Dairy Manure Nutrients: Variable but Valuable

Bill Jokela\textsuperscript{1} and John Peters\textsuperscript{2}

\textsuperscript{1}USDA-Agricultural Research Service, Dairy Forage Research Center, Marshfield/Madison, WI
\textsuperscript{2}Soil Science Dept., Univ. of Wisc, Marshfield/Madison, WI
Manure Management and Nutrient Management Planning

- Maximize utilization of manure nutrients for crop production
- Manage nutrients to prevent adverse impacts on water and air quality
  - Avoid excessive application rates
  - Improve management methods (timing, application techniques, etc.)
- Need to know the nutrient content of manure to be applied
Questions for Today

• What is the nutrient content of dairy manure? How reliable are book values?
• Have there been changes in average nutrient content over the past 10-15 years because of shifts in feeding or other management practices?
• What is the economic value of manure nutrients, especially with recent high fertilizer prices?
• How variable is manure nutrient content? (among farms/within a farm?)
• How important is regular manure sampling and analysis on individual farms?
Recent Long-term Summaries of Dairy Manure Lab Analyses

- **Vermont** (Jokela et al., 2005)
  - Time period: 1992-2006
  - 2366 dairy manure samples
  - University of VT Agricultural and Environmental Testing Lab

- **Wisconsin** (Peters, 2008)
  - Time period: 1998-2008
  - 14,835 dairy manure samples
  - Four WI labs (AgSource, Dairyland, Rock River, and UW Soil and Forage Lab)
Manure Lab Summaries vs. "Book" Values

- Book values: Estimates published in Extension bulletins, etc for use in nutrient management planning
  - WI: Nutrient application guidelines ... UW-Extension Publ. A2809 (Laboski et al., 2006)
  - Extension pubs from other states.
Liquid Dairy Manure Nutrients: Lab Summary vs Book Value

![Graph showing nutrient levels in liquid dairy manure compared to lab and book values for N, P2O5, and K2O.]

- **Lab - WI**
- **Lab - VT**
- **Book-WI**
- **Book - MWPS**

The graph displays the nutrient levels in various forms of liquid dairy manure, comparing lab summary values to book values for N, P2O5, and K2O.
Solid Dairy Manure Nutrients: Lab Summary vs Book Value
Lab Summary vs Book Values

• WI book values (A2809) agree quite well with average lab values for WI and VT
• MWPS book values agree in some cases but are high or low in others
• These are long-term averages... but have there been changes over time?
Liquid Dairy Manure N Content Trend over Time

Vermont, 1992-2006

Wisconsin, 1998-2008
Solid Dairy Manure N Content Trend over Time

Vermont, 1992-2006

Wisconsin, 1998-2008
Liquid Dairy Manure P Content Trend over Time, 1992-2006, VT
Liquid Dairy Manure P Content Trend over Time, 1998-2008, WI
Liquid Dairy Manure and TMR P Content Trend over Time, 1998-2008, WI

![Graph showing the trend of liquid manure and TMR P content over time from 1998 to 2008 in Wisconsin.](image)
Solid Dairy Manure P Content Trend over Time

Vermont, 1992-2006

Wisconsin, 1998-2008
Change over Time: NPK

- **Nitrogen**
  - Little or no consistent change in N content over time (slight decrease in WI?)
  - High year-to-year variability
- **Potassium (not shown)**
  - Variable and no consistent trends
- **Phosphorus**
  - No (WI) or some (VT) decrease in solid manure
  - Significant decrease (25-30%) in liquid manure in VT and WI
  - Parallel decrease in P content of TMR in recent years in WI supports P diet change as cause
Micronutrients in Manure

• Little or no consistent trends in VT samples over time for most micronutrients (Not routinely analyzed in WI labs)

• One noteworthy exception... Copper (Cu)
Liquid Dairy Manure Copper Content Trend over Time, 1992-1998, VT

DM Basis
Liquid Dairy Manure Copper Content Trend over Time, 1992-2006, VT

DM Basis
Solid Dairy Manure Copper Content Trend over Time, 1992-2006, VT

Cu, mg/kg

Year

DM Basis
Variability in Dairy Manure Copper Content (DM basis) 1992-2006, VT

Liquid Manure

Solid Manure
Trends in Cu Content in Dairy Manure

- Dramatic increase in liquid manure in recent years (post-1998) in VT manure samples
  - Average of <100 to >500 mg/kg
  - Some testing in 1000s
- No consistent trend in solid manure
- Attributed to waste copper sulfate foot bath solution discarded into manure pits
- Possible concerns about excessive Cu loading of soil
  - Toxic levels in crop and feed? But Cu binding to soil OM limits plant uptake.
  - Environmental regulations: EPA and state loading limits
  - If high Cu rates applied, monitor manure, soil, and feed.
  - Consider management changes to lower Cu loading from manure.
What is the economic value of nutrients in dairy manure?

