Manure Nutrient Value: Wisdom Gained from Experience in Southern Alberta

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Take Home Messages:

1. When generating a farm-specific manure nutrient content database, manure should be sampled for 3 to 5 years so as to account for variation due to climatic differences from year to year, which have a significant impact on nutrient losses during storage. Once a historical average has been generated from this database, the need for annual sampling diminishes.
2. Manure should be sampled immediately prior to application, where possible. Samples taken at this time will closely approximate what is being applied to the field.
3. Representative sampling is crucial when sampling manure. Although solid and liquid manure both present challenges to obtaining representative samples, producers should remember that the laboratory analysis will only be as good as the quality of the sample. A procedure for sampling manure is outlined in the environmental beneficial management practices (BMP) manuals put out by Alberta Agriculture.

Introduction

The County of Lethbridge is home to a large number of livestock operations, which has led to the identification of certain challenges that need to be overcome to ensure sustainability and growth of the agricultural sector in our region.

An on-going role that the County of Lethbridge continues to play through its involvement with Alberta Environmentally Sustainable Agriculture (AESA) Farm-Based Extension Program, is participating in various applied research projects, many of which have involved manure management issues. In the process, we have been able to learn a great deal about manure characteristics and quality.

Over the years a number of manure related information resources have been developed for target audiences including producers, researchers, and local authorities to assist them in addressing manure management related concerns, questions, and/or responsibilities. These resources have included information including the quality and quantity of manure, as well as proper testing and sample collection methods.

As long as intensive livestock operations exist, manure management issues will always require re-examination, particularly in light of the dynamic nature of modern livestock production systems, the growing interest around environmental sustainability issues, and more recently, the increased attention of lawmakers and regulators.

Project: Quality and Quantity of Manure Produced in Southern Alberta Feedlots (1993 to 1996)

Objective

The objective of this project was to gather better information on manure for producers and planners so that an appropriate decision could be made regarding manure management. First, the project was to determine the nutrient content of manure in a finishing lot. Second, the project was to determine the quantity of manure produced in a typical finishing lot.

Method

Three feedlots were chosen to participate in the study. As a condition of their participation they had to agree to keep some basic records (e.g., number of manure loads, weight of manure, straw bales used in bedding, etc.), and they had to agree to participate for a number of years.

Manure samples were taken from several locations, including from behind the feed-bunk, in and around the bedding pile. Samples were placed in double plastic bags and put into coolers to minimize deterioration of the samples as a result of decomposition (i.e., heating). The Soil and Animal Nutrient Laboratory in Edmonton analyzed samples the following day for nutrient content.

Records kept by the different feedlots, including truckload weights and number of truckloads, were used to estimate manure quantity.

Study findings

A summary of the nutrient composition of manure collected over the course of the project is presented in Table 1.

1993

Some significant differences regarding manure nutrient values were noticed between feedlots. As such, the study learned that for practical purposes, both soil and manure sampling should be done immediately prior to spreading. This is so that nutrient values from the manure closely approximate what will be applied to the land. Total nitrogen in manure was reported at 11.5 kg/tonne. No firm conclusions were to be reached with only one year of data.

1994

The study found that in order to get good manure nutrient test results, representative samples must be taken from each pen. With solid manure, this means a strict routine must be followed to ensure sampling consistency. It was estimated that the volume of manure produced was between 4.9 to 5.4 kg $head^{-1}$ day^{-1}.

1995

A comparison of the results from 1994 with 1995 demonstrates the variability in manure nutrient content from year to year. Some of the factors that may have contributed to this variation include climate, manure moisture content, feed rations, time of sampling, and consistency of sampling protocol. Year-to-year variation in manure nutrient content makes the argument for continuity in a multi-year sampling program, with the goal of producing a manure nutrient content database.

1996

No significant difference in manure nutrient content was noted between 1995 and 1996, but 1996 results showed similar differences to values obtained in 1994. These results further reinforce the importance of sampling continuity in order to develop a historical database.

Once a database consisting of data for 3 to 5 years has been developed, the practical need for annual sampling diminishes, as historical averages will serve as a relatively accurate basis for nutrient management decisions. It should be noted however that whenever there is a significant change in management (e.g., bedding practices) or feeding practices (e.g., switching major feed ingredients, changing supplement) that may potentially impact manure nutrient content, annual sampling will need to resume and/or new historical database will need to be developed.

