Nitrogen Availability from Manipulated Manures

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Current WI Manure Nutrient Availability Guidelines

- "Book Values" vs. Lab-analyzed
  - Book values: developed from lab data collected 1998-2001
    - ~1500 liquid dairy, ~1,200 solid dairy, ~900 poultry, ~500 liquid swine, ~600 solid swine, smaller numbers of other types
  - Lab-analyzed: An availability factor is applied to total N (also P, K, and S)
    - Nutrient availability studies conducted in WI and elsewhere
    - WI studies on dairy manure:
      - N availability ranged from 10-54% (10-65% within study)
      - Mean = 37.5%

Average nutrient & dry matter content from solid manure (A2809)

Species	% Dry Matter	N	P_2O_5	K_2O	S
	---------- Pounds per ton ----------				
Dairy	24	10	5	9	1.5
Beef	35	14	9	11	1.6
Swine	20	14	10	9	2.7
Duck	35	17	21	30	3.9
Chicken	60	40	50	30	3.9
Turkey	60	40	40	30	3.9
Sheep	45	26	18	40	2.7
Horse	45	10	6	10	2.5

Variation in Wisconsin liquid dairy manure *

Nutrient	Avg	Range	S.D.
N	22	1-73	9.2
P_2O_5	9	1-118	6.7
K_20	20	1-114	10.8

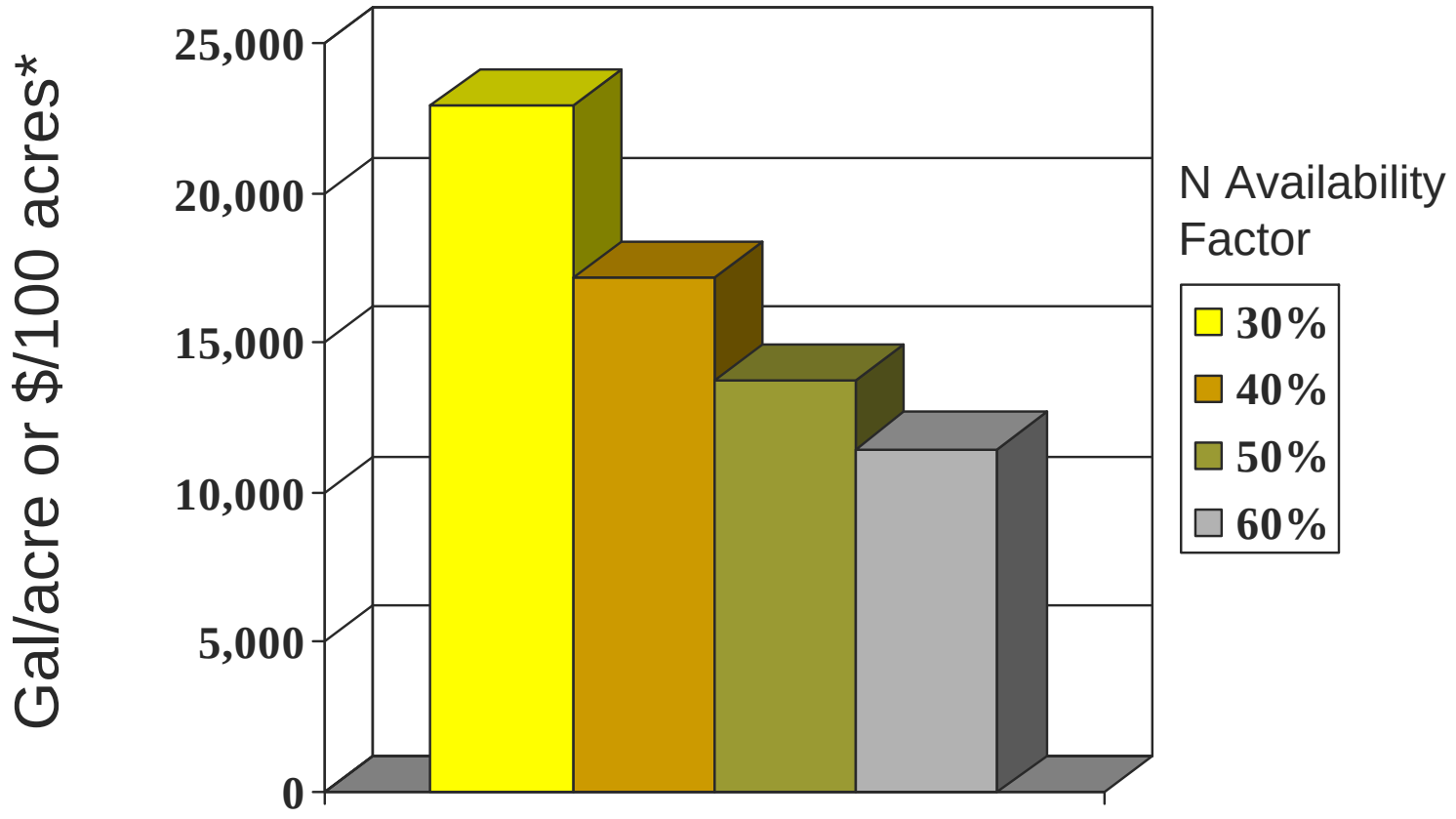
Values in lbs/1000 gal

* Based on 746 samples, 1998 – 2001,
Adapted from data presented by K. Kelling.

Estimated first-year nutrient availability factors of various manures*

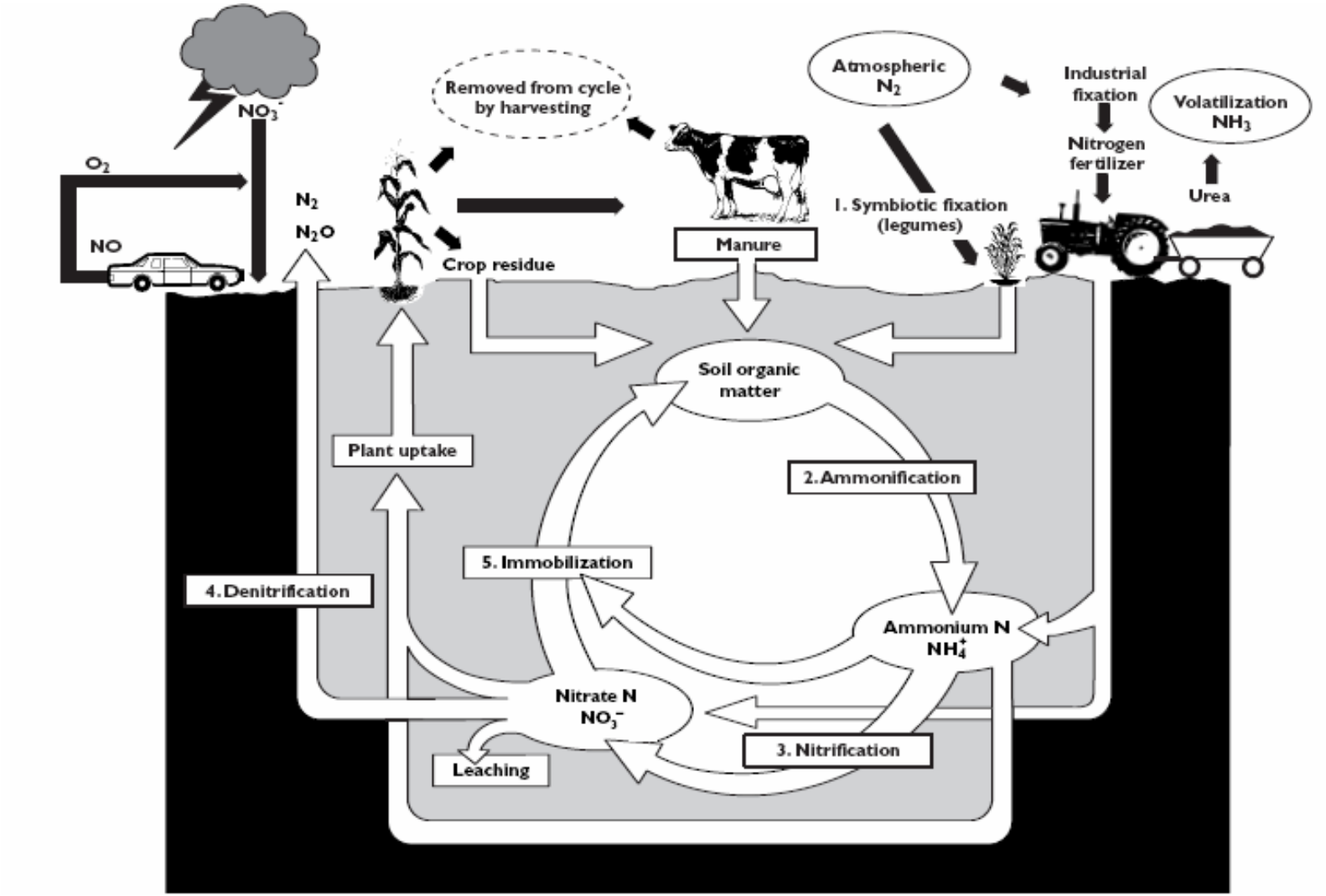
Species	N	P_2O_5	K_2O	S
Dairy, surface applied	30%	60%	80%	55%
Dairy, incorporated	40%	60%	80%	55%
Beef, surface applied	25%	60%	80%	55%
Beef, incorporated	35%	60%	80%	55%
Swine, solid surface applied	50%	60%	80%	55%
Swine, solid incorporated	65%	60%	80%	55%
Poultry, solid surface applied	50%	60%	80%	55%
Poultry, solid incorporated	60%	60%	80%	55%

