“Getting the Green from the Brown”

Fred Vocasek
CCA #01803
Senior Lab Agronomist, ServiTech
Dodge City KS, Hastings NE, Amarillo TX

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### Estimated Animal Agriculture Nitrogen and Phosphorus from Manure*

<table>
<thead>
<tr>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.81</td>
<td>4.64 million tons</td>
<td>available in manure</td>
</tr>
<tr>
<td>15</td>
<td>10 lb/ac</td>
<td>available as manure</td>
</tr>
<tr>
<td>27</td>
<td>9 lb/ac</td>
<td>applied as commercial fertilizer</td>
</tr>
</tbody>
</table>

LIVESTOCK PRODUCTION

C – N – mineral complexes

microbial activity (degradation)

rumen microorganisms

absorption, metabolism

C – N – mineral complexes

villi

small intestine

CH₄

WASTE

HARVEST

manure

grain, forage

ruminant microorganisms

“used” readily degradable

“unused” limited degradability

NH₃, "simple" CHO

WASTE

LIVESTOCK PRODUCTION

C – N – mineral complexes

absorption, metabolism

C – N – mineral complexes

HARVEST

WASTE

NH₃, "simple" CHO

"used"

readily degradable

"unused"

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limited degradability
microbial activity (degradation)

C – N – mineral complexes

absorption, metabolism

C – N – mineral complexes

manure

HARVEST

WASTE

grain, forage

rumen microorganisms

soil organic matter

NH₃, NO₃, PO₄

“used”

“unused”

LIVESTOCK PRODUCTION

CROP PRODUCTION

Villi

NH₃, “simple” CHO

soil microorganisms

manure

root hairs

root

CROP PRODUCTION

WASTE

HARVEST

C – N – mineral complexes

absorption, metabolism

C – N – mineral complexes

microbial activity (degradation)

C – N – mineral complexes

“used”

“unused”
Applying technology – Laboratory analysis

Percent solids

> 50%

25% - 50%

5% - 25%

1% - 5%

> 1%

> 25% - 50%

1 - 5%

5 - 25%

25 - 50%

> 50%
Beef manure nutrient survey
(median values from survey; equivalent to “book” values)

<table>
<thead>
<tr>
<th>Percent solids</th>
<th>Pounds of nitrogen in 8,350 lb. of manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 50%</td>
<td>1.25% 105 lb.</td>
</tr>
<tr>
<td>≈ 4¼ tons</td>
<td></td>
</tr>
<tr>
<td>25% - 50%</td>
<td>0.90% 75 lb.</td>
</tr>
<tr>
<td>5% - 25%</td>
<td>0.27% 22 lb.</td>
</tr>
<tr>
<td>1% - 5%</td>
<td>0.05% 4 lb.</td>
</tr>
<tr>
<td>&gt; 1%</td>
<td>0.01% 1 lb.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total nitrogen, N</td>
</tr>
</tbody>
</table>

Pounds per 8350 lb. (8350 lb ≈ 1,000 gal. ≈ 4¼ tons)
Brief manure nutrient survey
(range of values)

“box-and-whisker” plot

Total nitrogen, N

Pounds per 8350 lb.  (8350 lb ≈ 1,000 gal. = 4¼ tons)
Beef manure nutrient survey

(range of values)

Percent solids

> 50%

25% - 50%

5% - 25%

1% - 5%

< 1%

Total nitrogen, $N$

Pounds per 8350 lb. (8350 lb ≈ 1,000 gal. ≈ 4¼ tons)

ServiTech Laboratories, manure survey, 2006 - 2017
Total nitrogen, N
Organic nitrogen, N

Beef manure nutrient survey
(range of values)

Percent solids

> 50%

25% - 50%

5% - 25%

1% - 5%

< 1%

Pounds per 8350 lb.  (8350 lb ≈ 1,000 gal. ≈ 4¼ tons)
Beef manure nutrient survey
(range of values)

