Pilot Study on In Situ Bioremediation of a Former Wastewater Treatment Pond Containing High Levels of PCBs

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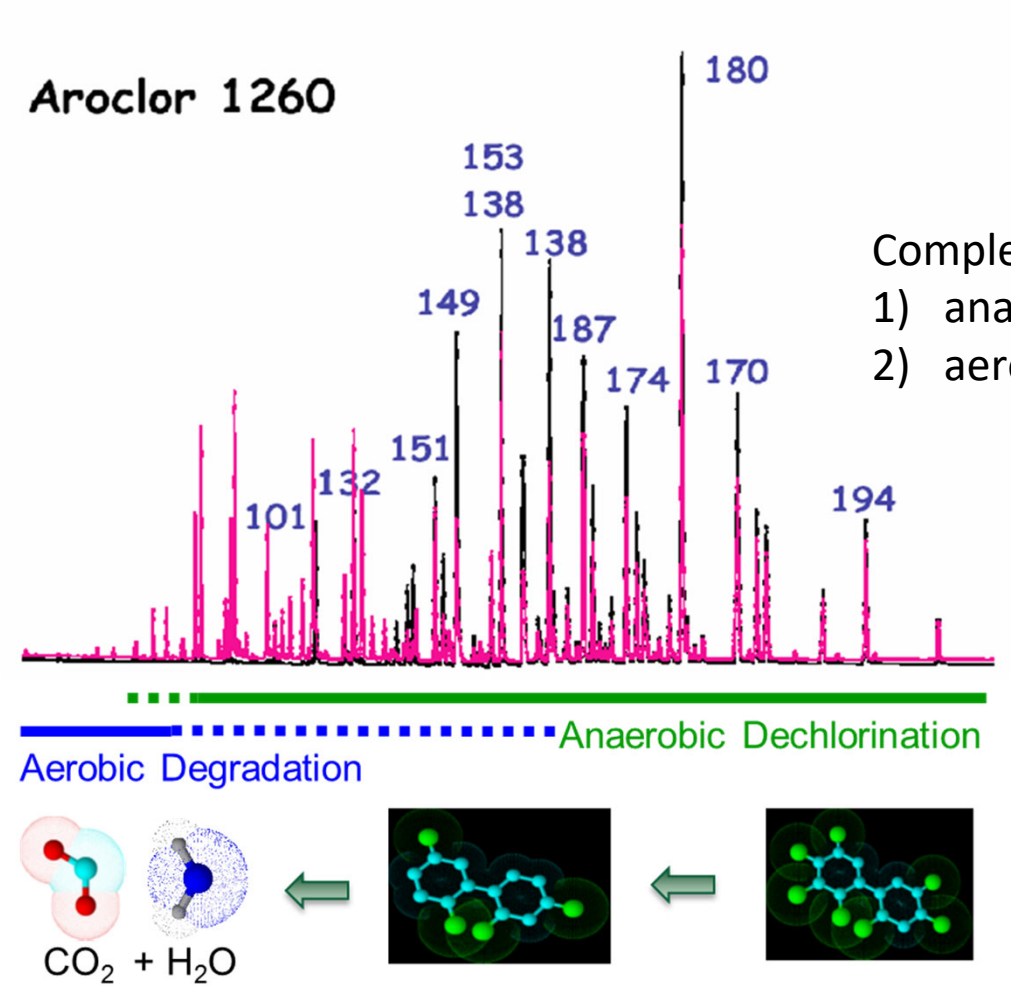
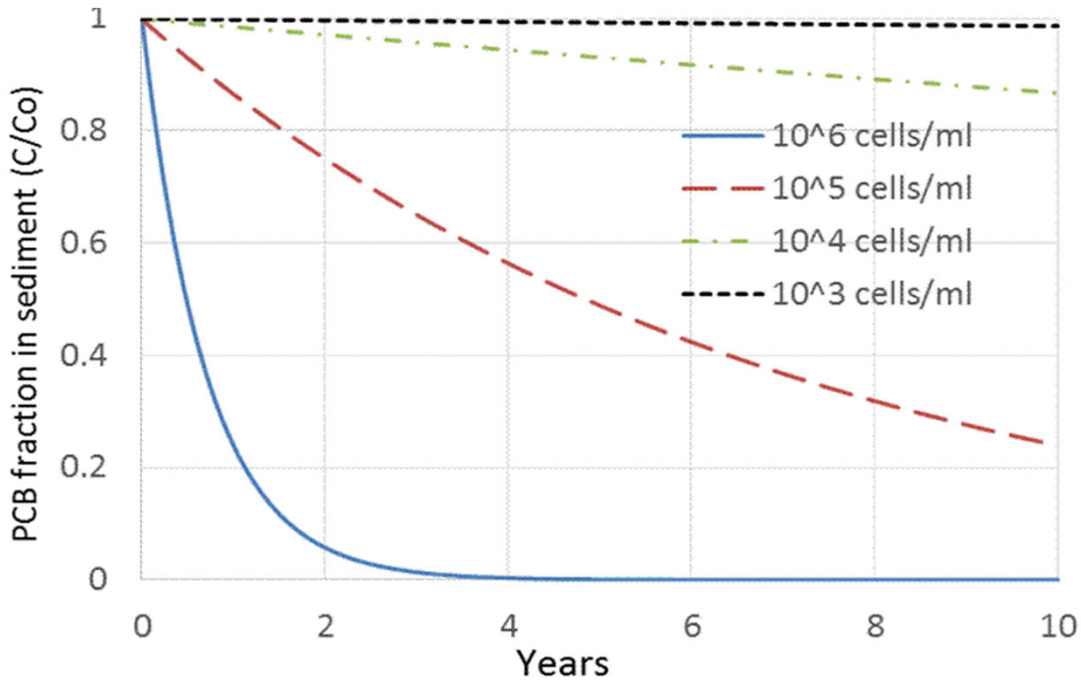
How Bioremediation of PCBs Works



Complementary activities of:

1) anaerobic halorespiring bacterium
2) aerobic oxidizing/dechlorinating bacterium

