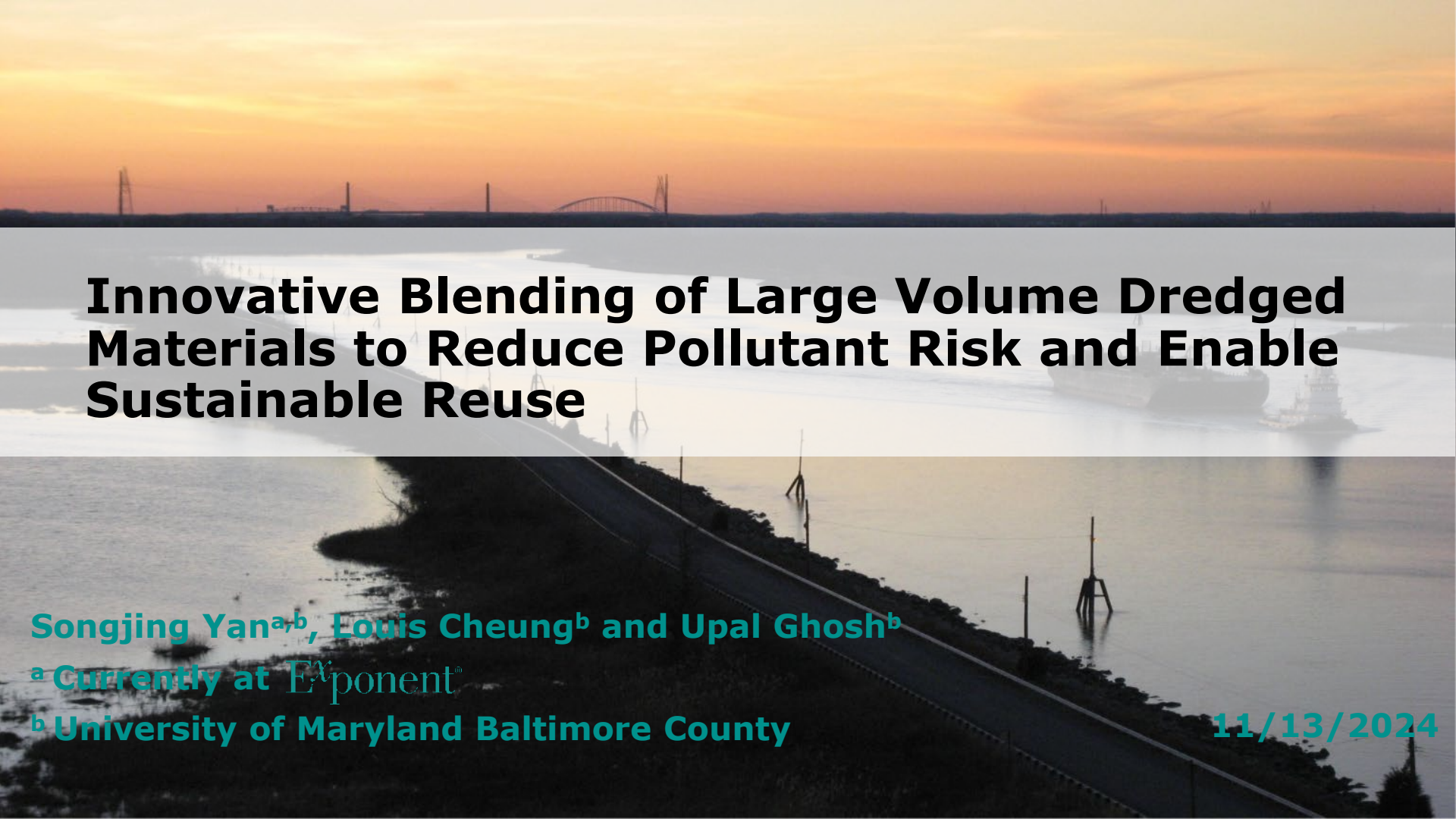

Innovative Blending of Large Volume Dredged Materials to Reduce Pollutant Risk and Enable Sustainable Reuse

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Background

Dredged materials:

- Sustainable
- Have a range of pollutants
- Innovative and beneficial use?