General Comments

The question is often asked about whether to use P or P_2O_5 with regards to phosphorus. According to the AAFRD document titled "Manure Nutrient Management: A Balancing Act", soil laboratories will usually report plant available phosphorus in kg of P per hectare or in pounds per acre. In contrast, commercial fertilizer phosphorus content and phosphorus fertilizer recommendations are given in P_2O_5.

Values presented in either form can be converted to the other form by using the following equations:

$$P \text{ (in kg/T or \%)} \times 2.291 = P_2O_5 \text{ (in kg/T or \%)}$$

$$P_2O_5 \text{ (in kg/T or \%)} \times 0.436 = P \text{ (in kg/T or \%)}$$

The Evolution of a Standard Reference for Manure Nutrient Content for Alberta

Several references have been developed over the years designed to provide guidelines on how to use manure as a source of nutrients for crop production in an environmentally responsible manner. Many of these reference included estimates of manure nutrient content under contemporary management conditions.

Confinement Livestock Facilities Waste Management Code of Practice (1973)

One of the earliest of these was the ***Confinement Livestock Facilities Waste Management Code of Practice*** (1973). The estimates in this reference were fairly basic, providing data for only a limited number of species and manure handling regimes. This reference included nutrient content estimates for dry matter, total N, P_2O_5 and K_20 of manure for a limited number of species and production systems.

Table 1. Summary of results for manure sampled over the course of the project (1994-96), in kg of nutrient per tonne of manure.

Nutrient	Component of manure	Nutrient Content 100% Dry Matter Basis (kg/tonne manure)			Nutrient Content 70% Dry Matter Basis (kg/tonne manure)			Nutrient Content 50% Dry Matter Basis (kg/tonne manure)		
		1994	1995	1996	1994	1995	1996	1994	1995	1996
Total N	Bedding	23^{x}	27^{xy}	34^{y}	16^{x}	19^{xy}	24^{y}	12	14	17
	Manure	19	24	23	13	17	16	8	12	11
Available N	Bedding	5	5	3	4^{x}	3^{xy}	2^{y}	2	3	2
	Manure	4^{x}	2^{y}	3^{xy}	3	2	2	2	1	2
Total P_2O_5	Bedding	19	19	22	13	13	15	10	9	11
	Manure	13	17	16	10	11	11	7	8	8
Available P_2O_5	Bedding	4^{x}	10^{y}	9^{y}	3^{x}	8^{y}	7^{y}	2^{x}	5^{y}	5^{y}
	Manure	2^{x}	9^{y}	6^{y}	2^{x}	6^{y}	4^{y}	1^{x}	5^{y}	3^{y}
Total K_2O	Bedding	26	28	30	18	19	21	13	14	15
	Manure	15	20	20	10	14	15	8	10	10
Available K_2O	Bedding	18^{x}	28^{y}	22^{xy}	13	19	19	9	14	14
	Manure	11	18	17	8	13	12	5	9	9
Total SO_4	Bedding	15	22	17	10	8	11	8	6	8
	Manure	11	15	12	8	10	8	6	8	6
Available SO_4	Bedding	1^{x}	4^{y}	3^{y}	0.65^{x}	3^{y}	3^{y}	0.5^{x}	2^{y}	2^{y}
	Manure	1^{x}	3^{y}	3^{y}	0.75^{x}	2^{y}	3^{y}	0.5^{x}	1^{xy}	2^{y}

^{x,y}different superscripts in rows for each dry matter level indicate statistically significant differences

Code of Practice for the Safe and Economic Handling of Animal Manures (1995)

In recognition of the shifting trends in animal production in Alberta, the ***Code of Practice For The Safe and Economic Handling of Animal Manures*** (AAFRD 1995) provided information for additional livestock species and more detail regarding confinement management systems. Specifically, the additional information presented in the 1995 code compared to the 1973 code included:

- Additional information about nutrient content:
    - *Total N* – Includes both mineral (nitrate and ammonium) and organic nitrogen.
    - *Available N* – portion of total nitrogen that is mineralized (usually ammonium) at the time of application.
    - *Crop N* – An estimate of the available nitrogen plus the portion of organic nitrogen that is mineralized over the growing season. Estimated volatilization losses are subtracted from the sum of available plus mineralized nitrogen to give Crop N.
    - P_2O_5 – Phosphorus is expressed as phosphate equivalent in kg/tonne of manure since phosphorus exists in both mineral and organic form in the manure. Phosphate is contained mostly in the solids portion of manure so proper mixing of manure is critical in order to get a representative sample.
    - K_2O – Potassium is expressed in kg/tonne of manure.
- Updated values based on data collected in the interval between the two codes
- Information for additional livestock species
- A breakdown of nutrient values by class of livestock

Code of Practice for Responsible Livestock Development and Manure Management (2000)

In 2000, a revised reference was released by AAFRD entitled the ***Code of Practice for Responsible Livestock Development and Manure Management***. Some of the changes that were made for this publication compared to the 1995 code included:

- Definitions for nutrient values:
    - *Crop N* – An estimate of the available nitrogen plus the portion of organic nitrogen that is mineralized over the growing season, less estimated losses.
    - *Total P* – Total P is expressed as total phosphorus in the manure including mineral and organic forms. Phosphorus is largely contained in the solids portion of manure so mixing of liquid manure is necessary for uniformity of phosphorus content.

$$P \times 2.3 = P_2O_5$$

    - *Total K* – Total K is expressed as total potassium in the manure.

$$K \times 1.2 = K_2O$$

- Reporting P and K, P_2O_5 and K_2O removed
- Livestock classes expanded further, with more class-specific values
- Provided ranges in moisture content along with an average
- Provided ranges in Total N

Manure Nutrient Content for Animal Species in the Agricultural Operation Practices Act (2001)

The most recent incarnation of standard values for manure nutrient content appears in *Agricultural Operation Practices Act*. This table is essentially the same as that from the 2000 *Code of Practice for Responsible Livestock Development and Manure Management*, with the notable difference being that the values for total K have been removed. At the present time this is the standard reference for manure nutrient content in Alberta.

Table 2. Typical nutrient content of livestock manures, from *Agricultural Operation Practices Act*.

Species	Livestock Class/management	Moisture (%)	Total N - Range (%)	Total N - Typical (%)	Available N (%)	Crop N (%)	Total P (%)
Beef	Feeders Finishers Feeder Calves Cow w/Calf Cows/Bulls	30-75 (50)	.65-1.25	10	2.6	3.2	2.4
	Paved Feedlot	50-75 (65)	.45-.80	7	2.7	2.5	.9
Dairy	Free stall	85-95 (92)	.35-.60	4	1.8	1.7	.9
	Tie Stall Loose Housing Replacements Calves	70-85 (80)	.45-.65	5	2.1	1.9	.9
Swine	Liquid	90-99 (96)	.20-.55	3.5	1.6	1.6	1.1
	Solid	40-70 (50)	.60-.90	8	3.2	3.1	1.5
Poultry	Layers (solid) Belt cage	30-60 (40)	2.50-3.50	30.1	20.1	18.9	15.4
	Layers (solid) Deep Pit	30-60 (50)	2.00-3.00	24.1	16	15.1	12.3
	Layers (liquid)	85-95 (90)	.50-1.00	6	4	3.8	2.5
	Broilers Pullets	30-50 (35)	3.50-4.00	34.1	19.5	18.4	9.5

