

COLUMN LEACHING EXPERIMENTS ON ACID SULFATE SOILS FROM THE RISÖFLADAN EXPERIMENTAL FIELD (VASA, FINLAND)

by

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The authors are participating in a three-year project, PRECIKEM. The aim of the project is to find and demonstrate chemical methods for mitigating the oxidation of sulfides and the simultaneous formation of sulfuric acid on farmlands. Subsurface irrigation with oxidation-inhibiting chemicals mixed into irrigation water is an important part of the project. This paper presents laboratory-scale column leaching tests with water, a dye tracer solution and calcium carbonate suspensions to simulate the large-scale irrigation experiments. Calcium carbonate injected as a suspension directly into the environmentally critical subsoil is not considered merely as a neutralizing agent but also as an oxidation-inhibiting chemical de-activating the acidophilic bacteria that mediate pyrite oxidation.

Acid generation by acid sulfate soils depends not only on the form and concentration of iron sulfides present in the soil but also on the permeability and structure of the soil. Especially important is the presence of water-conducting channels and wide pores in the soil. Depending on the soil structure, part of the sulfides may be inaccessible to oxidation.

The structure and properties of soil from the acid

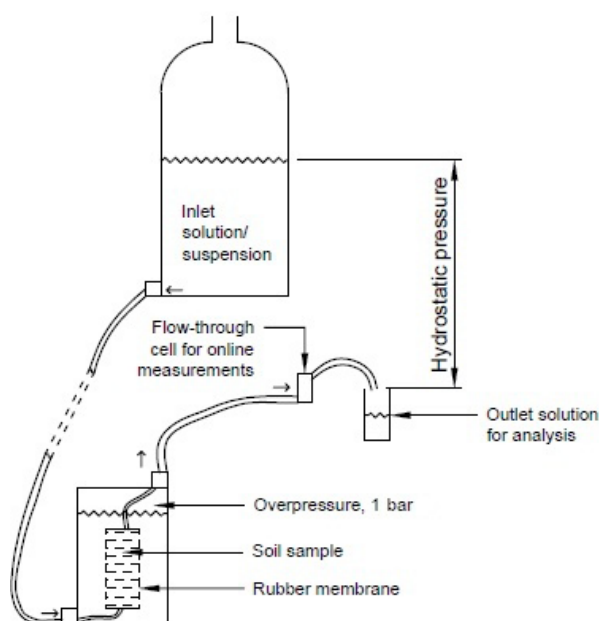


Fig. 1. Experimental set-up for the column leaching tests.

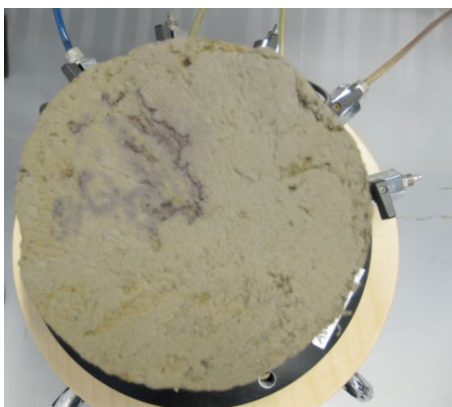


Fig. 2 (on the left). Cross-section of a soil sample after three days of flow of Alizarin solution. The dark-violet colour marks the regions around the channels in the soil where the dye was adsorbed.



Fig. 3 (on the right). Cross-section of a soil sample after the flow of 6.4 dm³ of calcium carbonate suspension through the column during eight days.

sulfate soil region at Risöfladan in Vasa was investigated by passing water and solutions/suspensions of selected reagents through soil samples in a column apparatus. Samples of soil were collected from the Risöfladan experimental field in Vasa by drilling plastic tubes into the ground. The obtained cores of 14.2 cm in diameter were then cut into 10–15-cm-long samples of the shape of a cylinder. The samples were placed in the column apparatus and the flow of water or the solution or suspension was initiated by employing a hydrostatic pressure difference of up to 3 m (Fig. 1).

