Bioavailability Control and In-situ Stabilization of Contaminated Sediments Using Carbon Sorbents

RTDF Sediments Remediation Action Team Meeting
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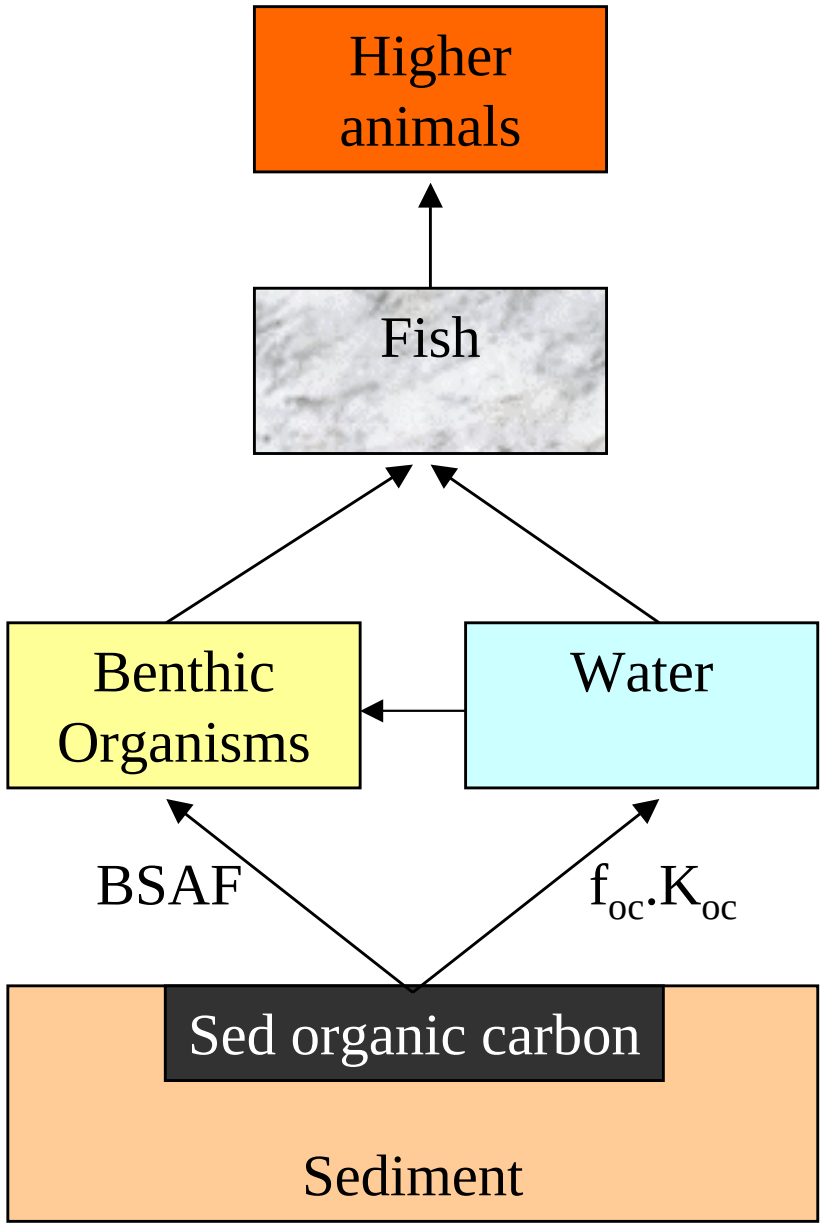
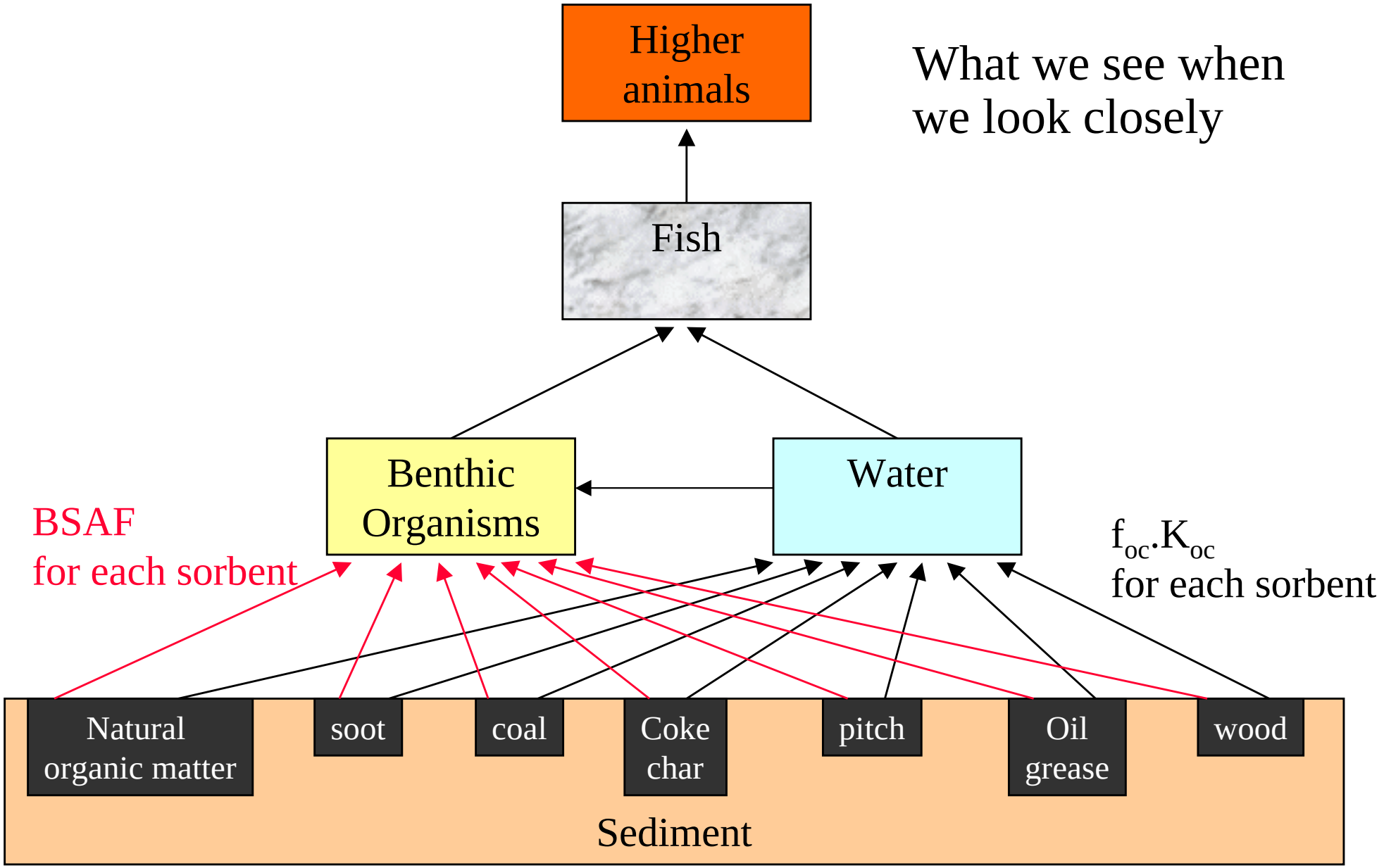
Sediment chemistry and bio-uptake



