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Loss of jarosite during remediation of a sandy acid sulfate soil

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When acid sulfate soils dry, they generate large amounts of sulfuric acid due to oxidation of iron (Fe) sulfides (e.g., pyrite), causing formation of Fe sulfates such as jarosite and strong acidification (pH < 4). After re-saturation of these sulfuric soils and re-establishment of reduced conditions, activity of Fe- and sulfate-reducing bacteria promote re-formation of Fe sulfides and pH increase. However, many reducing bacteria are heterotrophic and require sufficient available organic carbon (OC). Despite the general knowledge about positive impacts of OC addition to ameliorate sulfuric soils, little is known about the reduction of Fe sulfates (here: jarosite) to Fe sulfides and the formation of mineral-organic associations after establishing anoxic conditions.

We investigated the remediation of a sandy, jarosite-containing sulfuric soil (initial pH = 3.0, initial redox values approx. 400 mV) in a 20-week anoxic laboratory incubation experiment under re-submerged conditions. We used a control without OC addition plus treatments with wheat straw addition as substrate for reducing bacteria. Besides the natural sulfuric soil, an artificial acid sulfate soil composed of synthesized jarosite mixed with quartz sand was used to simulate a simple, mineralogically well-characterized model of the natural soil. To ensure similar conditions, the artificial soil was submerged with soil solution from the natural sulfuric soil. We monitored pH and redox values in the soil suspension weekly. After 20 weeks, concentrations of OC, Fe, and S were analysed in bulk soils and soil solutions. The mineral composition was characterised by X-ray diffraction (XRD).

Addition of wheat straw to the natural acid sulfate soil led to quick changes in redox and pH values, reaching pH ≥ 6.0 and redox values ≤ -100 mV within three weeks. XRD analyses revealed complete loss of jarosite during incubation. Addition of wheat straw to the artificial acid sulfate soil led to slightly lower pH and higher redox values than for the natural soil, resulting in approx. pH 5.7 and redox values ≤ 0 mV after three weeks. Some of the jarosite was reduced, but it is still detectable after incubation. Without wheat straw addition, for both soils pH values remained low (pH ≤ 4.0) and redox values remained high (≥ 300 mV). Jarosite concentration did not change during the incubation without straw. The results showed that microbial reduction of acid sulfate soils requires supply of sufficient organic matter, which effectively triggers the reduction of jarosite to sulfides.