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Does gypsum reduce P losses in an agricultural catchment?

The Trap project

Novel gypsum-based products for farm-scale P trapping

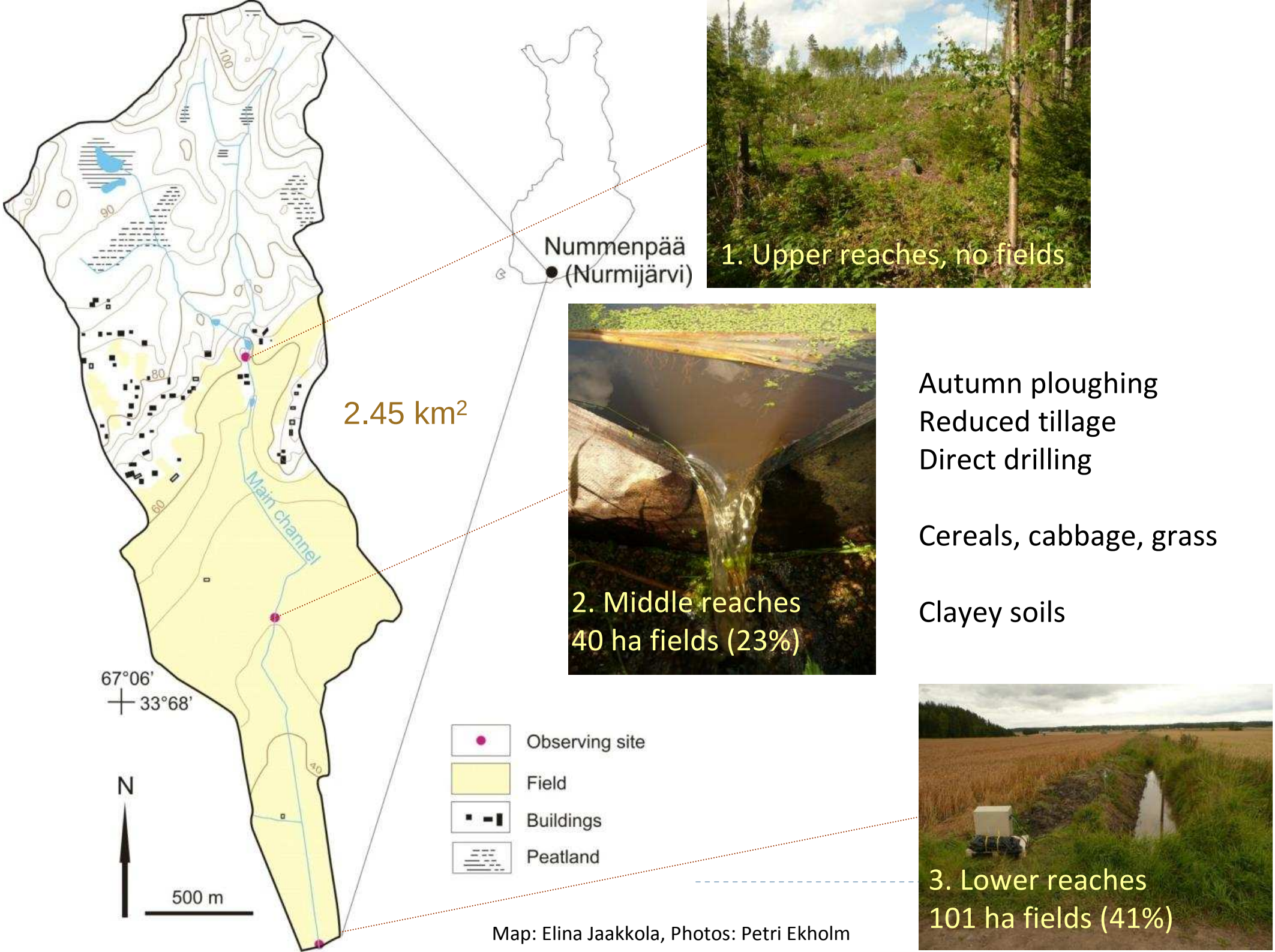
- **Aim**: To reduce P losses from agricultural hot spots areas
- – Field runoff (gypsum used as a soil amendment)
- – Manure (gypsum used to precipitate P in liquid manure)
- **Duration**: 2008 – 2011
- **Funding**: Yara International ASA & Finnish Funding Agency for Technology and Innovation (Tekes)
- **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

Hypothesis

- Easily soluble gypsum ($CaSO_4 \cdot 2H_2O$)
  - Increases the ionic strength and the concentration of Ca^{2+} in soil solution

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

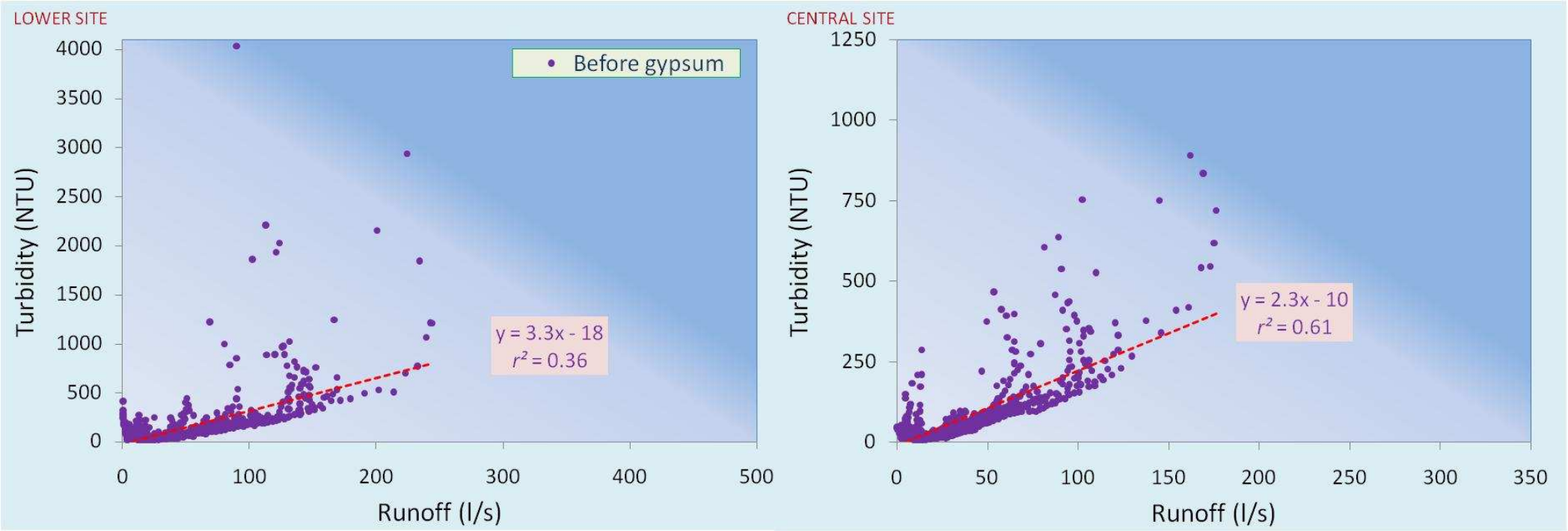
e.g. Aura et al. (2006)


