample with the free hand. Four subsamples at each farm location were taken from different places within the feedlot. Each location was sampled every 6 wk for a total of eight sampling periods per year for 2 yr. The sampling periods were January, March, April, June, July, September, October, and December.

Five dairy barn cleaner daily scrape-and-haul systems were sampled. In this system manure accumulated in the barn cleaner during milking. The manure was usually removed from the barn by the barn cleaner, dumped on a manure spreader, and spread directly on the field. This system was not subjected to direct weather conditions, nor was milkhouse waste added to the system.

In this study four subsamples were taken from different places along the barn cleaner. A 1-ft square core of manure was sampled directly from the gutter to the depth of the gutter. The core was mixed and a sample placed in a plastic bag. To obtain a representative sample of manure from the gutter, it was important that the liquid in the bottom of the gutter be mixed with the solid manure and bedding. Each location was sampled approximately every 6 wk for 2 yr.

The dairy bedded pack manure sampled was a mixture of bedding and manure that often came from calf or dairy feeder steer pens. This manure was mixed with bedding that was added daily and allowed to accumulate for several months at a time. The dairy bedded pack manure was under roof and not subject to additional moisture added by precipitation. In this system, any liquid waste was retained by the bedding.

ficients of variations, and number of samples of dairy gutter manure averaged over sampling dates for each producer.*

Producer	TKN	NH_3	P_2O_5	K_2O	Solids
DM					
Mean†	15.0a	8.2a	7.6a	7.8a	17.01d
C.V.	13.7	27.8	20.5	20.8	19.6
n	62	60	62	62	62
MK					
Mean	12.4b	5.4b	7.0ab	8.0a	22.93a
C.V.	12.5	27.9	34.4	27.7	24.6
n	62	62	62	62	62
SC					
Mean	12.0b	5.0bc	6.4bc	8.4a	18.93b
C.V.	18.3	42.0	74.9	38.0	18.5
n	62	60	62	62	62
LK					
Mean	12.0b	4.6cd	7.0ab	6.4b	18.68bc
C.V.	13.1	34.6	49.2	39.5	14.4
n	62	60	62	62	62
NK					
Mean	11.0c	4.2d	5.6c	5.6c	17.61cd
C.V.	12.7	38.8	26.4	37.9	13.2
n	62	60	62	62	62

* Means with the same letter within columns are not significantly different at P > 0.05.

† Nutrient means expressed in pounds per ton, solids in percentage.

In this study four dairy bedded pack handling systems were sampled. At each location the manure was subsampled four times from within the pack. The manure was sampled from the pack by taking a 1-ft square core of manure to the depth of the pack. The manure was then mixed and sampled in the same manner as the dairy feedlot manure. The manure was sampled four times a year, January, March, July, and October, to correspond to the most common manure application times in relationship to cropping systems.

All manure samples were analyzed for TKN, ammonium-N (Bremner and Mulvaney, 1982), P_2O_5, K_2O (American Public Health Association, 1985), the percentage solids and the wet bulk density. Ammonium-N analyses were reported as ammonia.

All data were statistically analyzed for differences between producers by using analysis of variance procedures. The nutrient determinations based on solid content were analyzed by proc regression (SAS, 1985). All nutrient data were expressed as a percentage of the wet sampling weight.

RESULTS AND DISCUSSION

The dairy feedlot manure showed significant differences among producers for the percentage of solids, ammonium-N, P_2O_5, and K_2O (Table 1). Dairy barn cleaner manure showed significant differences among producers for all nutrients and solid content (Table 2). Significant differences in means among producers were found for solids, N, ammonium-N, and K_2O for the dairy bedded pack manure, but not for P_2O_5 (Table 3).

