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

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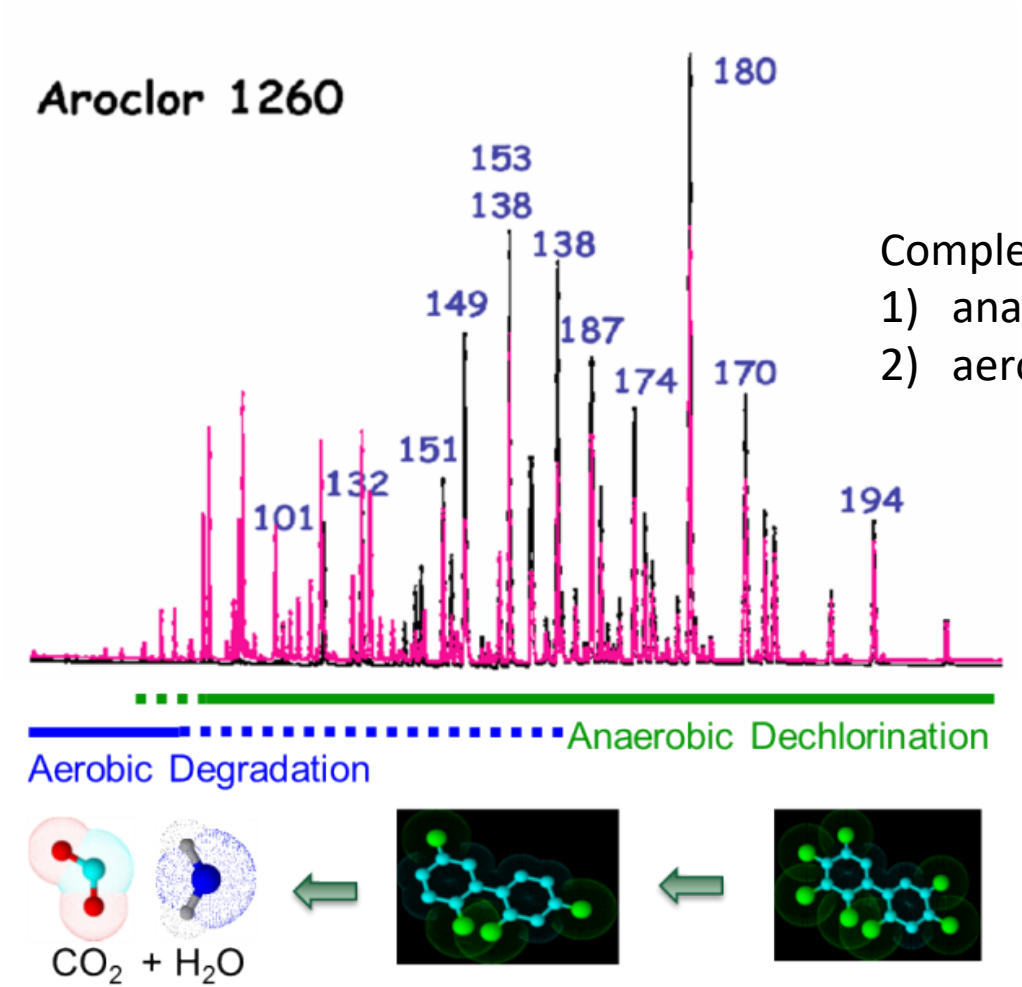
Microbial degradation of PCBs



Complementary activities of:

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

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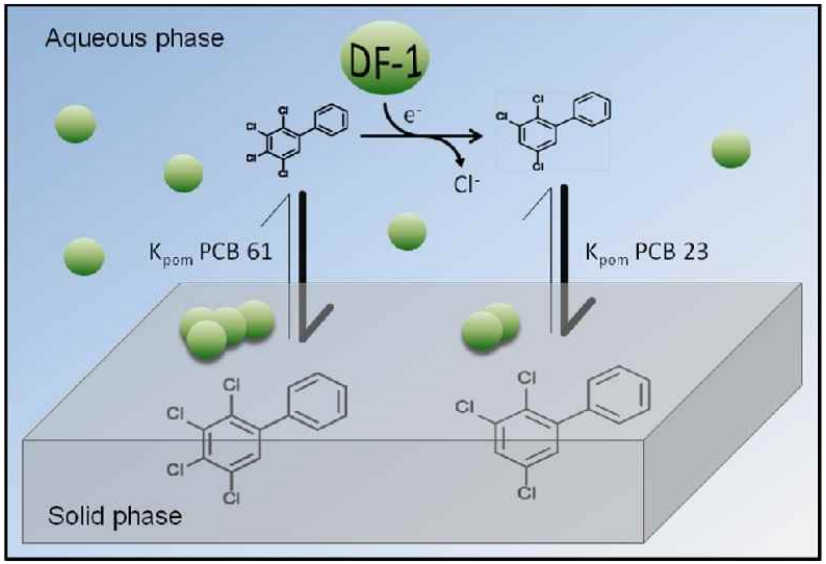
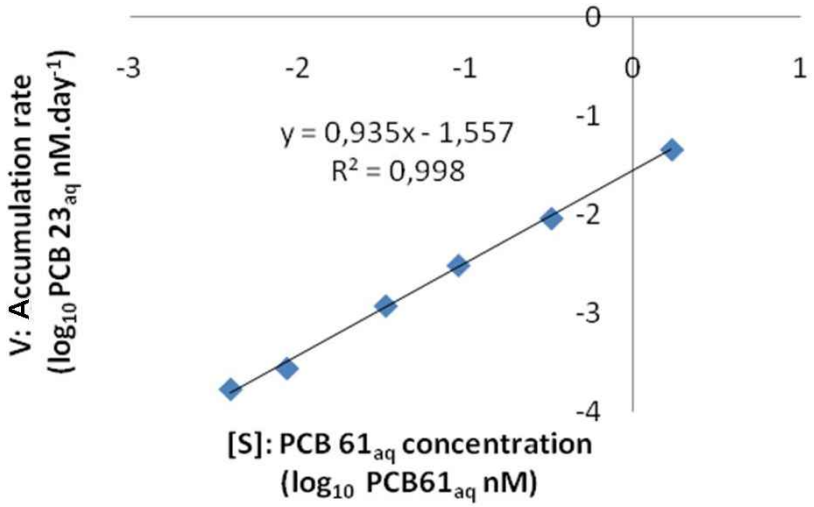
Halorespiring bacteria are ubiquitous but natural attenuation of PCBs is slow