Nummenpää
(Nurmijärvi)
2.45 km²
Main channel
67°06'
33°68'
N
500 m
Observing site
Field
Buildings
Peatland
1. Upper reaches, no fields
2. Middle reaches
40 ha fields (23%)
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

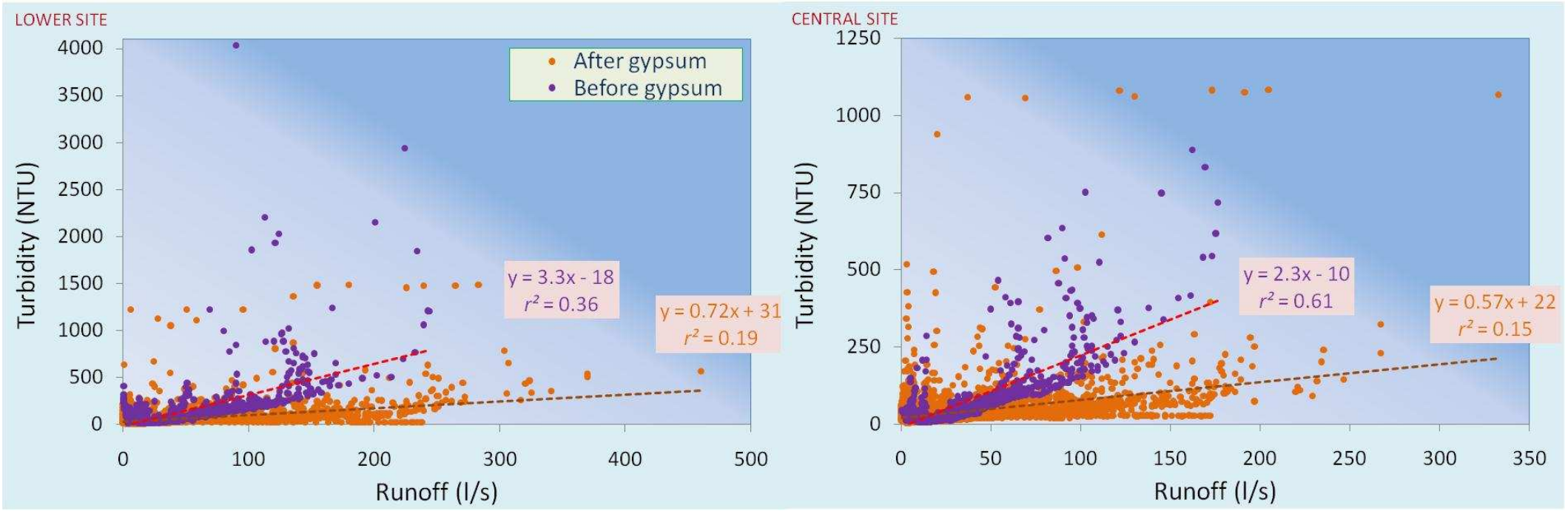
Photos: Pasi Valkama, Petri Ekholm