Why is understanding N availability important?



* **Assumptions: N rate =165 lb/acre, Manure total N content of 24 lb/1000gal, $0.01/gal application costs**

The Nitrogen Cycle



A2519, Soil and Applied Nitrogen, L.G. Bundy, 1998.

Factors affecting N availability from manures

- Soil & Environmental factors
  - Moisture
  - Temperature
  - Texture
  - OM content
- Management factors
  - Application timing
  - Incorporation vs. surface spread
- Source factors
  - Amount and forms of inorganic and organic N
  - Degradability/Stability of organic-N
  - Degradability/Stability of organic-C

Carbon, Nitrogen, and Soil N Availability

- Readily available (decomposable) carbon stimulates soil microorganisms and can immobilize N.
- Materials with high C/N ratio (> 20-30) typically immobilize N
- Materials with low C/N or with non-decomposable C tend to result in net N mineralization.

What Qualifies as a “Manipulated Manure”?

- Any manure that has been treated or stored such that it significantly alters the physical or chemical nature of the manure.
  - Liquid-solid separation
  - Anaerobic digestion
  - Composting

Common Liquid-Solid Separation Systems

Screw-press separators

Inclined-screen separators

How does liquid solid-separation affect manure composition?

- Removes largest particles from liquid
  - Decreases total C content and C/N ratio of liquid fraction
  - Most of N and P are associated with smallest particles
- Decreases in total N content are variable, but often less than 10%.
  - Greater decreases can be achieved with use of flocculants (i.e. PAM) or more sophisticated separation/treatment systems

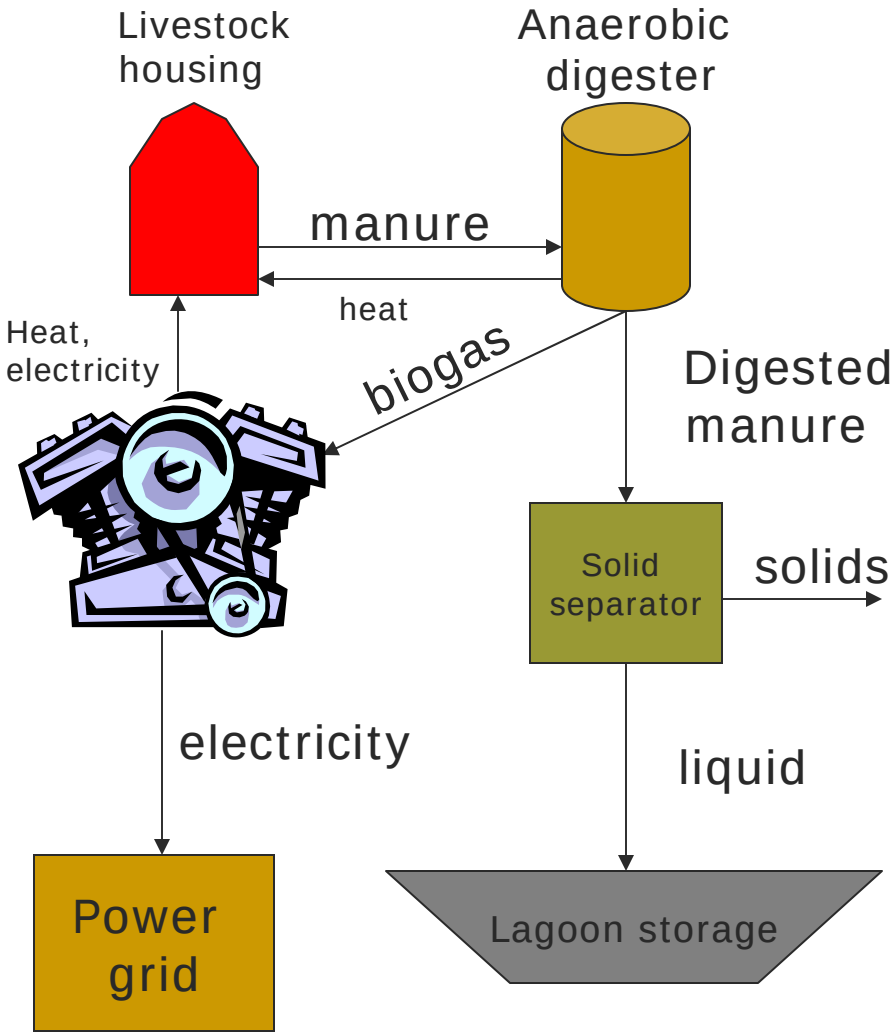
Effect of Separation on C and N contents of Liquid Fraction on 4 WI Dairy Farms