Natural Attenuation of PCBs is Slow



- PCB dechlorination follows first order rate kinetics
- Low cell numbers due to high k_{ow} of PCBs
- Increasing cell numbers increases the dechlorination rates

Lombard *et al.* 2014 ES&T 48 (8), pp 4353–4360

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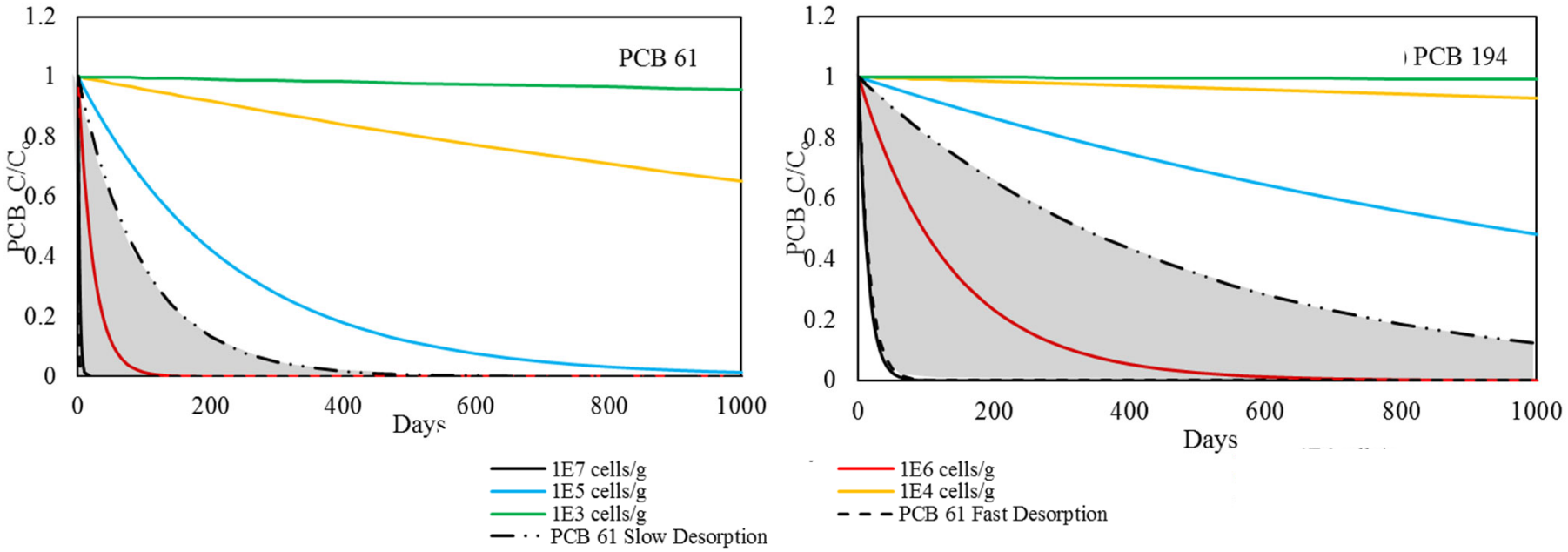
Dechlorination Rates vs Desorption Rates

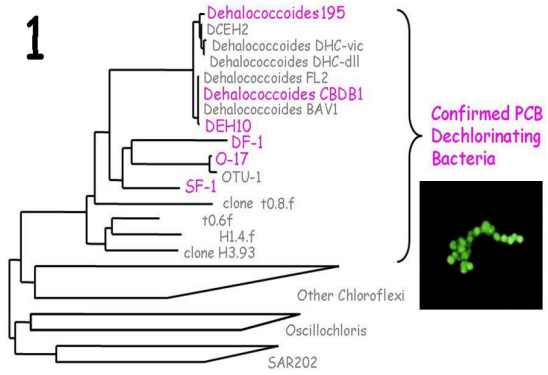


- PCB Desorption rates exceed dechlorination rates during natural attenuation
- Aqueous PCB concentrations too low to support larger halorespiring population
- Bioremediation increases dechlorination at rates similar to desorption rates

Needham *et al., submitted*

Technology/Methodology Description

1



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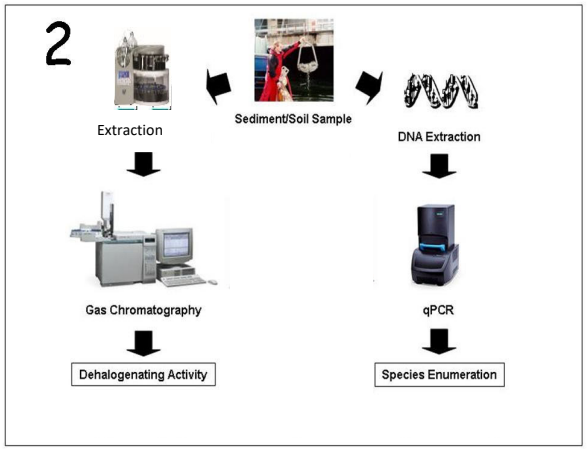