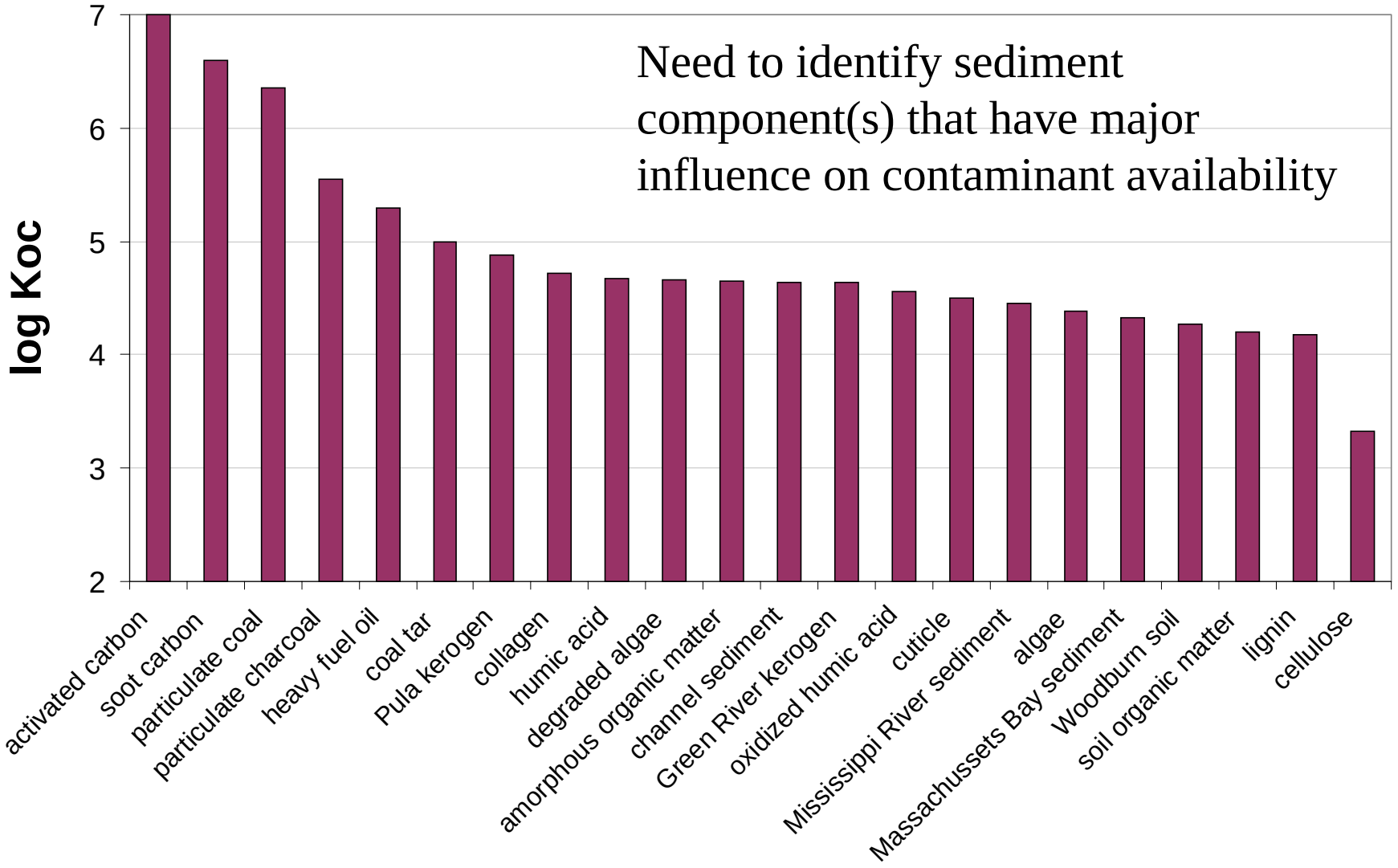
Traditional view

Sediment chemistry and bio-uptake



Sediment-water partitioning of phenanthrene

$$C_s = C_{aq} \cdot K_{oc} \cdot f_{oc}$$



Milwaukee Harbor Sediment

Likely sources of PAHs and coal: coking operations, gas manufacturing, harbor coal transport

Landtreatment to reduce PAH concentrations in CDF sediment

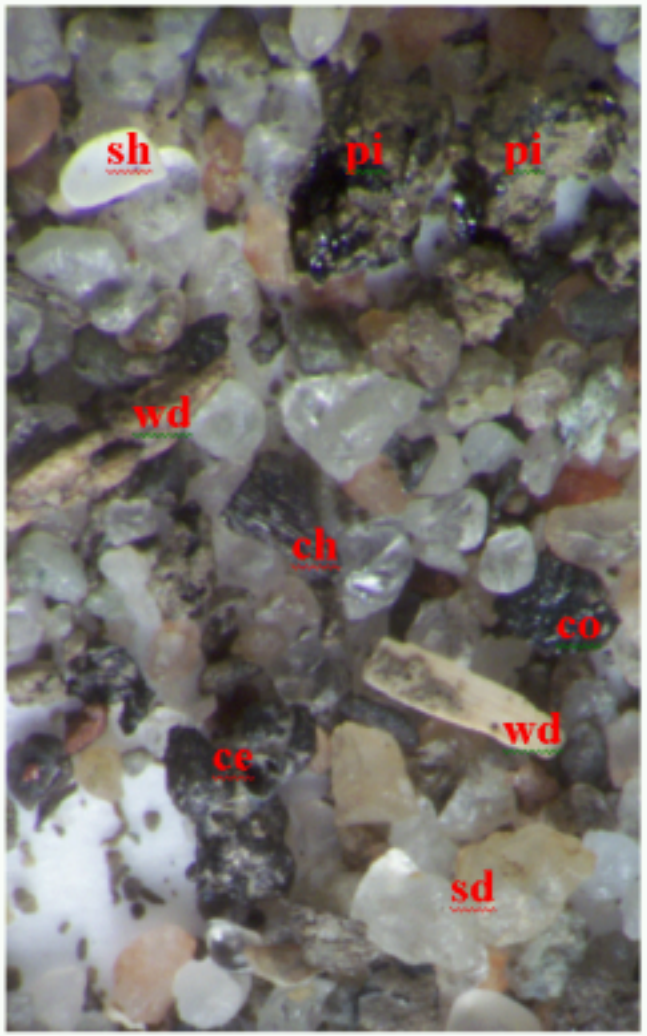
Manufactured Gas Operations
Utica, NY circa 1935