- Average nutrient content from 10-year WI lab summary
- Nutrient availability (fertilizer equivalent) estimates from UW Ext publication A2809
- Current fertilizer prices (11/08)
### Nutrient Content and $ Value of Liquid Dairy Manure in WI

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Total</th>
<th>Available</th>
<th>$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/1000 gal</td>
<td>$/1000 gal</td>
<td>$/10,000 gal</td>
</tr>
<tr>
<td>N</td>
<td>22</td>
<td>8.8</td>
<td>7.48</td>
</tr>
<tr>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>8</td>
<td>4.8</td>
<td>4.56</td>
</tr>
<tr>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>19</td>
<td>15.2</td>
<td>11.10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>23.14</td>
<td>230</td>
</tr>
</tbody>
</table>

Nutrient content from WI lab summary and availability from UW Ext A2809 (40, 60, and 80% availability for N, P, and K).
Prices: N, $0.85/lb; P<sub>2</sub>O<sub>5</sub> $0.95/lb; K<sub>2</sub>O. $0.73/lb
Nutrient Content and $ Value of Solid/Semi-solid Dairy Manure in WI

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Total</th>
<th>Available</th>
<th>$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/ton</td>
<td>$/ton</td>
<td>$/20 ton</td>
</tr>
<tr>
<td>N</td>
<td>11</td>
<td>4.4</td>
<td>3.74</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>6</td>
<td>3.6</td>
<td>3.42</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>10</td>
<td>8.0</td>
<td>5.84</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>13.00</td>
<td>260</td>
</tr>
</tbody>
</table>

Nutrient content from WI lab summary and availability from UW Ext A2809. (40, 60, and 80% availability for N, P, and K). Prices: N, $0.85/lb; P$_2$O$_5$ $0.95/lb; K$_2$O. $0.73/lb
Fertilizer $ Value of Dairy Manure

• N value
  - $7.50/1000 gal liquid manure
  - 3.75/ton for solid manure
• N, P, and K (if all needed)
  - $23/1000 gal or $13/ton
• At typical application rates for corn
  - $75 per acre for N
  - Over $200/acre for N, P, and K
• Varies (esp. N) with manure management and availability estimates used.
• But how do book values or lab summary averages compare with actual measured analysis on individual farms?
• OR... How variable are nutrient content values across farms?
Variability of Liquid Manure N
VT Manure Summary, 1992-2006

Mean = 24

Count

Total N, lb/1000 gal

Proportion per Bar
Variability of Liquid Manure P
VT Manure Summary, 1992-2006
Variability of Liquid Manure Nutrients by Farm - Nitrogen

- About 2/3 of samples within 8 lb N (+/-) and 4 lb P$_2$O$_5$ of the mean value.
- But 1/3 were not...
- Assume manure applied at rate to meet 100 lb/acre N need (10, 400 gal /acre) based on average (VT) of 24 lb/1000 gal
  - If actual analysis = 16 (8 lb less), then fertilizer equiv. of 67 lb/acre $\Rightarrow$ N Deficient
  - If actual analysis = 32 (+8 lb), then fertilizer equiv. of 133 lb/acre $\Rightarrow$ Increased leaching potential.
Variability of Liquid Manure Nutrients by Farm - Phosphorus

• Same manure application rate would approximate the P need of 150 bu/A corn crop (55 lb/A) with optimum STP
  - If actual analysis +/- 4 lb /A , then available P would be excess or short 25 lb \( P_2O_5 \)/A.
  - If NM Plan requires P-based rate, then this could result in big difference in application rate (7,000-18,000 gal/acre) and, therefore, land area required.
Variation in Manure Nutrient Content over Time on Same Farm
Examples: 2 Farms in VT over 4 Years

• Most analyses, esp. P, fairly similar over time
• But considerable variation at some sample times
• Need continued sampling and analysis

Jokela et al., 1994.
Value of Manure Book Values and Lab Summaries?

- General guideline only
- Shows trends over time
- Important to sample and analyze manure for individual farm and manure source
  - Sample at time of spreading
  - Multiple years to establish baseline
  - More sampling if change in feed, bedding, storage conditions, etc.
Summary: Dairy Manure Nutrients

• Average nutrient values from WI and VT lab summaries agree well with WI book values, not so well with MWPS values.

• Long-term trends
  - Minimal consistent change for N, K, and most micronutrients
  - P decreased, especially in liquid manure
  - Cu increased in liquid manure
Summary (cont.)

• Manure is valuable as a crop nutrient source
  - At typical application rate, $75/A for N, >$200/A for NPK
• High variability among dairy farms, so regular sampling is essential to maximize nutrient $ value and minimize environmental impact
Institute for Environmental Integrated Dairy Management, Marshfield, WI