Farm	Total C (%)		Total N (%)		C/N	
	Before	After	Before	After	Before	After
A	3.36	3.22	0.30	0.31	11.2	10.4
B	1.09	0.44	0.15	0.14	7.44	3.17
C*	1.95	1.20	0.25	0.24	7.66	5.00
D*	1.97	0.90	0.30	0.24	6.67	3.76

* On farms C and D separation was performed on digested manure

Anaerobic digestion

- Converts manure into simple organic compounds and biogas products
- Microbes (bacteria) do the work:
  - Psychrophilic: ambient temps
  - Mesophylic: 95°F
  - Thermophylic: 165°F
    - Most efficient biogas conversion
    - Require substrates



Effect of Anaerobic Digestion on Forms and availability of C and N

- Easily decomposed C forms converted to biogas
- Organic N forms mineralized to NH_4
- Loss of gaseous NH_3
- Liquid digestate typically has lower C/N ratio, higher NH_4-N than raw manure

Changes in C and N forms during Anaerobic digestion*

	Raw Manure	Digested Manure
Total Solids (%):	7.4	4.7
Fat (%):	1.1	1.1
Protein (%):	1.2	1.0
Glucose (%):	0.4	-
Cellulose (%):	3.5	1.4
Ash (%):	1.2	1.2
Volatile Solids (%):	6.2	3.5
TSS (mg/l):	58,893	54,232
BOD (mg/l):	18,057	8,113
TKN (%):	0.35	0.35
Ammonia-N (%):	0.15	0.18
Organic N (%):	0.20	0.17
Total P (ppm):	589	643
Total K (ppm):	2,331	2,287
pH:	7.5	8.3