Sediment sampling at Hunters Point

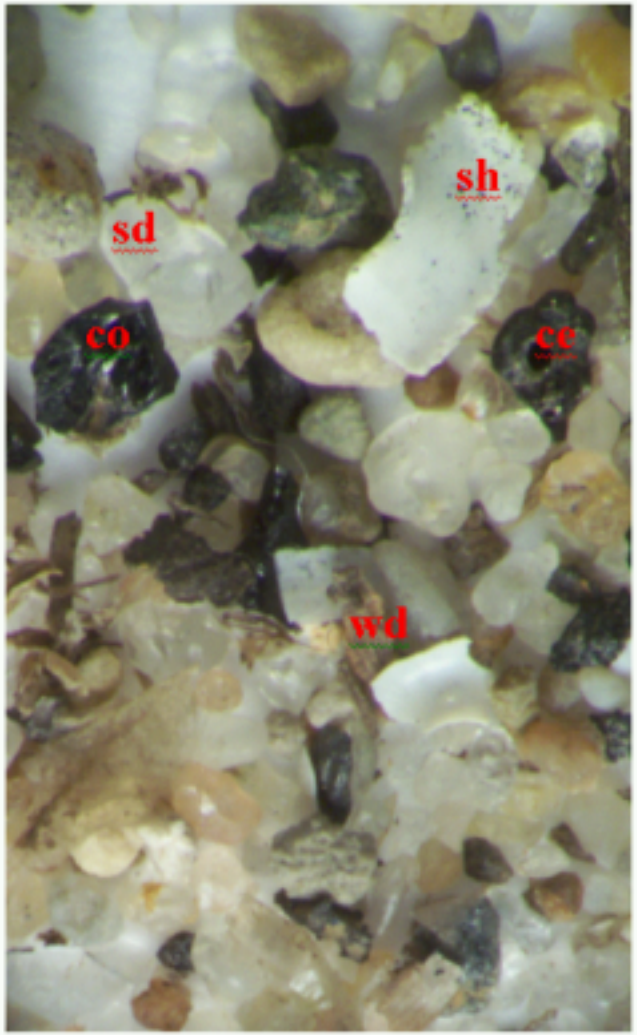
- PCB hot spot in San Francisco Bay
- Samples collected from intertidal zone in south basin

Light microscopy images of sediment particles

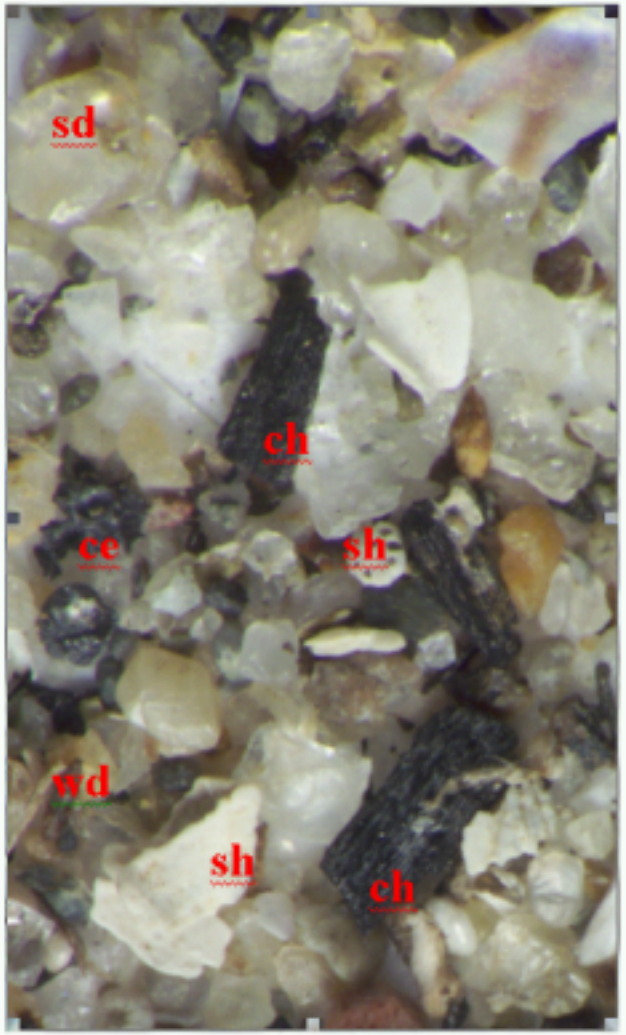
(250-1000μm)