Industrial byproducts: biochars and biosolids

- Unique sorption characteristics
- Low-cost amendments

Technical Approach

Select, procure, and characterize study sediments (dredged materials).

↓

Select, procure, and characterize potential amendments.

Conduct aqueous isotherm measurements for selected organic contaminants

↓

Determine optimal amendment and dose for treatment of dredged sediments.

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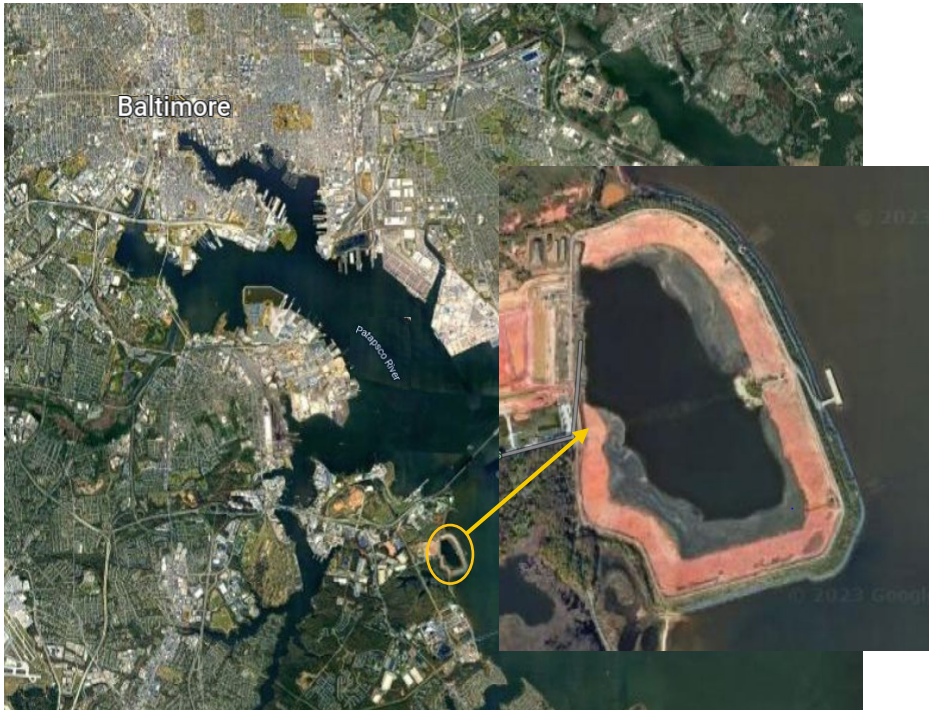
Perform aqueous availability, bioaccumulation measurements to assess the effectiveness of risk reduction.

↓

Evaluate engineered placement with strategic layering of treated sediments.

Methods

Select and characterize study sediments



Dredged materials collection sites

phots source: Google Map

Homogenization of sediment using a mixing paddle attached to an electric drill

- ❑ Cox Creek dredged material containment facility (DCMF)
  - Grain size distribution
  - Moisture content
  - Total organic carbon
  - Black carbon
  - Heavy metals
  - Organochlorine pesticides
  - 16 PAHs
  - PCBs

Select, procure, and characterize potential amendments

Type	Quantity available	Contaminants present	Sorption characteristics	pH	Carbon sequestration potential
COMMERCIAL SORBENTS					
Activated carbon	Large	No	High for organics, moderate for metals	High to neutral	Yes, for coconut AC
Apatite	Large	No	High for metals, no sorption of organics	Neutral	No
LARGE VOLUME INDUSTRIAL BYPRODUCTS					
Poultry litter biochar	Large	N, P, metals, organics	Strong for metals and some organics	high	Yes
Mushroom compost biochar	Large	N, P	Strong for organics	high	Yes
Wood biochar	Large	No	Strong for organics and Hg and MeHg	high	No
Flyash	Large	Metals	Moderate for metals	high	No
Biosolids	Large	N, P, metals, organics	Moderate for metals and organics	neutral	No