Turbidity in the stream before gypsum

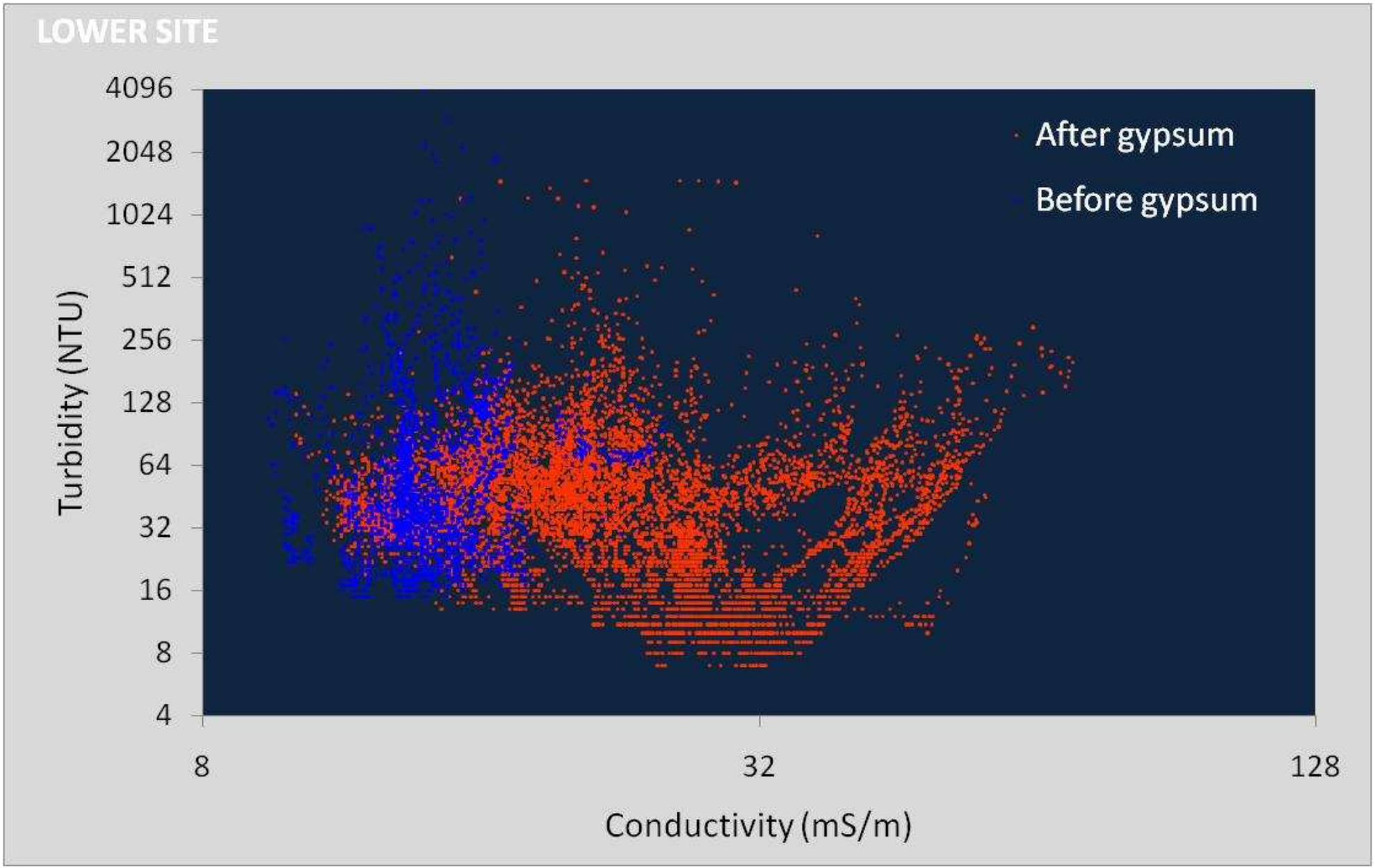


On-line continuous monitoring by a YSI 600 OMS sensor

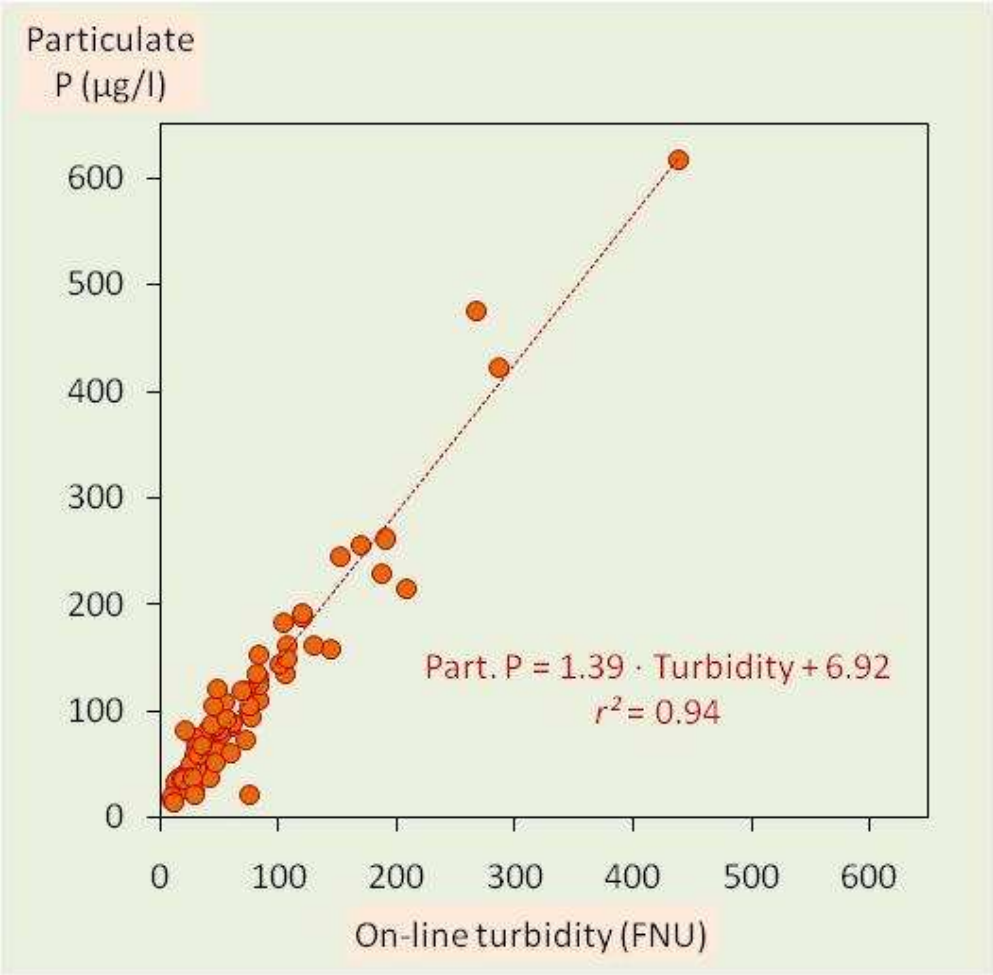
Turbidity in the stream after gypsum



On-line continuous monitoring by a YSI 600 OMS sensor

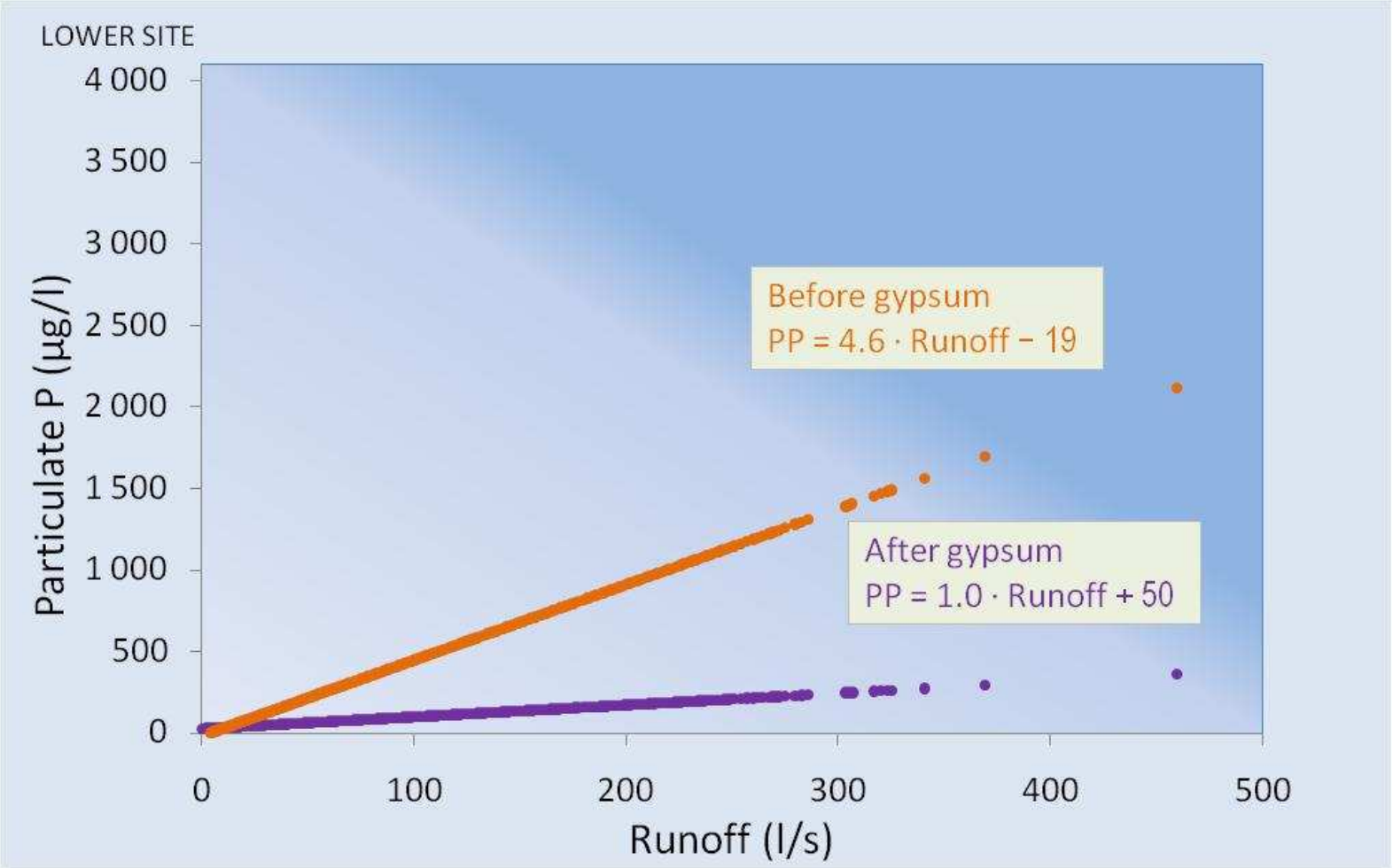