3

4

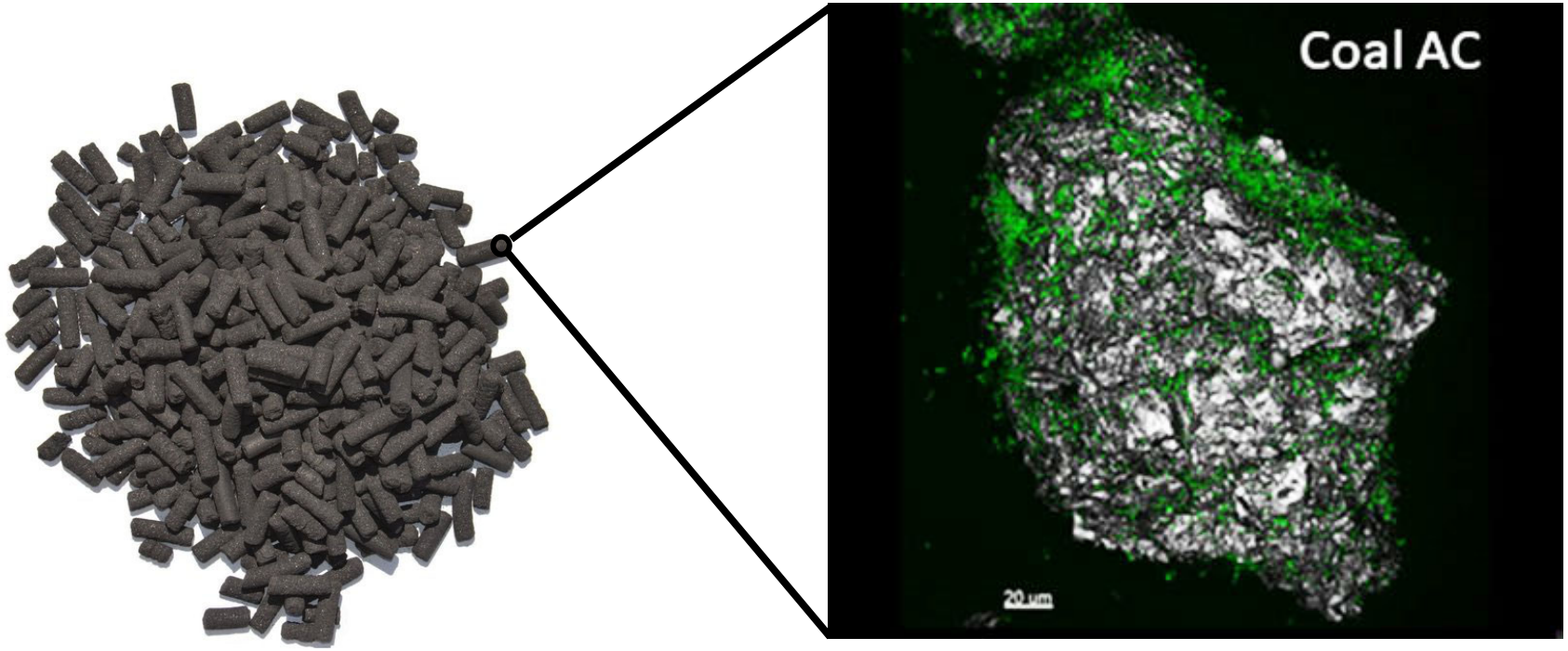
1) PCB anaerobic halorespirer and aerobic degrader available

2) Assays developed for monitoring treatment and bioamendments

3) Methods developed for biomass scale-up of bioamendments w/o PCB

4) System developed for *in situ* deployment of bioamendments on activated carbon agglomerate (SediMite)