Harbor Point, NY



Milwaukee Harbor, WI

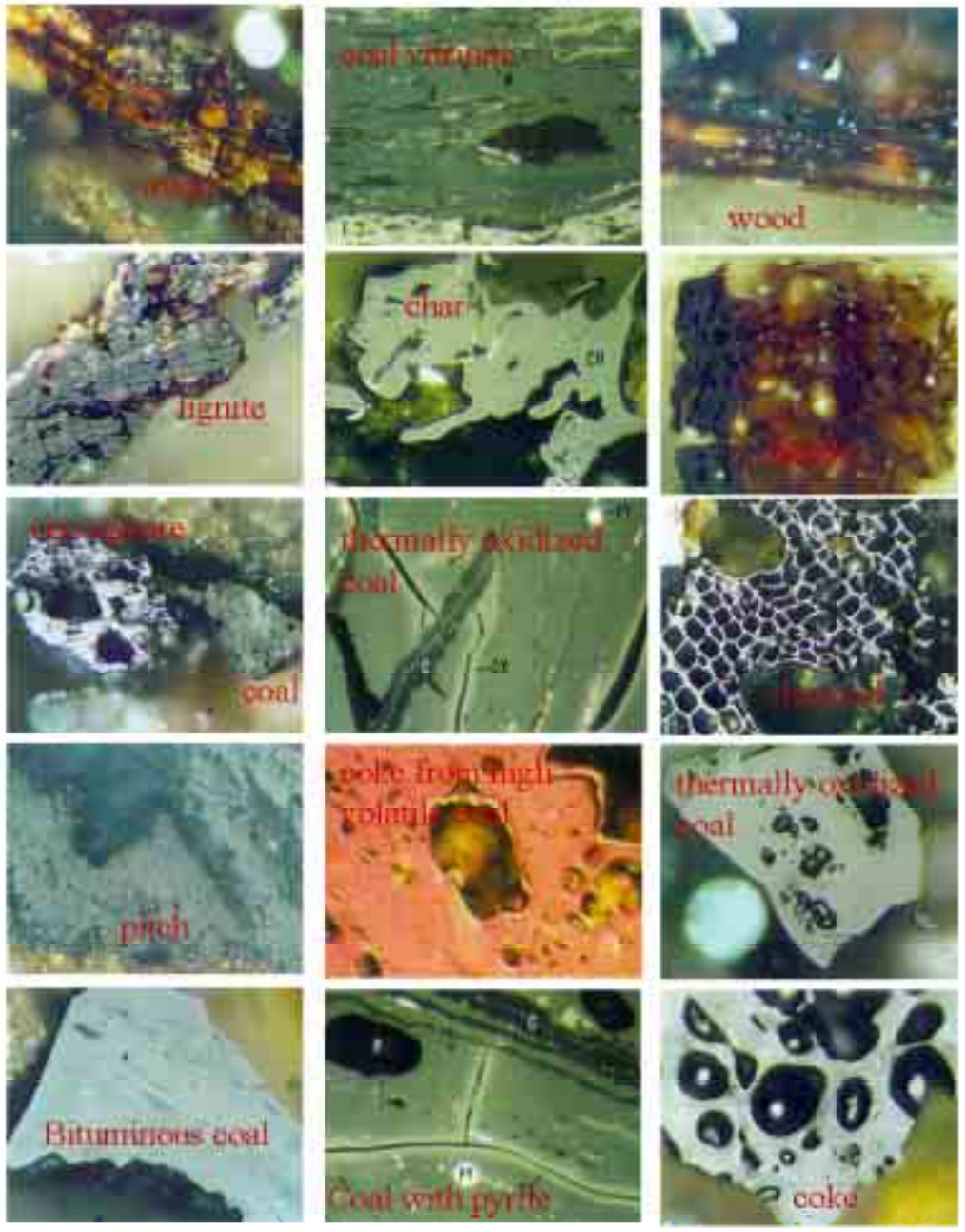


Hunters Point, CA

Heavy mineral particles: sand (sd), silt, clays

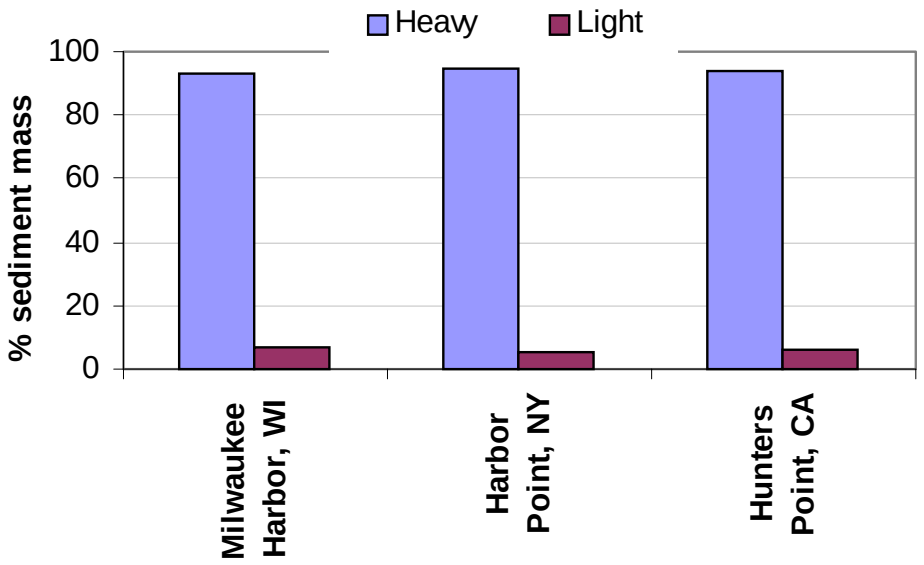
Light organic particles: coal (co), cenospheres (ce), charcoal (ch), pitch (pi), wood (wd),

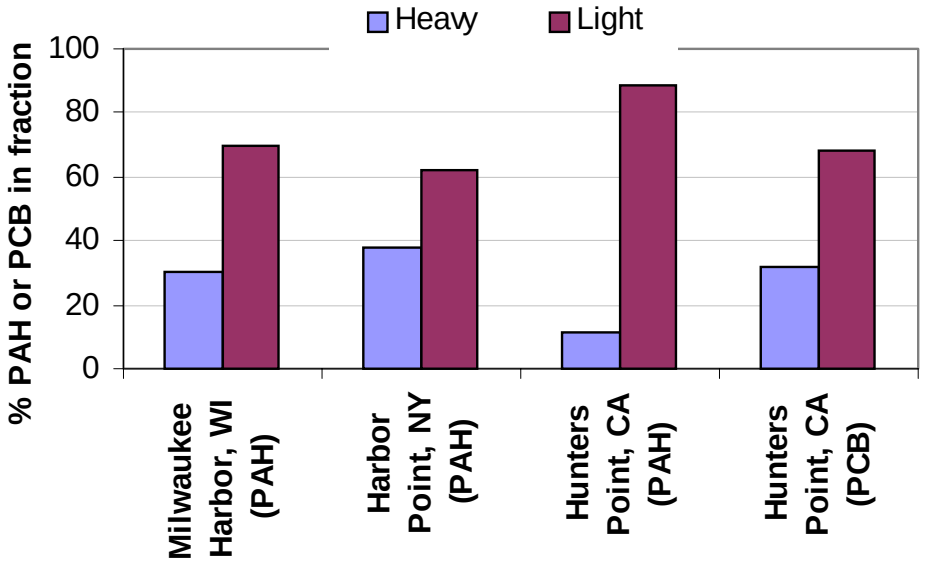
Petrography analysis of organic particles



Harbor Point, NY Milwaukee Harbor, WI Hunters Point, CA

Distribution of PCB/PAH in sediments





Three sites show 5-7% wt. lighter density carbonaceous matter (coal/charcoal/wood)

PCBs and PAHs associated with lighter density fraction (60-90%)

Lesson:
Over time PCBs [and PAHs] preferentially accumulate in coal/charcoal/coke where they are strongly bound and less bioavailable

See:
Ghosh et al., 2000, *ES&T*, 34, 1729-1736
Ghosh et al., 2001, *ES&T*, 35, 3468-3475
Talley et al., 2001, *ES&T*, 36, 477-483.