LOWER SITE
4096
2048
1024
512
256
128
64
32
16
8
4
Turbidity (NTU)
After gypsum
Before gypsum
8
32
128
Conductivity (mS/m)

Quantifying the effect of gypsum on P losses



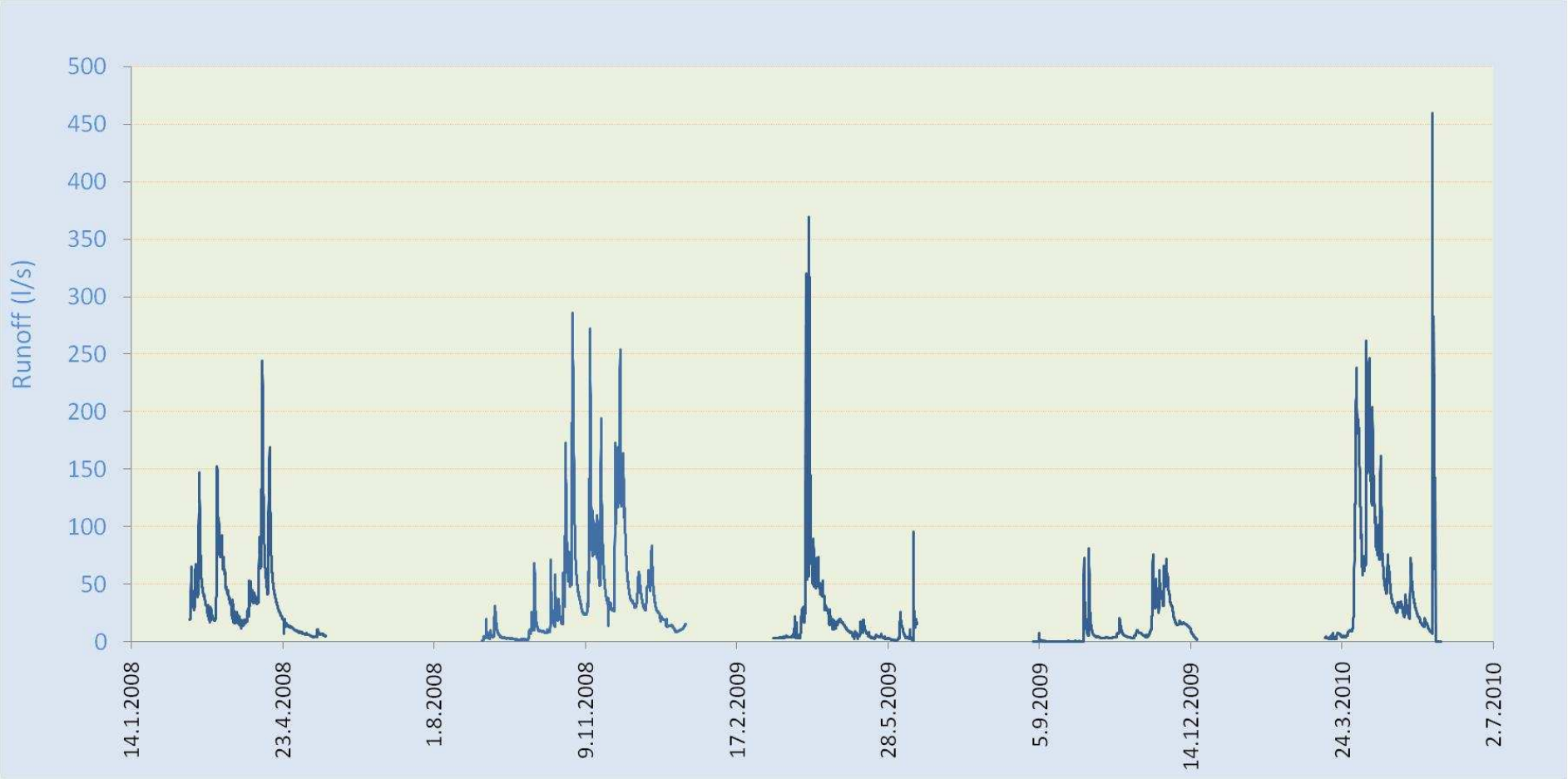
1. Transformation of on-line turbidity values into concentrations of particulate P

