Soluble Calcium Amendment: Co-Application with Poultry Litter to Reduce P Loss Following Surface Application

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National Soil Dynamics Laboratory
Benefits of Gypsum

• Improve soil properties
  – Improve water infiltration
  – Control soil erosion and crusting

• Reduce contaminates in water runoff.
Water Quality

• What is quality of water in the U.S.
  * 45% of river miles are impaired
  * 47% of lake acres,
  * 32% of estuarine water is impaired.

• Agriculture is considered to be one of the major contributors to water quality

• Phosphorus loss from agriculture

• Poultry Industry
  – Improper disposal of waste from poultry industry
Gypsum Interaction with Soluble P

- Formation of an insoluble Ca-phosphate complex
- Insoluble hydroxyapatite and fluorapatite

Orthophosphate $\text{PO}_4^{3-}$

$\text{Ca}_5(\text{PO}_4)_3(\text{OH})$

$\text{Ca}_5(\text{PO}_4)_3\text{F}$
ARS Multi Location Gypsum study

Use of FGD Gypsum to Improve Crop and Forage Production and reduce P loss on Erodible Soils of the South

Research Goals

• Establish rates of FGD gypsum and poultry litter
• Document improvements in water quality
• Develop guidelines for use of FGD gypsum
USDA-ARS  J. Phil Campbell Sr. Natural Resource Conservation Center, Watkinsville, GA
    Harry Schomberg – Pasture
    Dinku Endale

USDA-ARS National Soil Dynamics Laboratory, Auburn, AL
    Dexter Watts - Pasture
<table>
<thead>
<tr>
<th>Gypsum (tons/acre)</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
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<tr>
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<td>0-2</td>
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Rainfall Simulations
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<tbody>
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<td>0-4</td>
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<td>4-0</td>
<td>4-2</td>
<td>4-4</td>
<td>4-6</td>
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</tbody>
</table>
Time samples - 0, 10, 20, 30, 40, 50, 60
Cumulative samples
Unfiltered – Total nutrient
Filtered - Dissolved
Runoff

- 2 tons Gyp
- 6 tons PL

- 0 tons Gyp
- 6 tons PL
Runoff as % of Rainfall

Watkinsville 2012
Runoff

concentration (μg/ml)

Calcium

Poultry Litter

FGD Gypsum

0 0 6 6 6 6

4 0 1 2 4
Soluble P in Runoff

<table>
<thead>
<tr>
<th></th>
<th>Poultry Litter</th>
<th>Gypsum</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>0.5</td>
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<tr>
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<tr>
<td>3.5</td>
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</tbody>
</table>

P (μg/ml)
Soluble Reactive Phosphorus (mg L$^{-1}$) vs. FGD Gypsum (Mg ha$^{-1}$) for Initial Runoff in the Worst Case.
Soluble Reactive Phosphorus (mg L$^{-1}$) vs. FGD Gypsum (Mg ha$^{-1}$) for Initial Runoff (Worst Case)
Cumulative

Initial Runoff

Worst Case

Soluble Reactive Phosphorus (mg L\(^{-1}\))

FGD Gypsum (Mg ha\(^{-1}\))

\[ r^2 = 0.642 \]

58% reduction
Soluble Reactive Phosphorus (mg L\(^{-1}\)) vs. FGD Gypsum (Mg ha\(^{-1}\))

Six Weeks Runoff
After 5 inches

Graph Title

Y-axis: Soluble Reactive Phosphorus (mg L\(^{-1}\))
X-axis: FGD Gypsum (Mg ha\(^{-1}\))

Legend:
- 10 min
- 30 min
- 60 min
Six Weeks Runoff
After 5 inches

Cumulative Soluble Reactive Phosphorus (mg L\(^{-1}\))

FGD Gypsum (Mg ha\(^{-1}\))

\(r^2 = 0.913\)

50% reduction
Cumulative

Soluble Reactive Phosphorus (mg L$^{-1}$)

FGD Gypsum (Mg ha$^{-1}$)

34% reduction

End of Season Runoff
Percent soluble P reduction

Rate of gypsum Mg ha$^{-1}$

Percent reduction

- 0 + buffer
- 1 + buffer
- 3.2 + buffer
- 5.6 + buffer
Runoff

<0.50 μg/L

<table>
<thead>
<tr>
<th></th>
<th>Mercury</th>
<th>Poultry Litter</th>
<th>FGD Gypsum</th>
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</thead>
<tbody>
<tr>
<td>concentration</td>
<td></td>
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<tr>
<td>(μg/L)</td>
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## Not Detected