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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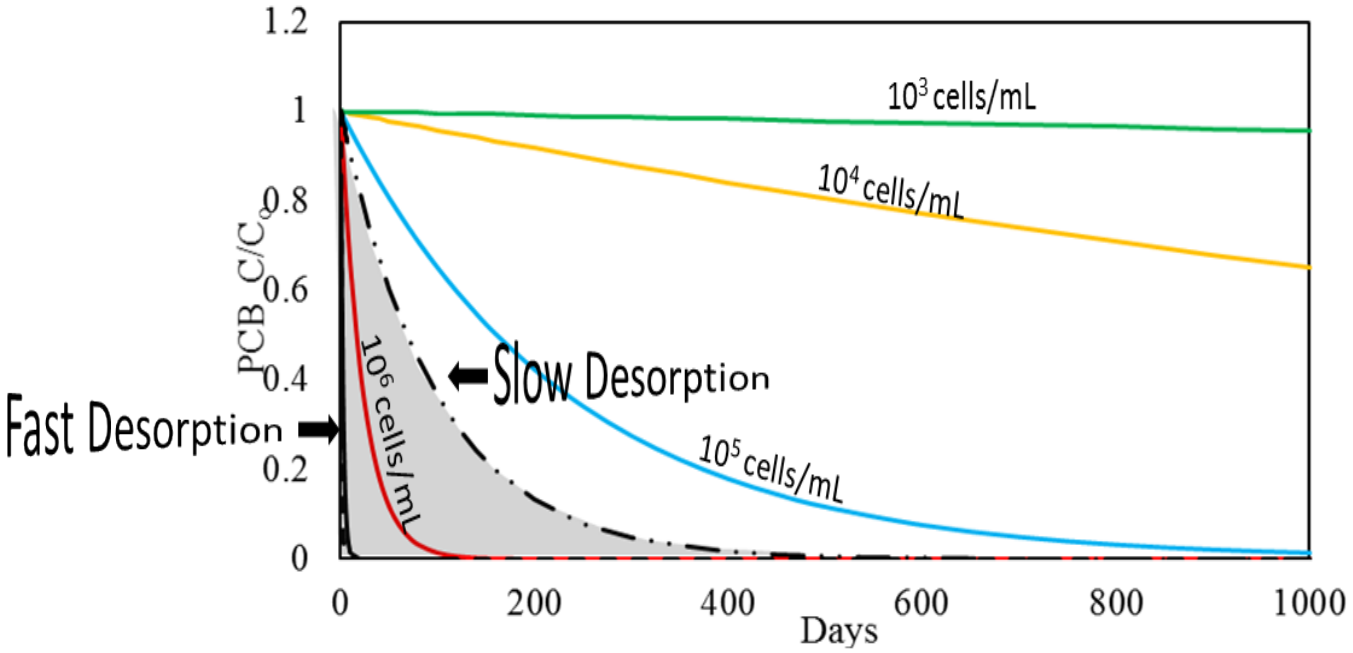
Desorption Rate vs Dechlorination Rate