Experiments with the aqueous solutions of Alizarin Red S dye showed that the flow of water through the soil is not uniform, as illustrated in Figure 2. Wide pores or even channels exist in the structure of the soil, and water or a solution preferably flows through them. Experiments with the suspensions of calcium carbonate showed that it is possible to introduce calcium carbonate to the soil without the destruction of the soil structure, as shown in Figure 3.

The flow rate, pH, conductivity and the concentration of sulfate, nitrate and chloride in the effluent were measured to characterize the soil samples and the emission of sulfuric acid from the soil. There is considerable variation in the permeability of the soil depending on the depth, but also between various samples taken from the same depth. Figures 4 and 5 show the results from a leaching test started with water but changed to a calcium carbonate suspension (5 g dm⁻³) after 9.8 dm³ water was passed through. In the beginning, the flow rate, indicated by the green line in Figure 4, goes down very rapidly. To ensure a reasonable flow, the driving hydrostatic pressure difference was increased from 60 to 160 cm after passing 1.8 dm³ of water through. The increase in the driving hydrostatic pressure difference probably opened new channels, resulting in a disproportionate increase in the flow rate. A minor increase in the driving hydrostatic pressure difference, and consequently in the flow-rate, took place when changing water to a calcium carbonate suspension, but in general the flow rate decreased slowly during the 5-day experiment.

The sulfate originally present or produced in the oxidation process was washed out from the soil, as illustrated by the decreasing concentration in the effluent. However, after introducing the calcium carbonate suspension, a sudden increase in the sulfate concentration of the effluent was observed. The minor fluctuation in the sulfate ion concentration and conductivity (Fig. 5) can be explained by the changes in the flow rate. As shown in Figure 5, pH is fairly constant at ca. 4, but suddenly increases to ca. 6 after introducing the calcium carbonate suspension.

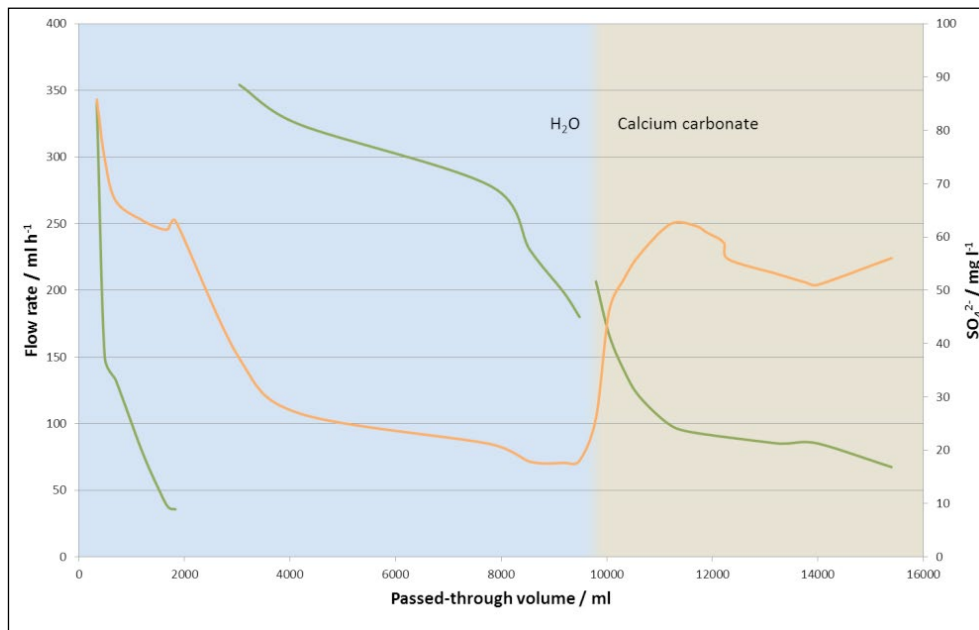


Fig. 4. The green line and left y-axis indicate the flow rate in a column leaching experiment. The driving hydrostatic pressure difference was increased twice, at the passed-through volumes of 1.8 dm³ and 9.8 dm³, resulting in discontinuities in the flow rate. The orange line and right y-axis indicate the sulfate ion concentration in the effluent of the experiment. The 10-cm soil sample, taken from the depth of 60...70 cm, was leached with 9.8 dm³ of pure water for two days. After this, 5.6 dm³ of calcium carbonate suspension (5 g dm⁻³) was used in the leaching for three days.