<table>
<thead>
<tr>
<th>Arsenic</th>
<th>Cobalt</th>
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<tbody>
<tr>
<td>Aluminum</td>
<td>Lead</td>
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<tr>
<td>Antimony</td>
<td>Nickel</td>
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<tr>
<td>Barium</td>
<td>Selenium</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Silver</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Thallium</td>
</tr>
<tr>
<td>Chromium</td>
<td>Vanadium</td>
</tr>
</tbody>
</table>

\[ \approx <50 \, \mu g/L \]
Not Detected

Dissolved Arsenic
Dissolved Aluminum
Dissolved Antimony
Dissolved Barium
Dissolved Beryllium
Dissolved Cadmium
Dissolved Chromium
Dissolved Cobalt
Dissolved Copper
Dissolved Lead
Dissolved Potassium
Dissolved Selenium
Dissolved Silver
Dissolved Sodium
Dissolved Thallium
Dissolved Vanadium
Dissolved Zinc
Kitchen Sink

≈ <50 μg/L
Gypsum Use to Reduce P Loss From Agricultural Fields
2013

Bulletin No. 680
Alabama Agricultural Experiment Station, 2013
William Batchelor, Director
Auburn University
Auburn, AL

FGD Gypsum may be stockpiled at the edge of the field until ready to spread.

In cooperation with the Alabama Cooperative Extension System (Alabama A&M University and Auburn University)
Reiterated manure use on agricultural fields at agronomic N rates has created a redistribution of P in soils which increases the risk of P contribution to surface waters. If manure use continues at current rates, refined prescriptions will be needed to reduce and prevent P losses from deteriorating surface water quality. **Gypsum** use as a soil amendment seems promising as a **BMP to reduce P losses** from agricultural fields.
Recommendations

Where P application rate or P application method will create an unacceptable risk for runoff according to the Alabama P index, either agricultural or FGD gypsum may be used as a BMP at the time of P application. A recommended rate of 2 ton/acre is needed to obtain the greatest benefit of reducing the threat of P loss from pastures fertilized with poultry litter.
Phosphorus Index for Alabama
A Planning Tool to Assess & Manage P Movement
Source Characteristics
Soil test P
P application rate
Application method
(surface vs. incorporated)
Grazing animals

Transport Characteristics
Underground outlet systems
Erosion rate
Hydrologic soil group
Field slope
Application distance to water
Filter strips width

Receiving Water Characteristic
Impaired or Outstanding Waters
Other Practices that May Reduce Risk

Reduced tillage systems and cover crops to reduced runoff

Implementation of intensive grazing systems to reduced runoff

Use of precision application equipment to increase the accuracy of applications

Application of other products with the litter that may reduced P loss risk
3. Nutrient Application Method considers the manner that phosphate fertilizer or organic P is applied to the site and the amount of time that the P fertilizer or organic P is exposed on the soil surface. Injection implies that the fertilizer P is buried below the soil’s surface at a minimum depth of two inches. Incorporation is the mixing of the P into the surface portion of soil. Surface applied manure or litter that has been treated with chemicals to reduce P solubility or the field has applications of gypsum at the same time as the manure/litter application should be considered as incorporated. Both chemical treatments and gypsum application should be done in accordance with Alabama Cooperative Extension Systems recommendations for reducing P solubility.
## Alabama P-Index

**Field Features & Management Practices**

<table>
<thead>
<tr>
<th>Source Characteristics</th>
<th>Value Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STP Test P Value</strong></td>
<td>Very Low / Low</td>
</tr>
<tr>
<td><strong>P Application Rate (lbs. P₂O₅/acre/year)</strong></td>
<td>---</td>
</tr>
<tr>
<td><strong>Precision Application</strong></td>
<td>---</td>
</tr>
<tr>
<td><strong>Phosphorus Application Method</strong></td>
<td>Injected deeper than 2&quot;</td>
</tr>
<tr>
<td><strong>Grazing Animals</strong></td>
<td>None</td>
</tr>
</tbody>
</table>

**Transport Characteristics**

| **Underground Outlet Systems** | None | Runoff passes through a filter strip before leaving the system | Outlets empty into grass waterways | < 30% of field has outlets emptying into drainageways | > 30% of field has outlets emptying into drainageways or waterbodies |
| **Erosion Rate (tons/acre)** | < 3 tons | 3-5 tons | 5-10 tons | 10-15 tons | > 15 tons |
| **Hydrologic Soil Group** | Common Soil Health | A | B | C | D |
| **Improved Soil Health** | A | B | C | D |
| **Field Slope (%)** | < 1% | 1-3% | 3-5% | 5-8% | > 8% |
| **P Application Distance to Water (ft)** | > 400 ft. | 201-400 ft. | 101-200 ft. | 50-100 ft. | < 50 ft. |
| **Vegetative Buffer Width (ft)** | ≥ 50 ft. or not required | 30-49 ft. | 20-29 ft. | 10-15 ft. | < 10 ft. |

**Receiving Water Categories**

| **Impaired, Outstanding, or Critical Habitat Waters** | Field not in watershed | > 400 ft. | 201-400 ft. | 101-200 ft. | < 100 ft. |
Conclusion

• Gypsum should be considered as a Best Management Practice for reducing Soluble P losses when Co-Applied with Poultry Litter.