The results of the dairy manure nutrient analysis show significant differences among handling systems for some nutrients (Table 4). For the most part, values in this study were slightly greater than previously reported data (Table 4). Manure nutrient values reported by Killorn (1984) and Sutton et al. (1983), which were determined in the 1970s, have been continually reported in recent publications, and are presently used as recommendations to producers. The values reported by Killorn (1984) were expressed in terms of first-year available nutrients for crop growth. The values from Sutton et al. (1983) were expressed in terms of total nutrients found in

Table 3. Mean values for nutrient content and percentage solids, coefficients of variations, and number of samples of dairy bedded pack manure averaged over sampling dates for each producer.*

Producer	TKN	NH_3	P_2O_5	K_2O	Solids
KS					
Mean†	15.2a	6.0a	5.8a	16.8b	21.47b
C.V.	26.4	24.6	57.8	57.9	9.3
n	24	24	24	24	24
SC					
Mean	15.4a	5.0b	6.0a	14.0b	26.92a
C.V.	25.6	27.4	49.3	32.6	18.6
n	24	24	24	24	24
LM					
Mean	15.2a	5.2ab	7.0a	12.6b	23.15b
C.V.	25.2	27.0	44.8	27.9	17.9
n	24	24	24	24	24
LK					
Mean	12.4b	4.6b	7.2a	66.0a	22.97b
C.V.	24.9	28.8	40.2	24.8	32.7
n	12	12	12	12	12

* Means with the same letter within columns are not significantly different at P > 0.05.

† Nutrient means expressed in pounds per ton, solids in percentage.

the manure. Mineralization rates and field losses were not accounted for in Sutton's values. Results of the Wisconsin survey (Combs, 1991) and the manure nutrient content reported in the findings of this study are based on total nutrients found in manure. Mineralization rates and field losses are not reported. The reasons for differences between the older studies and this research could be factors such as different extraction procedures used in analysis, better sampling and better storage of samples before analysis, and new feeding and dairy herd management techniques.

In this study the total nutrient values of dairy manure are somewhat greater than in previously reported results. Significant differences in nutrient content among handling systems exist, although these differences were as small as 1 lb of total nutrient per ton. Proper nutrient credit should be given depending on which handling system is used on the farm. Recommendations of the nutrient content for the three dairy manure handling systems are listed in Table 4. The total nutrient values are averaged over all landowners and sampling dates and do not account for variables in feeding or bedding inputs.

The second objective of this study was to determine if it is possible to predict the nutrient content of the manure from the solid content of the manure. This would save the producer time and money compared with having the manure sent to a lab for analysis. The TKN, P_2O_5, and K_2O content of dairy feedlot manure can be estimated from measurements of the solid content of the manure. Regression analyses were evaluated by plotting sampling date means for each nutrient analyzed (wet weight) against the solid content means for each sampling date. The relationship between TKN, P, and K_2O vs. the solid content are shown in Figs. 1, 2, and 3. The regression analysis of dairy feedlot manure for ammonia-N vs. solids was not significant. A correlation between solid content and nutrient content was not evident for dairy barn cleaner manure or dairy bedded pack manure. More samples have to be collected to evaluate the use of this procedure for manure that contains large amounts of bedding.

The third objective of this study was to determine how the nutrient content of the manure changed throughout the year. Higher nutrient values were found in the summer and fall than in winter and spring for the dairy feedlot manure (Table 5). An exception to this trend is the sampling date in March,

Table 4. Nitrogen, P_2O_5, and K_2O content of dairy manure as reported in several studies. Recommendations from this study based on total nutrients of dairy manure of the three handling systems by season.

Source		N	P_2O_5	K_2O	Solids
		lb/ton			%
Killorn†	gutter	10	5	10	
	packs	12	7	12	
Purdue‡	gutter	9	4	10	
Wisc.§	gutter	10	5	10	
	packs	11	7	16	
This study*					
feedlot		15a	8a	13b	22
summer		17	9	16	27
winter		12	7	7	18
gutter		12b	7b	7c	19
summer		12	7	7	20
winter		13	6	7	18
packs		15a	6b	18a	24
summer		14	7	15	23
winter		16	6	22	24

* Means with the same letter within columns are not significantly different at P > 0.05.

