In-Situ Treatment of PCB-Impacted Sediments with Bioamended SediMite

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Toxic Contaminants Workgroup
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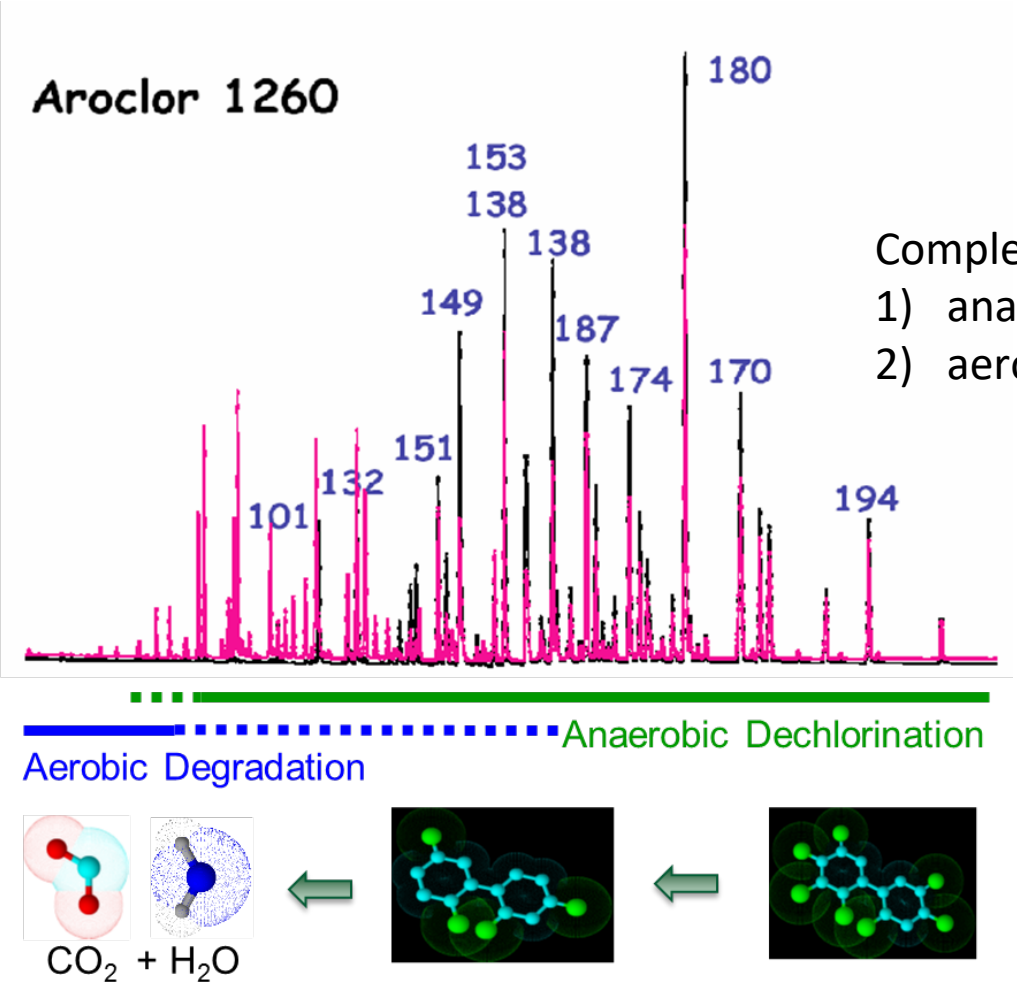
Microbial degradation of PCBs



Complementary activities of:

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

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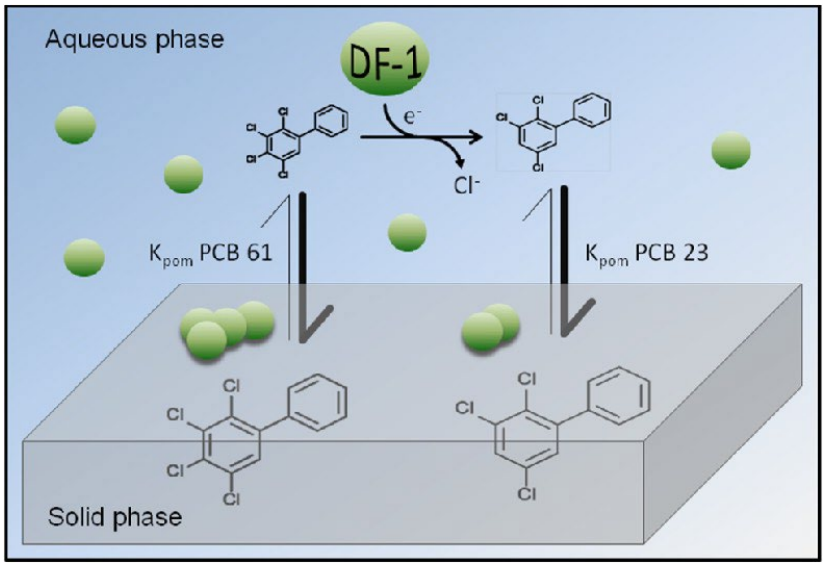
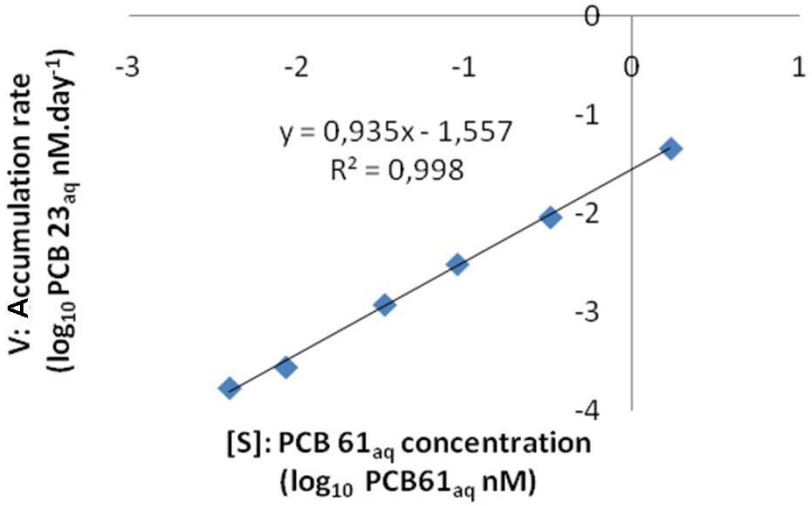
Halorespiring bacteria are ubiquitous but natural attenuation of PCBs is slow



Halorespiration = 1st order rate kinetics



- PCB dechlorinating population typically <10^3 cells mL^{-1}
- Halorespiration of PCBs occurs at 1 ng L^{-1} (limit of detection)
- Aqueous PCB concentrations too low to support large indigenous population

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

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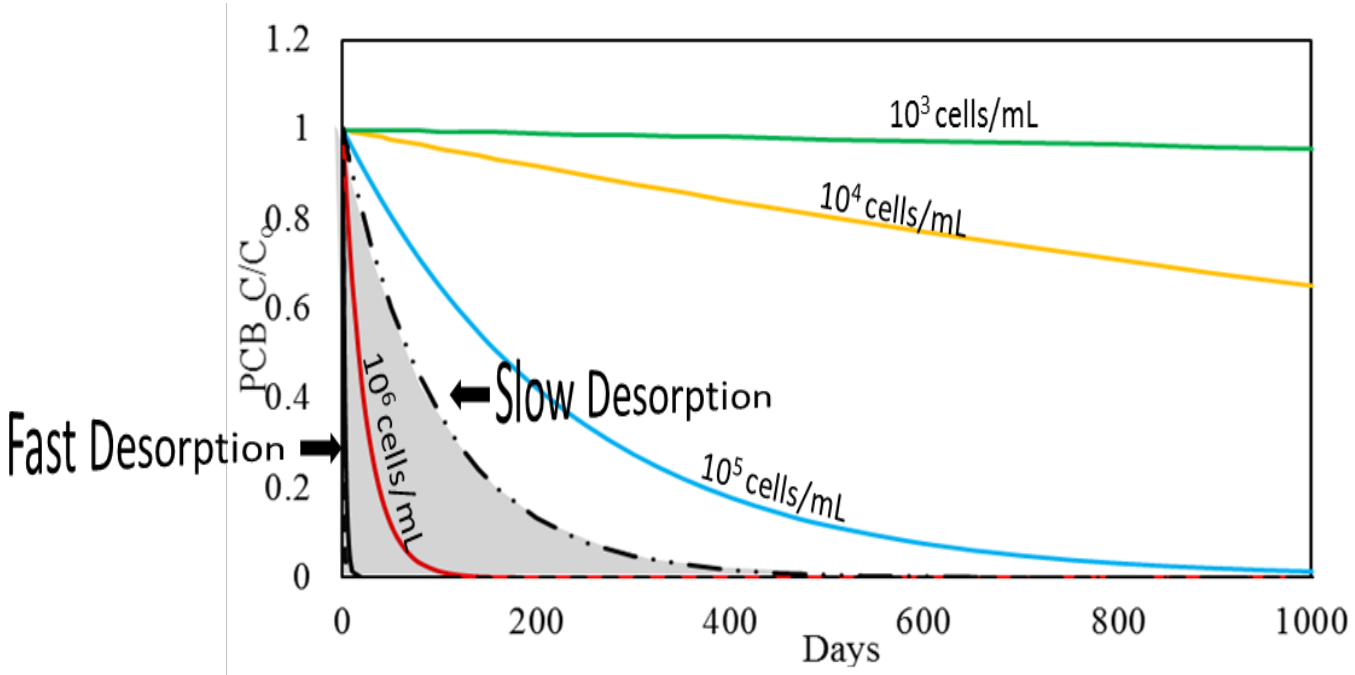
Desorption Rate vs Dechlorination Rate



- PCB desorption rates exceed dechlorination rates of indigenous halorespiring populations
- Bioaugmentation increases dechlorination at rates similar to desorption rates

