GREAT LAKES LEGACY ACT SEDIMENT REMEDIATION RESEARCH ON *IN SITU* TREATMENT

Manistique River and Harbor

Introduction

This factsheet is one of a series produced as a result of the U.S. EPA's Great Lakes Legacy Act research effort between the U.S. EPA Office of Research and Development and the USACE Engineer Research and Development Center (ERDC).

To support remediation and restoration efforts at Great Lakes Areas of Concern, this report provides a brief summary of remedial actions suggested for the Manistique Harbor/River Site.

Great Lakes contaminated sediment sites contain elevated concentrations of contaminants of concern (COCs), such as metals and hydrophobic organic compounds. *In situ* management of the contaminants via containment or sediment treatment has significant advantages over removal and *ex situ* treatment and disposal.

The Manistique River and Harbor Area of Concern (AOC) is located in Manistique, Michigan on the southern shore of Michigan's Upper Peninsula, The river and harbor discharge into Lake Michigan at a location that is about 0.2 miles from the AOC. The sediment contaminants at this site are polychlorinated biphenyls (PCBs) from historical industrial and paper milling operations.

Following Superfund remediation completed in 2004, pockets of sediment contamination remain in the AOC, posing long-term concern for impacts on the food chain. PCBs are hydrophobic organic compounds (HOCs) that can be managed in sediments by reducing their availability or mobility up through the food chain. HOCs — like PCBs — stay strongly sorbed (attached) to organic materials in sediment. *In situ* management measures and techniques using amendments were explored on sediments from Manistique in this study. When designing an in-place treatment or a cap, the materials used in the design are chosen based on their ability to reduce the bioavailability and mobility of PCBs. Amendments were tested to see whether they could achieve one or both goals. Potential amendments that can achieve both goals include granular activated carbon (GAC) and organophilic clay.

A major concern with amendments is the effect of interaction with natural organic material (NOM), including dissolved and colloidal material present in the site intersititial water (porewater). The analysis of sediment *in situ* remediation options such as capping or *in situ* treatment with amendments depend upon accurately determining sediment pore water characteristics, since NOM may compete with sorption sites. Natural organic matter can also interfere with the measurement of contaminants in the interstitial water and passive sampling is often required to accurately measure the mobile and available contaminants in the interstitial water. It is for these reasons that site-specific studies were undertaken. For HOCs, polymer sorbents such as polydimethylsiloxane (PDMS), polyethylene (PE) or polyoxymethylane (POM) are effective passive samplers

Experimental Studies

Figure 1. Column setup and amendments used for batch studies

- The goal of the experimental studies was to assess different in-place or *in situ* treatments on Manistique sediments to see which were the most effective at controlling contamination.
- Experimental studies conducted for Manistique used pore water generated from site sediment samples to account for effects of NOM; the studies included the following:
  - Equilibrium tests using granular activated carbon (GAC) to determine time needed to reach equilibrium between the porewater and the GAC
  - Batch isotherm adsorption tests to determine dosage using GAC, Aquagate+PAC (powdered activated carbon), PAC mixed with sand and organophilic clay
  - Static tests simulating *in situ* treatment using GAC and organophilic clay, which resulted in a total PCB removal percentage of 90% for 3% GAC and 100% for 10% GAC
  - Column tests simulating reactive capping using GAC and organophilic clay, which resulted in a total PCB removal percentage of 100% for both amendments over a time period of 5 months.
- Results for all the tests showed GAC to be the preferred sorbent choice, although organophilic clays also provided significant reductions in flux and interstitial water concentrations.
- GAC provides the greatest sorption and remedial effectiveness, although mixtures (e.g., Aquagate+PAC or Sedimite) may be useful formulations to aid in placement of the GAC.
- No non-aqueous phase contamination, such as oil, was noted in site samples. Organophilic clays would be preferred if there were a possibility of non-aqueous phase contamination.

In Situ Performance Evaluation

- If an amendment is added in place without dredging, the modeling results showed minimal movement of PCBs from the underlying sediment into the water column and biota. The results show a low steady-state flux at the surface of 340 $\mu g/m^2$-yr for a modeling scenario with a 1 cm/day groundwater upwelling flow rate.
- When using GAC as an *in situ* treatment, there was an approximate 75% reduction of PCB flux through pore water and minimal PCB concentrations at the surface of the underlying sediments. GAC was the most effective amendment found.
- A cap made up of a 30 cm sand layer yields little flux and concentration reduction at the surface after a few years. The maximum flux to the surface in the low upwelling rate scenario was approximately 500 times less than the unremediated baseline case. In the high upwelling rate scenario, rapid breakthrough into the cap was noted, although the maximum flux into the overlying water was still about 5 times less than the unremediated baseline case.
- A thin mat made up of GAC leads to much greater reduction in flux and concentrations at the surface, and effectively eliminates any flux to the surface for a design period of 100 years.

- The best treatment found was a cap that included the amendment – a cap with GAC mixed with sand – that eliminates any flux to the surface for a period of at least 1000 years.
- GAC mixed as an *in situ* treatment is not as effective as a cap amended with GAC, although it can still provide significant reductions in pore water concentrations.

Potential Remedial Implementation Based on Laboratory Studies

- An amended cap of GAC mixed with sand would reduce the bioavailability of PCBs in this site based on experimental and modeling results.

For Further Information

- **http://epa.gov/greatlakes/aoc/torchlake/index.html**
- **http://www.erdc.usace.army.mil/**
- **http://www.epa.gov/nrmrl/**

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