Treatment – Expanding Dredged Material Management Alternatives

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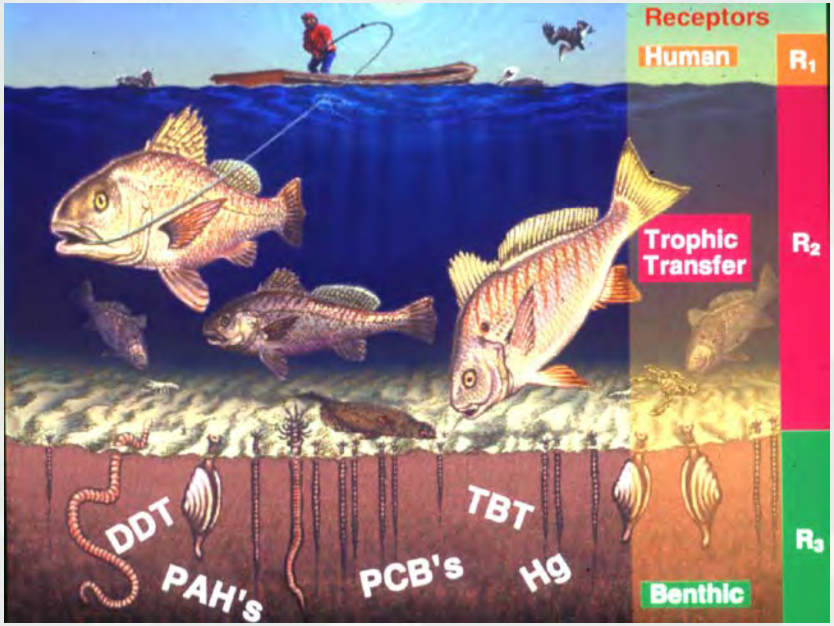
Problem

- Historic contamination poses ecological and human health concerns from potential bioaccumulation of contaminants placed dredged material placed in an aquatic environment for disposal or beneficial use
- Limiting placement alternatives and increasing costs
- Upland CDFs are filling up
- Need for cost-effective, implementable bioaccumulation control technology



Past Applications of Activated Carbon in Sediments

- Activated carbon has been applied directly to sediment only about a dozen times, mostly in small pilot demonstrations, but not applied to dredged material for placement in the aquatic environment.
- Additionally, activated carbon has been applied in caps at contaminated sediment sites at about a dozen sites, also mostly in small field demonstrations.
- All of the applications were intended to remediate in situ contaminated sediment, not dredged material , by reducing contaminant exposure/flux and limiting bioaccumulation.

Objectives

- Evaluate the dosage screening protocols and volume requirements for amended dredged material to adequately treat the bioactive zone
- Examine the performance of low activated carbon dosages suitable for controlling widespread low-level contamination
- Place amended dredged material at a demonstration site to reduce bioaccumulation using conventional placement methods
- Determine the long-term reduction in PCB bioavailability and bioaccumulation in the bioactive zone of the demonstration site
- Determine the efficacy of mixing activated carbon (both powdered and granular) within the barge using conventional dredging equipment
- Determine the potential loss of activated carbon (powdered and granular) during and after placement through 15 meters (50 feet) of water

Sediments Tested

Sediment	PCBs Conc. µg/kg	% Organic Matter			% Clay	% Silt	% Sand	% Solids
		Total	Soft	Refractory				
Ashtabula Harbor	110	3.4	0.8	2.6	21	69	10	60.7
Cleveland Harbor	43.7	4.1	1.6	2.5	20	69	11	58.6
Buffalo River	184	4.3	1.8	2.5	24	63	13	48.1

Unamended Bioaccumulation Results

Bioaccumulative properties for PCBs were characterized using 28-day tests with *Lumbriculus variegates*.

