Livestock Waste Sampling, Analysis, and Calculation of Land Application Rates

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I. SAMPLE COLLECTION

A. Semi-Solid Lot Manure

i. Scrapped directly from lot into spreader: From loaded spreader, collect about 2 lbs manure from different locations using nonmetallic collectors.

ii. From storage: Collect about 2 lbs manure from under the surface crust avoiding bedding materials using nonmetallic collectors.

B. Liquid Manure Slurry

i. Under-slotted-floor pit
   a. Extend a 1/2” nonmetallic conduit open on both ends into manure to pit floor.

   b. Seal upper end of conduit (e.g., by placing a thumb over end of conduit) trapping manure that has entered lower end, remove and empty slurry into plastic bucket or nonmetallic container.

   c. Take subsamples from 5 or more locations or at least 1 quart.

   d. Mix and add about 3/4 pint to nonmetallic sample container.
ii. Exterior storage basin or tank
   a. Make sure manure has been well mixed with a liquid manure chopper-agitator pump or propeller agitator.
   b. Take subsamples from about 5 pit locations, from agitator pump or from manure spreader and place in a plastic bucket.
   c. Mix and add 3/4 pint to a nonmetallic sample container.

C. Lagoon Liquid
   i. Collect about 3/4 pint of recycled lagoon liquid from inflow pipe to flush tanks in a nonmetallic sample container.
   ii. From lagoon
      a. Place a small bottle (1/2 pint or less) on end of 10-15' pole.
      b. Extend bottle 10-15' away from bank edge.
      c. Brush away floating scum or debris.
      d. Submerge bottle within 1' of liquid surface.
      e. Empty into a plastic bucket, repeat about 5 times around lagoon, mix, and add 3/4 pint to nonmetallic sample container.

D. Broiler or Turkey Litter
   i. House litter
      a. Visually inspect litter for areas of varying quality, e.g., areas around feeders and waterers, and estimate percent of floor surface in in each area.
      b. Take about 5 litter subsamples at locations proportionate to item a. E.g., if 20% of litter of similar visual quality is around feeders and waterers, take 1 subsample there and the other 4 subsamples from remainder of floor surface.
      c. At each location, collect litter from a 6" by 6" area down to earth floor and place in a plastic bucket.
      d. After 5 subsamples have been added to the bucket, mix, and add about 2-3 lbs litter to a nonmetallic sample container such as a 1-gallon freezer bag and seal.
ii. From stockpile

   a. Take subsamples from about 5 locations at least 18” into pile.

   b. Mix, add 2-3 lbs to nonmetallic sample container and seal.

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**II. SAMPLE PREPARATION AND TRANSFER**

A. Place sample into an expandable container that can be sealed. Rinse residues from container with clean water but do not use disinfectants, soaps, or treat in any other way.

B. Pack sample in ice, refrigerate, freeze, or transfer to lab quickly.

C. Hand-delivery is most reliable way of sample transfer.

D. If mailed, protect sample container with packing material such as newspaper, box or package with wrapping paper, and tape.

E. Commercial sample containers and mailers are also available. Contacts:

   i. A&L Eastern Agricultural Lab, Inc.
      7621 Whitepine Road
      Richmond, VA  23237
      Ph:  (804)743-9401

       3315 Winton Road
       Raleigh, NC  27604
       Ph:  (919)876-2351

   iii. Polyfoam Packers Corp.
        2320 S. Foster Avenue
        Wheeling, IL  60090
        Ph:  (312)398-0110

   iv. NASCO
       901 Janesville Avenue
       Fort Atkinson, WI 53538
       Ph:  (414)563-2446

F. Private analytical labs are available, but sample analyses are costly.

G. The NCDA&CS provides this service for North Carolina residents.

   i. Address:
      N.C. Dept. of Agriculture & Consumer Services Agronomic Division
      Plant/Waste/Solution Section
      4300 Reedy Creek Road
      Raleigh, NC 27607-6465
      Ph: (919)733-2655
      Attn: Dr. Bobby Walls
ii. Forward $4 along with the sample.

iii. Include the following identification information with sample:

   a. Livestock species (dairy, swine, turkey, etc.)

   b. Livestock usage (swine-nursery, finishing; turkey-breeders, brooderhouse, grower, number flocks grown on litter; etc.)

