Utilization and Remediation Of Manure Nutrient Loaded Soils

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Utilization and Remediation Of Manure Nutrient Loaded Soils

- Utilization of Manure
- Remediation Techniques
Using manure and manure by-products as a soil amendment or nutrient in an environmental responsible manner.

**Why?**

- Protect water quality
- Protect air quality
- Provide fertility for crop, forage, fiber production and forest products
- Improve or maintain soil structure
- Provide a source of energy
If utilized properly, manure is an excellent resource of plant nutrients and soil organic matter. Manure utilization recycles nutrients back to the land.
Potential Farms Needing a CNMP
(257,201 Farms)

Each dot represents 20 farms
U.S. watershed potentially impaired by Animal Manure Nutrient

Figure 1. US watershed potentially impaired by animal manure nutrients (USDA, NRCS, 2000, http://www.nhq.nrcs.usda.gov/land/).
CNMP involves both Strategic Planning and Annual Management

- Treatment of Related Natural Resource Concerns
- **Farm Nutrient Balance**
- Provides a plan for nutrient budgeting based on soil test levels, crops to be grown and yield expectations, other nutrient sources, application area, and waste analysis.
Whole Farm Nutrient Balance

• 11, 500 head feedlot = 650 tons N/yr - 120 tons P/yr
• 190 sow (farrow to finish) = 43 tons N/yr - 4.4 tons P/yr
• 120 Cow dairy = 22.3 tons N/yr - 1.8 tons P/yr

Source - LPES
Whole Farm Nutrient Balance

Figure 2-7. Four strategies are fundamental to addressing nutrient imbalances on modern livestock operations and achieving a sustainable nutrient balance between nutrient inputs and managed outputs.

- **Strategy 1:** Efficient use of manure nutrients in crop production offsets fertilizer inputs.
- **Strategy 2:** Alternative feed rations and efficient utilization of on-farm feeds offsets nutrient inputs as purchased feeds and forages.
- **Strategy 3:** Exporting of manure nutrients to off-farm users increases managed nutrient outputs.
- **Strategy 4:** Manure treatment allows disposal of manure nutrients. Some treatment options enhance the value of manure nutrients and complement manure marketing efforts.
Considerations when utilizing manure on the farm as a soil amendment or nutrient:

- Transportation method
- Calibrate application equipment
- Time applications based on crop need
- Use correct application technique
- Buffers (setbacks)
Considerations when utilizing manure on the farm as a soil amendment or nutrient

Transportation method

• Appropriate for the type (consistency) of manure.
• Controlling leakage or spillage

Calibrate application equipment

• Equipment is appropriate for type of manure (consistency)
• Calibrated to only apply the nutrients needed to produce the desired crop
• Equipment should be checked periodically
Considerations when utilizing manure on the farm as a soil amendment or nutrient

Time applications based on crop need

- To maximize nutrient uptake by a crop,
- Utilize techniques to maximize nutrient retention and availability for the crop (Use cover crop to uptake nutrients in the fall so they will be available to the crop the next spring)
- Local regulations regarding spreading on frozen or snow covered ground.

Use correct application techniques

- Traffic patterns to avoid tracking manure out of the field
- Spreading evenly
- Avoiding overlaps
- Avoiding soil compaction

Buffers

- Using buffers as a way to protect water quality.
Nitrogen in Soils

- Potential pollutant with nitrates in ground and surface water
- N2O is (a potent greenhouse gas and source of ozone depletion) produced during denitrification
- A lot of energy is consumed in producing N
- Higher rates of N is associated with acceleration of decomposition and loss of organic matter
- Very high rates of N are frequently associated with high levels of insect damage. (Preference, antibiosis, and tolerance.)
Figure 1. Total energy directly and indirectly consumed on U.S. farms in 2002 was 1.7 quadrillion Btu.

