INNOVATIVE IN SITU TREATMENT OPTIONS FOR CONTAMINATED SEDIMENTS

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Introduction:
Sediment contaminants contain a wide variety of compounds, including but not limited to polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), various metals and metalloids, tributyltinn (TBT), and military-unique compounds such as munitions constituents [1] dominating the ecological and human health risk associated with contaminated sediments. Although, only a minor part of sediments are contaminated (estimated approximately 10 %) the sediment contamination problem becomes evident with the need to periodically dredge the old deposited sediments to maintain navigable depths in waterways. Moreover, the need for environmental dredging is a growing factor of sediment management.

Technologies:
Depending on the high complexities involved, sediment treatment will likely consider a combination of multiple remedial approaches, like

- excavation of sources
- containment
- in situ treatment
- monitored natural recovery
- long term monitoring

Generally, in situ sediment treatment technologies cover processes like abiotic degradation, sequestration, reactive caps, bioremediation, and phytoremediation. Statutory criteria and precautionary principle have sustained a long-standing preference for dredging in remedial decision-making. So, in situ remedial approaches have to demonstrate clear advantages over dredging and disposal in terms of minimizing short-term risks, implementability, and cost. On the other hand in situ treatment shows some advantages with the potential for overall protectiveness and permanence. Additionally, there is a great potential for reduction in costs, compared to dredging and disposal, by avoiding sediment removal, ex situ treatment (dewatering, sizing), and solid disposal.

Case Study 1 – In Situ Aeration
It is well known that aerobic co-metabolisms are very effective, if oxygen or another donator is not limited. Since oxygen consumption is accelerated in contaminated sediments this limiting factor have to be broken during in-situ treatment by aeration and/or injection of solutions with other donators. During a pilot project in-situ bioremediation of contaminated harbor sediments was stimulated and maximized by venting (biosparging). Venting, and monitoring was conducted via vent screens and multilevel monitoring points directly installed in the sediment body by short screens. Pumps, piping, control devices and storage tanks were installed on a working platform located on the water table over the treatment area. Operation data showed that a sufficient airflow of 5-10 l/hr could be realized with a pressure of 400-500 mbar. A bubble breakthrough could not be avoided. On-site monitoring of dissolved oxygen, redox potential and conductivity in the pore water indicated a ROI of 2-4 m. According to preferential air flow paths a ROI up to 10 m could be observed. Chemical analyses of sediment cores have shown a reduction of TPH up to 60-75 % and PAH up to 75-85 % after 12 months of aeration.

Case Study 2 – Injection of Peroxide
Hydrogen Peroxide and Fenton's reagents play an important role during In Situ Chemical Oxidation (ISCO). During a demonstration project a pilot plant was installed in the Upper Main Harbor, Frankfurt/M., Germany. The fine-grained sediment (80 % clay and silt) was predominately contaminated by petroleum hydrocarbons (TPH max. 19 g/kg). In the laboratory tests injection was conducted with different peroxide dosages (25-500 g/kg sediment) to define appropriate concentration levels of the injection minimizing the risk of heavy metal mobilization. In the field tests a 1%-peroxide solution (according to 5 g/kg) was injected using 10 multiple slotted screens at the base of the sediment body (approximately 20 m³ were covered). Injection was automatically processed: every 3 hours 0,5 l peroxide solution was injected with 1 bar into each screen. Although a low concentrated peroxide solution was injected heavy metal mobilization was identified in the pore water creating a risk for the harbor water. As pore water-monitoring results showed, a homogeneous peroxide distribution was not realized within the radius of influence due to

preferential flow paths. Therefore, effective peroxide dosage may locally reach 20 g/kg. Nevertheless, a degradation of organic pollutants was not observed.

Case Study 3 – Floating Bioreactor

A floating device was developed to treat sediments with organic pollutants by on-site aeration. The major objective is to stimulate biodegradation by airlifting contaminated sediments and by resettling aerated sediments at almost the same place. Volatiles will be stripped and floating barriers will help to avoid dirty clouds during extraction and re-suspension. The main objective of the process is not to move dredged sediments to an on shore facility for treatment or disposal; but to recycle them more or less at the place where they have been accumulated. In the riser pipe of the airlift pump sediment particles and water are moved upwards by a stream of air bubbles. This allows stripping of volatile compounds as well as an intensive aeration of the water to enhance aerobic biodegradation within the suspension during the resettling process.

During a pilot test the capabilities of this technique were demonstrated on different test sites.

References: [1] U.S. Department of Defense's SERDP & ESTCP (2004): Final report – Expert Panel Workshop on Research and Development Needs for the In Situ Management of Contaminated Sediments