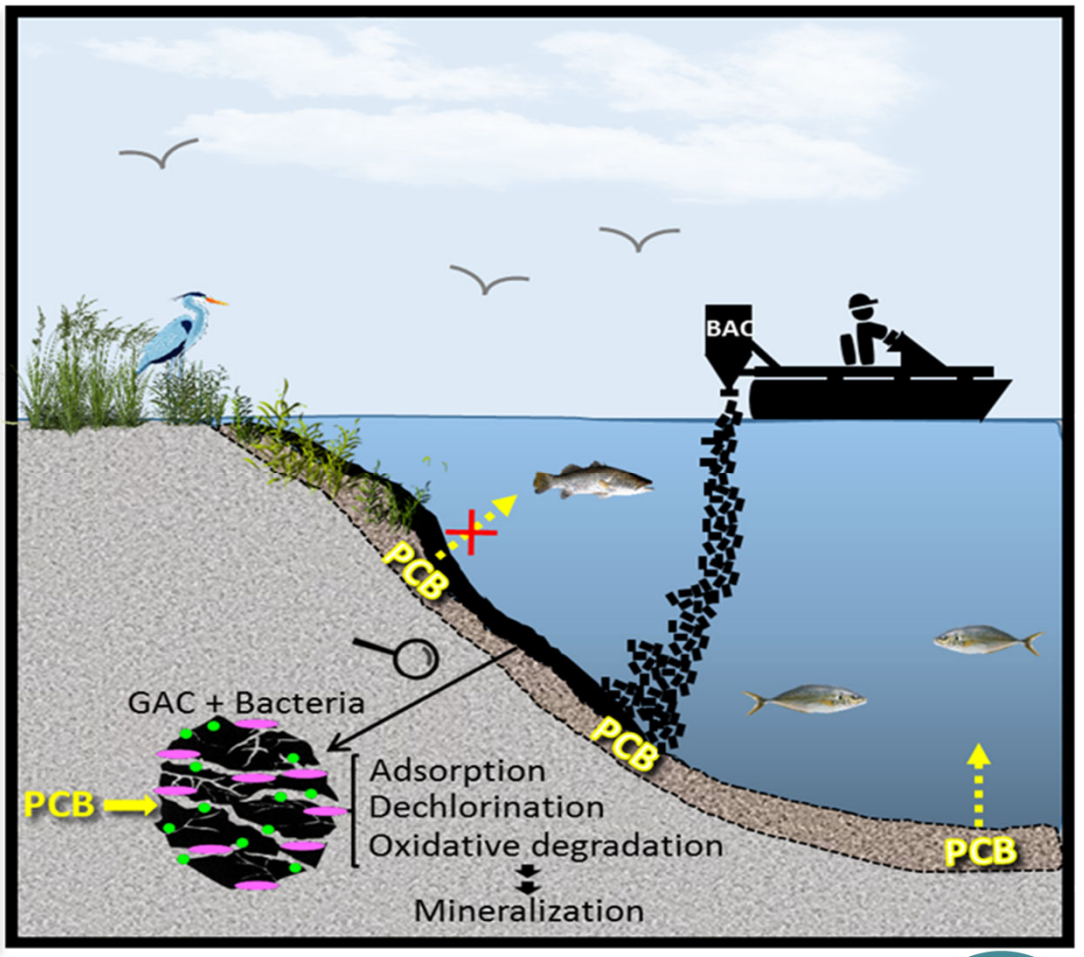
Bioamended Activated Carbon



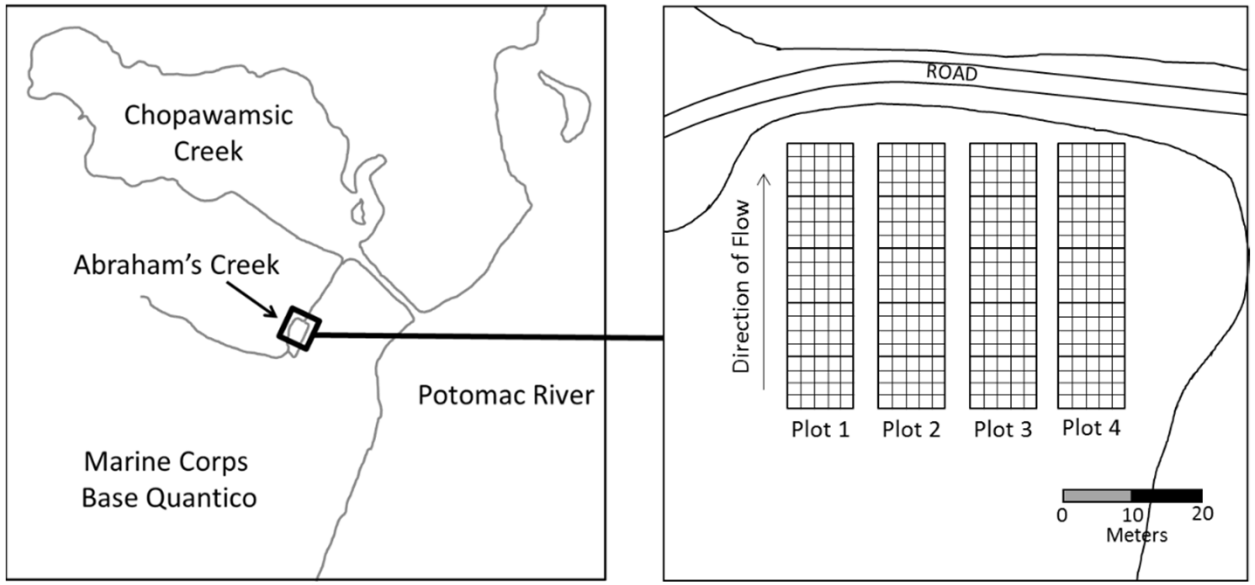
- SediMite™ with biofilm of PCB transforming microorganisms stained in green

Capozzi et al., 2019. Biofouling: 10.1080/08927014.2018.1563892

Application of Bioamended AC

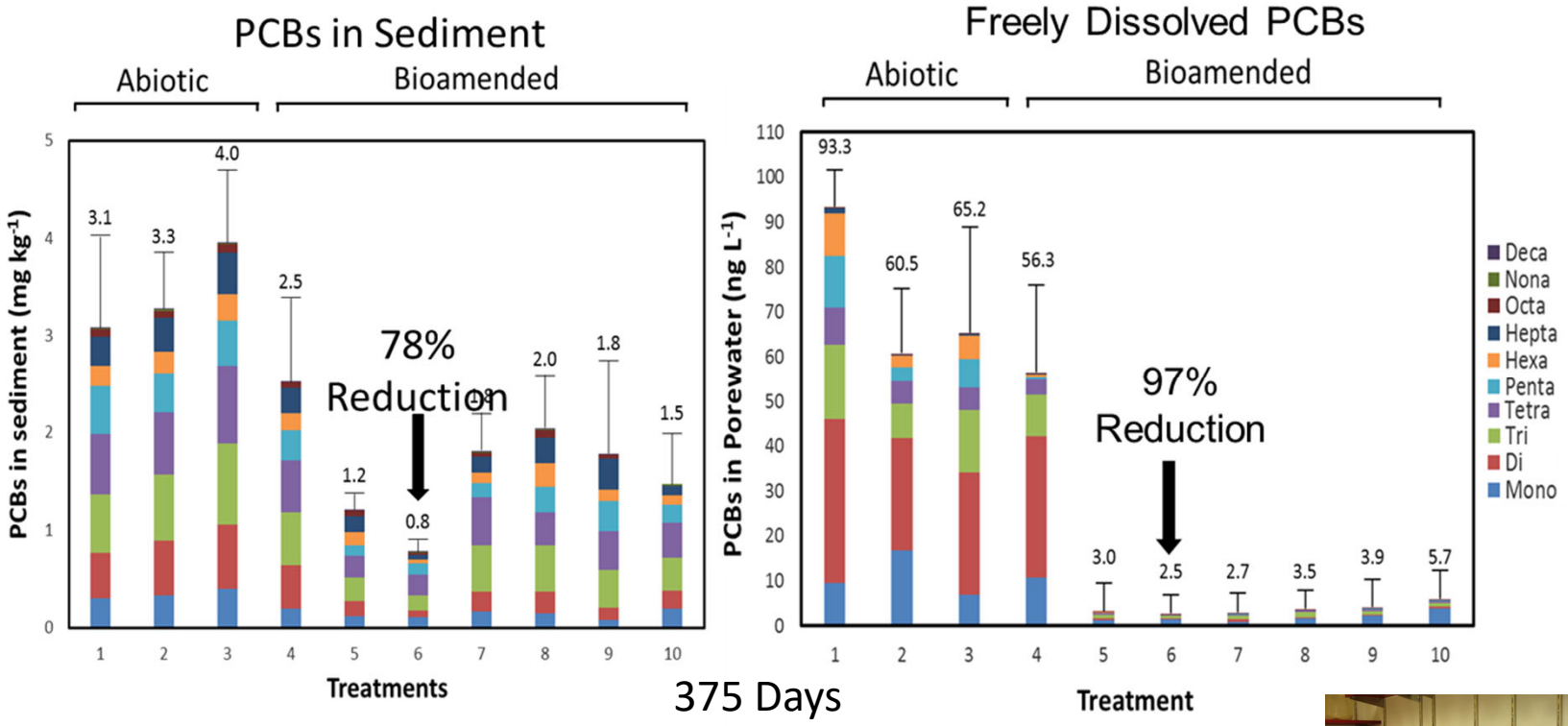


Abraham's Creek VA



- Abraham's Creek MCBQ is an 8 acre/32,000 m^2 watershed outflow
- Contaminated with an average 5 ppm weathered A1260
- Treatments in four 400 sq. m plots
- Load rate = 1 ton SediMite + 10^{12} cells/400 m^2