How many gallons of gas is equal to 1 ton of urea fertilizer

A. 200
B. 102
C. 300
D. 272
Putting Energy in Perspective

1 ton of Urea Fertilizer = 34 million Btu
1 gallon of gas = 125,000 Btu

1 ton of Urea Fertilizer = 272 gallons of gas

Average American commute to work is: 25 miles/day @ 22 mpg
6,000 miles/year/commute = 272 gallons of gas

WalMart Super Center = 187,000 sq ft (3,740,000 cu ft)
1 Super WalMart filled with Natural gas equals amount needed to make 150 units of N (Anhydrous NH₃) for a 1200 acre farm.
U.S= 86.4 million acres of corn (2008)
High Phosphorus in Soils

- Excess application of Fertilizer or more commonly application of lots of manure
- Nutrients in feed exceed the nutrients exported in animal products
- If manure is applied to supply N, than more P will be applied then what is needed.
- Potential environmental pollutant
• Many States and federal agencies set a soil test P limit.
  – For example: Oklahoma NRCS nutrient management guideline, no manure can be land applied if soil test P is over 400 lbs/A
High Phosphorus Soils Strategies

• Balance phosphorus in the Feed Ratio
  – Overfeeding Phosphorus is common in the US. The average dairy herd in US feds 25% more P then recommended (NRC) Impacts - extra cost and potential pollutant

• Apply manure based on sampling and testing
  – Monitoring of Soil P

• Enhance solid separation and Phosphorus removal
  – Gravity and Mechanical Separation
  – Biological removal of P
  – Chemical binding
    • Alum
    • Lime

• Reduce Manure rates, redistribute or export

• Deep Tillage (a one-time tillage to incorporate high P layer)
# Nitrogen versus Phosphorus Soil Management

## Table

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test soil and application rate for N</td>
<td>Test soil and application rate for P</td>
</tr>
<tr>
<td>Use legumes to supply N</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Time application use for use by the plant</td>
<td>Time application to reduce runoff potential</td>
</tr>
<tr>
<td>Use sod crops to reduce N leaching</td>
<td>Use sod crops to reduce runoff</td>
</tr>
<tr>
<td>Reduce N import</td>
<td>Reduce P import</td>
</tr>
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</table>
High Potassium in Soils

• Causes N Deficiency in Plants
• May uptake other positive ions such as Mg and Ca
  – Magnesium deficiency is a cause of Grass Tetany in cattle
• At extremely high levels can cause salinity concerns
  – NCSU has demonstrated that inclusion of K in starter fertilizers could result in salt damage to corn seedlings.
Using plant species that preferentially bioaccumulate nutrients or metals and use of deep-rooted crops in novel rotations for subsurface nitrate-N recovery is the definition of

A. Soil and manure amendments
B. Phytoremediation
C. Deep mechanical tillage
D. None of the above
Potential Remedial Techniques

- **Phytoremediation** (P, nitrate, metals) with plant species that preferentially bioaccumulate nutrients or metals and use of deep-rooted crops in novel rotations for subsurface nitrate-N recovery

- **Soil and manure amendments** with P immobilization chemicals and municipal or industrial byproducts to reduce dissolved reactive P and metal bioavailability (water treatment residuals, aglime, coal combustion by-products)

- **Addition of soil aggregation promoters**, coagulants or flocculants such as polyacrylamide polymers to reduce sediment and particulate nutrient offsite discharges (organic matter, N, P, metals);

- **Deep mechanical tillage** to dilute near-surface zone elevated nutrient concentrations and reduce odor emissions (P, metals, odor, trace greenhouse gases)

- **Conservation Practices** to remove dissolved reactive P from runoff and reduce edge-of-field losses of sediments and particulate nutrients and metals.
**Phytoremediation**: Using plants that preferentially bioaccumulate nutrients (N, P) and metals from soils.

Use Plant-extracted Nutrients as Sources of Dietary Minerals: Canola: Good for reducing soils high in Se

Bunuelos and Maryland 2000
Phytoremediation: Using plants that preferentially bioaccumulate nutrients (N, P) and metals from soils.

1. *Crop Rotations.* Temporal diversity incorporated into cropping systems, providing crop nutrients and breaking the life cycles of several insect pests, diseases, and weed life cycles (Sumner 1982).
2. **Polycultures.** Complex cropping systems in which two or more crop species are planted within sufficient spatial proximity to result in competition or complementation, thus enhancing yields (Francis 1986, Vandermeer 1989).
3. **Agroforestry Systems.** An agricultural system where trees are grown together with annual crops and/or animals, resulting in enhanced complementary relations between components increasing multiple use of the agroecosystem (Nair 1982)
4. **Cover Crops.** The use of pure or mixed stands of legumes or other annual plant species for the purpose of improving soil fertility, enhancing biological control of pests, and modifying the orchard microclimate (Finch and Sharp 1976).
Change in soil test P with P input or removal is well correlated.