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

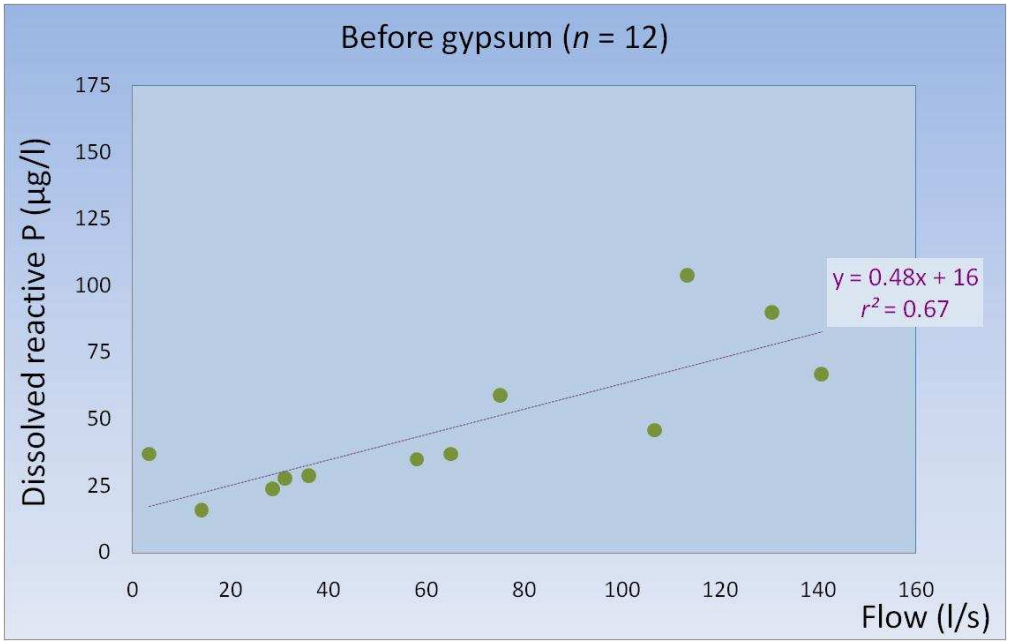
Quantifying the effect of gypsum on P losses



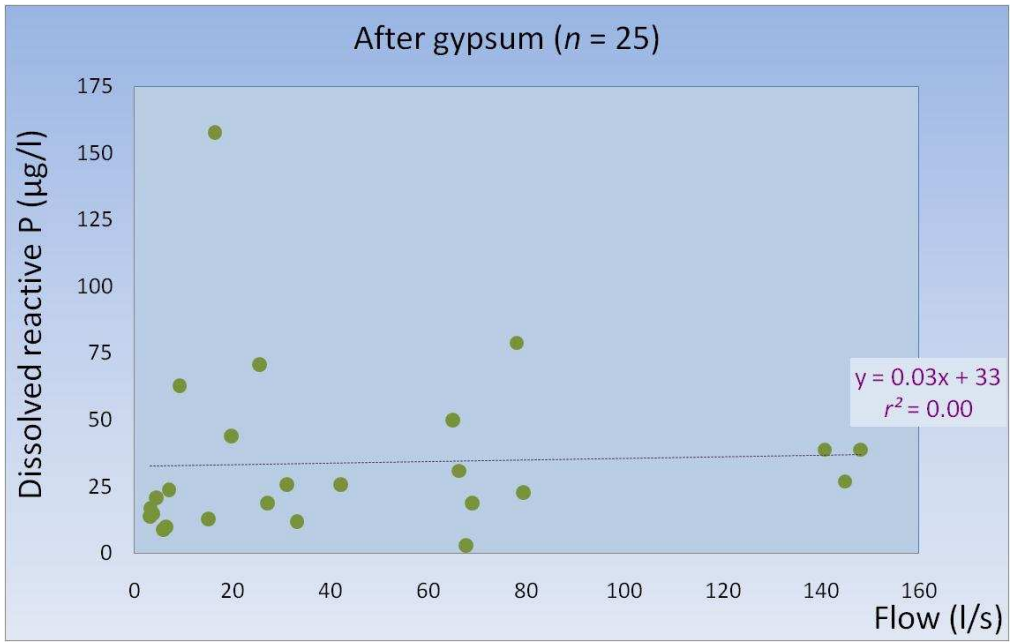
3. Multiplying the estimated concentrations of particulate P by the observed flow in 2008–2010

’Simulated’ flux of particulate P in 2008–2010

Particulate P	Lower site	Central site
No gypsum	490 kg	180 kg
Gypsum	170 kg	75 kg
Reduction	64%	59%