List of tailored sorbent materials and locally available high-volume industrial byproducts that could potentially be used for sediment amendments

Determine optimal amendment and dose for treatment of dredged sediments

UMBC

Sample preparation
- Add sediment (250g)
- Add amendment (various doses)
- Add water (350mL)

Mixing/Rolling
- 2 weeks of mixing

PE Deployment
- 0.25g PE per sample
- 4+1 weeks deployment

PE Retrieval
- Clean carefully
- Add Surrogates
- Add Na_2SO_4
- 3 x 24 h extraction
- 3 x 30 mL concentrate to 1mL

GC-MS Analysis
- Add IS
- Run Calibration samples
- Data analysis and interpretation

Dredged sediment with added amendment materials

Dredged sediment samples on the roller for equilibrium study

Polyethylene sheet retrieval after 28 days

Agilent GC-MS for quantification

Bioaccumulation measurement

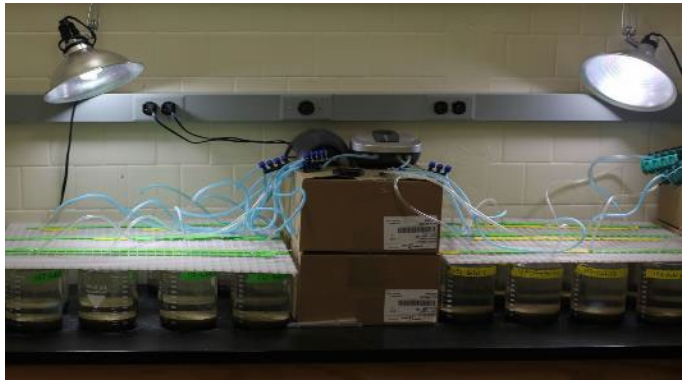
Sample preparation
- 1L beakers
- Add sediment
- Add amendment
- Add water
- Duplicates

Mixing/Rolling
- 2 weeks mixing

Worms Deployment
- *Lumbriculus variegatus*
- 1g worms per sample
- 4 weeks deployment

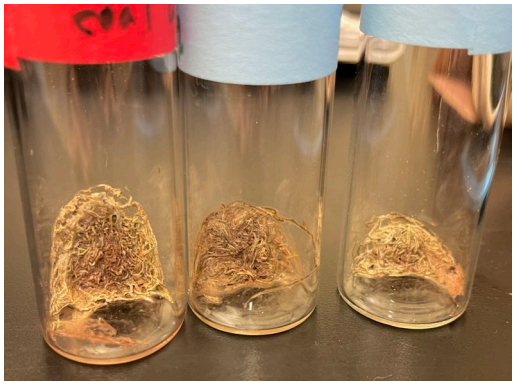
Worms Retrieval
- Worm collection
- Depuration
- Freeze dry
- 3 x 24 h extraction
- Mini-cleanup
- Concentration

GC-MS Analysis
- Add IS
- Run Calibration samples
- Data analysis and interpretation