Sediment	% lipids	Total PCBs Conc. in Tissues (ng/g)	Lipid Normalized PCBs Conc. (µg/g)	Bioavailability, µg PCBs / g Lipid per µg PCBs / g OM (Refractory)
Ashtabula Harbor	0.49	41.1	8.40	2.6 (2.0)
Cleveland Harbor	2.19	129	5.87	5.6 (3.4)
Buffalo River	2.10	701.7	33.2	7.7 (4.4)

Laboratory Testing

- Mixed 6 gallons of sediment plus PAC at target dosage in 20-gallon stainless steel barrel
- Rolled at 10 rpm for a minimum of 7 weeks
- Performed 28-day bioaccumulation testing using *Lumbriculus variegates*

PAC Amended Bioaccumulation Results

Sediment	Treatment	% Lipids	Total PCBs Conc. in Tissues (ng/g)	Lipid Normalized PCBs Conc. (µg/g)	Reduction in Lipid Normalized Bioaccumulation
Ashtabula Harbor	3% PAC static	1.3	6.39	0.52	93.8%
	0.3 % PAC rolled	1.5	8.24	0.92	93.3%
	0.06% PAC rolled	1.5	17.8	1.21	85.6%
Cleveland Harbor	0.3 % PAC rolled	1.3	27.2	2.14	63.6%
	0.1% PAC rolled	1.7	32.5	1.97	66.4%
Buffalo River	0.3% PAC rolled	1.4	103	7.54	77.3%
	0.1% PAC rolled	1.6	130	7.91	76.2%

Target bioaccumulation reductions range from 55 to 85%.

Low Dosage Performance

- Typical activated carbon dosages that have applied at contaminated sediment sites range from 3 to 6% on a dry weight basis to achieve bioavailability reductions of 95% to 98%.
- These results show that dosages of about 0.1% can achieve reductions of about 75%, which may be sufficient for low level widespread contamination.
- The reduction for a given PAC dosage may be a factor of the sediment’s organic matter composition, and the concentration, composition/distribution and bioavailability of the PCBs.

Treatment Effectiveness by Homolog

- Comparison of the homolog distributions in the tissues from the bioaccumulation testing of original unamended sediments and the sediments amended with 0.3% PAC dosages showed that activated carbon was effective in sequestering all of the dominant homologs in the Ashtabula and Cleveland sediments.
- The greatest reductions were for the tetra-PCBs and penta-PCBs.
- Similarly, penta-PCBs and less chlorinated PCB homologs were effectively sequestered by the PAC in the Buffalo River sediment, but the reductions in hexa-PCBs and hepta-PCBs were well below the overall reduction.
- The more chlorinated homologs were poorly sequestered, likely due to their low solubility.

Ashtabula Field Demonstration

- Place four barges of unamended mechanically dredged material at a point in the open water placement site in 50 ft of water (about 6000 cy to form a 1-ft high mound); sample the barges to characterize the unamended dredged material in August 2015

Dredged Material Characteristics

- Classified as CL (lean clay of low plasticity)
- Liquid Limit of 37, Plastic Limit of 22 and Plasticity Index of 15
- Engineering water content ranging from 65 to 67%
- Solids content of 60%
- Liquidity Index ranged from 2.7 to 3.0
- Toughness Index ranged from 1 to 1.3
- Amended dredged material: 0.934 g/cc dry bulk density in barge
  0.947 g/cc dry at placement site

Approach

- Mix both PAC and GAC in two layers of dredged material in the dump scow using a small conventional dredge bucket; sample the amended dredged material from each hopper of the dump scow to characterize the activated carbon distribution

