NCDA&CS
Waste and Compost
Analysis Guide

N.C. Dept. of Agriculture & Consumer Services
Agronomic Division
Waste and Compost Analysis Laboratory

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Table of Contents

List of Figures and Tables

Overview of Waste Analysis and Nutrient Management

The Agronomic Division's Waste Analysis Lab analyzes liquid and solid manure and other waste samples from farm, municipal and industrial sources to assess their use in agriculture. Analyses of swine waste for nitrogen, phosphorus, copper, and zinc are certified by the North Carolina Department of Environmental Quality (NCDEQ) for land application.

The Waste Analysis Lab also analyzes compost and compost feedstock samples. Commercial composters of waste products may be required to test the chemical properties of the compost to comply with NCDEQ regulations. Compost samples are also submitted by compost users to determine how chemical properties might limit use or impact application rates in gardens or landscapes.

The Waste Analysis Report provides 11 total nutrient concentrations (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron). Additional chemical measures may also be provided on the waste report, such as levels of sodium; pH; electrical conductivity (soluble salts); carbon; carbon-to-nitrogen ratio (C:N); dry matter (DM); calcium carbonate equivalent (CCE); heavy metals (lead, nickel, cadmium, arsenic, selenium, chromium); aluminum; molybdenum; and inorganic nitrogen (ammonium-nitrogen and nitrate-nitrogen). Detailed information about the analytical methods used in the Waste Analysis may be found in the NCDA&CS Waste Analysis Methods.

The Waste Analysis Report also provides an estimate of the nitrogen (N) available to plants in the first year. These values are based on estimates of mineralization rates for the specific waste type (e.g., lagoon liquid) as well as application method (e.g., irrigation). The application method influences the mineralization rate, with materials that are soil incorporated having faster mineralization rates than surface-applied materials. These estimated values are also influenced by factors such as the specific chemical or physical properties of the waste material (e.g., carbon-to-nitrogen ratio, specific surface area), soil physical properties (e.g., texture, soil moisture), soil chemical properties (e.g., pH, cation exchange capacity), and soil temperature and moisture. Mineralization rates used to calculate N availability are reviewed and revised periodically using current scientific literature by the North Carolina Interagency Nutrient Management Committee.

Knowledge of available nutrients and other chemical properties associated with waste applied to land, in conjunction with site-specific factors, is the basis for efficient nutrient management and responsible land stewardship. Waste application rates should be determined by levels of nitrogen, phosphorus, zinc, copper, sodium, boron, or CCE as discussed in the next section–Rate-Limiting Factors in Waste Application.

Rate-limiting Factors in Waste Application

Nitrogen (N)

The available N in manure determines the rate of application unless another element or chemical property is more restrictive. Nitrogen can be applied at rates determined by the realistic yield expectation (RYE) of a specific crop by soil type. Rates using the RYE approach are available online at https://realisticyields.ces.ncsu.edu/. Contact the North Carolina Interagency Nutrient Management Committee for guidelines when a specific RYE is not available. Since N is not measured in the NCDA&CS soil analysis, N status in crops should be monitored with plant tissue analysis.

Phosphorus (P)

Rates of waste application should be based on estimated available P when the site is vulnerable to off-site P movement. The North Carolina Phosphorus Loss Assessment Tool (PLAT) is used to assess the potential for P transport from fields to surface water. When animal manure or organic by-products are used in crop production, this software tool can identify whether the application rate should be based on N or P.

Zinc (Zn) and copper (Cu)

For sites receiving animal waste, monitoring soil Zn and Cu levels is required by Animal Waste Management Rules (15A NCAC 2T). Application rates should be limited when soil Zn and/or Cu levels are excessively high and/or the waste product has a high Zn and/or Cu concentration. Under these conditions, it is also advisable to monitor crop nutrient concentrations with plant tissue analysis. These practices will help prevent excess Zn and/or Cu accumulation in the crop and in the soil.