Decomposable forms of C lost

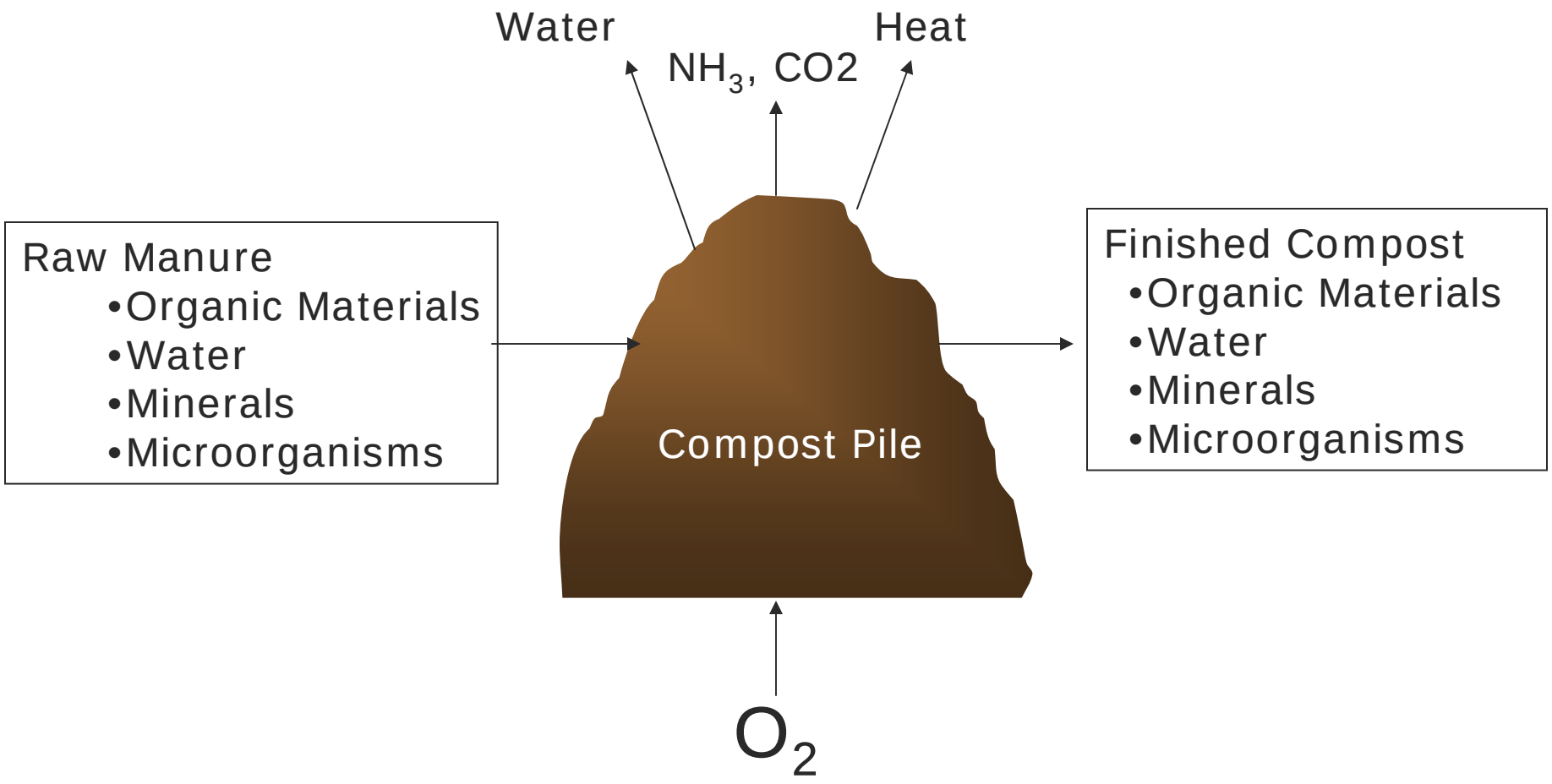
Organic N decreases, ammonium increases

* Thermophilic complete mix digestion systems with approx. 10% added substrates, data are averages of multiple samplings at three WI digester facilities.

Composting

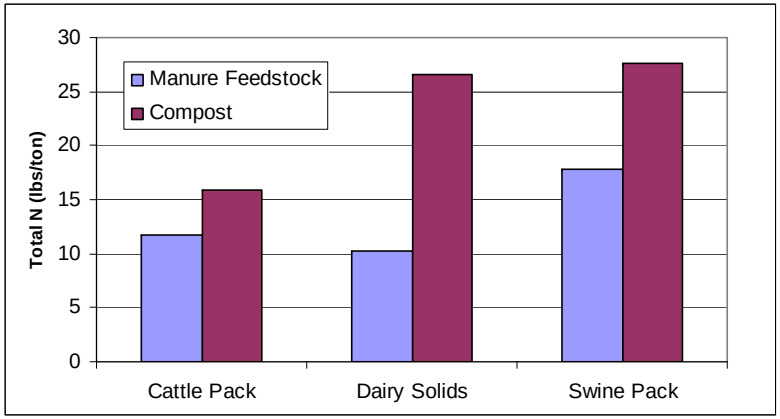
- Managed aerobic decomposition
- Easily decomposable carbon lost as CO_2
- Total N mass losses from composting can exceed 60%, but increases in total N concentration are often observed
- Inorganic NH_4-N decreases due to volatilization or conversion to org.-N
- NO_3-N concentrations typically increase compared to raw manure