Needham *et al.* 2019 ES&T 53:7432-7441

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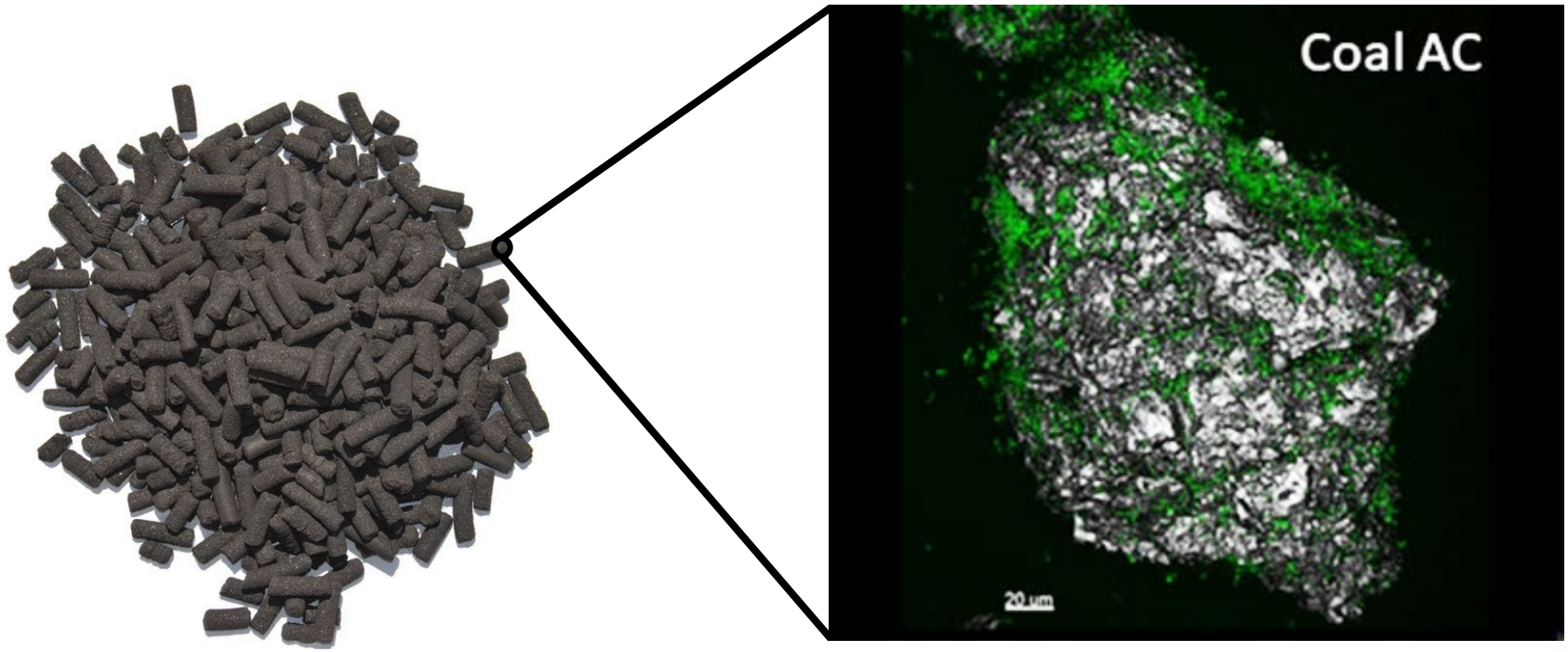
Bioamended Activated Carbon



• CLSM image of SediMite™ loaded with PCB transforming microorganisms stained with SYBR green