† Killorn, 1984.

‡ Sutton et al., 1983.

§ Combs, 1991.

when all nutrients were much closer in value to the summer and fall sampling dates. Seasonal variation did not exist for the dairy barn cleaner manure or dairy bedded pack manure. Producers may be able to better manage their soil fertility program if they base their nutrient management programs on the seasonal variation of the nutrient content found in manure (Table 4). More work has to be done on the barn cleaner manure and the bedded pack manure in terms of sampling over time to determine if a seasonal variation exists.

Effective use of manure nutrient credits in a fertilization program requires that proper credit be given to the type of handling system used, that potential seasonal variation in manure nutrient values is recognized, and that standardized methods to report manure nutrient values are adopted. Manure values are reported in the literature on both wet weight and dry weight basis. In this study the values were reported on a wet weight basis. The values were also analyzed on a dry

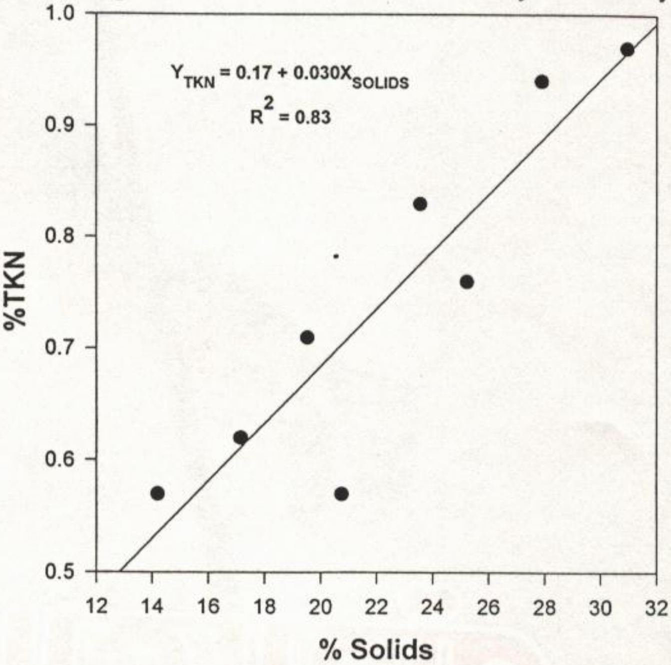

Fig. 1. Relationship between TKN and the solid content of dairy feedlot manure.

content were attributable to the differences in moisture content of the manure. When the dry weight data were analyzed significant differences between sampling dates and seasonal trends still existed, but the pronounced differences between winter and summer were reduced (Rieck, 1992). Manure values can be reported either as the oxide form of P and K or in the elemental form. Manure values are reported in the literature either as total nutrients contained in the manure or as values adjusted for expected field losses.

The results of the study can be very useful to producers using dairy manure as a nutrient source in their nutrient management program. Manure serves as a viable nutrient resource and can help farmers reduce inputs of commercial fertilizer, increase profitability, and, when managed during field application, reduce environmental loading.