Carbon Addition

Mixing

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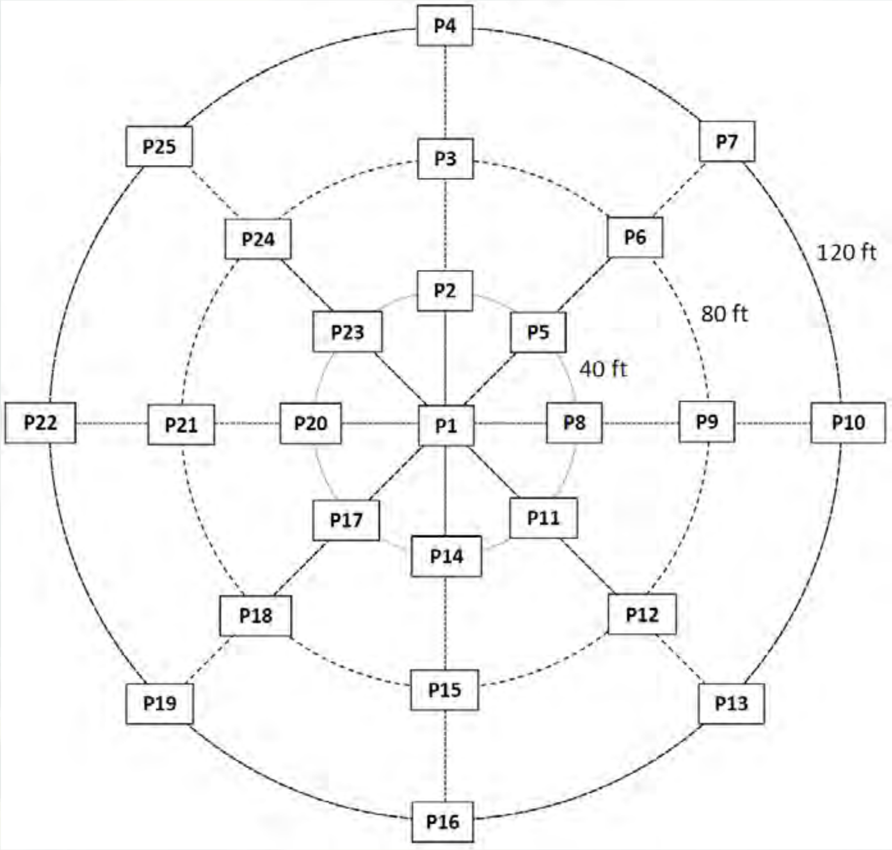
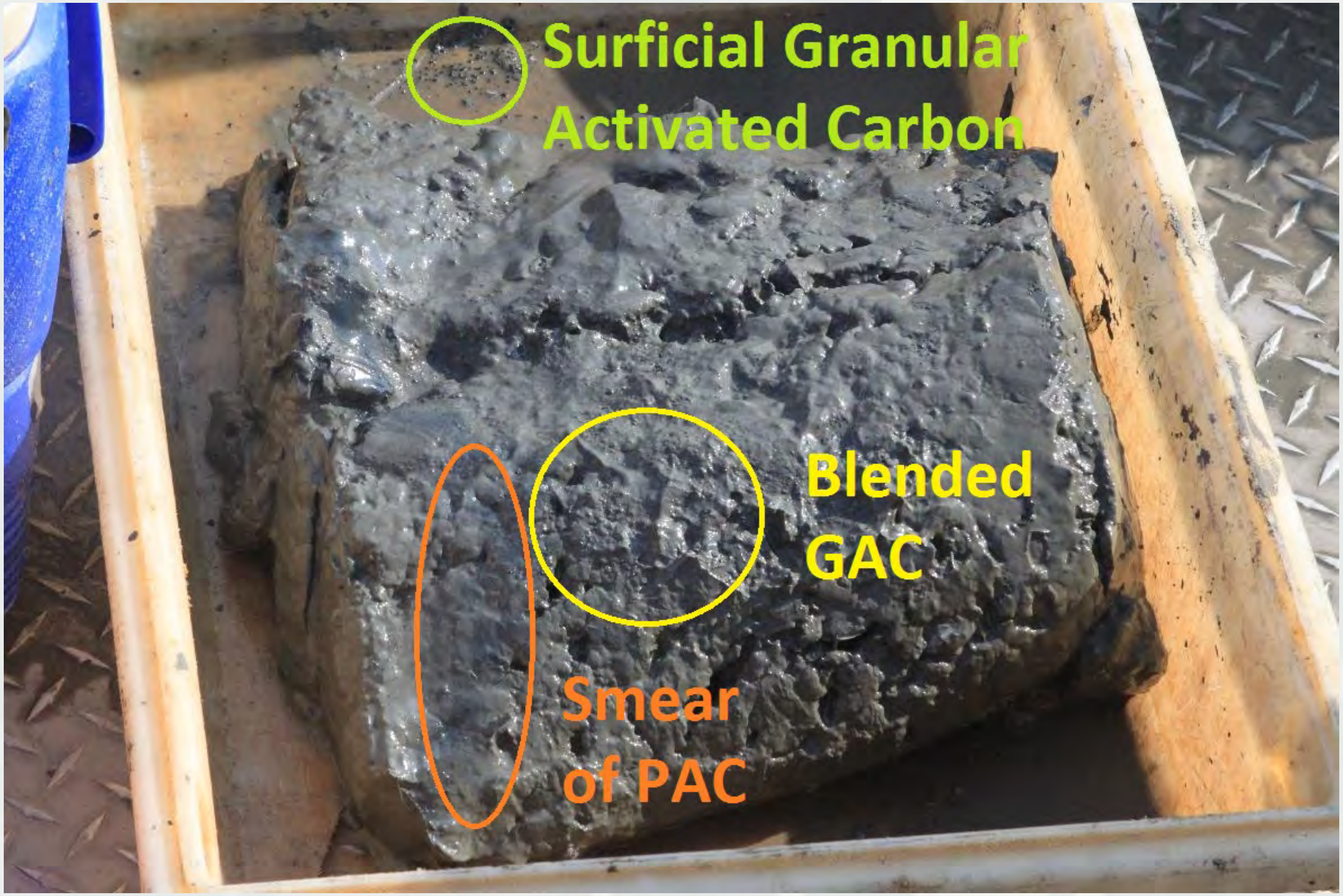
Approach