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

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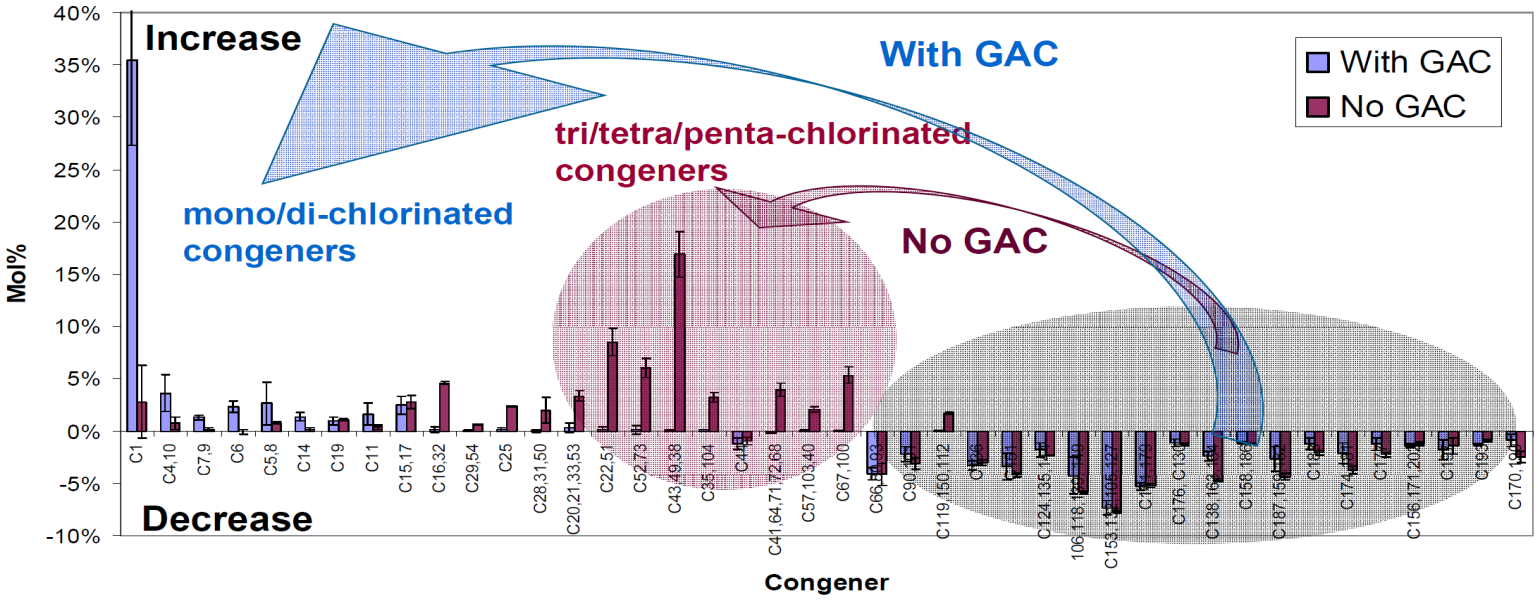
Effect of Activated Carbon on Halorespiration



- Halorespiration of Aroclor 1260 not inhibited by AC
- AC results in more extensive dechlorination of Aroclor 1260

Kjellerup *et al.* 2014 Wat. Res. 52:1-10

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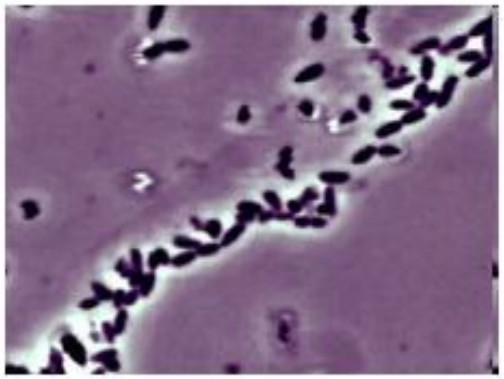
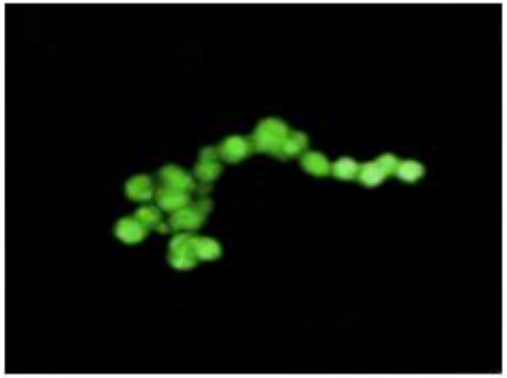
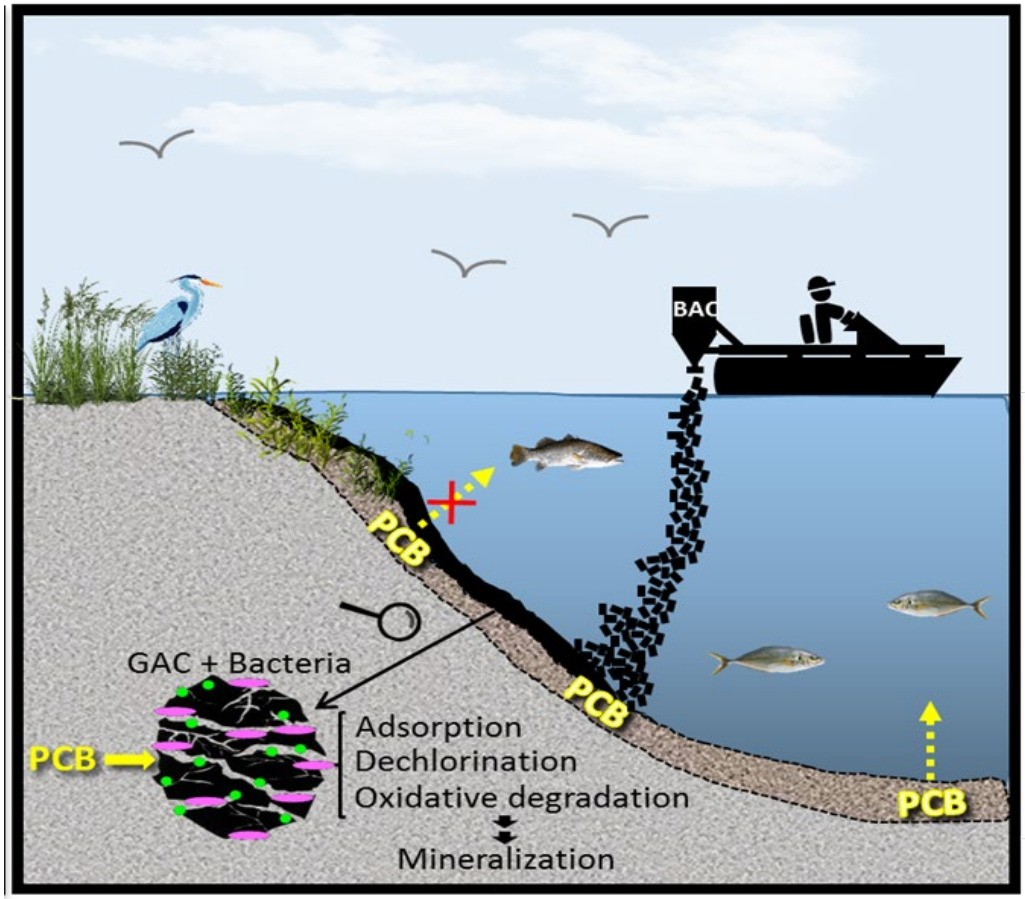
PCB Degrading Co-Culture