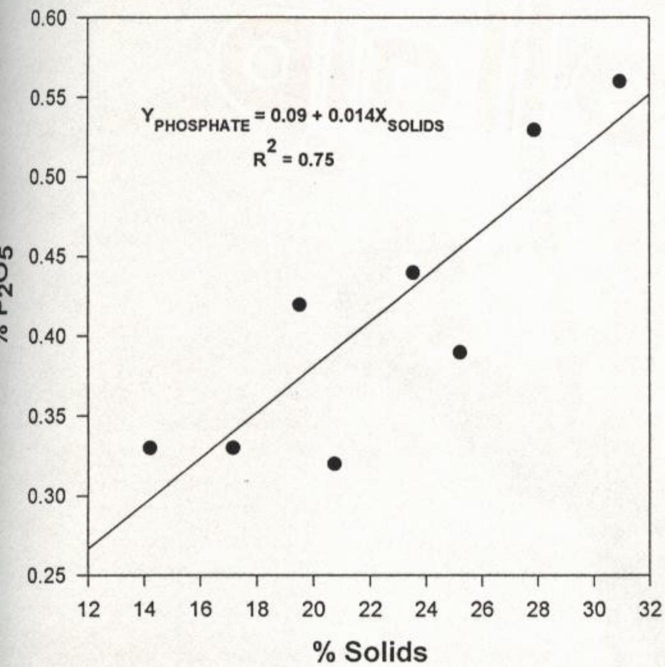

Fig. 2. Relationship between total P_2O_5 and the solid content of dairy feedlot manure.

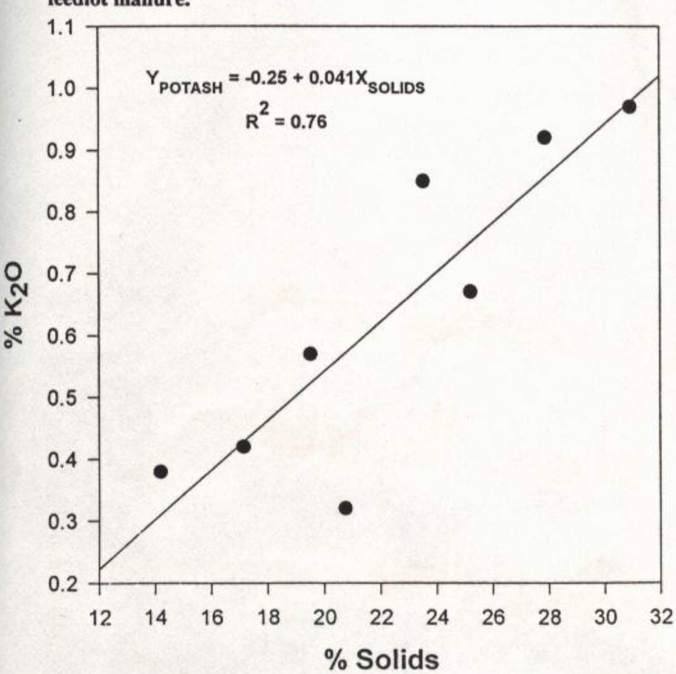

Fig. 3. Relationship between total K_2O and the solid content of dairy feedlot manure.

ents and solid content of dairy feedlot manure averaged over landowners.*

Producer	TKN	NH_3	P_2O_5	K_2O	Solids
January†	11.4d	5.0ab	6.6cd	7.6ef	18.1c
C.V.	18.30	31.82	85.47	32.15	14.63
n	32	32	32	32	32
March	14.2c	5.4a	8.4b	11.4d	19.5ed
C.V.	10.88	25.88	61.54	24.86	22.11
n	32	32	32	32	32
April	11.4d	3.2c	6.2d	6.4f	17.9c
C.V.	17.99	34.38	22.39	39.02	14.14
n	32	32	32	32	32
June	15.2c	5.2a	7.8bc	13.4c	25.2c
C.V.	33.58	38.18	35.46	40.02	36.02
n	24	20	24	24	24
July	19.4a	5.6a	11.2a	19.4a	30.9a
C.V.	30.13	34.16	30.45	48.41	32.51
n	32	32	32	32	32
September	16.6b	4.4b	8.4b	17.0b	23.5c
C.V.	13.60	37.93	14.63	25.02	9.27
n	32	32	32	32	32
October	18.8a	5.0ab	10.6a	18.4b	27.9b
C.V.	21.86	18.87	29.99	28.51	23.49
n	32	32	32	32	32
December	12.4d	5.0ab	7.0cd	8.4e	17.1e
C.V.	32.05	38.74	37.43	55.75	36.26
n	32	32	32	32	32

* Means with the same letter within columns are not significantly different at $P > 0.05$.

† Nutrient means expressed in pounds per ton, solids in percentage.

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