A large-scale laboratory column experiment to evaluate the effectiveness of capping fiberbank sediments in reducing contaminant transport

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Introduction: Waste historically discharged by the paper and pulp industry created large submerged deposits in adjacent water bodies. Called "fiberbanks" in Sweden, these deposits contain high organic content and are located in coastal areas and lakes, especially in northern regions; similar deposits also exist in other countries with similar industries [1,2]. Fiberbanks are often heavily contaminated with metals and various persistent organic pollutants (POPs) [3,4]. One alternative for managing the fiberbanks is using the accepted remediation method of *in-situ* capping, which generally involves placing a layer of "clean" material on top of the in-place contaminated sediments to limit erosion and dispersal of particle-bound and soluble-phase contaminants. In this study, we present a large-scale laboratory column experiment aiming to determinate the effectiveness of *in-situ* capping of fiberbank sediments at reducing sediment-to-surface water fluxes for metals and POPs.

Methods: Fiberbank sediment collected from a Swedish site (~ 95 L) was placed into two transparent acrylic columns (40 cm diameter, 2 m height) and covered with artificial seawater (~ 40 L). The filled columns were placed at 4°C to mimic natural aquatic environments where many fiberbanks are located. Capping layers consisting of crushed stone were then applied gradually (in sub-layers) until total target cap thicknesses were achieved (~ 20 or 45 cm). Passive samplers (DGT and SPMD) were placed into surface waters to estimate and compare water concentrations and fluxes of contaminants before and after capping. Surface water samples were also collected and analyzed to study the amount of resuspended particles created during and after capping. The columns were monitored for 244 days after which capping layers and sediments were sampled and analyzed. Organic contaminants were analyzed using gas chromatography coupled to mass spectrometry (GC-MS/MS) at SLU. Metals were analyzed at ALS Scandinavia AB using ICP-SFMS.

Results: Preliminary evaluation of pre- versus post-capping chemical flux data indicates that only the thickest cap reduced some organic contaminants from spreading into overlying surface waters when placed on fiberbank sediments that produce abundant biogenic gas. However, prior to capping, numerous gas voids formed inside the sediment over time, which forced porewater up and out of the sediment, resulting in increased water levels (corresponding to ~ 40 L). Sediment gas also vertically expanded cap surfaces, and multiple gas ebullition events through the caps were observed in both columns. Several pockmarks (gas escape features) were also noted on the surfaces of both caps by the end of the experiment.

Discussion: Compared to capping of typical, lower-organic content minerogenic sediments, reduced effectiveness when capping fiberbank sediments is likely due to extensive gas formation and upwards migration, which creates pathways through the capping layers that allow contaminants to rapidly disperse. Gas formation and migration also negatively impacts the physical integrity of the caps, which can further decrease a cap's long-term ability to reduce contaminant dispersal. Considering the high number and large volumes of contaminated fiberbanks in Swedish waters, and likely elsewhere, it is important to find suitable *in-situ* and/or *ex-situ* remediation techniques for this unique type of anthropogenic sediment.

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