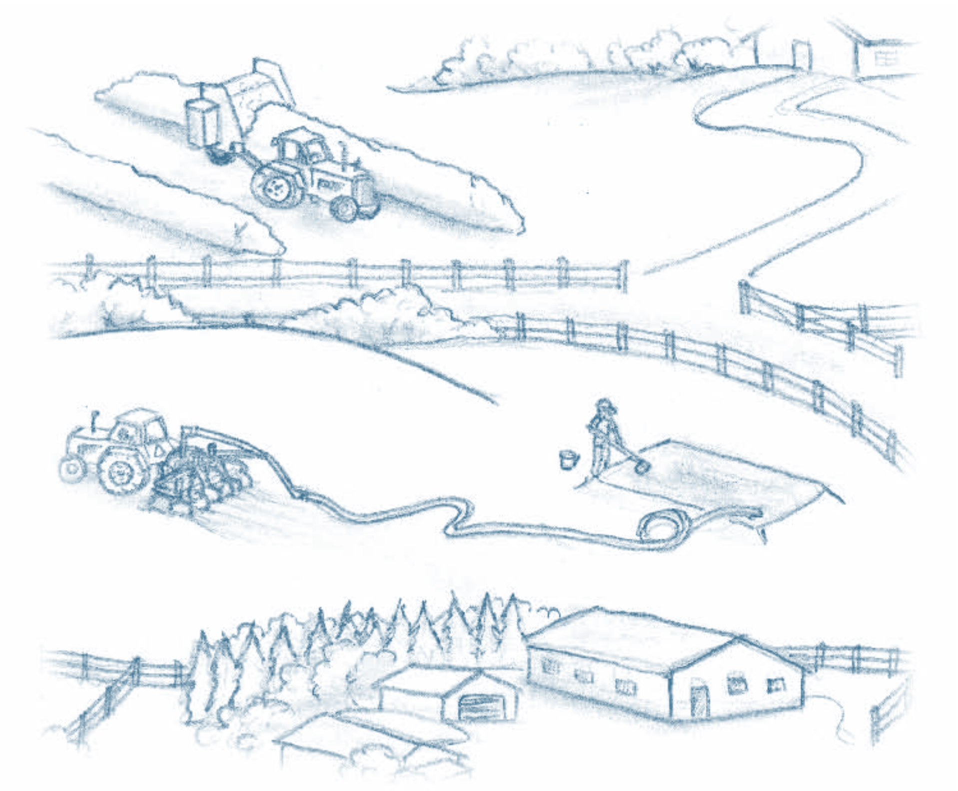
Chapter 4.3

Manure Test Interpretation



learning objectives

- Convert between units on a manure test report.
- Estimate available organic nitrogen and total crop available nitrogen from manure test information.
- Estimate crop available phosphorus and postassium from manure test information.
- Identify the relevance of additional manure test parameters for nutrient management.

Important Terms

Table 4.3.1 Key Terms and Definitions

Term	Definition
Crop Available Nutrient	Nutrients (e.g., nitrogen (NO_3-N)) that are in a form that plants can absorb and use.
Retained Ammonium-N	The amount of ammonium-N corrected to account for expected N losses that occur during application.

The most reliable source of information regarding manure nutrient content is obtained through laboratory analysis of a representative manure sample. Laboratories provide a range of manure analyses, but it is important that results be interpreted properly. The remainder of this chapter will focus on interpreting the results of manure analyses to facilitate nutrient management planning.

Book Values and Manure Test Results

Book values for manure nutrient content can be used to verify that manure test results are within expected ranges. If test results appear either low or high in comparison to book values, contact the testing facility to verify that there were no errors made during either analysis or data entry. Alternatively, extreme results may suggest faulty sampling method or inappropriate handling of samples prior to sending for analysis.

All laboratories generate reports that are returned to the person who submitted the manure samples for analysis. Every lab will have their own unique format of how this information is delivered, but all reports should contain the same basic information.

General Information on the Report

The report will identify the person to whom the report is to be sent as well as information that helps identify the sample and type of the manure (#1 and #2 in Figure 4.3.1). When reviewing test reports, verify that the information is accurate and review any comments included on the report (#7).