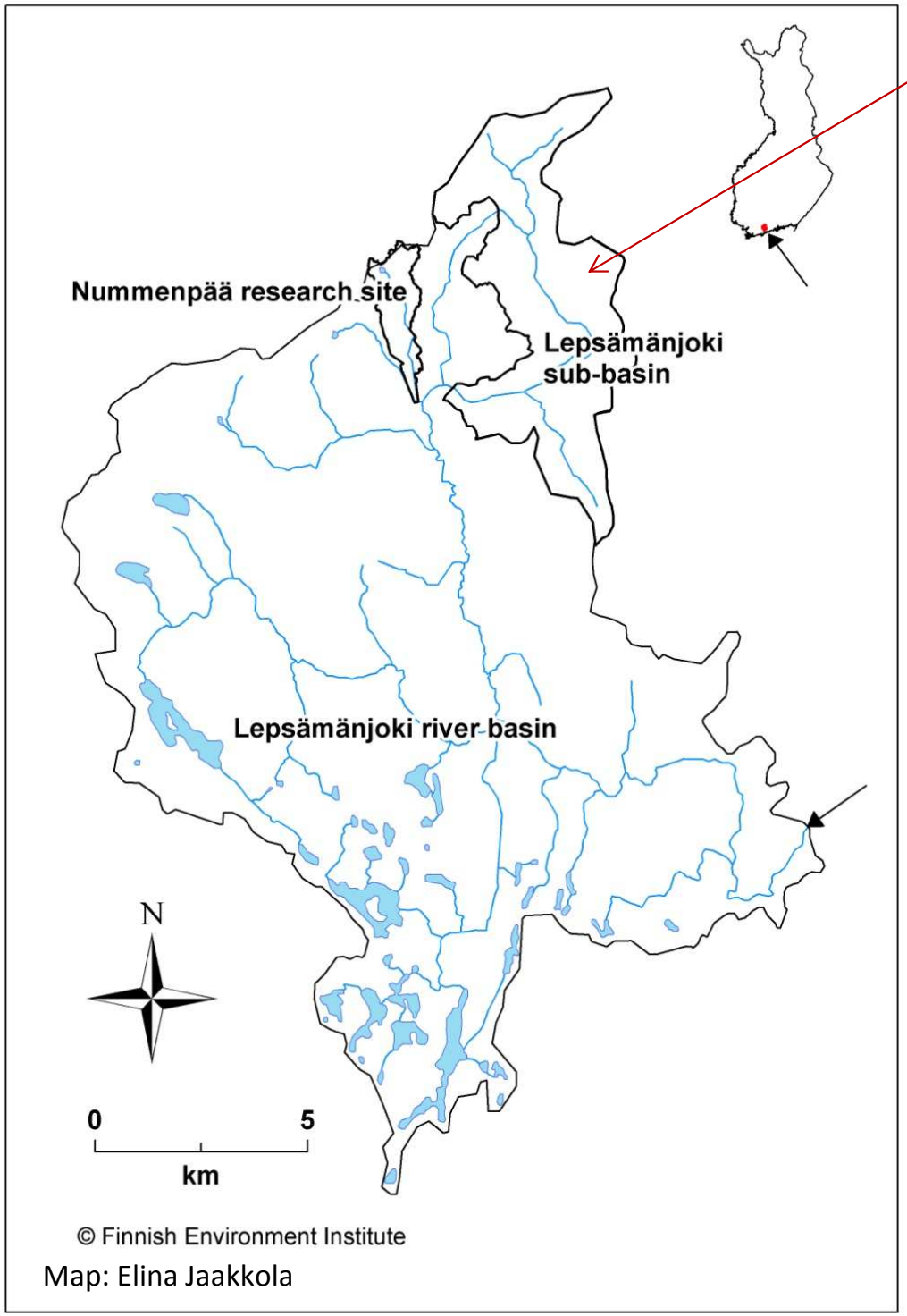


Flow-weighted mean 62 µg/l



Flow-weighted mean 35 µg/l

What happened to dissolved reactive P?