Burkholderia xenovorans LB400



Dehalohalobium chlorocoercia DF-1



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Waste Water Treatment Pond, Altavista VA

- 28,650 m^2 former wastewater treatment pond
- Contaminated with Aroclor 1248 from glass fabric factory
- Concentrations up to several thousand mg/kg

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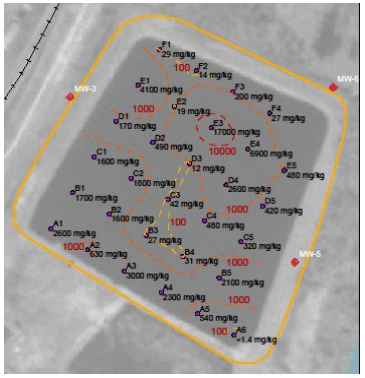
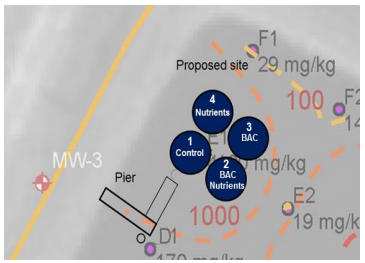
Waste Water Treatment Pond, Altavista VA

7.4 m Caisson Study





- 400 lbs bioamended SediMite deployed into four caissons
- Final concentration 3% bioamended SediMite & 10^5 cells g^{-1} sediment
- Sediments homogenize down to clay liner with sump pump

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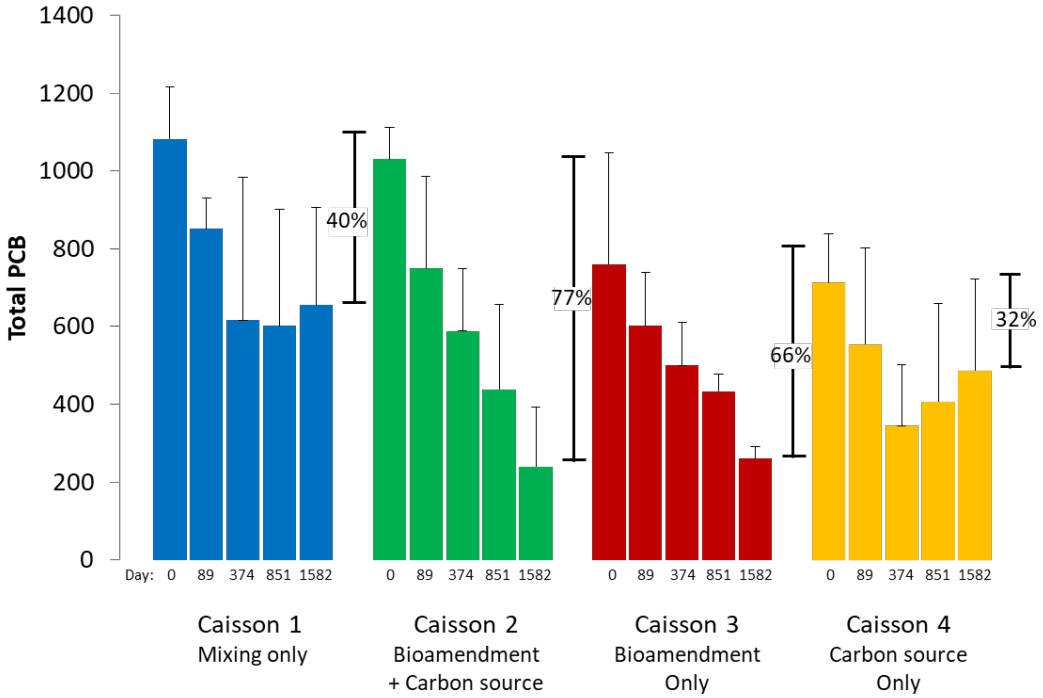
PCB Concentration Post Treatment