The report should include dates when the sample was received and processed (#3). Review these handling dates to see if there were any unusual delays in shipping that might affect the accuracy of the results. If not stated on the report, contact the lab to determine whether samples are retained for a period following analysis, in case analysis must be repeated to verify unusual results.

Some reports will also include reference to the procedure or analytical method used for individual nutrients or parameters (#6). If using different labs from year to year, this information can help verify that labs are using the same analytical procedures so that comparisons of nutrient content between years are valid.

Billing Information	Sample Information	Sample Processing Information
Bill to: NMP Consulting Ltd. **Report to:** NMP Consulting Ltd. Box 2007 Anywhere, AB X0X 0X0 **Attn:** I.M.A. Consultant **Phone:** (780) 222-2222 **Fax:** (780) 222-2221 1	**Producer:** ABC Livestock Ltd. **Sample ID:** A1 **Sample Description:** Cattle manure **Lab Assigned Code:** A430-2007 2	**Date Received:** March 30, 2007 **Date Reported:** April 04, 2007 **Sample Retained:** April 29, 2007 **Arrival Condition:** Good **Report Number:** 983395 3

Parameter 4	As Received (%)	As Received (per tonne or per 1000 L) 5	Dry Basis (%)	Analytical Method Reference 6
Moisture	37.8%			
EC (manure)	36.8			TMECC-04.10
Total Nitrogen	0.95%	9.5 kg	1.51%	AOAC-993.13
Total Phosphorus	0.522%	5.2 kg	0.830%	AOAC-985.01
Total P_2O_5	1.20%	12.0 kg	1.90%	
Total Potassium	1.08%	10.8 kg	1.72%	AOAC-985.01
Total K_2O	1.30%	13.0 kg	2.08%	
Sodium	0.205%	2.0 kg	0.327%	AOAC-985.01

Comments:

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Figure 4.3.1 Example of Layout of a Manure Analysis Report

Reporting Units

Typical laboratory analyses and reporting units are listed in Table 4.3.2 (see also #4 and #5 in Figure 4.3.1). Note that on a test report some of the values are measured directly while others are calculated from the results of analyses.

Preferences for the units used to express nutrient content of manure, should be indicated when submitting samples for analysis. It may be necessary to convert units appearing on the lab report, depending on testing laboratory and the units required for subsequent calculations (Table 4.3.3).

Table 4.3.2 Typical Laboratory Analyses and Report Units for Manure

<table>
<tr><th>Parameter</th><th>Measured or Calculated</th><th>Report Units (Solid)</th><th>Report Units (Liquid)</th></tr>
<tr><td>Moisture (or Solids)</td><td>Measured</td><td colspan="2">%</td></tr>
<tr><td>pH</td><td>Measured</td><td colspan="2">pH scale</td></tr>
<tr><td>EC</td><td>Measured</td><td colspan="2">deciSeimens/metre (dS/m)</td></tr>
<tr><td>C:N ratio</td><td>Calculated</td><td colspan="2">Ratio (Total C:Total N)</td></tr>
<tr><td>Total N</td><td>Measured</td><td rowspan="13">%
mg/kg
kg/tonne
lb/ton</td><td rowspan="13">%
mg/L
kg/1000 L
lb/1000 gal</td></tr>
<tr><td>Organic N</td><td>Calculated</td></tr>
<tr><td>Ammonium N</td><td>Measured</td></tr>
<tr><td>Nitrate N</td><td>Measured</td></tr>
<tr><td>Total Phosphorus</td><td>Measured</td></tr>
<tr><td>Phosphate (P_2O_5)</td><td>Calculated</td></tr>
<tr><td>Total Potassium</td><td>Measured</td></tr>
<tr><td>Potash (K_2O)</td><td>Calculated</td></tr>
<tr><td>Total Sulphur</td><td>Measured</td></tr>
<tr><td>Sodium</td><td>Measured</td></tr>
<tr><td>Calcium</td><td>Measured</td></tr>
<tr><td>Magnesium</td><td>Measured</td></tr>
<tr><td>Micronutrients</td><td>Measured</td></tr>
</table>

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"As Received" Versus Dried Basis