For all crops except peanuts, the NCDA&CS soil-test Zn-index (Zn-I) and Cu-index (Cu-I) caution level is 2000 (~142 lb Zn/acre and ~72 lb Cu/acre) and the critical toxic level is 3000 (~214 lb Zn/acre and ~108 Cu lb/acre). NCDEQ requires that a technical specialist be contacted to discuss options for future manure applications when Zn and/or Cu are at the caution or critical toxic level. At the caution level, growers should monitor crop growth and appearance, maintain a minimum soil pH of 6.0, and identify alternative fields better suited for the application of animal manure. At the critical toxic level, all application of animal manure or organic by-products should cease and a soil pH of at least 6.0 be maintained. Peanuts are much more sensitive to Zn than other crops. The caution level is 300 (~21 lb/acre) and the critical toxic level is 500 (~35 lb/acre).

Sodium (Na)

Waste that contains high Na in relation to calcium and/or magnesium may cause problems. A high level of Na in the soil can degrade soil structure (reduced infiltration and permeability) and damage plant roots. Sodium may also damage foliage when liquid waste is applied in an overhead irrigation system to a growing crop. Regular soil testing is recommended to monitor Na accumulation where the waste is routinely applied. Safe application rates of Na depend on many factors, including soil texture, soil calcium and magnesium levels, rainfall, irrigation volumes and crop sensitivity.

Boron (B)

Although B is an essential nutrient, the difference between the amount required by a crop and the amount toxic to that crop is very narrow. Therefore, consider the B concentration and limit B application to no more than 1-3 lb B per acre per year. Since B is not measured in the NCDA&CS soil analysis, B status in crops should be monitored with plant tissue analysis.

Calcium carbonate equivalent (CCE)

Calcium carbonate equivalent represents the acid-neutralizing capacity of a material expressed as weight percentage of calcium carbonate ($CaCO_3$). For materials with liming potential (e.g., lime-stabilized biosolids, poultry litter), the application rate may be limited by a high CCE. Waste with a high CCE should only be applied at rates needed to increase soil pH to the desired target. Overapplication can lead to high soil pH, which limits micronutrient availability.

Standard Analytes on Waste Analysis Report

Standard Analysis. Concentrations of total nitrogen (N) phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), aluminum (Al), and sodium (Na) are measured for all waste samples submitted to the lab. Units are in milligrams per liter (mg/L) for liquid and milligrams per kilogram (mg/kg) for solid waste samples and are reported in the Nutrient Measurements section of the NCDA&CS Waste Report (Fig. 1). See the NCDA&CS Waste Analysis Methods for more detailed information.

Nitrogen is analyzed and reported on an as-received (wet-weight) basis for samples that are assumed to contain appreciable amounts of ammonia, which is subject to volatilization when dried. These samples include all (manure and non-manure) liquid samples, all manure solid wastes, waste treatment by-products (e.g. biosolids), poultry and swine mortality compost, and vermicompost (Table 1). Solid non-manure waste samples (e.g. paper fibers, ash, non-composted crop residues, etc.) are analyzed and reported on a dry-weight basis.

Other elements (P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Al, Na) are analyzed and reported in the Nutrient Measurements section on an as-received (wet-weight) basis for liquid samples and on a dry weight basis for solid waste samples.

Figure 1. NCDA&CS Waste Report example.

NCDA&CS Agronomic Division **Phone: (919) 664-1600** **Website: www.ncagr.gov/Divisions/Agronomic-Services** **Report No.**

Predictive

Waste Report

Waste And Compost Analysis Section

Client:

Advisor:

Sampled:
Received:
Completed

PALS #:

PALS #:

Farm: Not Provided

Sample Information

ID: ASH
Code: CSO
Description: Ash, Mixed or Other
Grower Comments: Biosolids ash

Nutrient Measurements are given in units of milligrams per kilogram (mg/kg), unless otherwise specified.