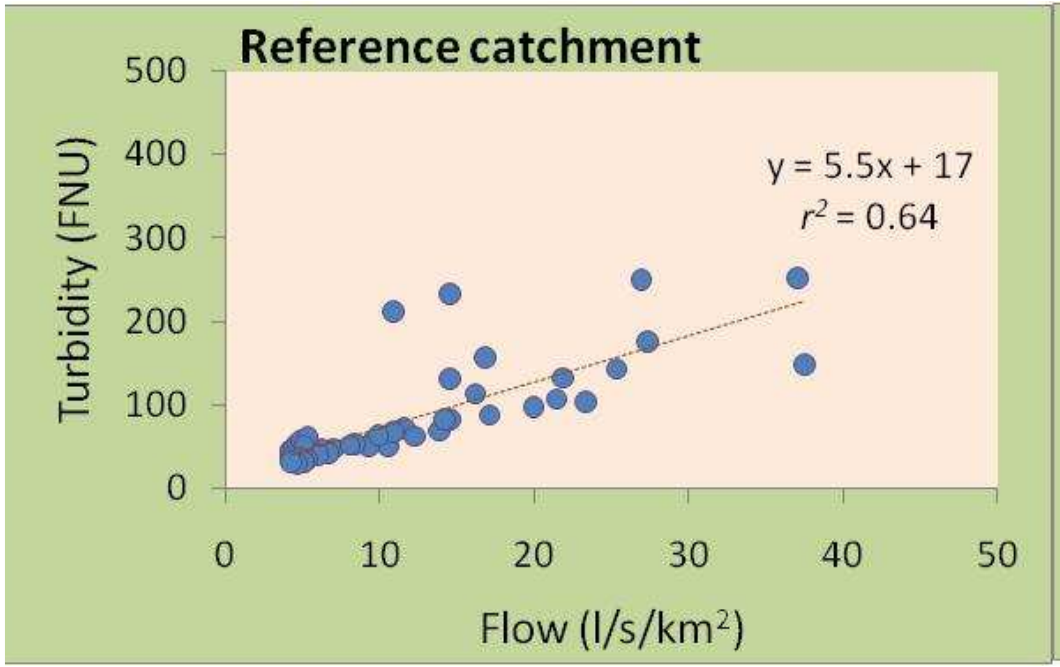
Map: Elina Jaakkola

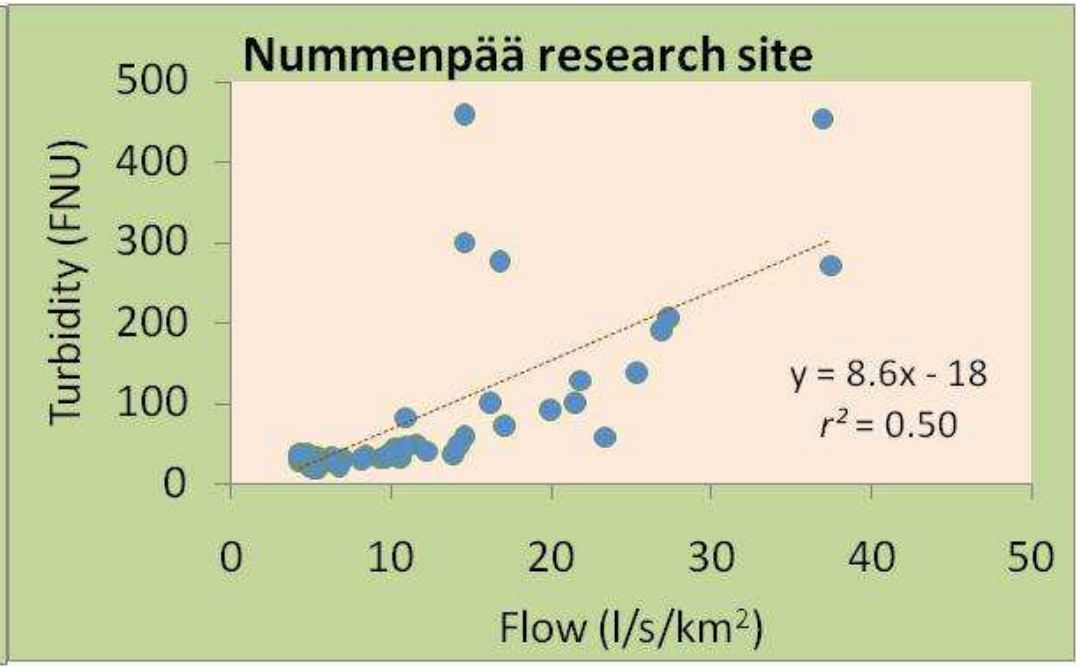
Reference catchment
- No gypsum*

- Comparison of the relationship between turbidity and flow

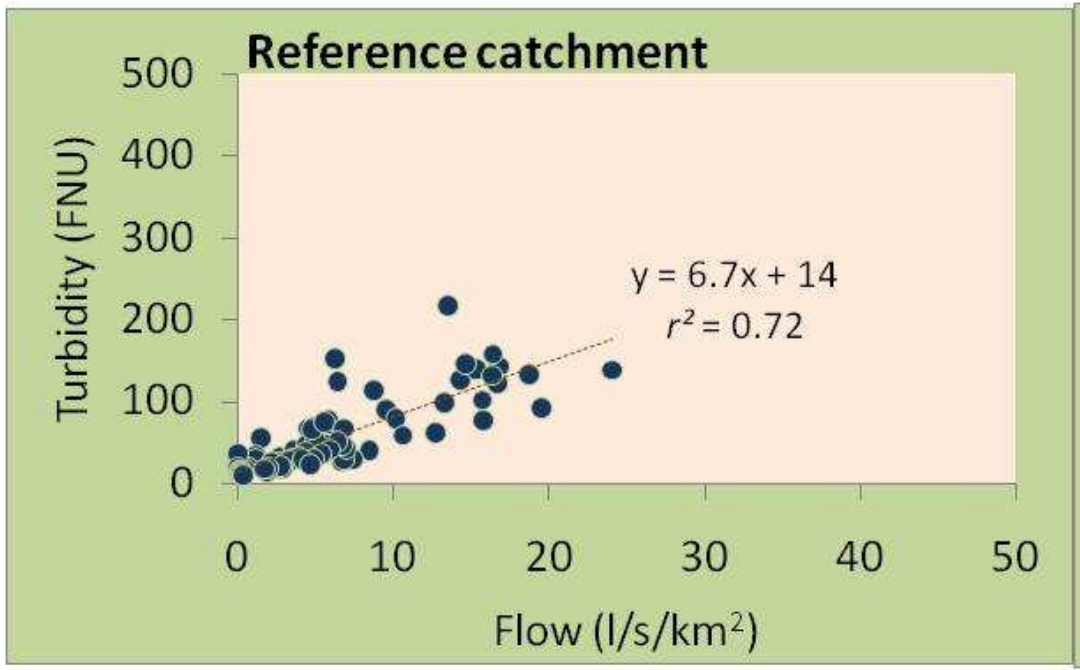
*Data: Water Protection Association of The River Vantaa and Helsinki region