Manure nutrient content on a laboratory report is only useful if expressed on a wet (or "as received") basis, since wet manure is what is being applied. If it is unclear from the laboratory report if this is the case, contact the laboratory for clarification. To convert nutrient content from a dry basis to a wet basis, use the following equation:

$$\text{Nutrient content}_{\text{(wet basis)}} = \text{nutrient content}_{\text{(dry basis)}} \times [1 - (\text{moisture content (\%)} \div 100)]$$

Table 4.3.3 Conversions for Units Commonly Appearing on Manure Test Reports

Starting Unit	Multiply By	Desired Unit
	Solid Manure	
%	10	kg/t
%	20	lb/tn
kg/t	2	lb/tn
mg/kg	0.001	kg/t
g/kg	1	kg/t
t/ha	0.4461	tn/ac
	Liquid Manure	
%	10	kg/m^3
kg/m^3	1	kg/1000 L
%	100	lb/1000 gal
kg/1000 L	10	lb/1000 gal
mg/L	0.001	kg/1000 L
g/L	1	kg/1000 L
ppm	1	mg/kg and mg/L
L/ha	0.089	gal/ac

Estimating Available Nutrient Content

Laboratory results will typically include measurements of total N, ammonium N (NH_4-N), total P and total K. Generally there is little nitrate NO_3-N in raw manure; therefore, there is no value to requesting this analysis. However, NO_3-N is present in composted manure and therefore a nitrate analysis should be requested. In order for these measures to be useful for nutrient management planning, the availability of each must be considered. Since a significant proportion of many nutrients are in organic forms not immediately available to the crop, estimating crop availability represents a real challenge. Manure application rate should be based on estimated available nutrient content.

Crop Available N

Crop available N estimates the amount of total manure N that could be available for crop use in the year of application. For this estimate, manure test results along with manure application method and timing can be used. Most labs provide measures of total and ammonium N (NH_4-N). The difference of these two parameters provides an estimate of organic N in the manure:

Organic N = Total N – NH_4-N

Although mineralization of organic N is controlled by soil moisture and temperature conditions, it is safe to assume that 25% of organic N will be mineralized to crop-available forms in the year following application:

Available Organic N (year of application) = Organic N × 0.25

Additional organic N will be mineralized in subsequent years and can be estimated when planning future manure applications.

Available Organic N (year 2) = Organic N × 0.12

Available Organic N (year 3) = Organic N × 0.06

Calculating Available Organic Nitrogen Content

An analysed sample of swine manure was found to contain 3.5 kg/1000 L total N and 1.8 kg/1000 L of NH_4-N. The estimated organic N content in this manure is:

Organic N content = Total N – NH_4-N
= 3.5 kg/1000 L – 1.8 kg/1000 L
= 1.7 kg/1000 L

The amount of organic N that is expected to become crop available over the next three years is:

Available Organic N (year of application) = Organic N × 0.25
= 1.7 kg/1000 L × 0.25
= 0.425 kg/1000 L

Available Organic N (year 2) = Organic N × 0.12
= 1.7 kg/1000 L × 0.12
= 0.204 kg/1000 L

Available Organic N (year 3) = Organic N × 0.06
= 1.7 kg/1000 L × 0.06
= 0.102 kg/1000 L

Approximately 0.425 kg/1000 L of N will become available to the crop from the organic portion of the manure N in year of application (year 1). An additional 0.204 kg/1000 L of N will come avaialble to the crop in the first year after application (year 2) and 0.102 kg/1000 L of N will come available to a crop in the second year after application (year 3).

Manure NH_4-N can be readily crop available, but is also at risk of being converted to ammonia (NH_3) and lost via volatilization. Volatilization losses depend on manure placement, weather conditions during application, and the elapsed time between application and incorporation. Table 4.3.4 provides NH_4-N retention factors to correct total NH_4-N for expected losses after application.

