Photo: Ilkka Vuorinen

GYPSUM

AN EFFECTIVE WATER PROTECTION MEASURE FOR AGRICULTURE

Gypsum treatment can significantly decrease phosphorus losses from agricultural soils

Phosphorus discharges cause eutrophication and excessive algal growth in waters

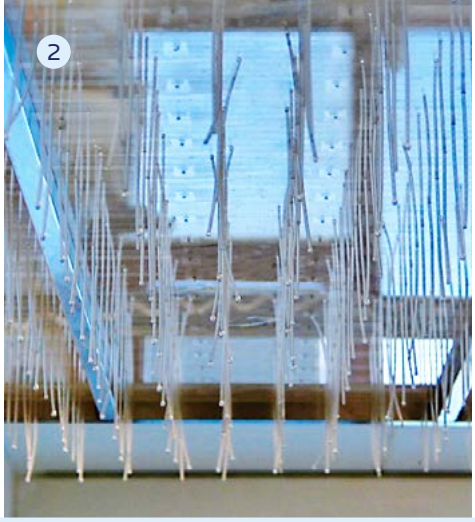
Rainfall and surface runoff detach soil particles and transport phosphorus-containing soil into watercourses. This can be seen as turbid water. Along with soil particles, dissolved phosphorus leaks from fields to watercourses. Together, the phosphorus discharges cause eutrophication and excessive algal growth.

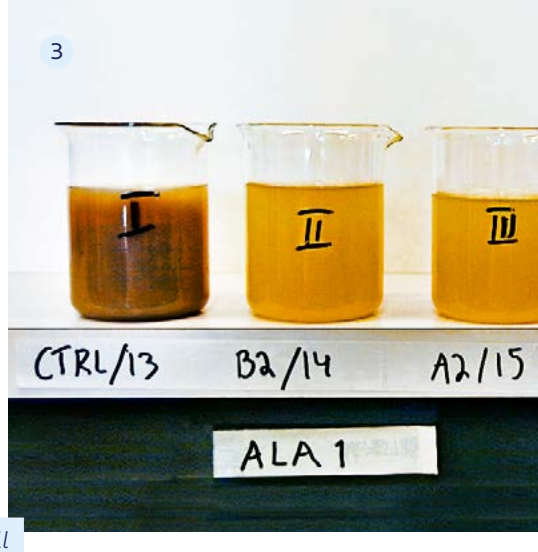
Phosphorus dissolved in water is readily available to algae. On the contrary, only part of the phosphorus attached to soil particles becomes available to algae and in this sense the soil-bound phosphorus is directly less harmful to water quality. In anoxic conditions prevailing in bottom sediments, the potential for phosphorus release from soil particles increases, however.

Gypsum spreading increases phosphorus retention and reduces leakage

Gypsum is calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), which can be spread on the soil surface like lime after harvest. It dissolves and improves soil aggregation and increases ionic strength for better phosphorus retention and thus reduces phosphorus leakage. Gypsum does not affect plant availability of phosphorus.

It is not necessary to apply gypsum every year. The effect is found to remain about 5 years.





LABORATORY ANALYSES: *1 Drilling of soil monoliths 2 Simulation of rainfall 3 Samples of runoff water. Photos: Natural Resources Institute, photo archive.*

GYPSUM HOLDS PROMISE TO CUT PHOSPHORUS LEACHING

Research evidence on gypsum as an effective water protection measure

1. Soil monoliths in laboratory rainfall simulations

Undisturbed soil monoliths representing clay-textured fields that were amended with gypsum were collected for rainfall simulations in laboratory conditions about 0.5, 1.5 and 2.5 years after the gypsum application.

Over the monitoring period, gypsum application resulted in 70% lower particulate phosphorus and about 50% lower dissolved phosphorus concentration in run-off water. Moreover, leaching of dissolved organic carbon was reduced by 35%. The effects of gypsum amendment were most evident in the samples collected 0.5 years after the gypsum application, and then gradually declined until the end of the study.

For more information, see *https://journal.fi/afs/article/view/4855.*

2. Nummenpää trial (93 ha)

Gypsum was spread onto 93 hectares of agricultural field in a 245-ha catchment in southern Finland in 2008. Runoff was monitored using online sensors and manual sampling for 2.5 years after the gypsum amendment.

After the gypsum treatment, runoff from the catchment became significantly less turbid. The concentration of particle-bound phosphorus decreased by 64% and dissolved phosphorus by one third.

For more information, see *https://journal.fi/afs/article/view/6831.*

3. Large scale pilot along the river Savijoki (1550 ha)

In 2016, gypsum was spread on 1550 hectares of agricultural field in southwest Finland. The upper reaches were left as a control area, where gypsum was not applied. Runoff quality was monitored with the help of continuous online sensors and manual water sampling. In addition, the effects of gypsum on agricultural yield, soil as well as freshwater biota (mussels, fish, moss, phytobenthos) were studied.