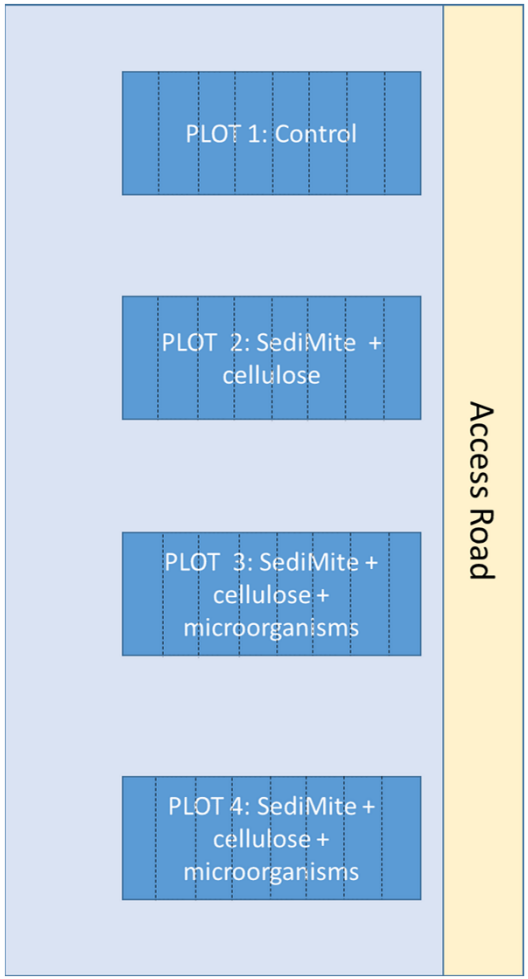
Treatability Study-Results



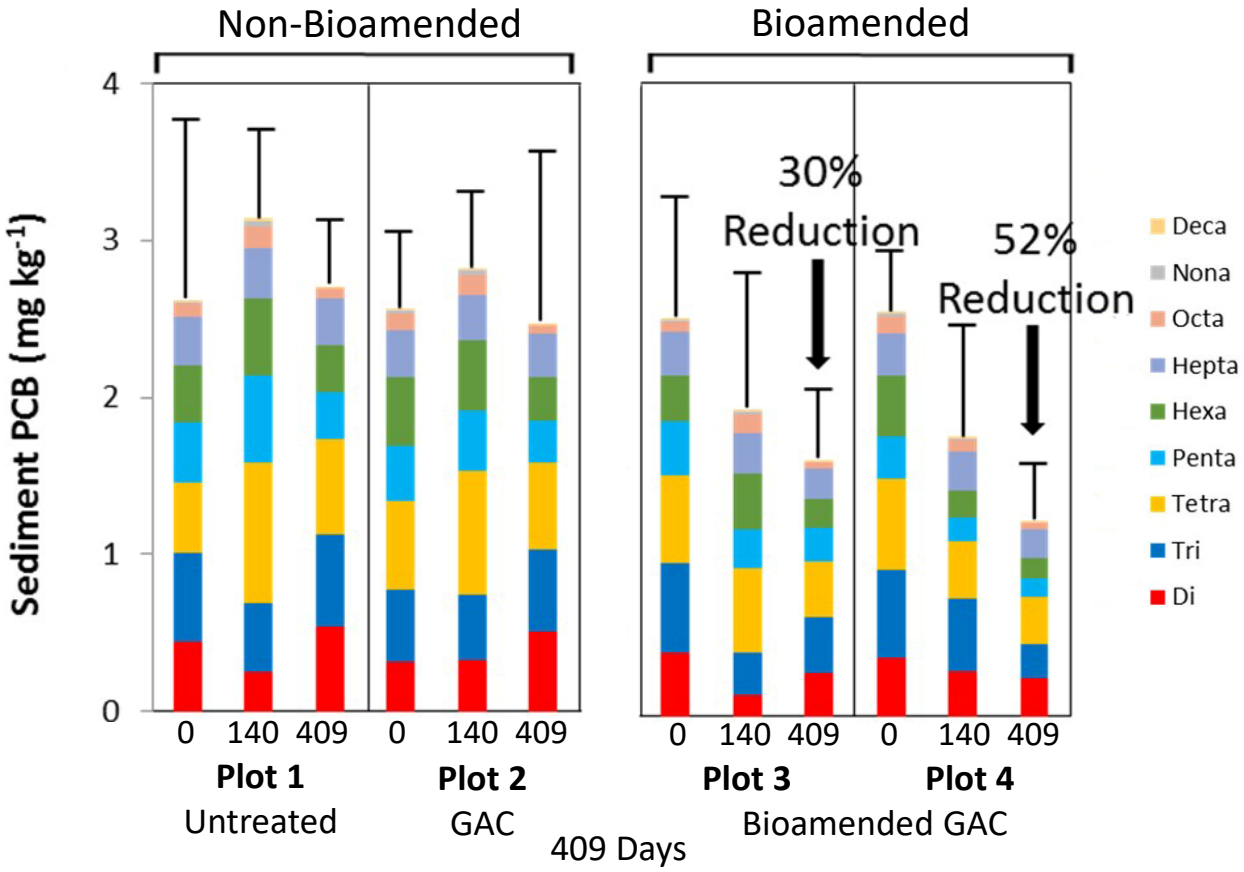
- No significant reduction in PCB mass without bioamendment
- 78% reduction in total PCB/97% reduction in soluble PCB with 10^5 cells/g
- Dioxin-like congeners levels reduced 90%
- DF1/LB400 combination catalyzed greatest reduction in mass

Field Test Design

- Plot 1 – no treatment
- Plot 2 – SediMite containing cellulose as a slow release carbon source
- Plot 3/4 – SediMite/cellulose amended with anaerobic PCB dechlorinating DF1 and aerobic dechlorinating/oxidizing LB400
- SediMite 3% + 10^5 cells g^{-1}