Table 4.3.4 Manure Ammonium Nitrogen Retention Factors Based on Expected Volatilization Losses Occurring Between Application and Incorporation

Application Strategy	Weather Conditions				
	Average	Cool-wet	Cool-dry	Warm-wet	Warm-dry
Surface applied, incorporated within 1 day[1]	0.75	0.90	0.85	0.75	0.50
Surface applied, incorporated within 2 days	0.70	0.87	0.81	0.69	0.43
Surface applied, incorporated within 3 days	0.65	0.85	0.78	0.62	0.35
Surface applied, incorporated within 4 days	0.60	0.83	0.74	0.56	0.28
Surface applied, incorporated within 5 days	0.55	0.80	0.70	0.50	0.20
Not incorporated	0.34	0.60	0.50	0.25	0.00
Injected	1.00	1.00	1.00	1.00	1.00
Cover crop[2]	0.65	0.75	0.25	0.40	0.50

[1] Use these factors for broadcast liquid manure (without incorporation) on bare soils.
[2] Use these factors for broadcast liquid manure (without incorporation) on land with residue, such as direct-seeded fields or forages.

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Retention Factors for Broadcast Liquid Manure

The retention of NH_4-N in broadcast liquid manure is dependent on the ability of manure to infiltrate into the soil. Once in the soil, NH_4 molecules adsorb to soil particles, reducing risk of loss. In situations where there is ground cover, some of the broadcast manure will coat crop residues and remain exposed to the air, increasing the potential for losses.

Using these correction factors, retained NH_4-N in manure is calculated as:

Retained NH_4-N = NH_4-N × Retention Factor (from Table 4.3.4)

The estimated crop-available N content of the manure is then calculated as:

Estimated Crop Available N = Available Organic N (year 1) + Retained NH_4-N

Estimating Crop Available N

Swine manure (1.8 kg/1000 L of NH_4-N) is to be surface applied using a splash plate application system on a soil under conventional tillage. This situation is assumed to be similar to surface application and incorporation within one day. Since application is planned over a period of several days, and the weather conditions during this period are expected to be quite variable, an average retention factor of 0.75 is used.

Retained NH_4-N = NH_4-N × Retention Factor (Table 4.6.3)
= 1.8 kg/1000 L × 0.75
= 1.35 kg/1000 L

Available organic N content for the year of application is:

Available Organic N = Organic N × 0.25
= 1.7 kg/1000 L × 0.25
= 0.425 kg/1000 L

The total amount of crop available N in this manure then is:

Estimated Crop Available N = Available Organic N (year 1) + Retained NH_4-N
= 0.425 kg/1000 L + 1.35 kg/1000 L
= 1.78 kg/1000 L

Calculating Available N in Compost

Nitrate concentration is usually very low in raw manure, but can be present in higher concentrations in compost. For composted material, a nitrate analysis should be requested. If compost contains detectable amounts of NO_3-N, this should be subtracted along with any NH_4-N from total N to estimate organic N content. Any NO_3 present should be included in the estimate of crop available N, together with retained NH_4-N and available organic N.

To calculate organic N content, subtract the NO_3-N and NH_4-N from total N:

Organic N = Total N – NH_4-N – NO_3-N

Because properly composted manure is a more stable source of organic N, less N will be mineralized. It is safe to assume that 13 percent of organic N will be mineralized to crop-available forms in the year following application:

Available Organic N (year of application) = Organic N × 0.13

Additional organic N will be mineralized in subsequent years and can be estimated at 7 % in year 2 and 4 % in year 3 when planning future manure applications.

Available Organic N (year 2) = Organic N × 0.07

Available Organic N (year 3) = Organic N × 0.04

To calculate crop available N, add NO_3-N to retained NH_4-N and percentage of organic N that will become available.

Estimated Crop Available N = Available Organic N (year 1) + Retained NH_4-N + NO_3-N

Crop Available P

Similar to N, P in manure is present in organic and inorganic forms, but most labs only report the amount of total P in a sample. Based on experience and research, about 70% of total P in manure will be crop available in the year it is applied:

Estimated Crop Available P (year 1) = Total P × 0.7

Similar to N, some of the residual applied P will be mineralized and become crop available in subsequent years:

Estimated Crop Available P (year 2) = Total P × 0.2

Estimated Crop Available P (year 3) = Total P × 0.06

Estimating Crop Available P

The total P content of a liquid manure sample is reported to be 1.1 kg/1000 L. The estimated amount of crop available P is:

Estimated Crop Available P (year of application)

= Total P × 0.7

= 1.1 kg/1000L × 0.7

= 0.77 kg/1000 L

Estimated Crop Available P (year 2)

= Total P × 0.2

= 1.1 kg/1000L × 0.2

= 0.22 kg/1000 L

Estimated Crop Available P (year 3)

= Total P × 0.06

= 1.1 kg/1000L × 0.06

= 0.07 kg/1000 L

Approximately 0.77 kg/1000 L of P will become available to the crop in year of application (year 1). An estimated additional 0.22 kg/1000 L of P will come available to the crop in the first year after application (year 2) and 0.07 kg/1000 L of P will come available to a crop in the second year after application (year 3).

Crop Available K

Unlike other nutrients, manure K exists exclusively in the crop available inorganic K^+ form. Research suggests that about 90% of manure K is effectively crop available:

Estimated Crop Available K = Total K × 0.9

Estimating Crop Available K

The total K content of a liquid manure sample is reported to be 1.7 kg/1000 L. The estimated amount of crop available K is:

Estimated Crop Available K = Total K × 0.9

= 1.7 kg/1000 L × 0.9

= 1.53 kg/1000 L

Crop Availability of Other Nutrients in Manure

The crop availability of sulphur, calcium, magnesium and micronutrients is of less concern. When manure application rate is based on either N or P, other nutrients will likely be applied at rates several times higher than agronomic requirements, or what would be necessary to correct soil deficiencies.

Other Parameters

Manure tests may provide other information about the manure including pH and EC. Neither parameter has clear implications for manure application, since the relationship between manure and soil pH and EC are not well defined.

If C:N ratio is provided for the manure, it can provide a sense of how rapidly and to what extent nutrients will become available from the manure. In general, the lower the C:N ratio the more rapidly organic nutrients will be released in crop available forms.

Net mineralization of organic N occurs when C:N is less than 20:1. When C:N exceeds 30:1, N becomes a limiting nutrient for decomposer organisms, and this can reduce the rate of decomposition and results in N immobilization (i.e., N tie-up). This can be an issue in manure with large amounts of bedding mixed in, such as poultry litter or certain types of beef manure. In these situations, requesting a C:N ratio from the lab may be valuable for identifying potential issues with N availability.

Similar to N, organic forms of P are mineralized by soil microorganisms to inorganic forms, but can also be immobilized depending on the ratio of carbon to P (C:P ratio). The C:P ratio can be estimated:

C:N ratio × Total N ÷ Total P = C:P ratio

When the C:P ratio in residues is between 200:1 and 300:1, mineralization and immobilization balance each other to result in no net release of P from the decomposing manure. When C:P is below this range, P is released, while above this range P will be tied up and not released for crop use.

Nitrate-N levels are typically higher in finished compost than fresh manure. Most inorganic N in fresh manure is in the NH_4-N form but nitrification during the composting process converts some of this to NO_3-N. The ammonium-N/nitrate N ratio is often used as an index of compost maturity with lower ratios denoting more mature or stable material. Ratios fall from 1000:1 for fresh manure to <10:1 for compost.

summary

- It may be necessary to convert units appearing on the lab report. Use the conversions in Table 4.3.3 to convert between units.
- Organic N content of manure is estimated as the difference between total N and ammonium N content.
- For fresh manure assume that 25% of the organic N will become available in the year of application, 13% the following year and 6% the year after that. For composted manure assume that 12% of the organic N will become available in the year of application, 7% the following year and 4% the year after that.
- Crop available N in manure is equal to the sum of available organic N in the year of application and retained ammonium N content of the manure.
- Assume that 70% of total P is available in the year of application, 20% the following year and 6% the year after that. Assume that 90% of K is available.
- Neither EC or pH have clear implications for manure application, since the relationship between manure and soil pH and EC are not well defined.
- A measure of C:N ratio in manure can be useful for identifying potential N availability issues in manure containing substantial amounts of bedding.
- Nitrate concentration is usually very low in raw manure, but can be present at higher concentrations in compost. Any NO_3-N should be factored into the estimate of crop available N.