- 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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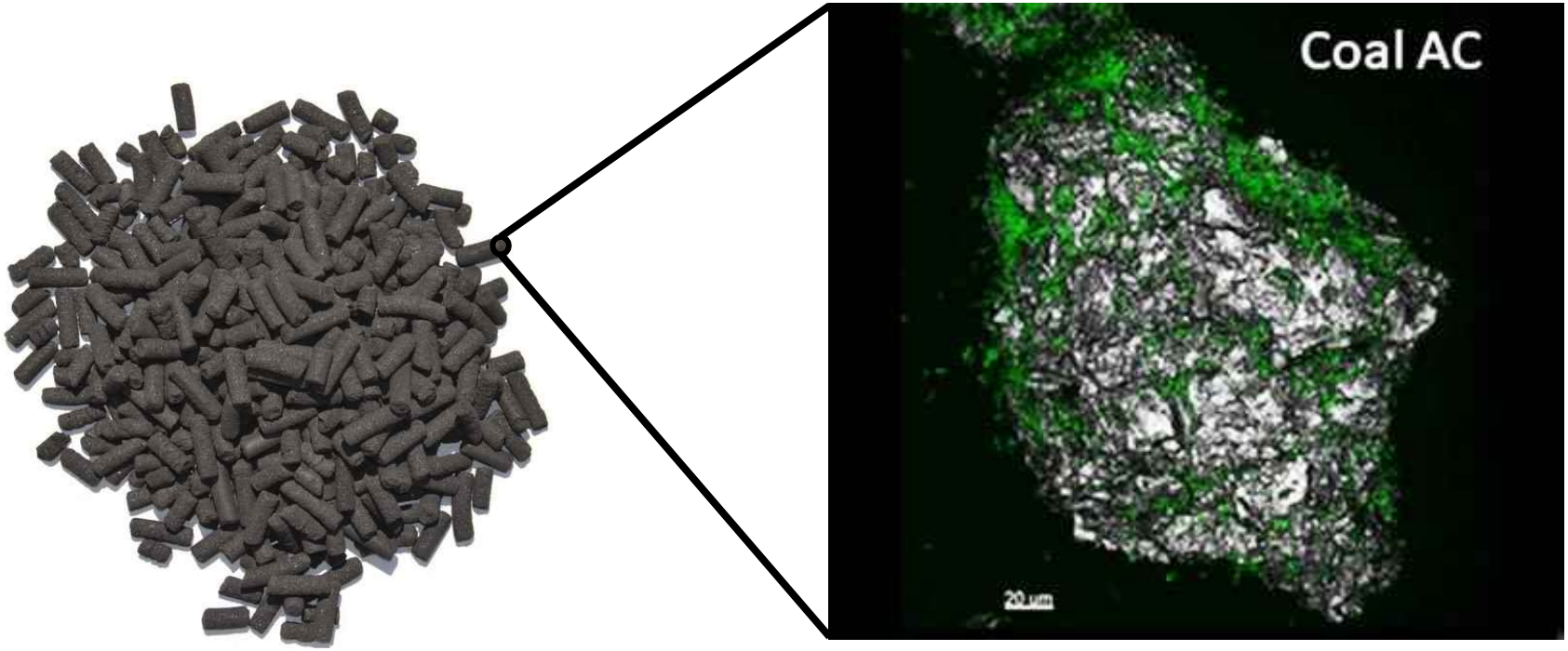
Bioamended Activated Carbon



• 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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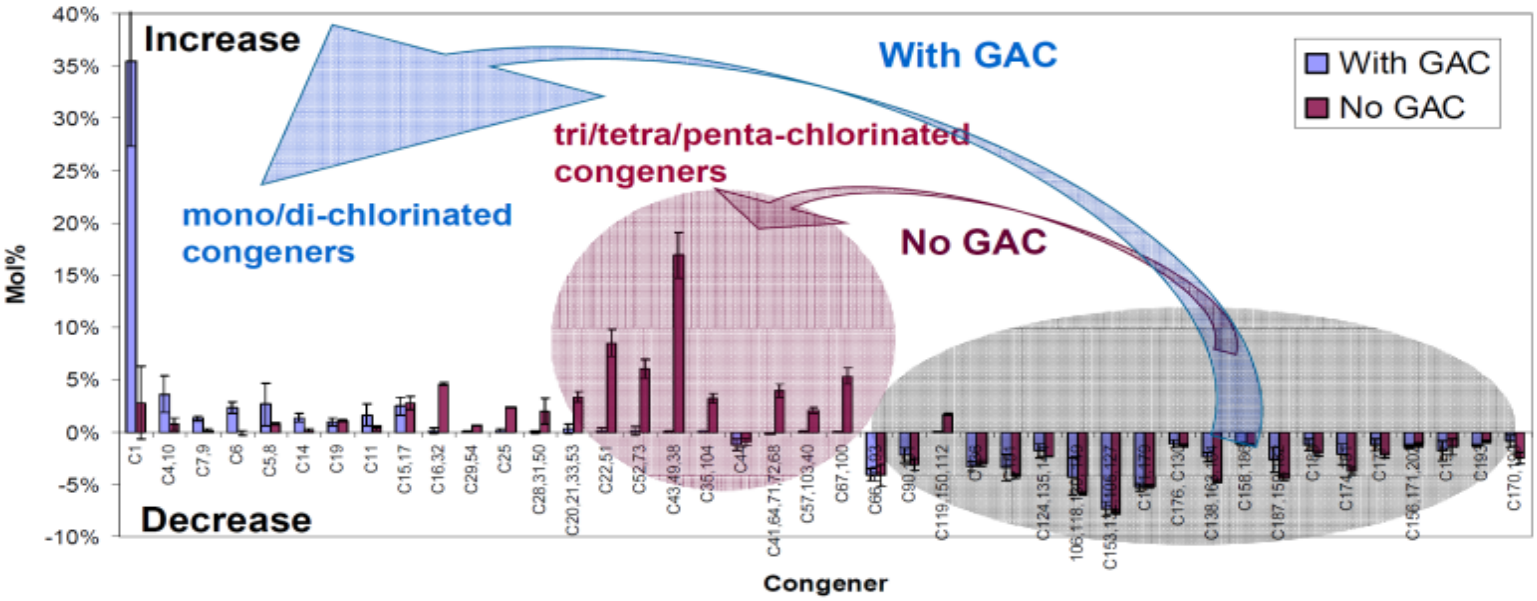
Effect of Activated Carbon on Halorespiration