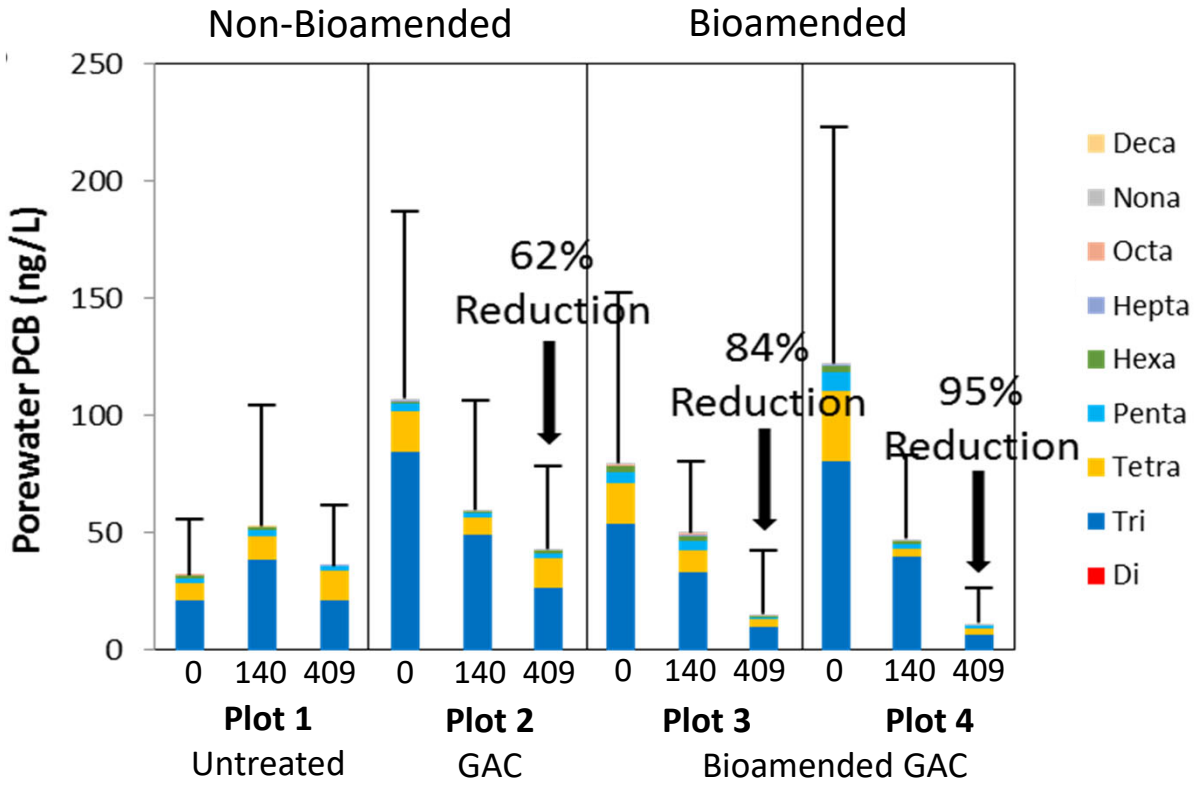


Effect of Treatment on Total PCBs



- No significant change in non-bioamended plots
- Significant decrease observed in both bioamended plots
- 80% reduction in total mass of coplanar PCBs in plot 4

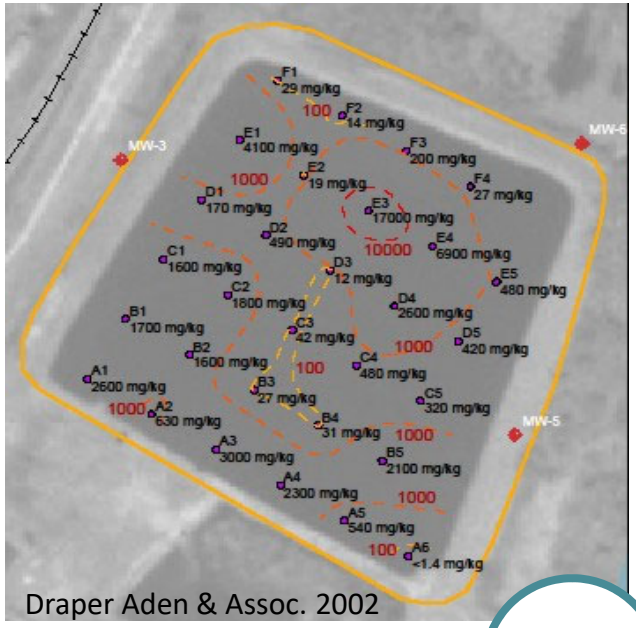
Effect of Treatment on Dissolved PCBs



- Significant decrease observed in bioamended plots
- Some decrease with AC due to adsorption, but significantly less than in bioamended plots
- No significant change in untreated plot or below 7.5 cm

In Situ Treatment of High PCB Levels

- Waste Water Emergency Overflow Pond primary treatment until mid-70's
- Area 6 acres/24,000 m^2
- Aroclor 1248 (<17,000 ppm) from glass fabric production
- Adjacent to Roanoke River
- Site is currently in VA DEQ voluntary remediation program



