Bioaccumulation Control Demonstration at Ashtabula Open Water Placement Site

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Background/Objectives. The U.S. Army Corps of Engineers (USACE) Buffalo District and Research and Development Center (ERDC) performed a demonstration of open water placement of dredged material amended with activated carbon in Ashtabula Harbor, Ohio and at the Ashtabula Lake Erie Dredged Material Placement Area as a control measure for bioaccumulation of polychlorinated biphenyls (PCBs). The objectives of the pilot project were three fold: 1) demonstrate effectiveness of activated carbon in managing PCB bioaccumulation from dredged material placed in open water (Lake Erie), 2) demonstrate that implementation can be performed within the normal dredging operation as an additional activity, and 3) verify sustained presence of both powder and granular activated carbon (PAC and GAC) throughout the bioactive zone of dredged material mound.

Approach/Activities. In early August 2015, 6000 cu yd of fine-grained sediment from the Ashtabula, Ohio Harbor on Lake Erie was mechanically dredged, sampled and placed as a mound at the demonstration site. Then, 1200 cu yd of fine-grained sediment was mechanically dredged and placed in a 1500-cy, eight-compartmented bottom dump scow with a total of 56 super sacks of activated carbon, both GAC and PAC. The activated carbon and dredged material were blended using a 10-cy clamshell bucket to mix the material in the scow. The amended dredged material was discharged from the surface at the same location as the dredged material to cover the mound with amended dredged material to control bioaccumulation. Additional GAC was dispersed across the surface of the amended dredged material prior to discharging the amended dredged material at the placement site. The surficial layer was sampled to determine activated carbon content shortly after placement and a year later to determine both carbon content and bioaccumulation.

Results/Lessons Learned. The dredged material prior to being amended with activated carbon had 2.8% organic matter. The amended dredged material sampled from the barge contained 3.7% activated carbon, 2.2% GAC and 1.5% PAC. The activated carbon concentrations in the barge were normally distributed and ranged from 1.5% to 6.6% with a coefficient of variation (CV) of 0.32. Additionally, the overall concentration of GAC in the barge was increased by 0.3% by spreading four super sacks of GAC across the surface of the amended dredged material prior to discharging the amended dredged material at the placement site. The surficial layer was sampled from about the top five centimeters (two inches) of the placement site showed a lower concentration of activated carbon than the amended dredged material samples from the barge, particularly for the PAC. The average activated carbon concentration was 2.7%, 1% lower than present in the amended dredged material in the barge.
Bioaccumulative properties for PCBs were characterized using 28-day tests with Lumbriculus variegatus. The lipid normalized PCB tissue concentration ranged from 6.5 to 13.3 mg/kg for the unamended dredged material. A second round of surface grab samples will be collected in August 2016 to determine the reduction in bioaccumulation resulting from the treatment.
INTRODUCTION

Sediments in the urban harbors often exhibit elevated levels of polychlorinated biphenyls (PCBs) bioaccumulation, limiting their suitability for beneficial use or placement in aquatic sites. Hydrophobic organic contaminants of concern are typically strongly bound to the organic fraction of fine-grained sediment. Amendment of dredged material in the bioactive zone with activated carbon has the potential to provide bioaccumulation control, permitting expanded use of aquatic placement where confined disposal facility (CDF) capacity is being exhausted. Activated carbon has been applied directly to sediment only about a dozen times, mostly in small pilot demonstrations (Patmon et al. 2015). Only a few of these applications were larger than our current demonstration and half of the applications were much smaller. None of these applications used techniques representative of common dredging operations; however, their goal like ours was to remediate contaminated sediment by reducing contaminant exposure and limiting bioaccumulation.

OBJECTIVES

The purpose of this demonstration is to determine the efficacy of mixing activated carbon (both powdered and granular) within the barge using conventional dredging equipment, the potential loss of activated carbon (powdered and granular) during conventional placement through 15 meters (50 feet) of water and during the long term after placement, the extent of replacement of the bioactive zone with activated carbon amended dredged material, and the long-term reduction in PCB bioavailability and bioaccumulation in the bioactive zone of the demonstration site.

APPROACH

In August 2015, fine-grained sediment from the Ashtabula, Ohio Harbor on Lake Erie was mechanically dredged and placed in an 1150-cu m (1500-cy) eight-compartmented bottom dump scow (Figure 2). The dump scow sampled to characterize its material had 3.7% activated carbon, 2.2% GAC and 1.5% PAC. The activated carbon and dredged material were blended using a 7.6-cu m (10-cy) clamshell bucket to mix the material in the barge (Figure 4). The amended material was discharged over the dredged material mound to create a treated bioactive zone.

RESULTS

Characterization

The unamended dredged material had 2.8% organic matter. The amended dredged material sample from the barge contained 3.7% activated carbon, 2.2% GAC and 1.5% PAC. The activated carbon concentrations in the barge were normally distributed and ranged from 1.5% to 6.6% with a coefficient of variation (CV) of 0.32. The surface grab samples from about the top five centimeters (two inches) of the placement site showed that the GAC content was largely unchanged while the PAC content was only 0.5% despite being 1.5% in the barge. The results suggest that both mixing with the surface of the mound and loss of PAC during descent and collapse of the amended discharge from the eight bins of the dump scow. The detailed results are given in Table 1. Initial PCBs bioaccumulation data is given in Table 2.

SUMMARY AND CONCLUSIONS

- Activated carbon can be applied for bioaccumulation control using conventional dredging equipment. Good coverage of the dredged mound was achieved.
- GAC appears to be less effective in the short term due to the diffusion kinetics in a low mixing environment.
- Losses of PAC during descent and collapse of the amended discharge were much greater than expected. However, the losses would still provide benefits to the project.

ACKNOWLEDGMENTS

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Figure 1: Conventional dredging operation
Figure 2: Dump scow
Figure 3: Activated carbon addition
Figure 4: Mixing in activated carbon
Figure 5: Grab sampling
Figure 6: Surface grab sample from placement site

Table 1: Bioactive Zone (10-cm deep) Characteristics

<table>
<thead>
<tr>
<th>Sample</th>
<th>GAC (%)</th>
<th>PAC (%)</th>
<th>PAC content</th>
<th>Total AC content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>0.04</td>
<td>0.02</td>
<td>0.06</td>
<td>0.08</td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>0.03</td>
<td>0.09</td>
<td>0.12</td>
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Table 2: Bioaccumulation results for unamended dredged material

<table>
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* Assuming GAC is about 20% as effective as PAC in the short term and that 1% of PAC particles in the dredged material
** Toc is 1.4% composed of 0.4% carbon from soft sarie organics and 0.4% carbon from tare refractory carbon.