Nitrogen (N) (mg/kg)
Total N: 1840
Inorganic: 531
NH_4-N 517
NO_3-N 13.6

P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
70300	7040	60100	7440	411	55300	1340	3260	675	21.7	6.86

SS (10^{-5} S/cm)	EC (mS/cm)	pH (Unitless)	BD (lb/yd³)	CCE (%)	ALE (tons)	C:N (Unitless)	DM (%)
13	0.13	8.06	-	13.5	15.1	4.41 : 1	44.2

Other Results

C	Al	Na	Cl
8120	82000	2480	-

Application Method: Broadcast

Estimate of Nutrients Available for First Year (lb/ton)

N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
1.63	142	7.46	53.1	6.57	0.36	48.9	1.18	2.88	0.60	0.02	0.01

Other Results (lb/ton)

Al	Na	Cl
72.5	2.19	-

Heavy Metals are given in units of parts per million (ppm) on a dry-weight basis.

As	Cd	Cr	Ni	Pb	Se
4.54	1.82	117	81.3	29.0	3.23

Heavy Metals are given in ppm on an as-received basis.

Application Method: Broadcast

As	Cd	Cr	Ni	Pb	Se
2.01	0.80	51.6	35.9	12.8	1.43

The standard analysis may also include measurements of pH, electrical conductivity (EC), dry matter percent (DM%) and carbon (C) for certain types of samples, depending on the waste code specified by the client on the Waste Sample Submission Form. The tests performed automatically in addition to the standard analysis based on each waste code are listed in Table 1. Upon request these tests can be provided at no additional charge for any sample, except that carbon can only be measured for solid waste samples.

pH

The pH of liquid samples is measured directly on homogenized samples. For solid and semi-solid samples, pH is measured on a subsample of the material, wetted up to a slurry. pH is a unitless parameter expressed on a scale of 0-14.

Electrical conductivity (EC)

Electrical conductivity (EC) is a measure of soluble salts (SS) and of the ability of an aqueous solution to carry a current. The EC of an aqueous solution depends on the total concentration and valence of ions and on the temperature of the sample. The EC of liquid samples is measured directly on homogenized samples. For solid and semi-solid samples, EC is measured on a subsample of the material, wetted up to a slurry. EC is reported in units of mS/cm and SS is expressed in units of 10^{-5} S/cm.

Dry Matter (DM%)

Percent dry matter is inversely related to percent moisture and is determined on all samples analyzed as solids. The DM% is used to calculate the as-received nutrient concentrations reported in the Estimate of Nutrients Available for First Year section of the Waste report (Fig. 1). Dry matter percentage is calculated according to equation 1.

$$[1] \qquad DM\% = (dw \div ww) \times 100$$

where:
dw = the dry weight of the sample after drying at 80°C for 24-48 hours
ww = the wet weight of the sample upon receipt at the lab

Carbon (C)

Total C analysis is primarily used to measure the carbon to nitrogen ratio (C:N) of an organic material, which is useful for determining compost feed stock mixing ratios and is an important indicator in finished compost stability. High C:N ratios slow the composting and mineralization processes because microbial decomposition of carbohydrates is limited by metabolic nitrogen requirements. When C:N ratio is low (< 15:1), oxygen is rapidly depleted and the aerobic carbohydrate metabolism necessary for the production of quality compost shifts to anaerobic metabolic pathways. Total C is measured on solid and semi-solid composts, non-composted raw materials (except lime by-products), combustion/thermal by-products (e.g. ash), and solid waste treatment by-products (e.g. biosolids) (Table 1). Total C is not available for or applicable to liquid samples. Carbon is reported mg/kg and is measured on either a dry-weight or as-received basis depending on whether N is measured dry or as-received (Table 1). When C is analyzed, the carbon to nitrogen ratio (C:N) is calculated according to equation 2.

[2] $C{:}N = C\ (mg/kg) \div N\ (mg/kg)$

Table 1. Additional lab tests included in the standard analysis for specific waste codes. If requested on the submission form, pH, electrical conductivity (EC) and/or carbon (C) can be measured for most solid samples at no additional cost.