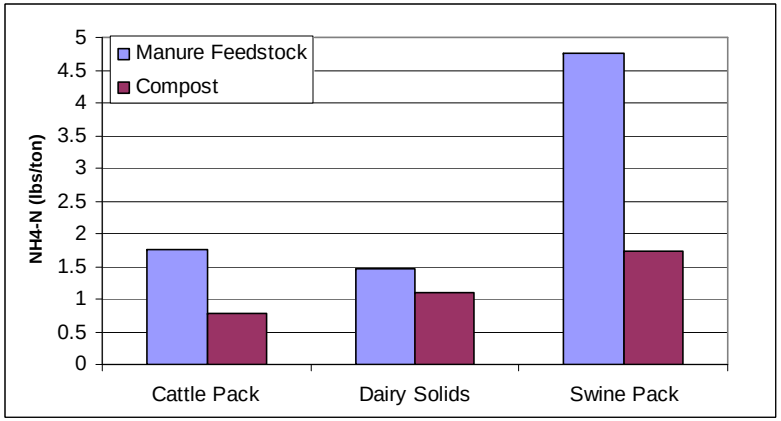
Composting Basics



Changes in Total-N and Ammonium-N in Three Manure Composts

- Concentration of total N increased due to mass losses related to decomposition
- NH_4-N concentration decreased in all manure types
- Detectable concentrations of NO_3-N in all composts (data not shown).





Wilkens and Baxter, 2006

What can I do if I think that I'm not accurately crediting N from treated manures?

- If you haven't already done so, test manure.
  - Liquid
    - Total N, NH_4-N
  - Solids
    - Total C, Total N, NH_4-N, NO_3-N (composts)
- When using materials with a high C/N ratio (>50), check soil N with pre-sidedress NO_3 test.
- Use guidelines that account for the amount of inorganic-N (NH_4, NO_3) in the manures.

Guidelines for Estimating 1st Year N Availability of Treated Manures

- Guidelines assume all of inorganic N is available, plus 25% of organic-N (10% if high C/N ratio)
- Liquid Manures
  - Incorporated

    NH_4-N + [0.25 x (Total N – NH_4-N)
  - Not incorporated (assumes 50% loss of NH_4-N)

    (0.5 x NH_4-N) + [0.25 x (Total N – NH_4-N)

Guidelines for Estimating 1st Year N Availability of Treated Manures

- Solid Manure (C/N < 50)
  - Incorporated:

    $NH_4\text{-}N + NO_3\text{-}N + [0.25 \times (TN - NH_4\text{-}N - NO_3\text{-}N)]$
  - Not Incorporated

    $(0.05 \times NH_4\text{-}N) + NO_3\text{-}N + [0.25 \times (TN - NH_4\text{-}N - NO_3\text{-}N)]$
- Solid Manure (C/N > 50)
  - Incorporated:

    $NH_4\text{-}N + NO_3\text{-}N + [0.1 \times (TN - NH_4\text{-}N - NO_3\text{-}N)]$
  - Not Incorporated

    $(0.5 \times NH_4\text{-}N) + NO_3\text{-}N + [0.1 \times (TN - NH_4\text{-}N - NO_3\text{-}N)]$

Example using guidelines for treated manures

- Treated liquid manure with total N content of 28 lb N/1000 gal and NH_4-N = 15 lb/1000 gal being used to meet N need of corn crop (rec. = 140 lb N/acre)
  - Standard recommendation (incorp):
    Avail N = 28 lb/1000 gal x 0.4 = 11.2 lb/1000 gal
    Recommendation = 140 / 11.2 = 12,500 gallons/acre
  - New recommendation:
    Avail N = 15 + [0.25 x (28-15)] = 18 lb/1000 gal
    Recommendation = 140 / 18 = 7,800 gallons/acre

On-going Research to Determine the Effect of Treatment on Manure N Availability

- 21 dairy manure samples collected from various farms. Treatments include
  - Anaerobic digestion (mesophilic and thermophilic)
  - Composting (bedded pack and active aeration)
  - Liquid/Solid separation (various separator types)
- Laboratory incubations being conducted on 5 representative WI soils
- Potentially available N will be calculated and related to manure composition data
- Expected outcomes:
  - Better understanding of the effect of manure treatment on manure C and N
  - Improved prediction of manure N availability

Summary

- Manure treatment has the potential to significantly alter the composition of manure and affect manure N availability.
- Standard manure N recommendations do not account for changes in N availability due to changes in N and/or C forms.
- Producers concerned with N availability values should have manure analyzed for NH_4-N, NO_3-N, and C/N. Apply appropriate calculation for estimating available N, follow up with in-season soil nitrate testing.
- Stay tuned for outcomes of on-going research!


Questions?
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