- Approximately 14 lb P$_2$O$_5$ is required to raise or lower soil test P (STP) 1 unit (dependent on pH, texture, OM, and other soil properties—also depends on source—manure or biosolids).

Figure 2. Changes in soil test P resulting from 27 years of fertilizer input and wheat grain removal at Lahoma, OK. (The net P$_2$O$_5$ is the difference of total P fertilizer applied to the plots and P removed from plots as wheat grain; no other possible losses are considered.)

Agriculture Experiment Station, Lahoma Oklahoma
Phytoremediation: It is not a quick fix, but an overall management approach

Figure 3. Predicted number of years needed to decrease soil test P by 100 lbs/A (Mehlich-3 extraction) with different amounts of forage harvested annually (assume 14 lbs of P₂O₅ changes soil test P by 1).
Dry Matter mineral nutrient composition of selected hays

<table>
<thead>
<tr>
<th>Species</th>
<th>N %</th>
<th>P² %</th>
<th>K² %</th>
<th>Ca %</th>
<th>Mg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>2.8</td>
<td>0.35</td>
<td>2.20</td>
<td>1.80</td>
<td>0.26</td>
</tr>
<tr>
<td>Annual ryegrass</td>
<td>3.4</td>
<td>0.34</td>
<td>2.80</td>
<td>0.65</td>
<td>0.35</td>
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<tr>
<td>Bermudagrass</td>
<td>2.5</td>
<td>0.28</td>
<td>1.80</td>
<td>0.37</td>
<td>0.15</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>2.9</td>
<td>0.54</td>
<td>3.58</td>
<td>0.58</td>
<td>0.31</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>2.0</td>
<td>0.20</td>
<td>2.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Red clover</td>
<td>2.6</td>
<td>0.25</td>
<td>1.62</td>
<td>1.53</td>
<td>0.43</td>
</tr>
<tr>
<td>Smooth bromegrass</td>
<td>3.4</td>
<td>0.45</td>
<td>3.20</td>
<td>0.55</td>
<td>0.32</td>
</tr>
<tr>
<td>Sorghum/sudangrass</td>
<td>1.6</td>
<td>0.18</td>
<td>1.80</td>
<td>0.48</td>
<td>0.30</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>2.3</td>
<td>0.37</td>
<td>2.00</td>
<td>0.51</td>
<td>0.19</td>
</tr>
<tr>
<td>White clover</td>
<td>3.5</td>
<td>0.31</td>
<td>2.62</td>
<td>1.35</td>
<td>0.48</td>
</tr>
</tbody>
</table>


²P₂O₅ = 2.29 × P; K₂O = 1.2 × K
Nutrient removal under grazing systems:

Table 3. Approximate quantities of nutrients removed under grazing and haying systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Nutrient Removal (lbs/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Grazing¹</td>
<td>12.5</td>
</tr>
<tr>
<td>Bermudagrass²</td>
<td>250</td>
</tr>
<tr>
<td>Orchardgrass³</td>
<td>174</td>
</tr>
</tbody>
</table>

¹Assumes 1,500 lb calf on 1 acre on a year-round basis.
²Assumes 5-ton/A yield with all forage removed as hay crop.
³Assumes 3-ton/A yield with all forage removed as hay crop.
Remediation Options

• **Deep mechanical tillage** to dilute near-surface zone elevated nutrient concentrations and reduce odor emissions (P, metals, odor, trace greenhouse gases)

• **Conservation Practices**
  
  Use of conservation practices such as residue management, buffers, crops rotations, etc to reduce runoff and reduce edge-of-field losses of sediments.
Whole Farm Approach

- Protect water quality
- Protect air quality
- Provide fertility for crop, forage, fiber production and forest products
- Improve or maintain soil structure
- Provide feedstock for livestock
- Provide a source of energy
What element makes up the majority of the air in Earth’s atmosphere?

A. Neon
B. Argon
C. Nitrogen
D. Hydrogen
Questions ???