Draper Aden & Assoc. 2002

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Treatment Goals

- VA DEQ voluntary remediation program requires reduction of PCBs to <50 PPM

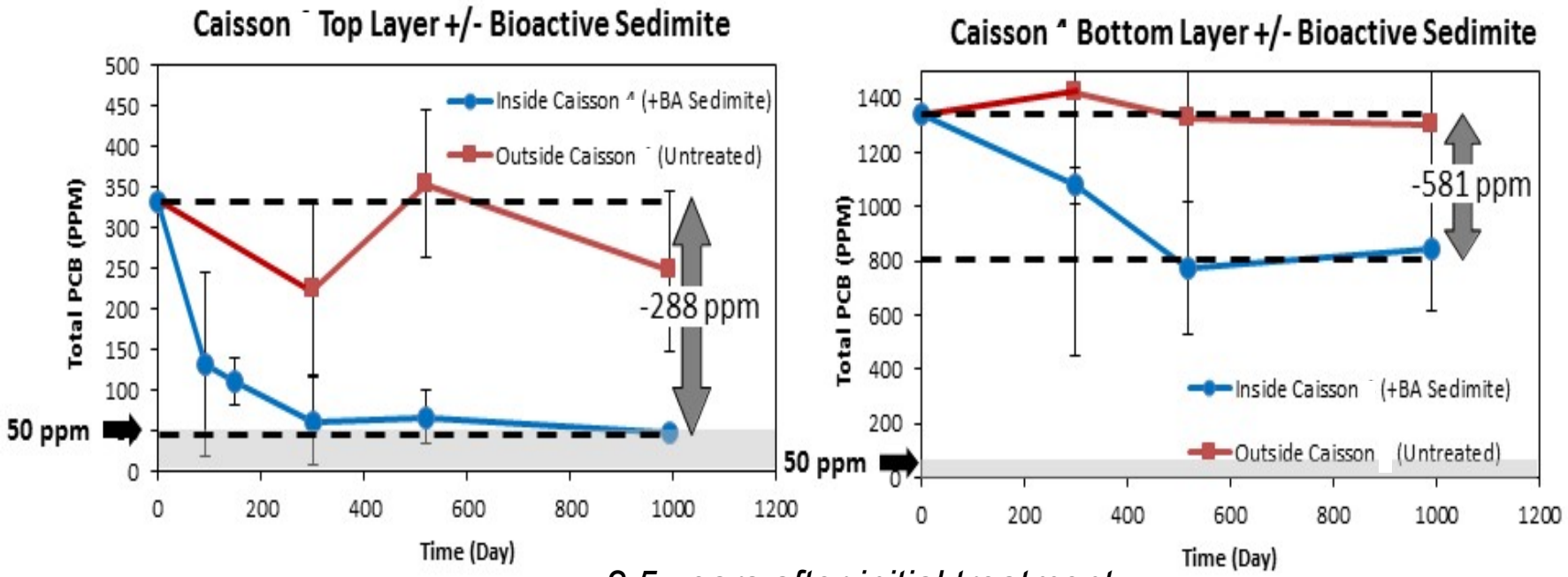
- Of currently accepted technologies: dredging is expensive; capping prevents use of emergency overflow basin

- *In situ* treatment with Bioamended Activated Carbon:
  - cost-effective for town
  - provides sequestering & degradation of PCBs
  - negates requirement for extensive waste management
  - maintains function of emergency overflow basin

In Situ Treatability Study

- Deployed oil drums with ends removed down to clay liner
- Bioamended SediMite added at a 5% dry wt sediment
- Mixed into sediment with a mud mixer
- Triplicate core samples tested inside and outside of caisson