Laboratory bioaccumulation experiment set up

Freshwater L. variegatus in samples



Collected and freeze-dried worms

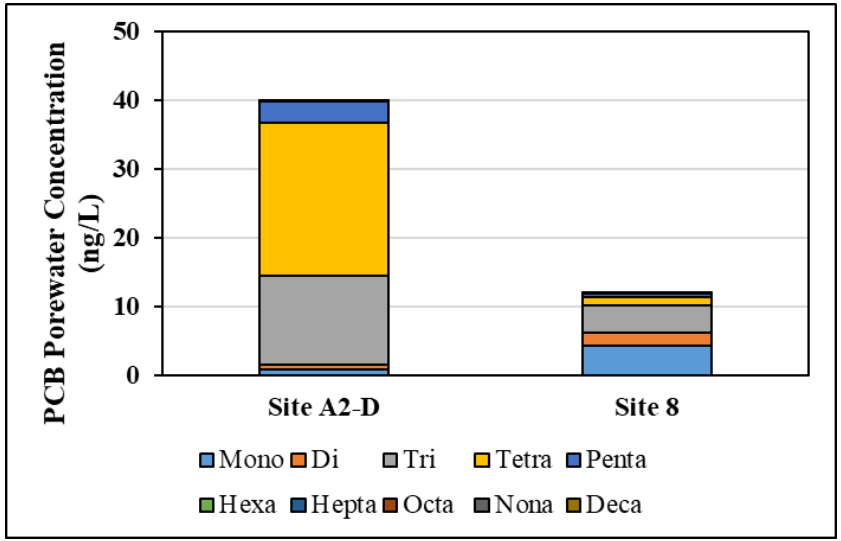
Results

Selection and characterization of sediments.

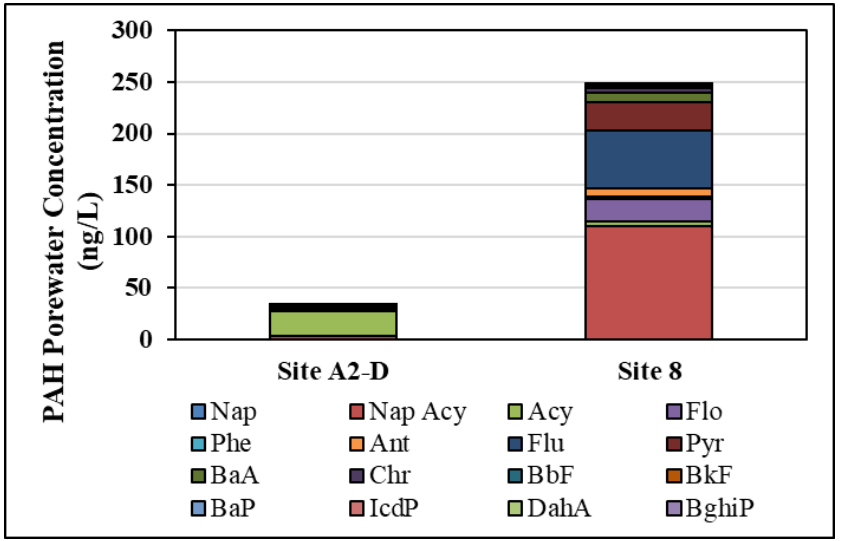
- Based on the characterization, **site A2-D** and **site 8** were selected that provide a range of concentrations for ultimate use in this research.

Sediment sample	TOC %	Dry Bulk Density (g/mL)	Moisture Content (%)	ΣPCB Sediment Conc. (ng/g)	Σ_{16}PAH Sediment Conc. (mg/kg)
Site 8	2.57	0.41	67.9	89.0	16.72
A2-D	1.01	0.75	46.7	844.1	0.94

