Innovative methods to determine efficiency of remediation by sediment capping

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Introduction: Capping of contaminated sediments with a layer of clean material to create a barrier between the sediment and the aquatic environment is a widely used method for sediment remediation [1-3]. In order to asses the remediation efficiency (RE) of a cap, direct measurement of diffusive transport of contaminants is essential for both the design and the monitoring phase of the project. This paper present two innovative methods for flux measurements and discuses the applicability and limitations of mineral materials in engineered caps.

Methods: Diffusive flux of PAHs and PCBs from sediment with native contamination with and without a mineral cap was measured in microcosm tests. Microcosms were prepared in glass beakers and consisted of sediment from Oslo harbour and crushed gneiss or limestone cap (Fig. 1a), 2 cm seawater above the sediment and 50 mL cyclohexane overlaying the water [4]. The cyclohexane was acting as an infinite sink for the HOCs and was sampled at predefined times to analyse the amount of PAHs and PCBs accumulated (directly by GCMS). The flux from the capped or uncapped sediment was calculated from the area of the sediment surface and the test-time elapsed at each sampling event. Fluxes were also measured under field conditions using infinite sink diffusion chambers (ISDC), a redesign of the diffusion chamber commonly used for measurements of oxygen and nutrient flux (Fig. 1b). Measurements of water concentrations were replaced by an infinite sink sorbent inside the chamber accumulating PAHs and PCBs [5]. Both SPMDs and Silicone sheets were tested as infinite sinks in the ISDC.

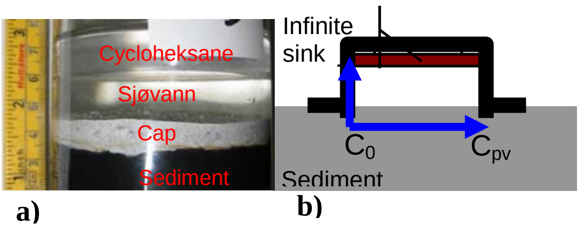

Fig. 1: Outline of test design a) microcosm test, b) Infinite sink diffusion chamber

Results and discussion: The diffusive flux of both PCB_7 and PAH_{16} from sediment capped with 1cm mineral cap measured in the microcosm (Fig. 2) was less than 10 % of the flux from the uncapped sediment. Implying an RE > 90%. It can also be shown that if diffusion is the dominant flux 10 cm mineral cap can be enough to obtain a RE of >99% [4]. A reduction of the flux from the contaminated sediments with 99% or more surpasses in many cases the reduction under field conditions when the flux from newly formed sediment above the cap is taken into account. In these cases a relatively thin mineral cap can be sufficient for remediation of the contaminated sediments.

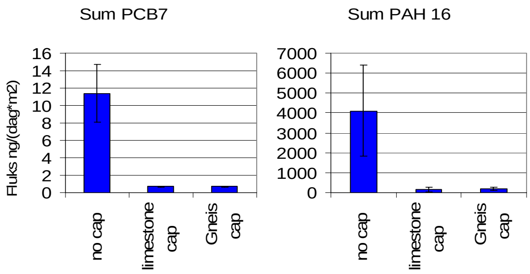

Fig. 1: Diffusive flux (ng m^{-2} d^{-1}) of PCB and PAH with and without cap.

Modeling of the flux in the microcosm test and the ISDC based on measured diffusive boundary layer thicknesses and freely dissolved concentrations in the pore water showed good agreement with measured fluxes. This implies that the methods presented here can be good tools for both pre design assessment and post construction monitoring of the RE of engineered caps.

References: [1] Ling et al. (1996) In: M. Kamon (Ed.), Environmental Geotechnics. Balkema Rotterdam, pp. 575-580, [2] Azcue et al. (1998) In: Sêco e Pinto, P.S. (Ed.), Environmental Geotechnics. Balkema Rotterdam. pp. 537-542, [3] Fredette and French, 2004 Mar. Pollut. Bull. 49, 93-102, [4] Eek et al 2007 submitted to Chemosphere, [5] Eek et al in prep.