Does gypsum reduce P losses in an agricultural catchment?
The Trap project
Novel gypsum-based products for farm-scale P trapping

- **Aim**: To reduce P losses from agricultural hot spots areas
  - Field runoff (gypsum used as a soil amendment)
  - Manure (gypsum used to precipitate P in liquid manure)
- **Duration**: 2008 – 2011
- **Funding**: Yara International ASA & Finnish Funding Agency for Technology and Innovation (Tekes)
- **Partners**
  - SYKE Finnish Environment Institute
  - MTT Agrifood Research Finland
  - TTS Work Efficiency Institute
  - Luode Consulting Ltd.
  - Water Protection Association of The River Vantaa and Helsinki region
- [www.yara.com/sustainability/sustainable_agriculture/Environmental_research](http://www.yara.com/sustainability/sustainable_agriculture/Environmental_research)
Hypothesis

- Easily soluble gypsum (CaSO$_4 \cdot 2$H$_2$O)
  - Increases the ionic strength and the concentration of Ca$^{2+}$ in soil solution

- Resulting in
  - Aggregation of fine clay particles $\rightarrow$ Lower erosion and the losses of particulate P
  - Suppression of P desorption by water $\rightarrow$ Lower losses of dissolved P

E.g. Aura et al. (2006)
1. Upper reaches, no fields

2. Middle reaches
40 ha fields (23%)

2.45 km²

3. Lower reaches
101 ha fields (41%)

Autumn ploughing
Reduced tillage
Direct drilling

Cereals, cabbage, grass

Clayey soils

Map: Elina Jaakkola, Photos: Petri Ekholm
4 t ha$^{-1}$ of gypsum applied in autumn 2008

Photos: Pasi Valkama, Petri Ekholm
Turbidity in the stream before gypsum

On-line continuous monitoring by a YSI 600 OMS sensor

<table>
<thead>
<tr>
<th>Site</th>
<th>Turbidity (NTU)</th>
<th>Runoff (l/s)</th>
<th>Regression Equation</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Site</td>
<td></td>
<td></td>
<td>y = 3.3x - 18</td>
<td>0.36</td>
</tr>
<tr>
<td>Central Site</td>
<td></td>
<td></td>
<td>y = 2.3x - 10</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Turbidity in the stream after gypsum

On-line continuous monitoring by a YSI 600 OMS sensor
Quantifying the effect of gypsum on P losses

1. Transformation of on-line turbidity values into concentrations of particulate P

\[
\text{Part. P} = 1.39 \cdot \text{Turbidity} + 6.92 \\
\] \[r^2 = 0.94\]
Quantifying the effect of gypsum on P losses

2. Calculating the relationship between flow and particulate P before and after gypsum by the analysis of covariance
Quantifying the effect of gypsum on P losses

3. Multiplying the estimated concentrations of particulate P by the observed flow in 2008–2010
’Simulated’ flux of particulate P in 2008–2010

<table>
<thead>
<tr>
<th>Particulate P</th>
<th>Lower site</th>
<th>Central site</th>
</tr>
</thead>
<tbody>
<tr>
<td>No gypsum</td>
<td>490 kg</td>
<td>180 kg</td>
</tr>
<tr>
<td>Gypsum</td>
<td>170 kg</td>
<td>75 kg</td>
</tr>
<tr>
<td>Reduction</td>
<td>64%</td>
<td>59%</td>
</tr>
</tbody>
</table>
What happened to dissolved reactive P?

Flow-weighted mean 62 µg/l

Flow-weighted mean 35 µg/l
Comparison of the relationship between turbidity and flow

Reference catchment - No gypsum*

*Data: Water Protection Association of The River Vantaa and Helsinki region

Map: Elina Jaakkola
Before gypsum - Spring 2007

Reference catchment

\[ y = 5.5x + 17 \]
\[ r^2 = 0.64 \]

Nummenpää research site

\[ y = 8.6x - 18 \]
\[ r^2 = 0.50 \]

After gypsum - Autumn 2009

Reference catchment

\[ y = 6.7x + 14 \]
\[ r^2 = 0.72 \]

Nummenpää research site

\[ y = 1.1x + 19 \]
\[ r^2 = 0.07 \]
Soil sampling

<table>
<thead>
<tr>
<th>Means</th>
<th>P (mg/l)</th>
<th>pH</th>
<th>EC (g/l)</th>
<th>Ca (g/l)</th>
<th>K (g/l)</th>
<th>Mg (g/l)</th>
<th>S (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before gypsum</td>
<td>40.5</td>
<td>6.86</td>
<td>1.7</td>
<td>4.35</td>
<td>0.29</td>
<td>0.41</td>
<td>34.5</td>
</tr>
<tr>
<td>After gypsum 1</td>
<td>40.2</td>
<td>6.87</td>
<td>2.2</td>
<td>4.36</td>
<td>0.30</td>
<td>0.42</td>
<td>77.0*</td>
</tr>
<tr>
<td>After gypsum 2</td>
<td>40.4</td>
<td>6.82</td>
<td>2.9***</td>
<td>4.96</td>
<td>0.32</td>
<td>0.42</td>
<td>87.0**</td>
</tr>
</tbody>
</table>

*Significant at 0.05 level
**Significant at 0.01 level
***Significant at 0.001 level
How long does the effect of one gypsum application last?

- After the first 2 years, about 23% of gypsum was lost, i.e. more than 75% still remains in the soil.
Does the cure have side-effects?

- Finnish igneous apatite does not contain Cd or radioactivity
- But contains fluoride
  - No increase in F⁻ concentration in runoff
- No negative effect on yields
- No difference in soil test P or Mg
- No difference in N losses
- Clear increase in SO₄ losses
Sulphate-mediated eutrophication

Preliminary conclusions

- Surface application of gypsum (4 tons per hectare) appears to have reduced the loss of P on a clayey catchment
  - In accordance with the laboratory studies made at MTT
- Duration of the effect?
- Effect under different conditions?
- Restriction: may not be suitable in areas with sulphate-poor fresh waters
Thanks to

Elina Jaakkola, Jouni Lehtoranta, Sirkka Tattari, Ljudmila Vesikko (Finnish Environment Institute)

Liisa Pietola (Yara International ASA)

Mikko Kiirikki (Luode Consulting Ltd)

Sakari Alasuutari (TTS Work Efficiency Institute)

Kirsti Lahti, Pasi Valkama (Water Protection Association of The River Vantaa and Helsinki region)
Poster presentations related to Trap project

- Hämäläinen, Kulokoski, Pietola: *Gypsum effects on soil characteristics and phosphorus sorption*

- Pietola, Kulokoski: *Gypsum effects on percolated water characteristics at various soil P status*

- Uusitalo, Ylivainio, Nylund, Pietola, Turtola: *Rainfall simulations of Jokioinen clay soils amended with gypsum to decrease soil losses and associated P transfer*

- Valkama, Lahti, Särkelä: *Applying on-line monitoring for quantification of diffuse load*