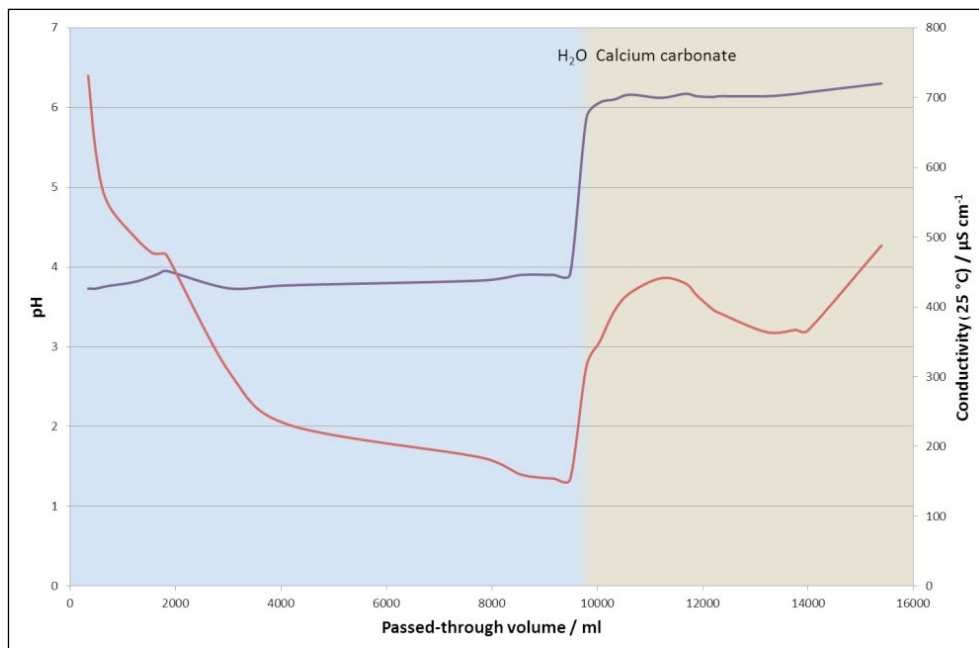


Fig. 5. The pH (blue curve and left y-axis) and conductivity (red curve and right y-axis) of the effluent of the column leaching experiment discussed in Figure 4.

ACKNOWLEDGEMENTS

The PRECIKEM project is funded by the European Agricultural Fund for Rural Development via the Rural Development Programme for Mainland Finland 2007-2013. This programme is administered by the Centre for Economic Development, Transport and the Environment in Ostrobothnia. Co-funding is provided by the Field Drainage Association, Maa- ja vesitekniikan tuki, the Central Union of Agricultural Producers and Forest Owners and Österbottens Svenska Producentförbund. The investments needed in the drainage system, field monitoring equipment, pumps, etc., are funded by the Oiva Kuusisto Säätiö, Aktiastiftelsen i Vasa, K.H. Renlunds stiftelse and Stiftelsen Handlande Gustaf Svanljungs Donationsfond. Aid and support in the construction of the field, as well as in performing experiments, are provided by KWH Pipe and Nordkalk companies. We would also like to express our deep gratitude to Professor Mats Åström and Environment Councilor Pertti Sevola for their continuing support of, and interest in, the PRECIKEM project. Mr Timo Riikonen is acknowledged for skilfully preparing the soil samples for the column tests.