Total nitrogen, N
Organic nitrogen, N
Ammonium-nitrogen, NH$_4$-N

Percent solids

> 50%

25% - 50%

5% - 25%

1% - 5%

< 1%

Pounds per 8350 lb. (8350 lb $\approx$ 1,000 gal. $\approx$ 4½ tons)
Total phosphorus as $\text{P}_2\text{O}_5$

Total nitrogen, N

Beef manure nutrient survey
(range of values)

Percent solids

> 50%

25% - 50%

5% - 25%

1% - 5%

< 1%

Pounds per 8350 lb.  (8350 lb ≈ 1,000 gal. = 4¼ tons)
“... To acquire the carbon and nitrogen a soil microorganism needs to stay alive (body maintenance + energy) it needs a diet with a C:N ratio near 24:1, with 16 parts of carbon used for energy and eight parts for maintenance. ...”
Nitrogen mineralized %

C:N ratio

% $N_{\text{min}} = 60 - (1.5 \times \text{C:N})$

- Young alfalfa hay
- Mature alfalfa hay
- Rye cover crop (anthesis)
- Corn stalks, small grain straw

Vigil & Kissel, 1991, SSSAJ 55:757-761, Fig 3
Nitrogen immobilization vs. temperature

amended with paper mill sludge
C:N ratio ≈ 29:1
(≈ 12% to 13% crude protein)

*amended soil concentration minus unamended soil concentration

Honeycutt et al. 1988, SSSAJ 52:1346-1350, Fig. 6
Nitrogen mineralization vs. temperature

Calendar days
- unamended soil -
Nitrogen mineralization vs. temperature

Degree days
- unamended soil -

Nitrate, ppm NO$_3$-N vs. Degree days

- 86°F
- 77°F
- 68°F
- 64°F
- 61°F
Changing technology – changing productivity

- In both 1970 and 2010, 24 million tons of beef produced in the U.S.
- 1970 ≈ 140 million head of beef
- Today ≈ 90 million head of beef
Changing technology – feedstuff processing

- whole corn
- dry rolled
- steam flaked
- high moisture
Starch disappearance

94% - whole corn
90% - dry rolled
97% - steam flaking
98% - high moisture

100% disappearance

$y = 0.98x$

Starch Intake, g/day

after F. Owens, "Corn Grain Processing and Digestion"
Applied technology – Emissions intensity

kg CO₂eq / $ of output

Ruminant meat
Dairy
Non-ruminant meat

USA  EU27  Brazil  China  India

Changing technology – ration ingredients

**Crude protein, %**
- SOYBEAN MEAL: 8.6
- CORN, WHOLE: 30.3
- DRY DISTILLERS GRAIN: 52.3

**Phosphorus, %**
- SOYBEAN MEAL: 0.28
- CORN, WHOLE: 0.85
- DRY DISTILLERS GRAIN: 0.76
Impact of distillers grains on beef feedlot diets and excreted phosphorus

Dietary phosphorus (% of DM)

- 85% corn, 0% DGS
- 20% DGS
- 40% DGS
- Future (?) 75% DGS and CGF

Retained by animal

Excreted by animal

Animal phosphorus requirement

DGS = distillers grains with solubles
CGF = corn gluten feed

after Regassa, et. al., UN-L Ext. Pub RP190
Impact of distillers grains and agronomic nutrient requirement on land area requirement

Crop-available nutrients produced annually
per 100 head feedlot capacity

After Regassa, et al., UNL Ext. Pub RP190

Acres required per 100 head feedlot capacity

+425%
SUMMARY

• Manure is a waste product, but has resource potentials.
• Changing livestock production efficiencies may change manure volume and/or qualities:
  • Feed processing?
  • Ingredient choices?
  • Improved health?
  • Improved genetics?
  • ........
• Sustainability often requires more -- not less -- application of technology.
  • Laboratory analysis - account for variability?
  • Field data collection – impacts on plant growth, microbial activity?
• Our challenge: balancing economic sustainability objectives vs. environmental/societal sustainability objectives.