Initial porewater concentrations of PCBs

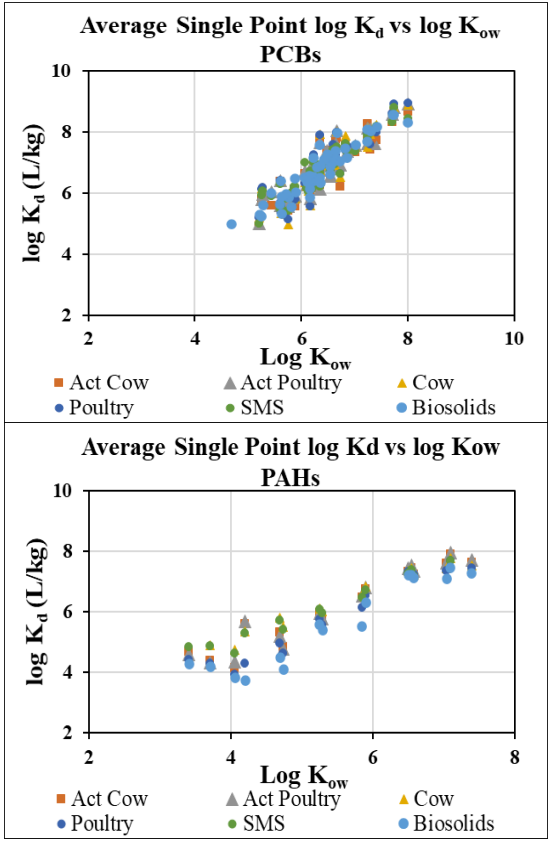


Initial porewater concentrations of PAHs



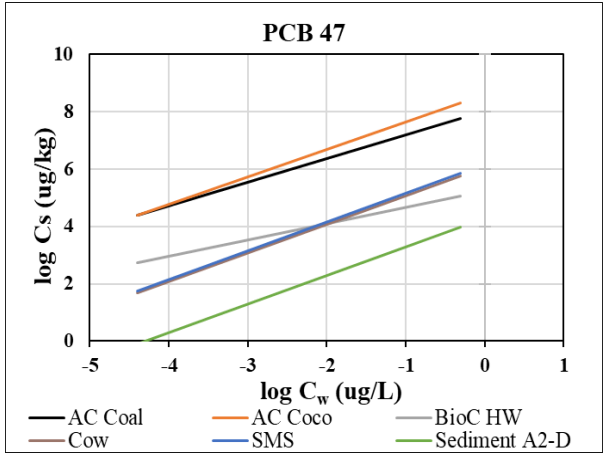
Select and characterize potential amendments

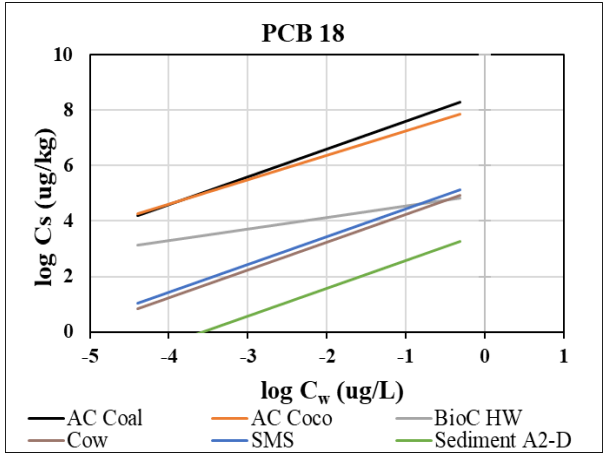
Average Single Point log K_d vs log K_{ow}



- The spiked amount resulted in good concentration gradients.
- Six different biochars gave consistent isotherm results.