- 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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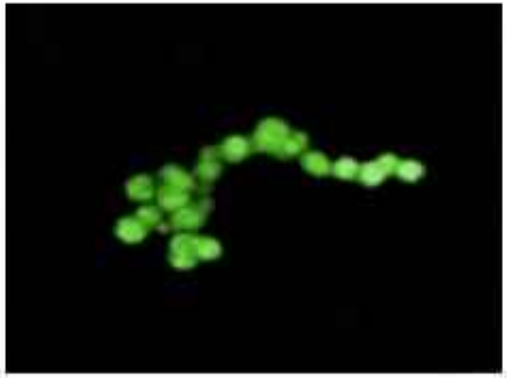
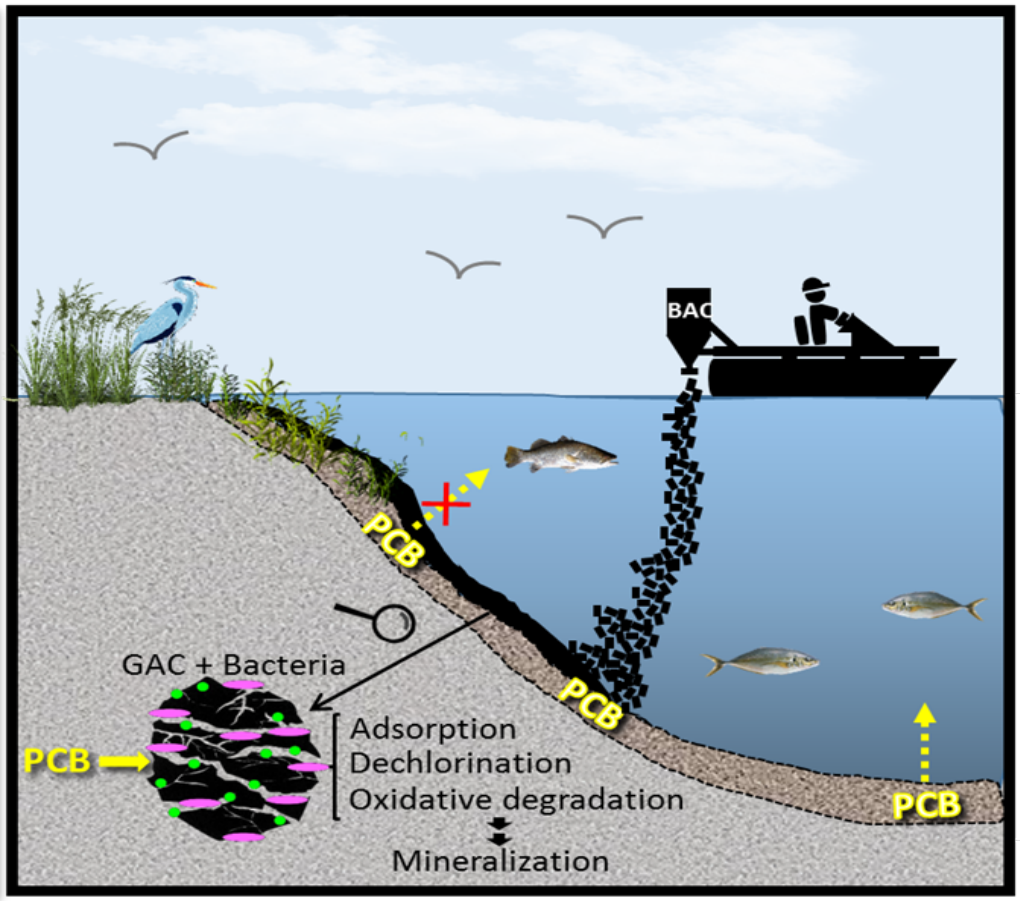
PCB Degrading Co-Culture

Burkholderia xenovorans LB400



Dehalohalobium chlorocoercia DF-1



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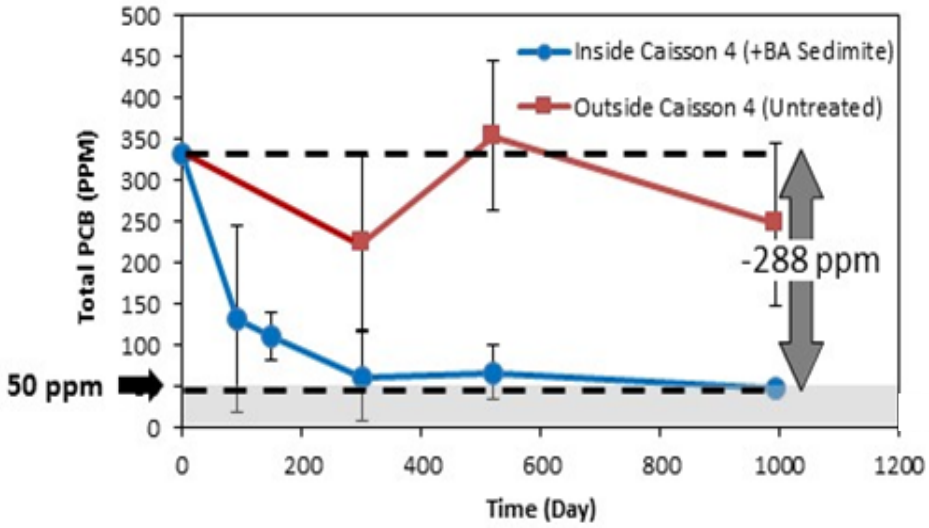
Waste Water Treatment Pond, Altavista VA