   c. Waste type (dairy-lot scraped manure, liquid slurry; swine- pit slurry, lagoon liquid, sludge; broiler-house litter, stockpile

iv. Routine analyses performed on all samples: N, P, K, Ca, Mg, Na, S, Fe, Mn, Zn, Cu, B

v. Additional analyses performed upon request: DM, Mo, Cd, Ni, Pb

III. INTERPRETATION OF ANALYTICAL RESULTS

A. Results are usually either on a percent (%) of total weight or a parts per million (ppm or mg/L) basis.

B. Results may be reported on a dry-weight basis (db) or on an AS-IS or wet-weight (wb) basis.

C. Results expressed as dry-basis should be converted to wet-basis before calculating land application rates by multiplying reported values by % dry matter (% expressed as decimal). If a dry matter analysis is not performed, average dry matter values may be obtained from appropriate tables of average characteristics.

D. If ammonia-nitrogen tests are not performed, refer also to appropriate tables for average percentages of the total nitrogen as ammonia.

E. Phosphorus and potassium results can be reported as elemental P and K or in fertilizer forms of P2O5 and K2O. Recommended fertilization rates of various crops are usually reported as P2O5 and K2O.

F. The following conversion factors apply:

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<tr>
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<th>BY</th>
<th>TO GET</th>
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<tbody>
<tr>
<td>lb P</td>
<td>2.29</td>
<td>lb P2O5</td>
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<tr>
<td>lb K</td>
<td>1.20</td>
<td>lb K2O</td>
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<td>in</td>
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TO GET BY DIVIDE

G. Example 1 : Liquid dairy manure slurry from an earthen storage basin

i. Lab analysis
   a. Total N = 0.270 %wb
   b. NH3N = 41.0 % of Total N
   c. Total P = 0.073 %wb
   d. K = 0.210 %wb

ii. To convert to equivalent total fertilizer concentrations:
   a. Total N = 0.270 x 83.5 = 22.5 lbs/1000 gals
   b. NH3N = 0.410 x 22.5 = 9.2 lbs/1000 gals
   c. P2O5 = 0.073 x 83.5 x 2.29 P2O5/P = 14.0 lbs/1000 gals
   d. K2O = 0.210 x 83.5 x 1.20 K2O/K = 21.1 lbs/1000 gals

H. Example 2 : Swine lagoon liquid

i. Lab analysis
   a. Total N = 0.060 %wb
   b. NH3N = 81.7 % of Total N
   c. Total P = 0.010 %wb
   d. K = 0.049 %wb

ii. To convert to equivalent total fertilizer concentrations:
   a. Total N = 0.060 x 2266 = 136 lbs/acre-inch
   b. NH3N = 0.817 x 136 = 111 lbs/acre-inch
   c. P2O5 = 0.010 x 2266 x 2.29 = 53 lbs/acre-inch
   d. K2O = 0.049 x 2266 x 1.20 = 133 lbs/acre-inch

I. Example 3 : Broiler house litter

i. Lab analysis
   a. Dry matter = 78.3 %wb
b. Total N = 4.62 %db

\[ \text{NH}_3H = 15.4 \% \text{ of Total N} \]

d. Total P = 2.19 %db

e. K = 2.43 %db

ii. To convert to equivalent total fertilizer concentrations:

\[ \text{Total N} = 4.62 \times 0.783 \times 20 = 72.3 \text{ lbs/ton} \]

\[ \text{NH}_3N = 0.154 \times 72.3 = 11.1 \text{ lbs/ton} \]

\[ \text{P}_2\text{O}_5 = 2.19 \times 0.783 \times 20 \times 2.29 = 78.5 \text{ lbs/ton} \]

\[ \text{K}_2\text{O} = 2.43 \times 0.783 \times 20 \times 1.20 = 45.8 \text{ lbs/ton} \]

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**IV. NUTRIENT AVAILABILITY**

A. Equations:

i. Plant avail N (PAN) = A x NH3N + 0.5 x (Total N - NH3N)

ii. Avail P2O5 = B x Total P2O5

iii. Avail K2O = C x Total K2O

iv. where A, B, C are availability coefficients from following table:

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**B. Nutrient Availability Coefficients**