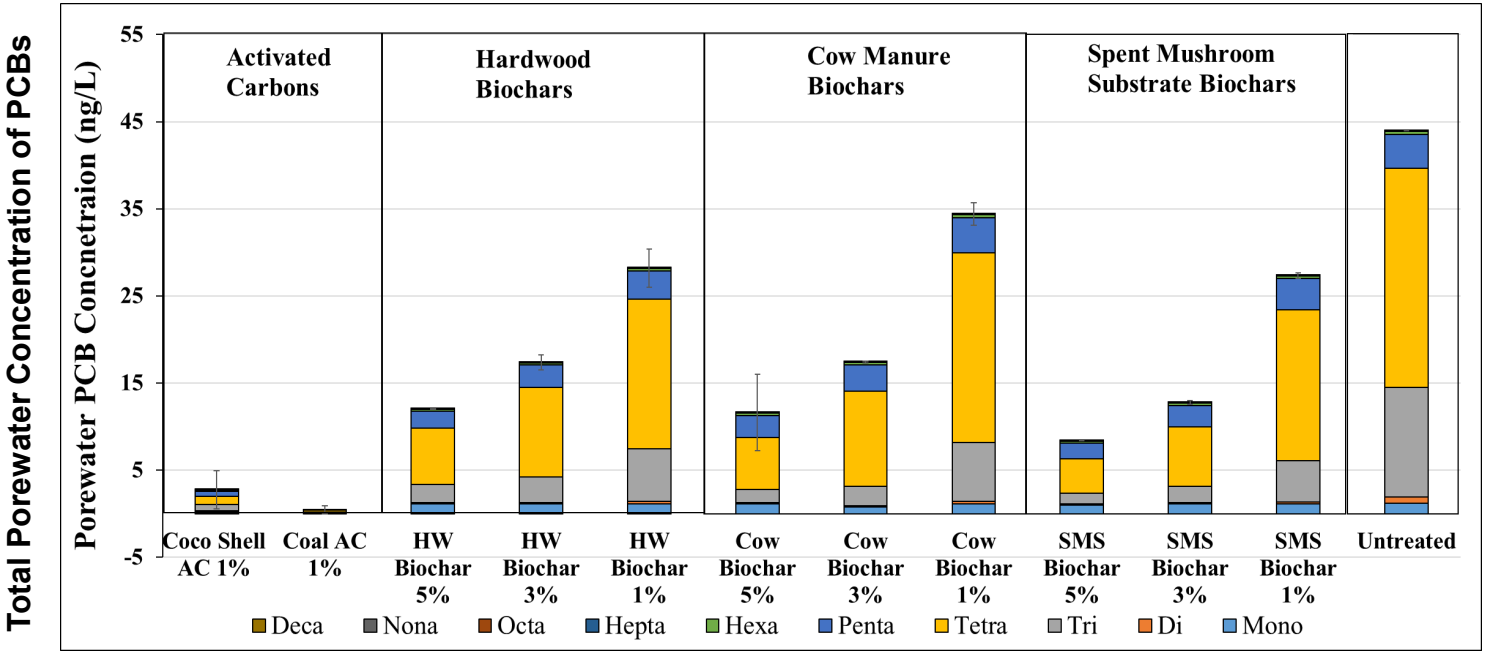
Isotherm results of log C_S vs log C_w





- Biochars were comparable with literature data (Gomez 2013).
- The biochar materials showed 1-2 orders of magnitude lower sorption coefficients than AC for PCBs.

Determine optimal amendment and dose

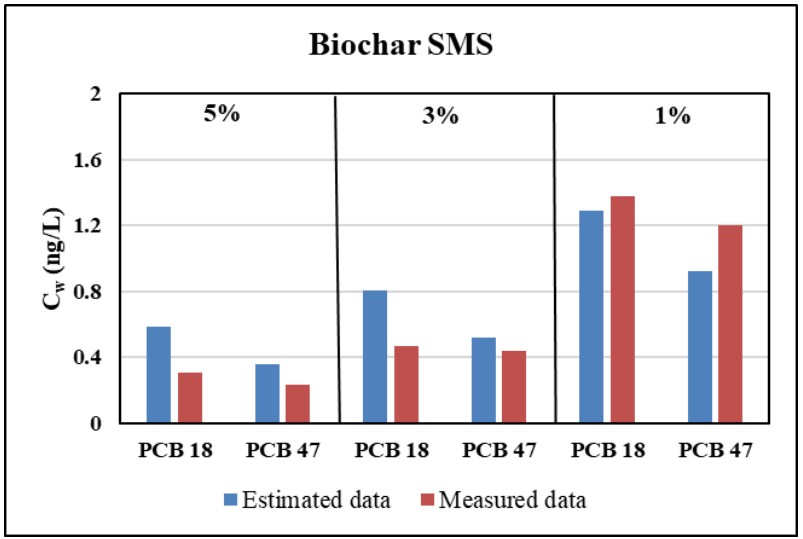


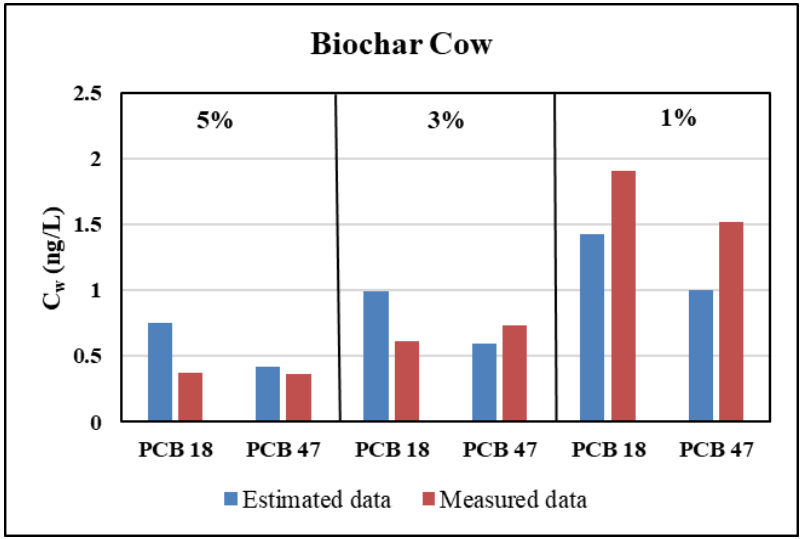
Reductions%	94%	99%	73%	60%	36%	74%	60%	22%	81%	71%	38%