0.26m^2 Caisson Pilot Study



- 28,650 m^2 former wastewater treatment pond contaminated with Aroclor 1248
- Concentrations from a few mg/kg to several thousand mg/kg
- Treated with 3% Bioamended AC
- **80%** decrease in mass from **275 to 49 mg/kg** after 2.7 years
- No significant change in untreated controls
- Objective: reduce PCB concentration to <50 mg/kg

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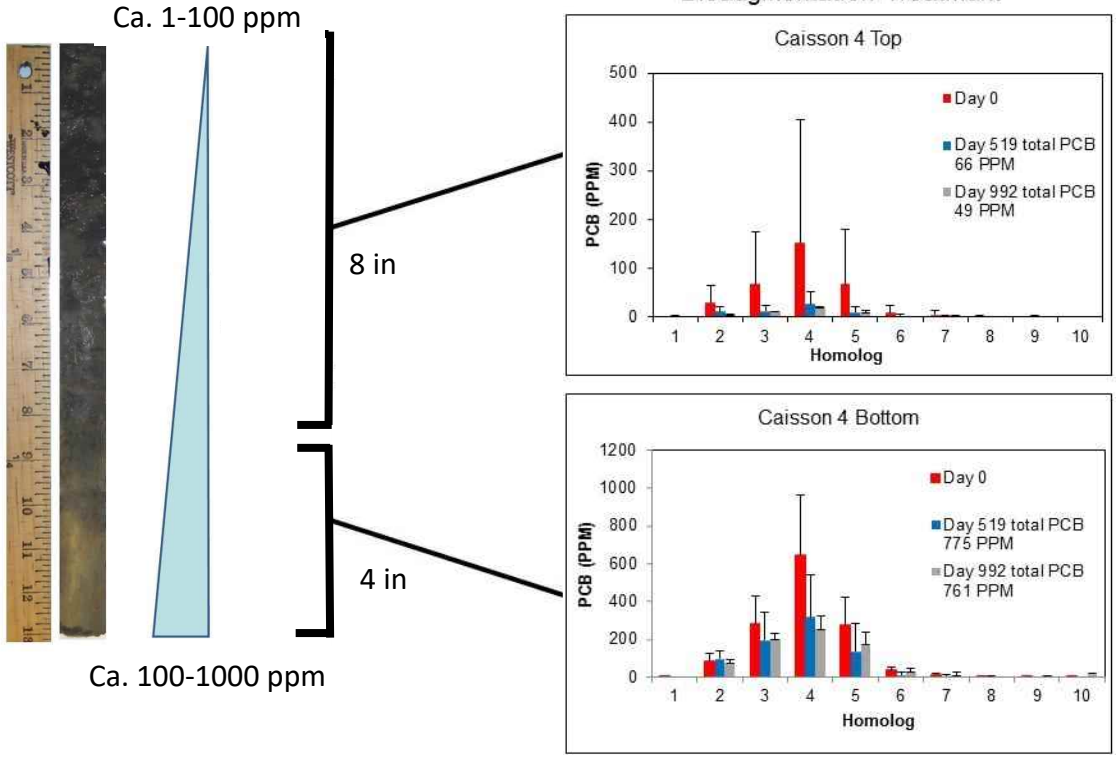
PCB Depth Profile



- Highest concentrations of PCBs in lower sediment
- Bioamendment was less effective in lower depth due to lack of penetration
- Sediment would have to be tilled for effective bioremediation

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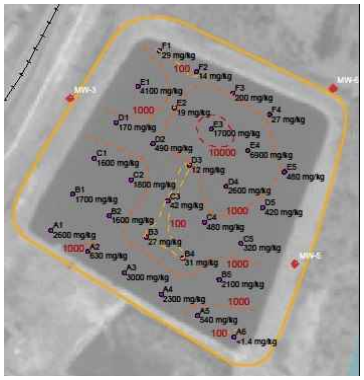
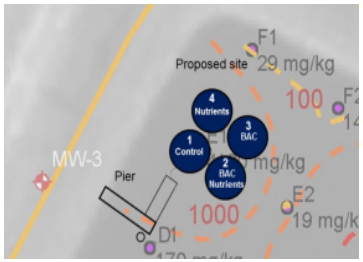
Waste Water Treatment Pond, Altavista VA