- Only significant changed observed in bioamended caissons
- Bioamendment + carbon source decreased by **800 PPM** after 4.3 years
- Untreated & carbon source without bioamendment showed some activity but stopped after 1 year
- PCB concentration on downward trend

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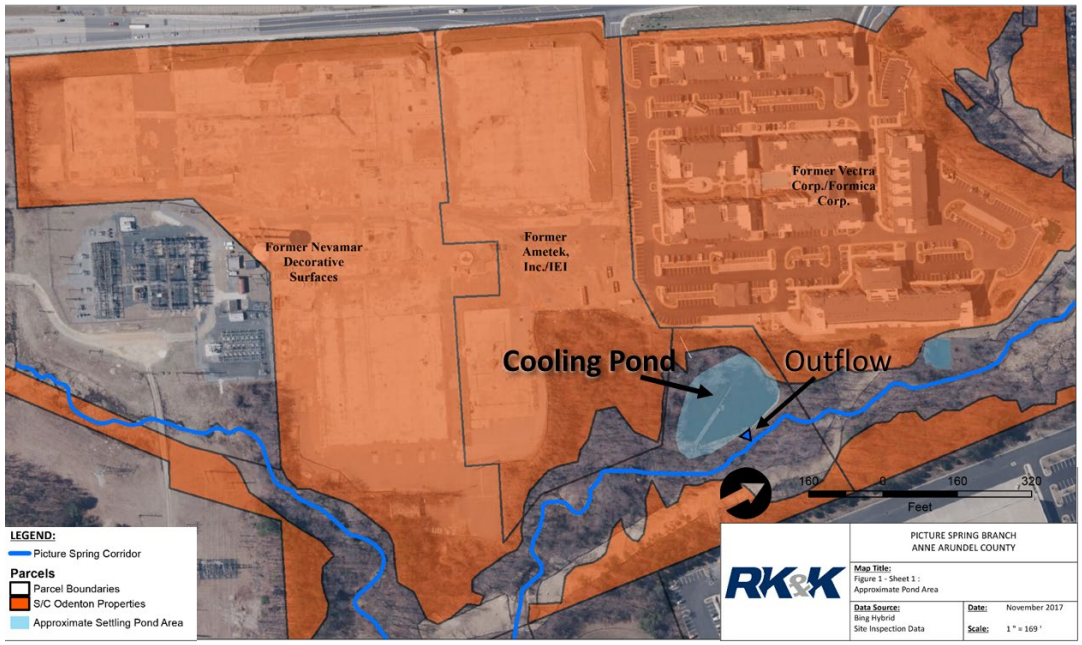
Former laminate plant cooling pond

Anne Arundel County, MD



- Surface area 22,072 ft^2 (2,050 m^2)
- Average water depth between 2 and 4 ft (60-120 cm^2)
- Aroclor 1254 and 1260 detected at a mean concentration of 704 µg/kg
- Objective: reduce point sources of PCBs flowing to Severn River watershed

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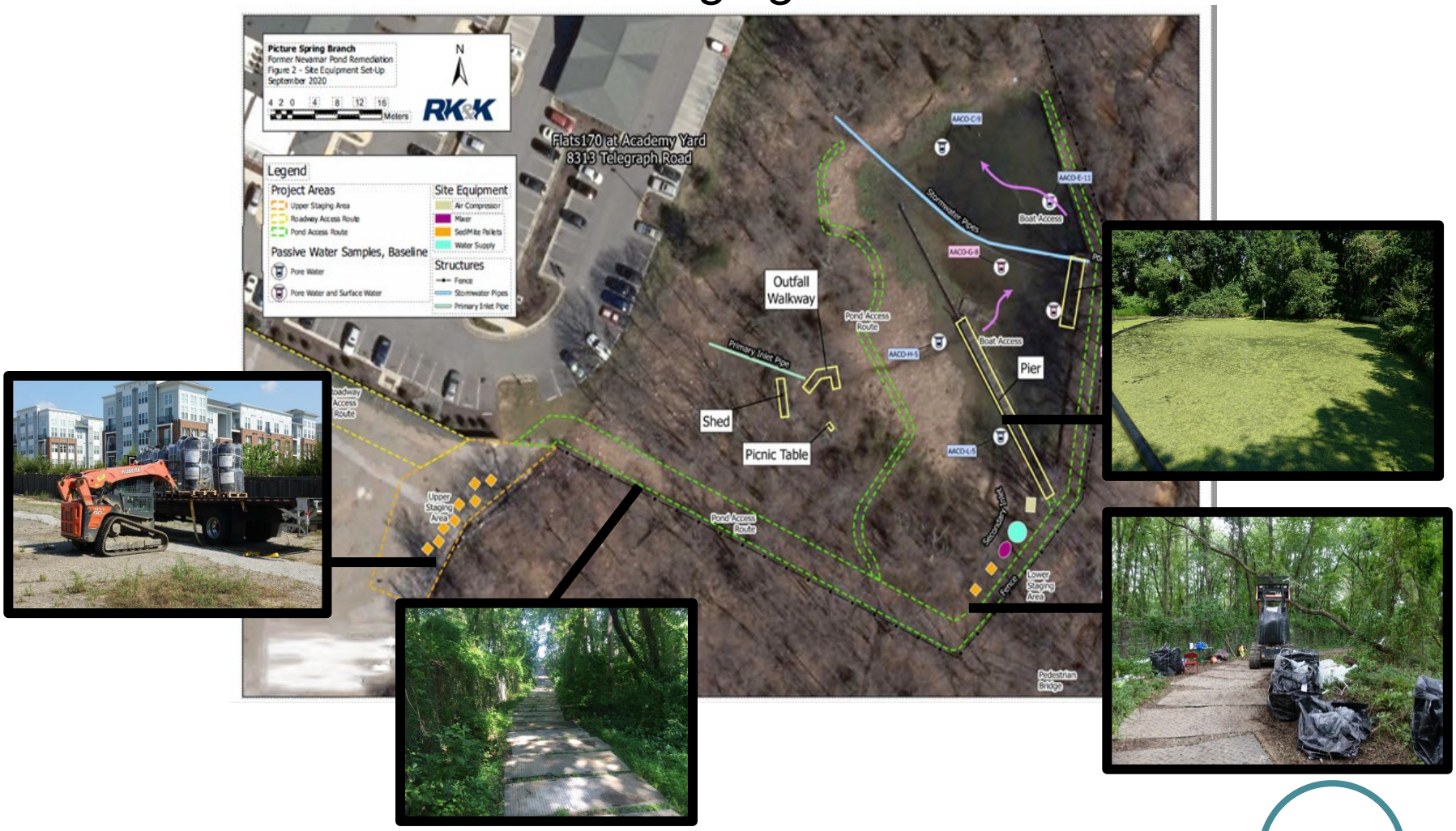
Former laminate plant cooling pond