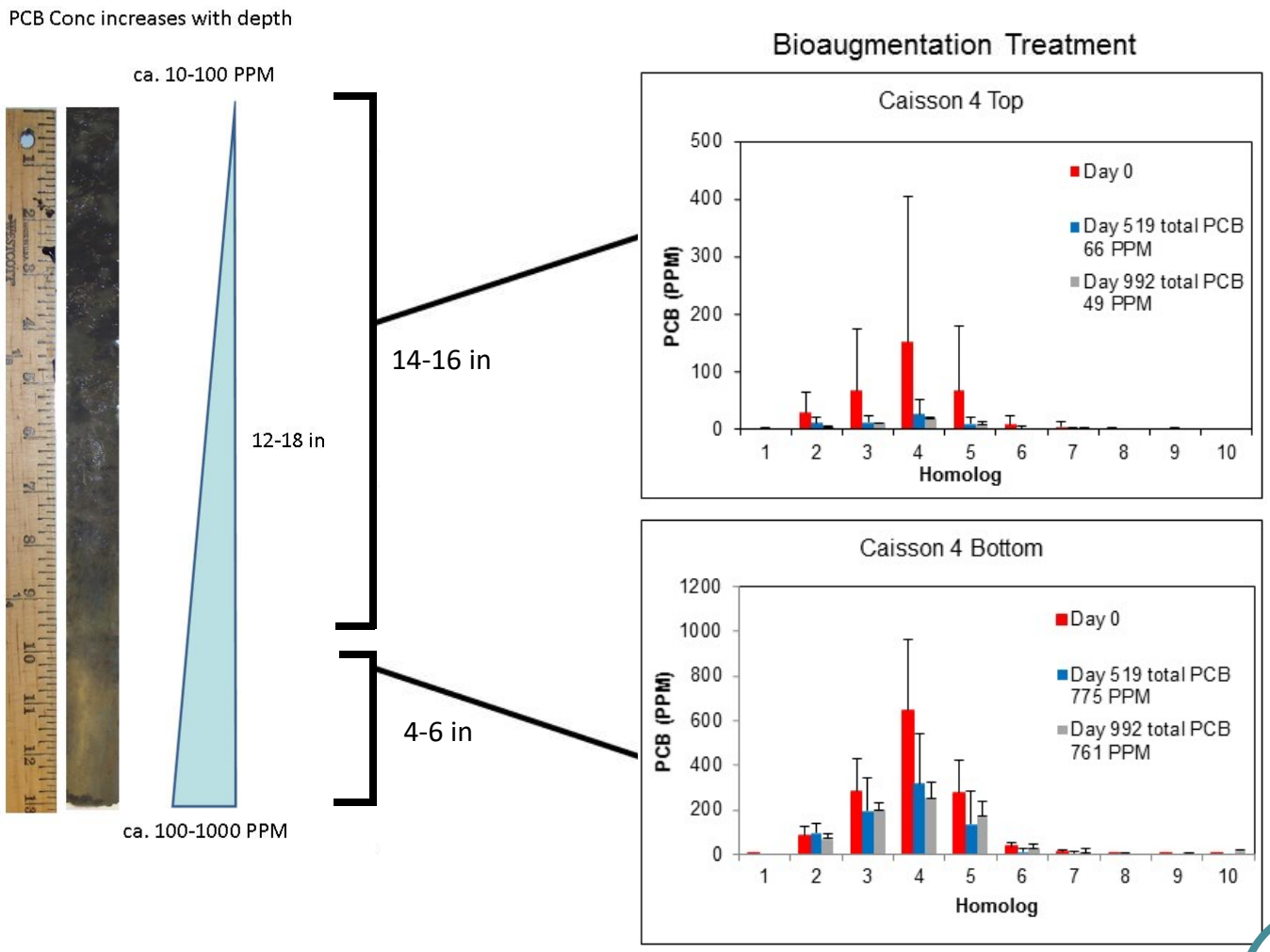
Effect of Treatment on Total PCBs



2.5 years after initial treatment

- PCB level in upper 14 inches of sediment reduced 80%
- PCBs in 0-4 inch bottom layer of sediment reduced 45%
- Mixing sediments during application increased activity

Effect of Treatment on Total PCBs

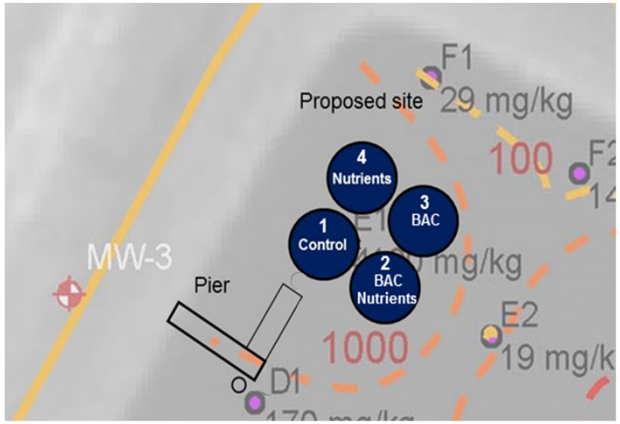


Summary – In Situ Test

2.5 years after initial treatment

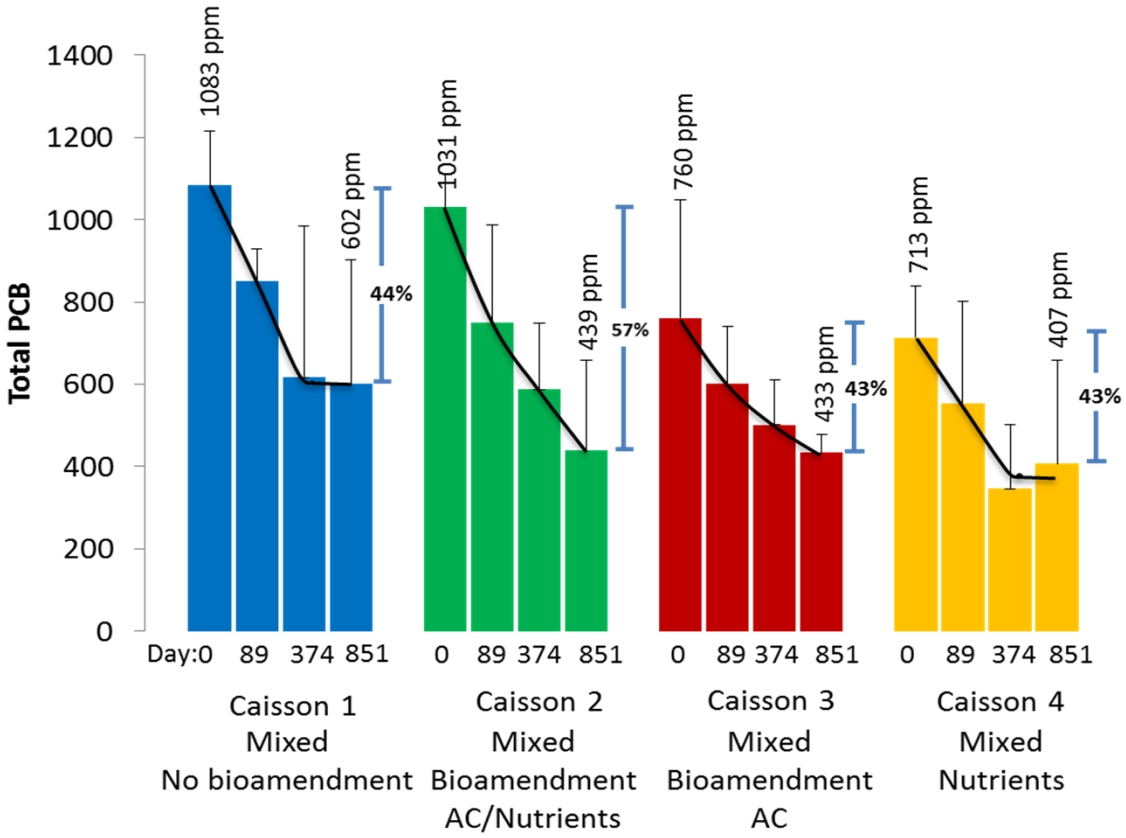
- PCBs in upper 14 inches of sediment degraded below 50 PPM
- PCBs in 0-4 inch bottom layer of sediment reduced 45%
- Mixing sediments during application increases activity

Pilot Scale Field Study



- Four - 80 sq. ft (7.4 sq. m.) caissons
- PCB levels 500 – 1500 PPM
- Applied approximately 1200 lbs bioamended SediMite
- Sump pump used to homogenize sediments

Pilot Scale Field Study-Results



- Mixing alone has some stimulatory effect that levels off after 1 yr
- Treatments with bioamendment continue to degrade after 2.3 yr
- Year 4 sampling in 2019

Summary

- Bioamended GAC effective for treatment of <1300 mg kg^{-1} PCBs
- In situ test showed up to 80% PCB mass reduced in 2.3 yr
- Pilot test indicates mixing has a stimulatory effect for 1 yr
- Bioamendment continues to reduce PCB mass continues after 1 yr
- Full scale treatment will require tilling in bioamendment

Contributors & Collaborators

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Questions

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