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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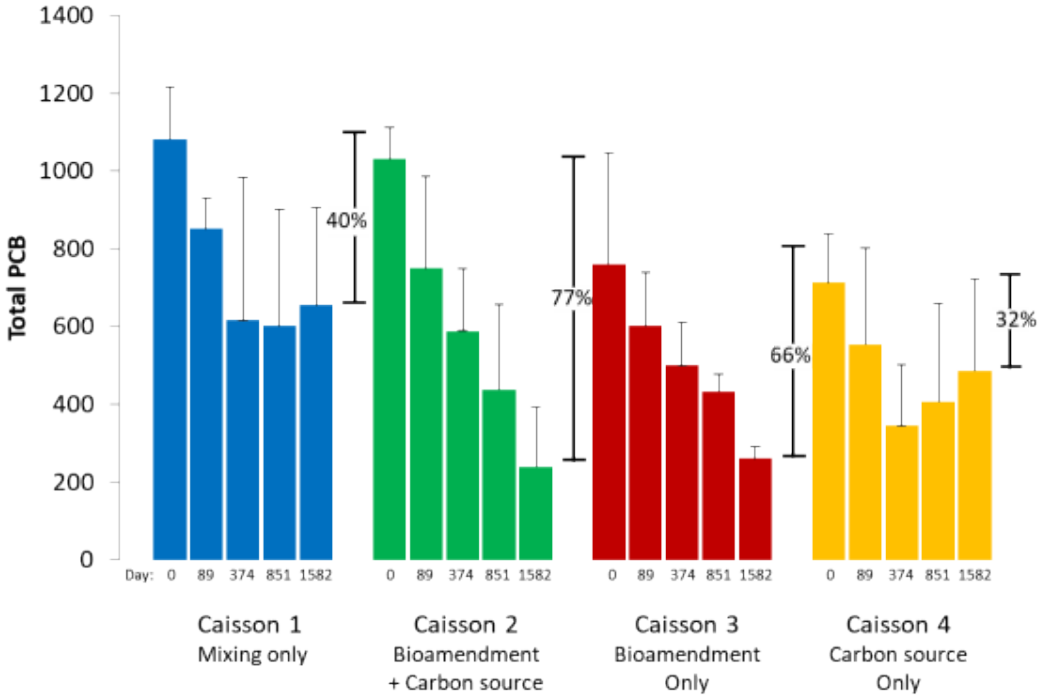
PCB Concentration Post Treatment



- 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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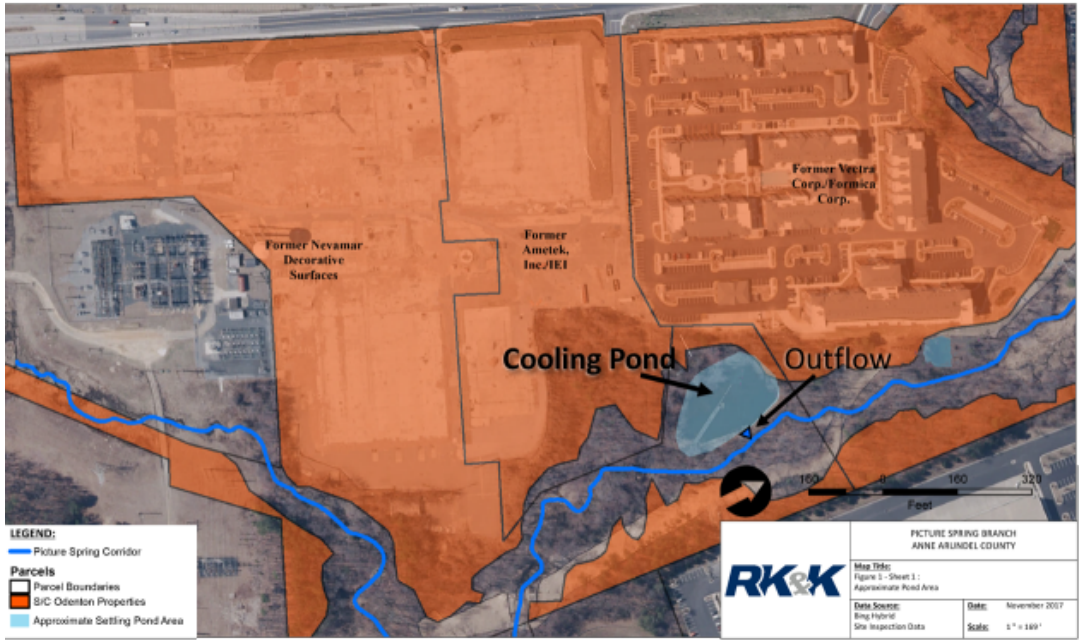
Former laminate plant cooling pond

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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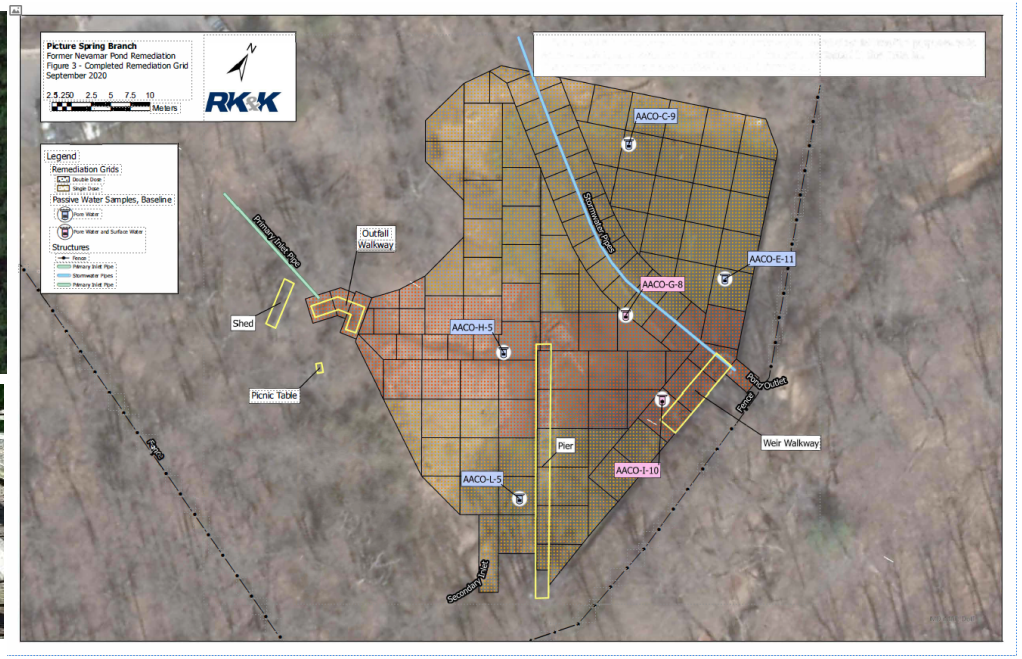
Former laminate plant cooling pond