In the Savijoki, gypsum application halved erosion and the discharges of particulate phosphorus and also reduced dissolved organic carbon. No harmful effects on vegetation, soil or biota were observed.

For more information, see *https://blogs.helsinki.fi/save-kipsihanke/files/2018/11/Loppuseminaari-Ekholm-6.11.2018.pdf* and *https://blogs.helsinki.fi/save-kipsihanke/files/2019/03/SAVE-hankkeen-loppuraportti-2018.pdf* (in Finnish).

4. Gypsum application along the river Vantaa (3500 ha)

The project involves gypsum treatment of ca. 3500 hectares in southern Finland in 2018–2020.

According to preliminary results, the water quality measurement results show a clear decrease in turbidity and particulate phosphorus discharges. Gypsum can be considered to further reduce erosion and phosphorus leaching also in this area where other water protection measures focusing on erosion control, such as winter vegetation cover, are already widely used. In addition, gypsum was not found to affect trout reproduction in the river.

For more information, see *https://johnnurmisensaatio.fi/en/projects/the-river-vantaa-gypsum-treatment-project/.*

CATCHMENT STUDIES: *1 Spreading of gypsum*
2 Water quality monitoring point. Photos: Ilkka Vuorinen & Petri Ekholm.

According to Finnish studies, gypsum has the potential to decrease phosphorus loads up to 50%

Effects of gypsum application

- \+ Gypsum has been found to reduce the mobility of P in a range of soil types and conditions. Although the positive effect of gypsum on soil structure is mostly expected on dispersive clay soils or high sodium soils, significantly improved soil structure has also been reported in silt and sandy loams, and even in sandy and organic soils.
- \+ Gypsum also decreases the loss of particulate and dissolved organic carbon.
- \+ No change in soil phosphorus status or in other growth factors has been found. There has not been any effect on yields or product quality except that the elevated concentration of sulfate in soil solution may decrease the plant uptake of selenium.
- \+ Gypsum provides sulfur fertilisation especially needed by cruciferous plants.
- \+ Gypsum has no effect on land use or cultivation practices.
- • Unlike agricultural lime, gypsum does not increase soil pH, which is preferable in the cultivation of certain plants. Gypsum amendment usually results in a slight decrease in soil pH.
- − Gypsum application may result in a lower selenium content of crops.
- − Gypsum increases the concentration of calcium in soil solution, which may promote the exchange of Mg and K to soil solution while Ca is bound to cation exchange sites. This may result in shortage of Mg or K.

Preconditions for gypsum application

Gypsum needs to be suitable for agricultural use

Gypsum must be free from contaminants. In organic farming, it is only possible to use natural gypsum. Farmers practicing conventional farming can also utilise gypsum that is an industrial side product of e.g. fertilizer production or flue-gas desulfurisation gypsum.

Gypsum is suitable for river catchments, but sulfate may have adverse effects in lakes

As sulfate may accelerate eutrophication in lakes by increasing phosphorus release from bottom sediments, the measure is not suitable for lake catchment areas. Gypsum has no adverse effects in running waters or in the Baltic Sea as the seawater is inherently rich in sulfate.

As a precaution, in the Finnish pilots gypsum has not been applied to groundwater recharge areas or Natura 2000 sites, either.

Selection of parcels & no direct drilling immediately after gypsum application

Gypsum is not to be applied to fields where there is a shortage of Mg or K. Simultaneous gypsum amendment and seeding under no-till cultivation technology is not recommended. Gypsum should not be spread on frozen soil or on snow.

The best results have been achieved when gypsum has been mixed with the soil (tilled). The effect of gypsum may be considerably smaller in direct drilling.

Photo: Ilkka Vuorinen

Effect of large-scale gypsum application in the Baltic Sea region

Gypsum amendment can provide a promising solution to agricultural phosphorus loads for the entire Baltic Sea region. Agricultural phosphorus runoff to the Baltic Sea from five countries – Denmark, Estonia, Finland, Poland and Sweden – amounts to 8000 tonnes annually.

By preliminary estimates, gypsum amendment of arable fields could reduce the load by up to 1500–2000 tonnes from these five countries alone. This would correspond to approximately 10% of all needed phosphorus reductions called for in the HELCOM Baltic Sea Action Plan.

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- Trapping phosphorus for a cleaner Baltic Sea 2010. Project brochure by Yara International

Gypsum initiative

The project "Gypsum Initiative" aims to disseminate information to the countries surrounding the Baltic Sea about treating agricultural fields with gypsum as a means of efficient water protection, and to investigate whether this method is applicable in the different countries.

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