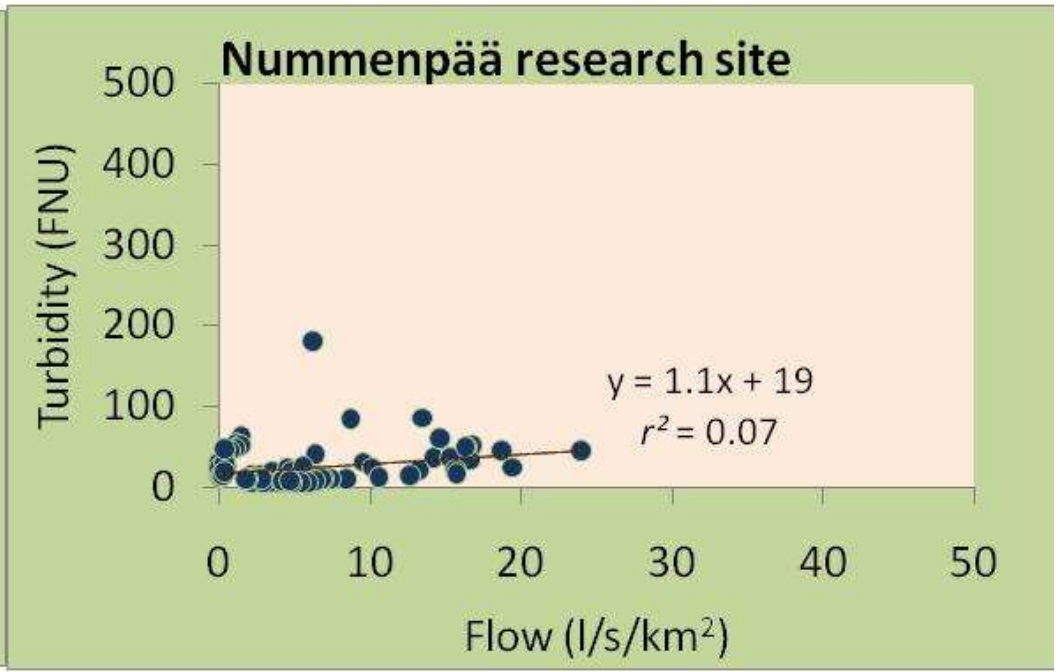
Before gypsum - Spring 2007





After gypsum - Autumn 2009



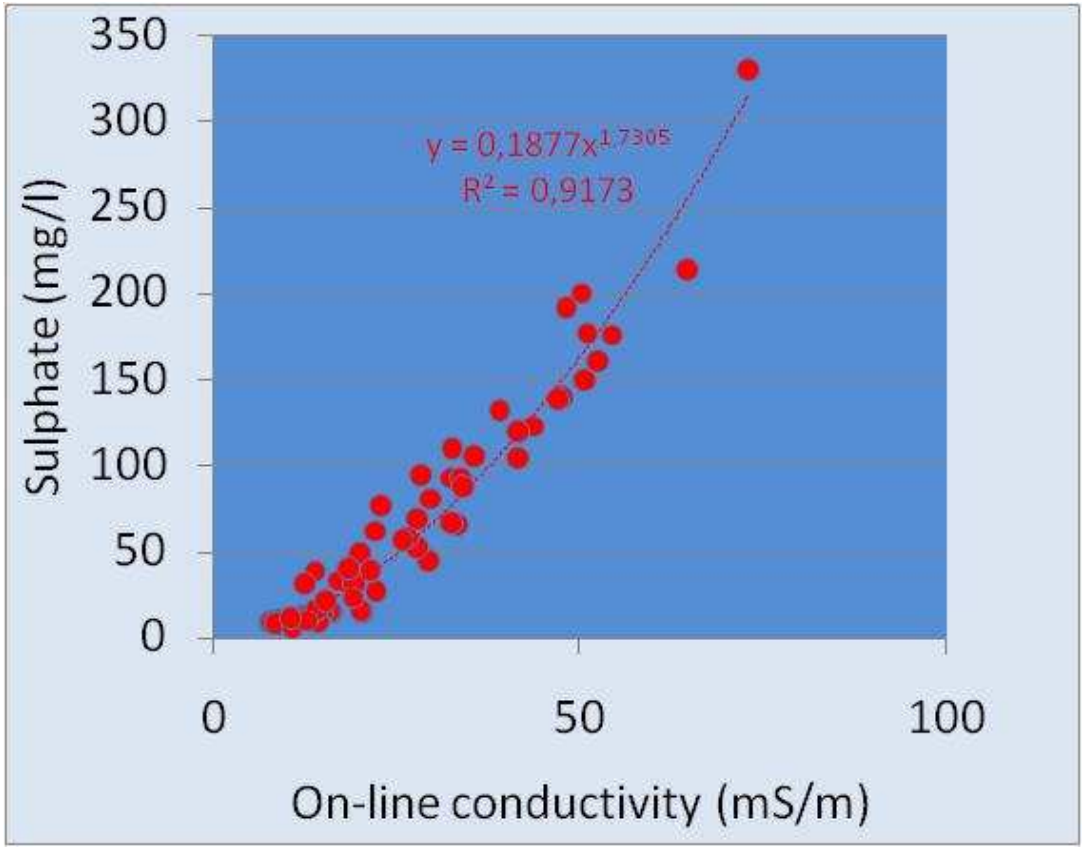


Soil sampling

Means	P mg/l	pH	EC	Ca g/l	K g/l	Mg g/l	S mg/l
Before gypsum	40.5	6.86	1.7	4.35	0.29	0.41	34.5
After gypsum 1	40.2	6.87	2.2*	4.36	0.30	0.42	77.0*
After gypsum 2	40.4	6.82	2.9***	4.96	0.32	0.42	87.0**

Photo: Elina Jaakkola

How long does the effect of one gypsum application last?

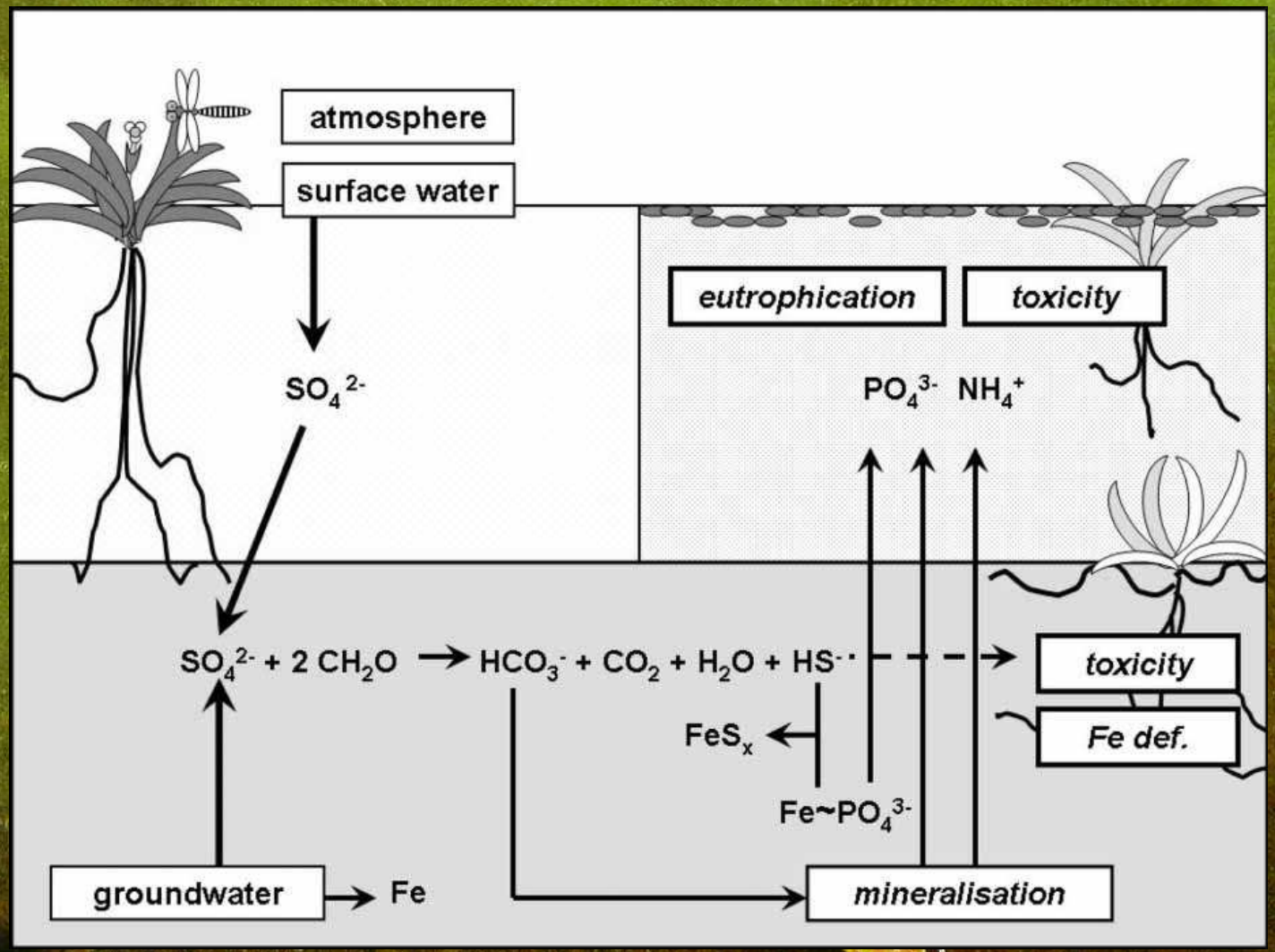


- After the first 2 years, about 23% of gypsum was lost, i.e. more than 75% still remains in the soil

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 SO_4 losses

Sulphate-mediated eutrophication



Smolders A, Roelofs JGM. 1993. Sulphate-mediated iron limitation and eutrophication in aquatic ecosystems. Aquat. Bot. 46:247–253.

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***)**

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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*