Animal Manure*					
Waste Type	**Waste Source**	**Waste Code**	**X =Included with standard analysis**		
			pH	**EC (SS)**	**C**
Lagoon Liquid	Swine	ALS	X		
	Swine Nursery	ALF	X		
	Poultry	ALP	X		
	Other	ALO	X		
Lagoon Sludge	Poultry	ASP	X		
	Swine	ASS	X		
	Other	ASO	X		
Liquid Slurry	Beef	LSB	X		
	Dairy	LSD	X		
	Swine	LSS	X		
	Other	LSO	X		
Surface Scraped or Stockpiled	Beef	SSB			
	Dairy	SSD			
	Horse	SSH			
	Swine	SSS			
	Other	SSO			
Poultry House	Broiler Breeder	HBB			
	Broiler Pullet	HBP			
	Broiler	HLB			
	Duck House	HLD			
	Layer	HLL			
	Layer Pullet	HLP			
	Turkey	HLT			
	Other	HLO			
Composted	Beef	FCB	X	X	X
	Dairy	FCD	X	X	X
	Horse	FCH	X	X	X
	Poultry	FCP	X	X	X
	Swine	FCS	X	X	X
	Other Animal	FCO	X	X	X

Other Waste (not animal manure)					
Waste Type	**Waste Source**	**Waste Code**	**X =Included with standard analysis**		
			pH	**EC (SS)**	**C**
*Waste Treatment By-products	Biosolids, composted	BCO	X	X	X
	Domestic septage	BID	X	X	X
	Biosolids, other	BIO	X	X	X
	Biosolids, mixed	BIX	X	X	X
	Leachates/effluents	BLL	X	X	
Ash By-products	Biochar	CSB	X	X	X
	Coal ash	CSC	X	X	X
	Wood ash	CSW	X	X	X
	Poultry ash	CSP	X	X	X
	Ash, mixed or other	CSO	X	X	X
Composted, Other	*Vermicompost	FCV	X	X	X
	Plant material	FCW	X	X	X
	Mixed material	FCX	X	X	X
	*Poultry mortality	FPM	X	X	X
	*Swine mortality	FSM	X	X	X
Non-Composted, Other	Grease trap (liquid)	GTL	X		
	Paper fibers	IOC	X	X	X
	ǂLime by-product	IOL	X	X	
	Wood waste	NBS			X
	Plant/Crop Residue	NCR			X
	Food/Bev (liquid)	NLF	X	X	
	Food/Bev (solid)	NSF			X
	Animal byprod (liquid)	NLA	X	X	
	Animal byprod (solid)	NSA			X
	Liquid, Other	NLO	X	X	
	Solid, Other	NSO			X

*Nitrogen and Carbon are analyzed as-received.
ǂCCE is required for IOL waste code at an additional $10.

Additional Analyses

Special tests (inorganic nitrogen, heavy metals, CCE and molybdenum) can be performed in addition to the standard analysis upon request for an additional fee (Table 2).

Table 2. Optional special tests available in addition to the standard analysis.

Special Tests	Abbreviation
Nitrate-nitrogen & ammonium-nitrogen	NO_3-N; NH_4-N
Heavy metals: arsenic, cadmium, chromium, lead, nickel, selenium	As, Cd, Cr, Pb, Ni, & Se
Calcium carbonate equivalent	CCE
Molybdenum	Mo

Nitrate-nitrogen (NO_3-N) and Ammonium-nitrogen (NH_4-N).
Inorganic nitrogen in organic material primarily consists of nitrate-nitrogen (NO_3-N) and ammonium-nitrogen (NH_4-N), which are not included in the standard analysis. In manure, inorganic nitrogen is primarily in the form of NH_4-N. Requests for NO_3-N and NH_4-N may be for regulatory compliance due to an accidental discharge or because the client needs to know the relative organic and inorganic N that comprise total N for other reasons. On the waste report, NO_3-N and NH_4-N listed in the Nutrient Measurements section are in mg/L (as-received basis) for liquid samples or mg/kg (dry-weight basis) for solid samples.