Livestock Species	Class/management	Moisture (%)	Total N - Range (%)	Total N - Typical (%)	Available N (%)	Crop N (%)	Total P (%)
	Breeders	30-50 (35)	1.60-2.10	30.1	17.2	16.3	9.5
Turkeys	Breeders	30-50 (35)	1.5-2.0	17.5	10	9.5	5.9
Horse	Feedlot	30-60 (50)	1.0-2.0	15	7.5	7.1	2.3
	PMU	50-80 (75)	0.50-0.70	6	3	2.9	1.3
	Donkey Mules	30-70 (50)	0.80-1.10	10	5	4.8	2.3
Fur	Mink	----	1.50-2.00	18	9	8.6	10.9
	Fox	----	.20-.60	4	2	1.9	.9
Rabbit		----	.30-.60	5	2.1	2.3	5.2
Cervid	Elk Deer	25-50 (35)	.50-.75	6.5	2	2.2	2.2
Bison		25-50 (35)	.50-.75	6.5	2	2.2	2.2
Alpaca/Llama		25-50 (35)	.80-1.20	10	4	3.6	2
Sheep	Ewes w/Lambs Ewes/Rams Feeders	30-65 (50)	.65-1.25	10	4	3.6	2
	Lambs	30-65 (50)	.50-1.00	7.0	2.8	2.5	2
Goats		30-65 (50)	.50-.75	6.3	2.5	2.3	2.3
Ratite		25-50 (35)	1.50-2.00	17.5	10	9.5	5.9

Manure sampling

It should be emphasized that the values for manure nutrient content presented in AOPA and other references are average values and may not necessarily be a good estimate for individual farms. The most accurate representation of the nutrient content of manure for an individual farm is farm-specific sampling. While the task can be relatively unappealing to many producers, it will provide a key piece of information for a manure management planning system.

Over the past few years, Alberta Agriculture in cooperation with the livestock industry commodity groups has produced commodity-specific manuals outlining environmental beneficial management practices (BMPs). All of these manuals have similar sections on proper manure sampling and shipping protocols and producers are advised to consult these manuals for concise information on these topics.

Some of the key recommendations outlined in these manuals when sampling manure include:

- Collect composite samples that reflect the overall variability of manure. If the manure contains bedding materials, ensure that the sample reflects the relative proportions of manure and bedding.

- When sampling liquid manure, agitate the prior to sampling. If agitation is not possible, sample from different locations and depths of the storage facility. Solid manure is best sampled directly from the manure truck (3 to 4 samples per load).
- Collect about 20 samples from each manure source. Mix the samples together, remove a representative sub-sample (about 1 kilogram), and place it in a sealed container. Keep it in a cooler and send to a laboratory as soon as possible, preferably no later than 24 hours.
- Sample manure as close to land application as possible. Manure nutrient content (in particular N) will change over time depending on the characteristics of the storage facility and climatic factors. Sampling immediately prior to manure application will give the most accurate representation of what is being applied to the field.

When shipping manure for laboratory analysis, avoid any handling that could alter the physical and chemical composition of manure (leakage, nutrient losses to air, moisture losses, etc.). Key recommendations when shipping manure for analysis include:

- Use appropriate containers for shipping to minimize the chance of leakage. Use sealable freezer bags for solid manure, and double-bag to prevent leakage. For liquid manure, use plastic or glass containers.
- Send samples for laboratory analysis immediately. If this is not possible, they should be frozen until delivery. Ideally, samples should be analyzed within 24 hours after collection.
- In all situations, the container should only be half full and should be clearly labelled with name, date, and some sort of sample identification.
- Contact the laboratory to confirm shipping instructions and sample size. Laboratories differ in their specifications for shipping samples and the cost of analysis.

Summary

Manure nutrient content is one of the key pieces of information required to increase the precision of manure management planning. Experience from applied research in Southern Alberta holds several lessons for producers looking at developing nutrient content databases for their operations. Specifically,

- It is important to sample for at least 3 to 5 years when developing a database. Manure nutrient content is known to vary based on climatic factors, feeding regimen and other management decisions. Collecting data for several years will allow producers to be confident in the operation specific averages that result, and will negate the need to sample every year (provided there are no significant changes in feeding or management practices).
- It is also important that when sampling, there is consistency from year to year in the sampling protocol, so that the samples that are collected are representative of the whole of the manure produced. This means making sure that manure and bedding proportions in the sample are reflective of what is in the pile.

Several reference documents have been published over the years, which include tables containing estimated nutrient content of manure for various animal species and classes under various production systems for Alberta.

What must be remembered is that these are average values and may not necessarily reflect the nutrient composition of the manure on a given operation. On farm sampling is the best way to obtain farm-specific manure nutrient content information. Procedures for sampling and sample preparation for analysis are outlined in the environmental BMP manuals that were authored by Alberta Agriculture and Alberta livestock commodity organizations.

References

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