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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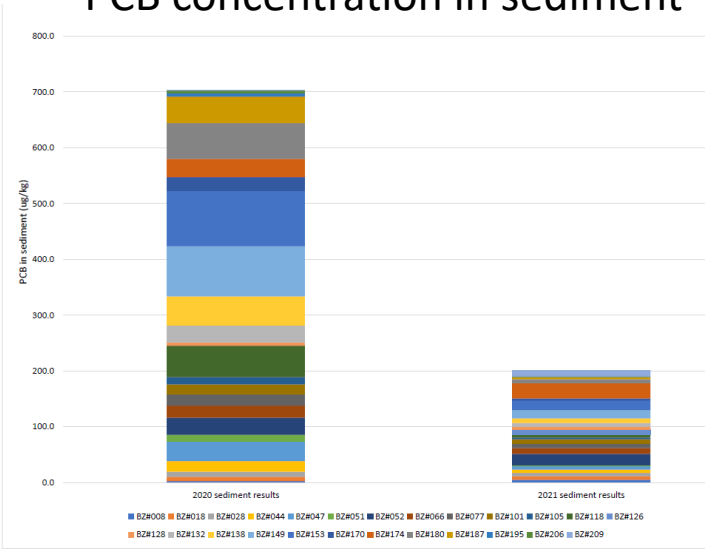
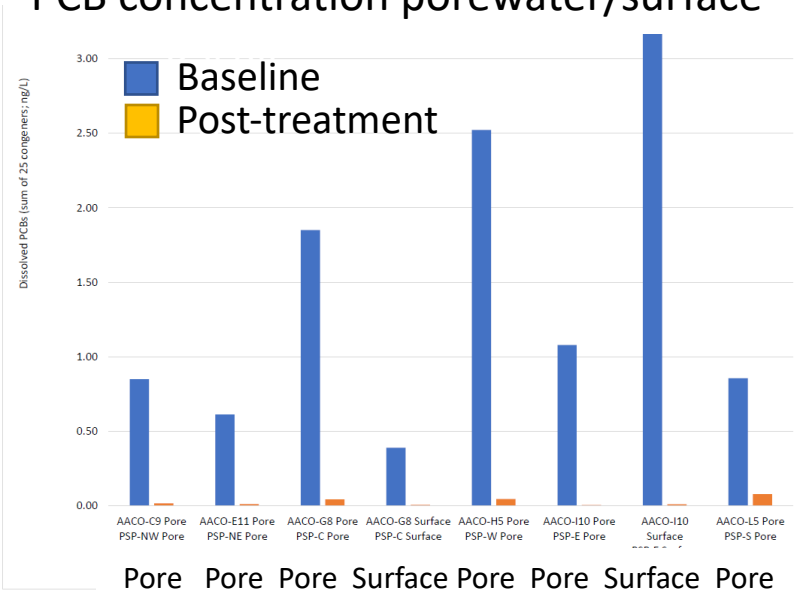
PCB Concentrations Pre- and Post Treatment