Staging



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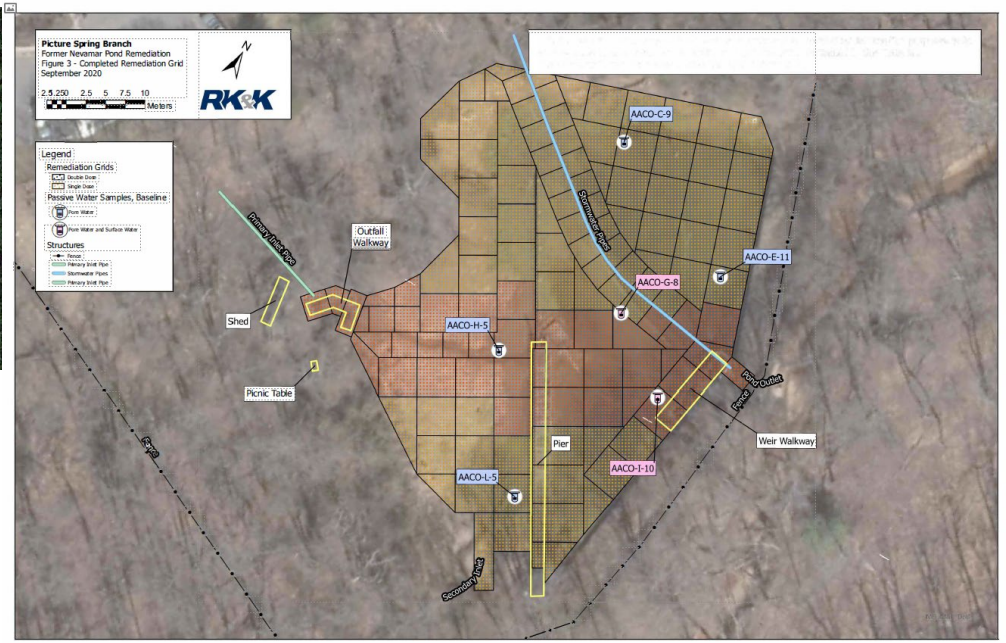
Former laminate plant cooling pond

Treatment Approach



- 15 tons of bioamended AC manually deployed into 10 and 15 ft^2 grids
- Final concentration 3% bioamended SediMite in north and south portions of pond and 6% bioamended SediMite in central pond between inlet and outlet
- Final bioamendment concentration was 10^5 cells/g sediment