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<thead>
<tr>
<th>METHOD OF APPLICATION</th>
<th>AVAILABILITY COEFFICIENT</th>
<th>DRY LITTER</th>
<th>SEMI-SOLID MANURE</th>
<th>LIQUID MANURE SLURRY</th>
<th>LAGOON LIQUID</th>
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<tr>
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C. Example 1 : Liquid dairy manure broadcast & disked under within 48 hrs

i. \( \text{PAN} = A \times \text{NH}_3\text{N} + 0.5 \times (\text{Total N} - \text{NH}_3\text{N}) \)
\[
= 0.75 \times 9.2 \text{#/1000 gals} + 0.5 \times (22.5 - 9.2) \text{#/1000 gals}
= 13.6 \text{ lbs/1000 gallons}
\]

ii. \( \text{PAP}_2\text{O}_5 = B \times \text{Total P2O5} \)
\[
= 0.75 \times 14.0 \text{ lbs/1000 gals} = 10.5 \text{ lbs/1000 gals}
\]

iii. \( \text{PAK}_2\text{O} = C \times \text{Total K2O} \)
\[
= 0.75 \times 21.1 \text{ lbs/1000 gals} = 15.8 \text{ lbs/1000 gals}
\]

D. Example 2 : Swine lagoon liquid irrigated w/o cultivation.

i. \( \text{PAN} = 0.50 \times 111 \text{ lbs/ac-in} + 0.5 \times (136 - 111) \text{ lbs/ac-in} \)
\[
= 68.1 \text{ lbs/acre-inch}
\]

ii. \( \text{PAP}_2\text{O}_5 = 0.75 \times 53 \text{ lbs/ac-in} = 39.7 \text{ lbs/acre-inch} \)

iii. \( \text{PAK}_2\text{O} = 0.75 \times 133 \text{ lbs/ac-in} = 100.0 \text{ lbs/acre-inch} \)

E. Example 3 : Broiler litter broadcast w/o cultivation.

i. \( \text{PAN} = 0.25 \times 11.1 \text{ lbs/ton} + 0.5 \times (72.3 - 11.1) \text{ lbs/ton} \)
\[
= 33.4 \text{ lbs/ton}
\]

ii. \( \text{PAP}_2\text{O}_5 = 0.60 \times 78.5 \text{ lbs/ton} = 47.1 \text{ lbs/ton} \)

iii. \( \text{PAK}_2\text{O} = 0.60 \times 45.8 \text{ lbs/ton} = 27.5 \text{ lbs/ton} \)

V. CALCULATION OF APPLICATION RATES

A. Example 1 : Liquid dairy manure broadcast and disked into corn silage land.

i. Recommended corn silage fertilization rates:
   a. 200 lbs N/acre/year
   b. 50 lbs P2O5/acre/year
   c. 150 lbs K2O/acre/year

ii. Waste application rates
   a. N: 200 #/ac/yr / 13.6 #/1000 gals = 14,749 gals/ac/yr
   b. P2O5: 50 #/ac/yr / 10.5 #/1000 gals = 4,770 gals/ac/yr
   c. K2O: 150 #/ac/yr / 15.8 #/1000 gals = 9,485 gals/ac/yr

iii. IF ENOUGH LAND EXISTS, SELECT THE LOWER OF THE N OR P2O5 RATES AND SUPPLEMENT WITH COMMERCIAL FERTILIZER, OTHERWISE, N SHOULD DETERMINE MAXIMUM RATE.
**a. Supplemental** N and K2O needed at P2O5 rate = 4,770 gals/ac/yr

1. N: 4,770 gals/ac/yr x 13.6 #/1000 gals = 65 #/ac/yr
   200 - 65 = 135 lbs/ac/yr supplement

2. K2O: 4,770 gals/ac/yr x 15.8 #/1000 gals = 75 #/ac/yr
   150 - 75 = 75 lbs/ac/yr supplement

**b. P2O5 and K2O applied at N rate = 14,749 gals/ac/yr**

1. P2O5: 14,749 gals/ac/yr x 10.5 #/1000 gals = 155 #/ac/yr
2. K2O: 14,749 gals/ac/yr x 15.8 #/1000 gals = 233 #/ac/yr

**B. Example 2: Swine lagoon liquid irrigated onto control-grazed bermudagrass pasture.**

i. Recommended grass fertilization rates:
   a. 300 lbs N/acre/year
   b. 75 lbs P2O5/acre/year
   c. 240 lbs K2O/acre/year

