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Geochemical and microbiological processes during the transition of a sulfidic dredge spoil into a boreal acid sulfate soil

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The river mouths of two adjacent rivers on the Finnish west coast were dredged during 2014-2018 in order to minimize the risk of upstream flooding. The dredge spoils were likely to be rich in sulfides and metals as the conditions were favorable for sulfide formation and since the catchments contained large areas of boreal acid sulfate soils used for agricultural purposes. A total of 115 000 m3 sediment was removed and deposited on approximately 20 hectares of dry land close to the river mouth of one of the rivers. In an attempt to mitigate the release of acid and toxic metals, layers of lime (10 kg $CaCO_3$/m3) were added on top of and below the dredge spoil and the drainage water was directed through a lime barrier before being released into the Baltic Sea bay. Despite the presence of metal sulfides in the deposited sediment, the area overlying the dredge spoils is planned to be drained and used for agriculture in the future.

Dredging of the river mouths presented a unique opportunity to study the initial processes occurring in sulfidic sediments in a large scale as they are lifted onto land and exposed to oxygen. The present study spatially and temporally follows the geochemical and microbiological processes occurring in the sulfidic dredge spoils with the aim to contribute to an improved understanding of their environmental consequences. Sampling from the dredge spoils was performed on five sampling occasions between November 2016 and May 2018. Triplicate samples were aseptically taken at 10, 20, 30, and 60 cm below the surface and from each sampling depth, parallel samples were taken for geochemical and microbial analyses. As a reference, intact sediment was sampled from one of the dredged river mouths in April 2018. Directly after sampling, pH, conductivity, and the oxidation-reduction potential were measured. Sulfur and iron speciation was further made on thawed samples and multi-element analysis with ICP-OES/MS on soil leachates. For microbial community analyses, high throughput 16S rRNA gene sequencing on community DNA extracted from intact bacterial cells was performed.

The results showed that liming of the dredge spoils was unsuccessful and pH values under 3.5 were measured in the top 10 cm in May 2017. This layer consisted of sediment dredged and limed the same winter. The dredge spoil furthermore quickly developed into a typical boreal acid sulfate soil with pyrite oxidation and leaching of ferrous iron and sulfate. High concentrations of leachable toxic metals, i.e. Al, As, Cd, Co, Cu, Ni, and Zn were also detected, with a peak in August 2017. The results from the 16S sequencing will be compared with the results from the geochemical analyses in order to identify microbial processes during the acid sulfate soil ripening. The data showed that despite attempts to neutralize the dredge material with lime, microbiologically mediated sulfide oxidation started very soon after deposition releasing large quantities of acidity and toxic metals posing a local threat to the environment.