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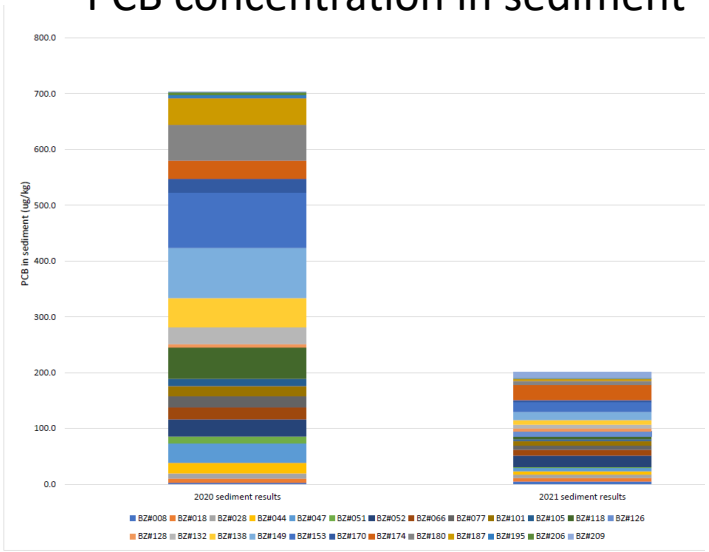
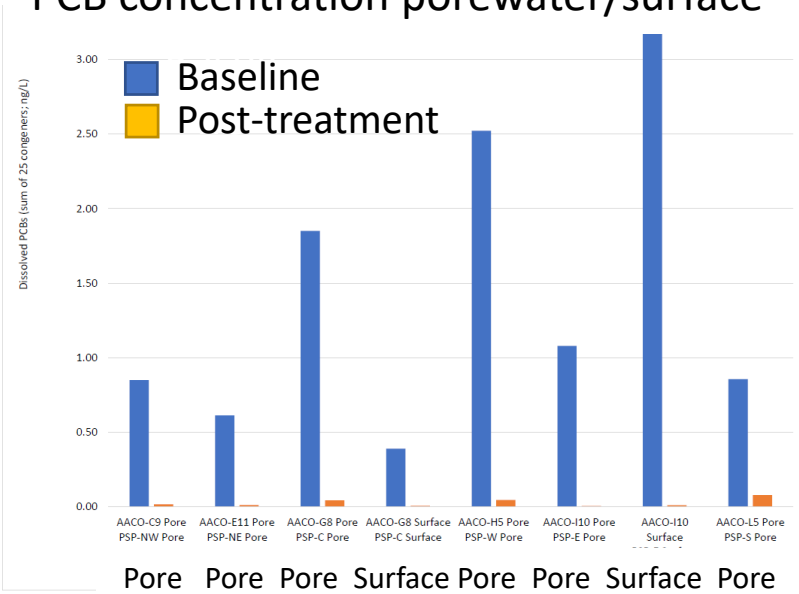
PCB Concentrations Pre- and Post Treatment

PCB concentration in sediment



PCB concentration porewater/surface



- **72%** reduction total PCBs in sediment 1 year after treatment
- **97-99%** reduction PCBs in porewater 1 year after treatment
- Congeners driving dissolved concentrations fully equilibrated

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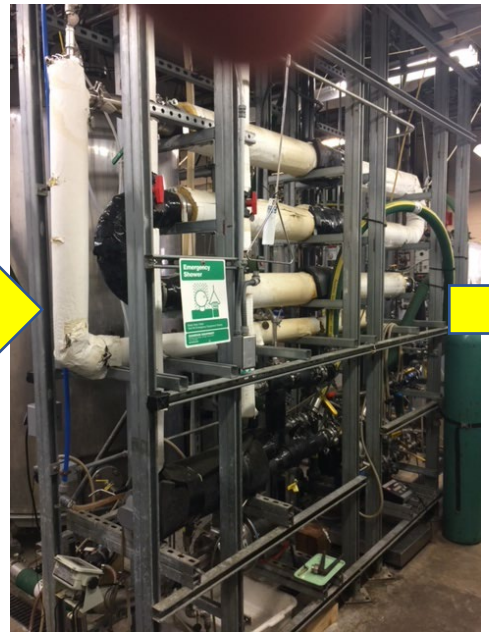
Mass Cultured for Large-Scale Treatment



- Biomass production at high volumes
- Optimized yields 4 x 10^8 cells/L
- Harvested and concentrated
- Stored and transported in SS canisters

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Large-Scale Deployment

- 45 MT bioamended SediMite deployed over 1 acre marine sediment
- Final SediMite concentration = 3 g/10 g sediment
- Final bioamendment concentration = 10^6 cells/10 g sediment
- Deployment completed in 3 days - results pending

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Outcomes & Lessons Learned

In situ bioremediation was effective for treating PCBs in a sites with:

- limited access
- high PCB concentrations
- both PCB impacted soil and sediment
- fluctuating seasonal temperatures
- environmentally sensitive sites

Limitations:

- physical mixing required in absence of benthic activity
- sites with high energy disturbance may require stabilization

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Advantages of bioamended AC

- Both sequesters & degrades total and soluble PCBs
- Rapidly deployed and minimally invasive
- Low carbon footprint
- No extensive waste management or habitat restoration
- Different application methods available depending on site requirements
- Treatment effective in rivers, ponds, marine and freshwater sediments

Other treatment projects with bioamended SediMite on-going or in planning stages

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Contributors, Collaborators, Funding Sources

- **Kevin R. Sowers and Upal Ghosh**
  RemBac Environmental & University of Maryland Baltimore County

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  University of Maryland Baltimore County

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IMET Institute of Marine and Environmental Technology

UMBC AN HONORS UNIVERSITY IN MARYLAND

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SEDIMENT SOLUTIONS

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