ii. Waste application rates:
   a. N: 300 #/ac/yr / 68.1 #/ac-in = 4.41 ac-in/ac/yr
   b. P2O5: 75 #/ac/yr / 39.7 #/ac-in = 1.89 ac-in/ac/yr
   c. K2O: 240 #/ac/yr / 100.0 #/ac-in = 2.40 ac-in/ac/yr

iii. Nutrient application rates:
   a. Supplemental N and K2O needed at P2O5 rate = 1.89 ac-in/ac/yr
      1. N: 1.89 ac-in/ac/yr x 68.1 #/ac-in = 129 #/ac/yr 300 - 129 = 171 lbs/ac/yr supplement
      2. K2O: 1.89 ac-in/ac/yr x 100.0 #/ac-in = 189 #/ac/yr 240 - 189 = 51 lbs/ac/yr supplement
   b. P2O5 and K2O applied at N rate = 4.41 ac-in/ac/yr
      1. P2O5: 4.41 ac-in/ac/yr x 39.7 #/ac-in = 175 #/ac/yr
      2. K2O: 4.41 ac-in/ac/yr x 100.0 #/ac-in = 441 #/ac/yr

**C. Broiler litter broadcast onto fescue pasture.**

i. Recommended pasture fertilization rates:
   a. 200 lbs N/acre/year
   b. 40 lbs P2O5/acre/year
   c. 60 lbs K2O/acre/year

ii. Waste application rates:
   a. N: 200 lbs/ac/yr / 33.4 lbs/ton = 6.0 tons/ac/yr
   b. P2O5: 40 lbs/ac/yr / 47.1 lbs/ton = 0.85 ton/ac/yr
   c. K2O: 60 lbs/ac/yr / 27.5 lbs/ton = 2.2 tons/ac/yr

iii. Nutrient application rates:
   a. Supplemental N and K2O needed at P2O5 rate = 0.85 ton/ac/yr
      1. N: 0.85 ton/ac/yr x 33.4 lbs/ton = 28 lbs/ac/yr 200 - 28 = 172 lbs/ac/yr supplement
      2. K2O: 0.85 ton/ac/yr x 27.5 lbs/ton = 23 lbs/ac/yr 60 - 23 = 37 lbs/ac/yr supplement
   b. P2O5 and K2O applied at N rate = 6.0 tons/ac/yr
VI. TOTAL LAND AREA REQUIREMENTS

A. Total Steady-State Live Animal Weight

i. Dairy
   - calf per head, one-time capacity 350 lbs
   - heifer per head 1000 lbs
   - milk cow per head 1400 lbs

ii. Beef
   - stocker per head, one-time capacity 550 lbs
   - feeder per head, one-time capacity 800 lbs
   - brood cow per head 1000 lbs

iii. Veal calf per head, one-time capacity 200 lbs

iv. Swine
   - nursery pig per head, one-time capacity 30 lbs
   - feeder-to-finish per head, one-time capacity 135 lbs
   - farrow-to-weanling per active sow 433 lbs
   - farrow-to-feeder per active sow 522 lbs
   - farrow-to-finish per active sow 1417 lbs

v. Sheep
   - feeder lamb per head, one-time capacity 60 lbs
   - ewe per head 160 lbs
   - ram per head 240 lbs

vi. Goat
   - kid per head, one-time capacity 50 lbs
   - doe per head 140 lbs
   - buck per head 210 lbs

vii. Horse
   - per head 1000 lbs

viii. Rabbit
   - per head, doe and litter 10 lbs

ix. Layer
   - hen per bird 4 lbs
   - pullet per bird, one-time capacity 1.5 lbs

x. Broiler
   - broiler per bird, one-time capacity 2 lbs
   - roaster per bird, one-time capacity 4 lbs
   - breeder per bird 6 lbs

xi. Turkey
   - poult per bird, one-time capacity 2.5 lbs
   - grower hen per bird, one-time capacity 10 lbs
   - grower tom per bird, one-time capacity 15 lbs
   - breeder per bird 20 lbs

xii. Duck
   - per bird, one-time capacity 3 lbs

B. Minimum Land Area Calculations

i. Example 1: Liquid manure slurry from 100-cow dairy farm broadcast and disked into corn silage land.
   - a. Total animal live weight = 100 cows x 1400#/cow = 140,000 #
   - b. Total manure = 140000# x 21.2 gals/1400#/day x 365 day/yr
c. Acres of land