Heavy metals (HM).
Analysis of HM includes arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), and selenium (Se). These analytes are not part of the standard analysis and are analyzed only by request at sample submission. Units are in mg/L (as-received basis) for liquid samples. Solid samples are reported on both a dry weight and as-received basis in mg/kg.

Calcium carbonate equivalent (CCE%) and agricultural lime equivalent (ALE).
Calcium carbonate equivalent is a measure of the acid-neutralizing capacity of a waste material and is expressed as a percentage of pure calcium carbonate on a dry-weight basis for solids and an as-received basis for liquid samples. When CCE% is measured, ALE is also calculated. ALE indicates the amount (in tons or gallons) of the waste required to equal the neutralizing value of one ton of agricultural grade limestone on an as-received basis. The ALE is calculated according to equations 3 and 4 for solid and liquid waste samples, respectively. One gallon of liquid waste is assumed to weigh 8.34 pounds.

$$\text{[3]} \quad \text{ALE (tons)} = 1800 \div [(\text{DM\%} \div 100) \times (\text{CCE\%} \div 100) \times 2000]$$

$$\text{[4]} \quad \text{ALE (1000 gallons)} = 1800 \div [(\text{CCE\%} \div 100) \times 8340]$$

Estimate of Nutrients Available for the First Crop

In the Estimate of Nutrients Available for First Year section of the Waste Report (Fig. 1), all measured nutrients are converted from mg/kg or mg/L and reported on an as-received basis in lb/ton or lb/1000 gal.

Nitrogen. For manure samples where nitrogen is measured on un-dried, as-received samples, the estimate of available nitrogen calculation includes a mineralization coefficient (Table 3) that depends on the type of animal, type of manure (e.g. liquid, slurry, sludge, solids) and application method. The four application methods are:

- broadcast (BR) — waste broadcasted on the soil surface and left uncovered for one week or longer
- injection (IN) — waste injected directly into the soil and covered immediately
- irrigation (IR) — waste applied through the irrigation system and left uncovered for one week or longer
- soil incorporation (SI) — waste broadcasted on the soil surface and plowed or disked into soil within two days

Manure N availability is calculated for solids and liquids according to equations 5-6.

[5] N available (lb/ton) = (N mg/kg ÷ 1,000,000) × NAC × 2000

[6] N available (lb/1000 gal) = (N mg/L) ÷ 1,000,000) × NAC × 8340

where:
NAC = the N availability coefficient listed in Table 3

Nitrogen mineralization rates for non-animal waste sources (e.g. paper fibers, ash, crop residue, biosolids) have not been determined. The N availability estimate for these types of materials assumes a conservative approach—that all N is available in the first year—and therefore includes no availability coefficient in the calculation. In addition, these types of materials, when solid, are analyzed and reported in the Nutrient Measurements section on a dry-weight basis and the dry matter percent (DM%) is used to determine the as-received concentrations reported in the Estimate of Nutrients section. Non-manure N availability is calculated for solids and liquids according to equations 7 and 8, respectively.

[7] N available (lb/ton) = (N mg/kg ÷ 1,000,000) × 2000 × (DM% ÷ 100)

[8] N available (lb/1000 gal) = (N mg/L) ÷ 1,000,000) × 8340

where:
DM% = the dry matter percentage determined on samples processed as solid

Table 3. First year nitrogen availability coefficients by application method in animal manure samples as determined by the Interagency Nutrient Management Committee.

