

Mitigating the effects of an acid sulfate soil – the importance of macropore surfaces

Sten Engblom (1), Eva Högfors-Rönnholm (1), Pekka Stén (2), Stephan Christel (3), Sören Fröjdö (4), Tom Lillhonga (1), Paweł Nowak (5), Peter Österholm (4), and Mark Dopson (3)

(1) Novia University of Applied Sciences, Vaasa, Finland, (2) Vaasa University of Applied Sciences, Vaasa, Finland, (3) Linnaeus University, Kalmar, Sweden, (4) Åbo Akademi University, Turku, Finland, (5) Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Kraków, Poland

Coastal zones in Finland, when drained for agriculture and infrastructure, are often characterized by acid sulfate soils formed from fine-grained Holocene marine sediments rich in organic matter. When dried, a structure is formed that is blocky in the upper subsoil and more prismatic below to a depth of 1 m or more. Heterogeneity in the well-developed macropore structure leads to preferential flow patterns with a high hydraulic conductivity that enables a very efficient drainage of these soils. Atmospheric oxygen easily enters the soil using the same conduits during periods with a low groundwater table. Exposed macropore surfaces are the sites where chemical and microbiological sulfide oxidation commences, the pH is lowered, and acidophilic microorganisms become active. Once oxidized, acid sulfate soils release metals and acid that can cause severe environmental problems in receiving water bodies.

Soil core samples were collected at the Risöfladan experimental field, situated in Vaasa in Western Finland where old marine sediments have developed into a typical acid sulfate soil after 60 years of drainage. These cores were used in column experiments to investigate strategies to mitigate metal and acid release by addition of chemicals designed to raise the soil pH and/or retard metal release. The mitigation substances used were: (i) ultrafine-grained CaCO_3 with a median particle diameter of $2.5 \mu\text{m}$, (ii) a mixture of ultrafine-grained CaCO_3 with a median particle diameter of $0.3 \mu\text{m}$ and a biodegradable dispersing agent, and (iii) fine-grained peat of biodegradation level H1 and a median particle diameter of $20 \mu\text{m}$. Randomly chosen soil cores were cut at the oxidized zone at 70–85 cm below ground surface. A core was first flushed with autoclaved ultrapure water and then treated with a stirred suspension pumped through the core. In a combination of treatment methods, first a suspension of CaCO_3 was applied and then the peat suspension was introduced. After treatment, the core was again flushed with autoclaved ultrapure water. All experiments were conducted at 10°C . Permeate emerging from the core was led through a flow-through cell for the measurement of pH, EC, and ORP. Samples for the determination of metals and anions were collected regularly. The cores were stored for 4 weeks at 10°C in the dark before taking samples for geochemical and microbiological characterizations. The geochemistry was explored in S and Fe speciation and XRF analyses, and bacterial cells were harvested according to an indirect DNA extraction method.

The treatments, especially the combination with CaCO_3 and peat strongly influenced the geochemical and microbiological conditions at the treated macropore surfaces. Important consequences are e.g. a reduced metal content of the drainage water and a decreased abundance of sulfur-oxidizing bacteria on macropore surfaces. The results from the study clearly suggest the importance of the exposed macropore surfaces as sites of key importance, both in the progress of the oxidation process as well as in the development of any in-situ mitigation technique. The data also support that it is sufficient to treat the macropore surfaces to mitigate metal and acid release.