1. N: \[ \frac{775,000 \text{ gals/yr}}{14,749 \text{ gals/ac/yr}} = 53 \text{ acres} \]
2. P2O5: \[ \frac{775,000 \text{ gals/yr}}{4,770 \text{ gals/ac/yr}} = 162 \text{ acres} \]

ii. Example 2: Lagoon liquid from 200-sow farrow-to-finish swine unit irrigated onto control-grazed bermudagrass pasture.

a. Total animal live weight = 200 sows x 1417 #/sow = 283,400 #

b. Total liquid = 283400 # x 2.7 gals/135#/day x 365 days/yr
   = 2,100,000 gals/year / 27,154 gals/ac-in
   = 77 acre-inches/year

c. Acres of land

1. N: \[ \frac{77 \text{ ac-in/yr}}{4.41 \text{ ac-in/ac/yr}} = 18 \text{ acres} \]
2. P2O5: \[ \frac{77 \text{ ac-in/yr}}{1.89 \text{ ac-in/ac/yr}} = 41 \text{ acres} \]

iii. Example 3: Litter from a 20,000-bird capacity broiler house broadcast onto fescue pasture.

a. Total bird live weight = 20000 birds x 2 #/bird = 40,000 #

b. Total litter = 40,000 # x 0.038 #/2#/day x 307 days/yr
   /2000 lbs/ton = 117 tons/year

c. Acres of land

1. N: \[ \frac{117 \text{ tons/yr}}{6.0 \text{ tons/ac/yr}} = 20 \text{ acres} \]
2. P2O5: \[ \frac{117 \text{ tons/yr}}{0.85 \text{ ton/ac/yr}} = 138 \text{ acres} \]

VII. SPREADER CALIBRATION

A. Irrigation (stationary sprinkler):

i. Example 2a: How many hours are needed to apply 0.5 inch with a 17.2-gpm sprinkler on an 80 ft by 80 ft spacing?

ii. Depth (in) = \( \frac{\text{flow rate (gpm)} \times \text{applic period (hrs)} \times 96.3}{\text{irrigated area (ft2)}} \)

iii. Period (hrs) = \( \frac{\text{applic depth (in)} \times \text{irrigated area (ft2)}}{\text{flow rate (gpm)} \times 96.3} \)
   = \( \frac{0.5 \text{ in} \times (80 \text{ ft} \times 80 \text{ ft})}{17.2 \text{ gpm} \times 96.3} \) = 1.9 hours

B. Irrigation (hard-hose or cable-tow travelling sprinkler):

i. Example 2b: What travel speed is needed to apply 1 inch with a 500-gpm
gun on a 300-ft lane spacing?

\[ \text{ii. Depth (in)} = \frac{\text{flow rate (gpm)} \times 1.605}{\text{lane spacing (ft)} \times \text{travel speed (ft/min)}} \]

\[ \text{iii. Travel speed (ft/min)} = \frac{\text{flow rate (gpm)} \times 1.605}{\text{lane spacing (ft)} \times \text{applic depth (in)}} \]

iii. Travel speed (ft/min) = \frac{500 \text{ gpm} \times 1.605}{300 \text{ ft} \times 1.0 \text{ in}} = 2.7 \text{ ft/min}

C. Semi-Solid, Liquid Slurry, or Dry Litter Spreader:

i. For semi-solid and dry litter spreaders, weigh one typical load.

ii. As long as the same spreader is loaded with similar quality and quantity of manure or litter, one weighing will be adequate.

iii. Liquid tank spreaders are rated in gallons of capacity.

iv. Through a field trial and operating the spreader in a typical spreading or unloading mode, determine:

a. effective spreading width

b. time required to unload a typical load

v. Example 3: What forward speed would be needed to apply 6.0 tons litter per acre from a spreader with a 6-ton capacity a 5-min spreading time, and a 25-ft spreading width?

a. Rate (tons/ac) = \frac{\text{spreader capacity (tons/load)} \times 495}{\text{time (mins)} \times \text{width (ft)} \times \text{forward speed (mph)}}

b. Forward speed (mph) = \frac{\text{spreader capacity (tons/load)} \times 495}{\text{time (mins)} \times \text{width (ft)} \times \text{rate (tons/ac)}}

= \frac{6 \text{ tons} \times 495}{5 \text{ mins} \times 25 \text{ ft} \times 6.0 \text{ tons/ac}} = 4 \text{ mph}

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