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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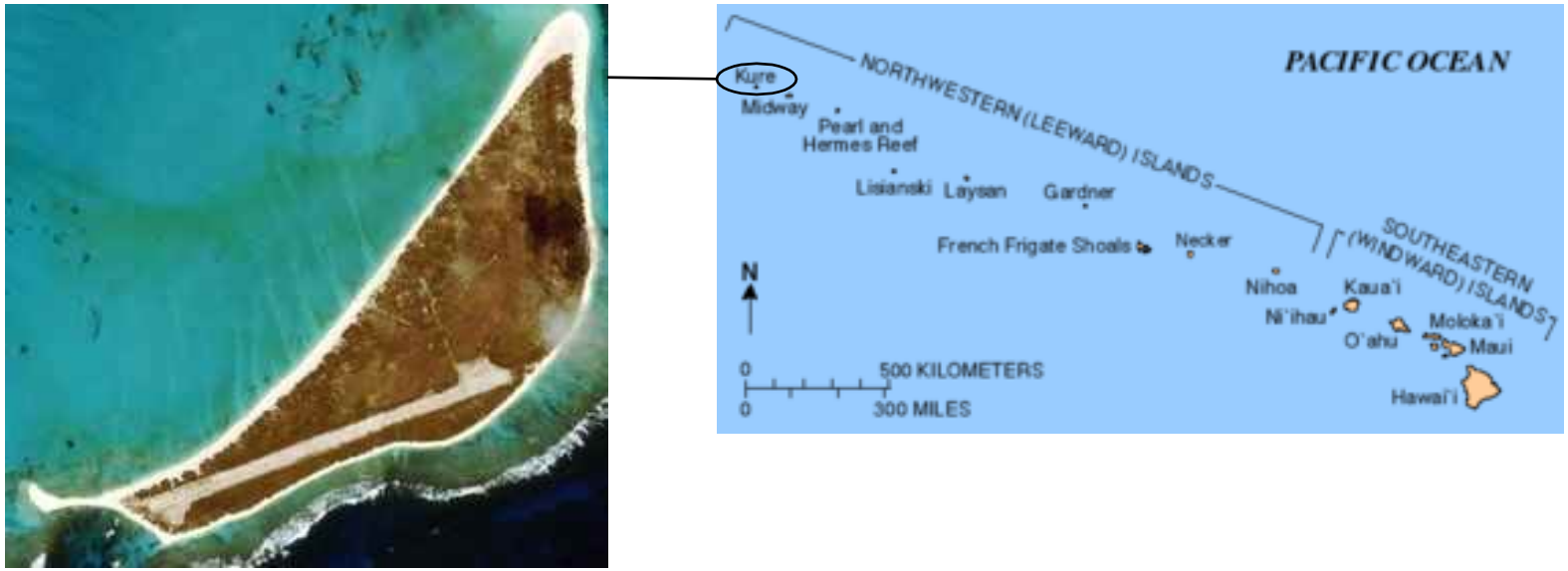
Green Island, Kure Atoll, HI



- Former LORAN station contaminated with Aroclor 1260 from waste dump
- Extreme logistical challenges: 1,400 miles from Honolulu; no infrastructure/power
- Access only by ship and landing craft: standard dig and haul not practical
- An in situ remedy was preferred due to remote location and logistics

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Green Island, Kure Atoll, HI

Treatment

- Element Environmental excavated contaminated soil and transferred to trench lined with AC fabric in center of island
- Bioamendment was mixed with nutrient buffer
- Soil treated by spraying bioamendment onto sequential layers
- Cores returned to lab and incubated in dark

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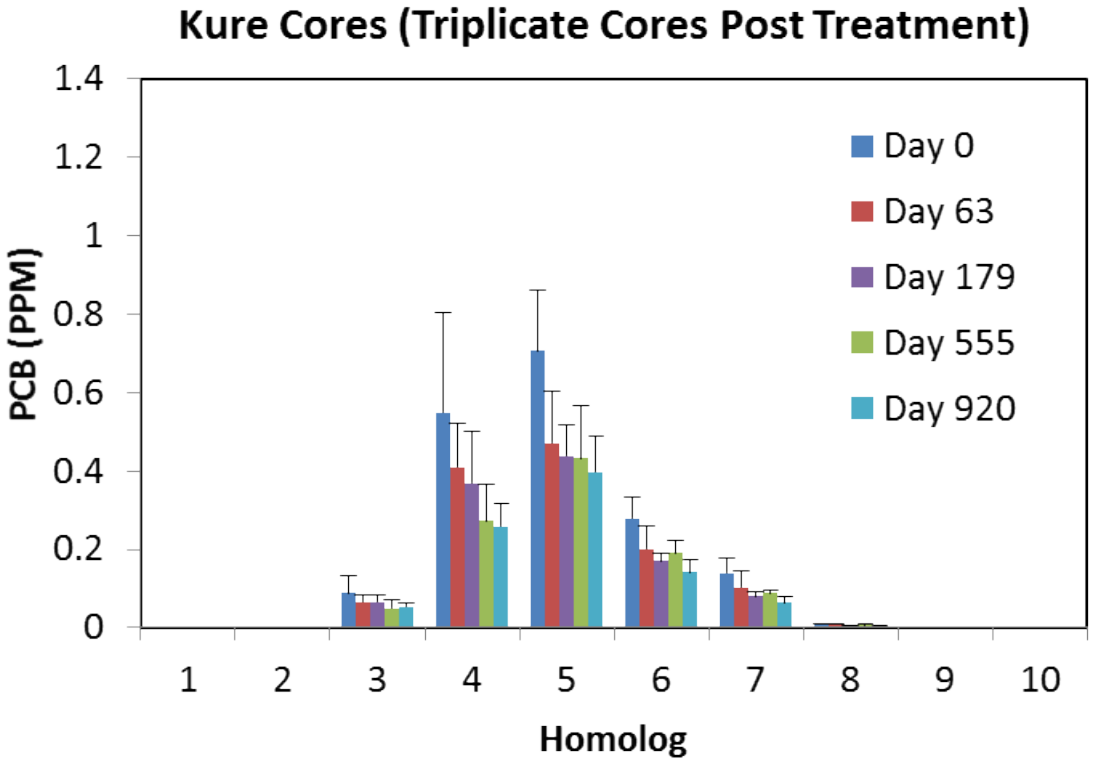
Green Island, Kure Atoll, HI

Results



- 48% decrease in mass from 1.7 to 0.9 mg/kg after 2.7 years
- Return to site for sampling anticipated in 2024

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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

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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

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

- **Rayford Payne, Nathalie Lombard and Trevor Needham**
  University of Maryland Baltimore County

- **Hal May**
  Medical University of So. Carolina

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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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