- AC materials reduced PW concentrations more than biochars.
- Higher doses of biochar resulted in higher reductions.
- The high (99%) reduction with 1% Coal AC is likely due to low f_{oc} (1%) in sediment.

Comparison of calculated and measured concentrations

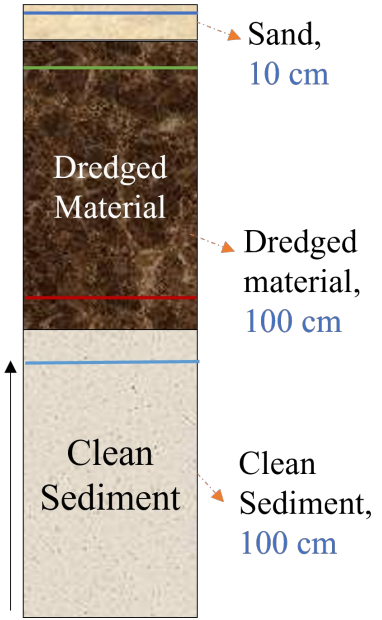
Porewater Concentrations in SMS and Cow Biochar Amendment Samples



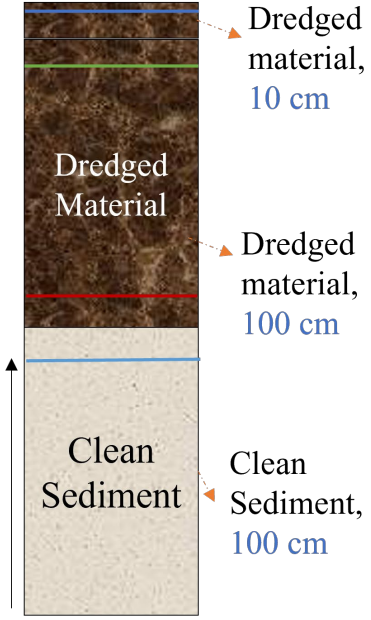


- C_w estimations based on K_d values.
- Using mass balance (assuming achieved equilibrium after 2 weeks).
- Estimated C_w data agreed with the experimental results.

Evaluation of engineered placement with strategic layering of treated sediments



Steady upwelling flow, Darcy Velocity = 1000-5000 cm/yr



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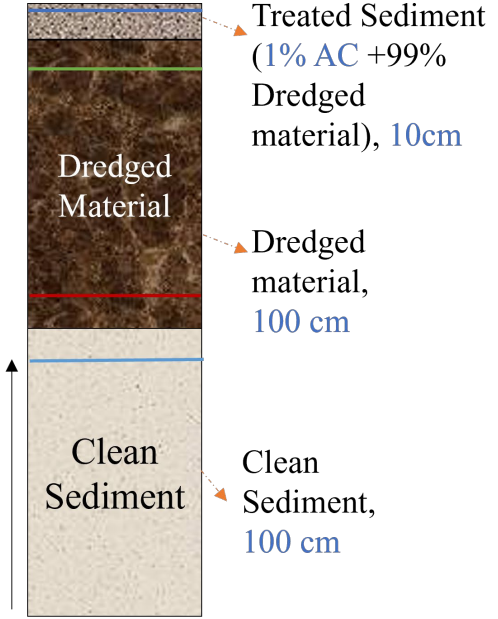