- Disperse GAC on the surface of the amended dredged material in the dump scow
- Bottom dump the amended dredged material on the placement mound
- Sample the top four inches of the placement mound to characterize the activated carbon distribution three weeks after placement at end of August 2015



Placement Site Sample



1-Year Bioaccumulation Reductions

Sample	% GAC	% PAC	%AC	Effective % AC	Percent reduction in PCB concentrations in lipids after 1 year
No AC	0	0	0	0	0
Low AC	0.40	0.48	0.88	0.52	52
Medium AC	1.34	0.38	1.74	0.56	56
High AC	1.78	0.62	2.40	0.84	75

*Assuming GAC is about 10% as effective as PAC in the short-term due to distance between AC particles in the dredged material.

** TOC is 1.4% comprised of 0.4% carbon from soft labile organics and 1.0% carbon from hard refractory carbon.

3-Year Bioaccumulation Reductions

Sample	% GAC	% PAC	%AC	Effective % AC	Percent reduction in PCB concentrations in lipids after 3 years
No AC	0	0	0	0	0
Low AC	0.09	0.29	0.38	0.31	61
Medium AC	0.3	0.43	0.73	0.49	67
High AC	0.99	0.68	1.67	0.88	79

*Assuming GAC is about 10% as effective as PAC in the short-term due to distance between AC particles in the dredged material.

** TOC is 1.4% comprised of 0.4% carbon from soft labile organics and 1.0% carbon from hard refractory carbon.

Conclusions

- These results show that PAC dosages of about 0.3% (and perhaps as low as 0.1%) can achieve reductions of about 75% in both laboratory and field applications, which may be sufficient for low level widespread contamination.
- Dredged material treatment is a viable option for placement marginally unsuitable dredged material in aquatic placement settings rather than placement in confined disposal facilities.
- PAC needs to be applied only to the bioactive zone to achieve the bioaccumulation reduction benefits.
- Bioaccumulation reductions are greatest in the tri-, tetra- and penta-chlorinated PCB homologs.

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