Animal Manure				
Waste Type	Waste Source	Waste Code	Nitrogen Coefficients	
			Broadcast/ Irrigation	Injection/ Soil Incorporation
Lagoon Liquid	Swine	ALS	0.5	0.6
	Swine Nursery	ALF	0.5	0.6
	Poultry	ALP	0.5	0.6
	Other	ALO	0.5	0.6
Lagoon Sludge	Poultry	ASP	0.5	0.6
	Swine	ASS	0.5	0.6
	Other	ASO	0.5	0.6
Liquid Slurry	Beef	LSB	0.4	0.6
	Dairy	LSD	0.4	0.6
	Swine	LSS	0.4	0.6
	Other	LSO	0.4	0.6
Surface Scraped or Stockpiled	Beef	SSB	0.4	0.6
	Dairy	SSD	0.4	0.6
	Horse	SSH	0.4	0.6
	Swine	SSS	0.4	0.6
	Other	SSO	0.4	0.6
Poultry House	Broiler Breeder	HBB	0.5	0.6
	Broiler Pullet	HBP	0.5	0.6
	Broiler	HLB	0.5	0.6
	Duck House	HLD	0.5	0.6
	Layer	HLL	0.5	0.6
	Layer Pullet	HLP	0.5	0.6
	Turkey	HLT	0.5	0.6
	Other	HLO	0.5	0.6
Composted	Beef	FCB	0.4	0.6
	Dairy	FCD	0.4	0.6
	Horse	FCH	0.4	0.6
	Poultry	FCP	0.5	0.6
	Swine	FCS	0.5	0.6
	Poultry mortality	FPM	0.5	0.6
	Swine mortality	FSM	0.5	0.6
	Other Animal	FCO	0.4	0.6

Phosphorus and Potassium. All nutrients other than N, are measured on a dry-weight basis for solids and as-received for liquids. For solid samples, the dry matter percent (DM%) is used to determine the as-received concentrations reported in the Estimate of Nutrients section. Additionally, in 2013, the Interagency Nutrient Management Committee adopted a more conservative approach to estimating the availability of P and K in manure sources and assumed 100% availability. All P_2O_5 and K_2O values reported in the Estimate of Nutrients section are now calculated according to equations 9 and 10 for solid and liquid wastes, respectively.

[9] P_2O_5 or K_2O (lb/ton) = (P or K mg/kg ÷ 1,000,000] × CF × 2000 × (DM% ÷ 100)

[10] P_2O_5 or K_2O (lb/1000 gal) = (P or K mg/L ÷ 1,000,000] × CF × 8340

Where:

CF = the conversion factor needed to express P as P_2O_5 and K as K_2O. The CF for P is 2.29 and for K is 1.20.

DM% = the dry matter percentage determined on samples processed as solids

Other nutrients. All nutrients other than N, are measured on a dry-weight basis for solids and as-received for liquids. For solid samples, the dry matter percent (DM%) is used to determine the as-received concentrations reported in the Estimate of Nutrients section. All other nutrient values reported in the Estimate of Nutrients section are calculated according to equations 11 and 12 for solid and liquid wastes, respectively.

[11] Nutrient (lb/ton) = (Nutrient mg/kg ÷ 1,000,000) × 2000 × (DM% ÷ 100)

[12] Nutrient (lb/1000 gal) = (Nutrient mg/L ÷ 1,000,0000) × 8340

Conversion of units. If the lab analyzed samples as solid waste but the client plans to apply the waste in liquid form, equations 13 and 14 can be used to convert from solid waste application units (lb/tons) to liquid waste application units (lb/1000 gallons), and vice versa. These conversions assume that one gallon of liquid waste weighs 8.34 pounds.

[13] lb/ton × 4.17 = lb/1000 gal.

[14] lb/1000 gal. × 0.24 = lb/ton

For some applications, such as the use of compost on gardens or landscapes, it is useful to plan for application of pounds to an area of 100 or 1000 ft^2 rather than tons per acre. Refer to equations 15 and 16 for these conversions.

[15] tons/acre × 45.9 = pounds/1000 ft^2

[16] tons/1000 ft^2 × 4.6 = pounds/100 ft^2

Additional resources

Waste Sample Information form

NCDA&CS Waste Analysis Methods

Crop Fertilization Based on North Carolina Soil Tests

Sampling for Waste Analysis

Quick Sampling Guides for Waste

Understanding the Waste Analysis Report