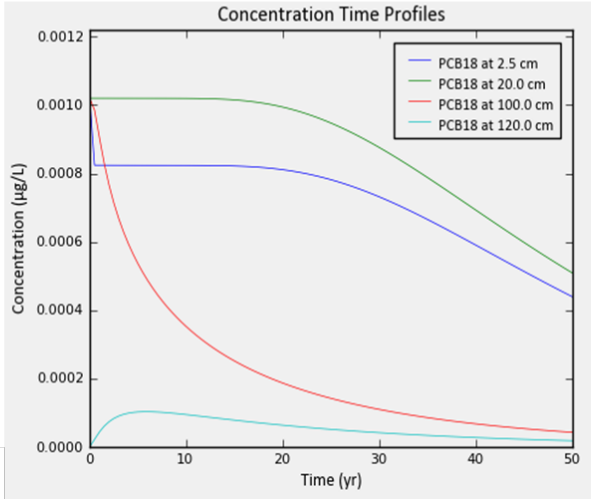
Steady upwelling flow, Darcy Velocity = 1000-5000 cm/yr

Evaluate strategic placement of engineered layers

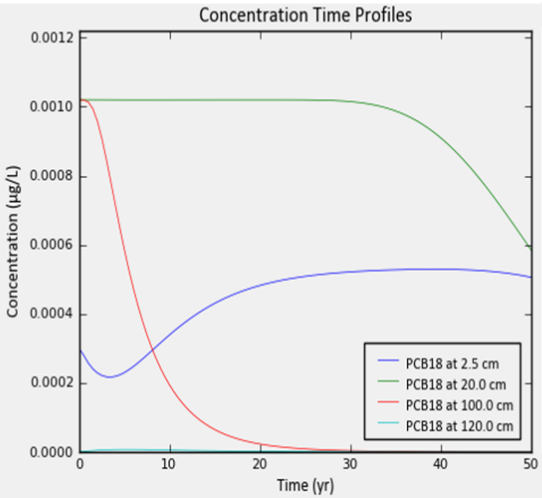
PCB 18 Results

Darcy V: 5000 cm/yr

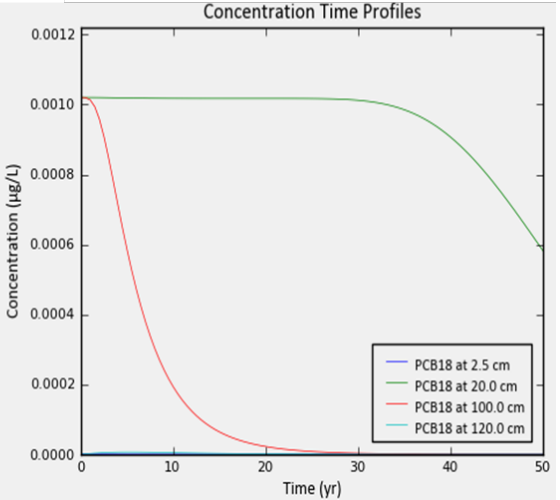
Top layer: Sand



Top layer: Dredged Material + Biochar SMS 5%



Top layer: Dredged Material + AC Coal 1%



- All scenarios show the effectiveness of layered amendment placement for bio-active layer (top 2.5cm).
- Early breakthroughs in top sand layer
- Breakthrough after 10 years in top biochar amended layer
- No breakthrough in 50 years for top AC amended layer

Take home messages

Amendments provide an alternative for the sustainable reuse of dredged materials.

- The six different types of biochars provide similar absorption for PCBs.
- 5% biochar provides modest reductions for porewater concentrations.
- Much larger reductions in porewater were observed with 1% PAC.
- Simulations of engineered placement with a strategic layering of treated sediments show:
  - early breakthrough in 5% biochar treated bioactive layer
  - no breakthrough in 1% PAC treated bioactive layer
- Dredged materials with low TOC need low AC dose for porewater concentration reductions

Photo Source:2019 Dredged Material Management Program Annual Report

Thank you!

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Photo Credit: Philadelphia District US Army Corps of Engineers