Our experimental strategy:

- PCB/PAH particle-scale measurements
- PCB flux and aqueous equilibration
- Mass transfer of PCB/PAH to sorbent and binding energy
- PCB bio-uptake:
  - Three organisms: amphipod,worm, and clam
  - Two sorbents: coke and regenerated activated carbon
  - Variables: dose, contact time, particle size
- Sorbent type & PCB assimilation efficiency by clams
- Organism survival, growth, reproduction, stress

Link chemistry and bio-uptake

- *Hypothesis:* The bioavailability of PCBs, PAHs, & DDT, depends on particle type to which they're bound
- Can we change PCB bioavailability?
- New strategy for sediment management by in situ stabilization

Benthic organisms in Hunters Point sediment accumulate PCBs

Sediment-sorbent contact

- Sediment-sorbent contact experiments to assess effect of particle size, dose, and contact time on PCB availability
- Sorbent dose: 2x & 5x TOC
- Sorbent size: 100-250 μm & 63-100 μm
- Contact time: 1 month & 6 months

Bioaccumulation studies

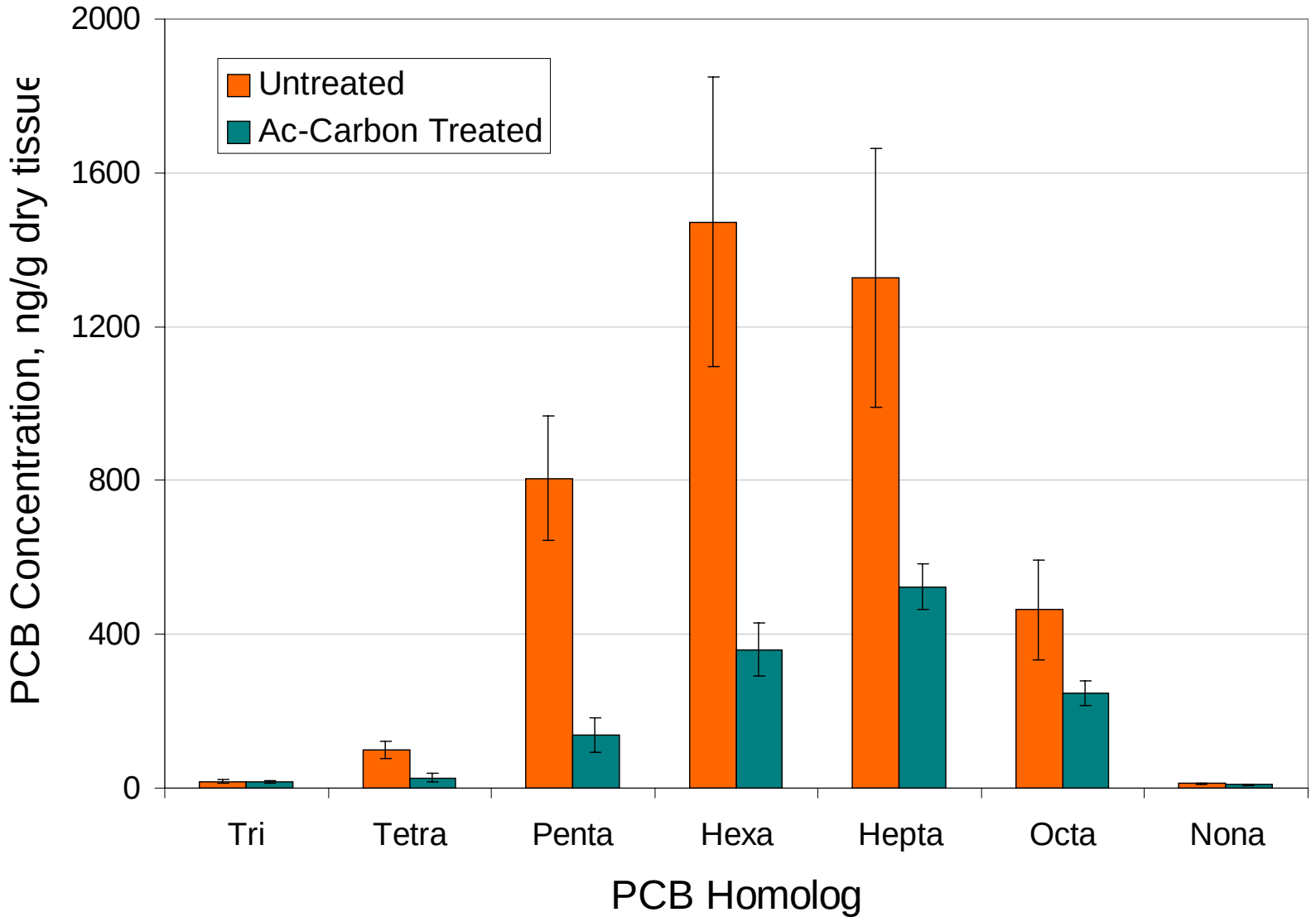
Macoma Balthica

Neanthes arenaceodentata

Leptocheirus plumulosus

- Survival, growth, reproduction, activity
- PCB bioaccumulation

PCB Bioaccumulation in Clams



Overall reduction in PCB bioaccumulation after 1 month contact with Ac. Carbon:

Macoma: 69% Leptocheirus: 72%

Aqueous equilibrium tests

Measure PCB equilibrium concentrations for untreated and various sorbent-treated sediments:

- 17 ppt seawater + sodium azide
- contact 14 days on bottle roller
- flocculate colloids with alum and centrifuge

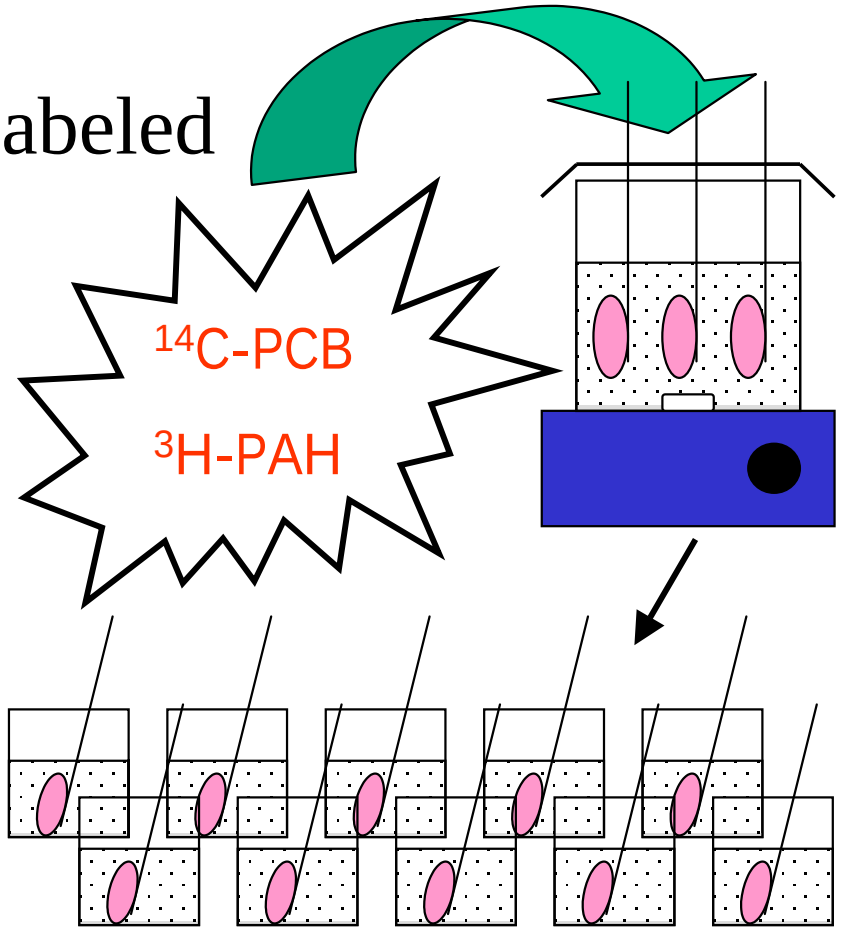
3.4 wt% activated carbon:

86% reduction in aqueous PCBs

Alum-flocculation to remove colloids (Ghosh et al., ES&T 2000)

Controlled particle feeding tests: assimilation efficiency

Prepare labeled particles

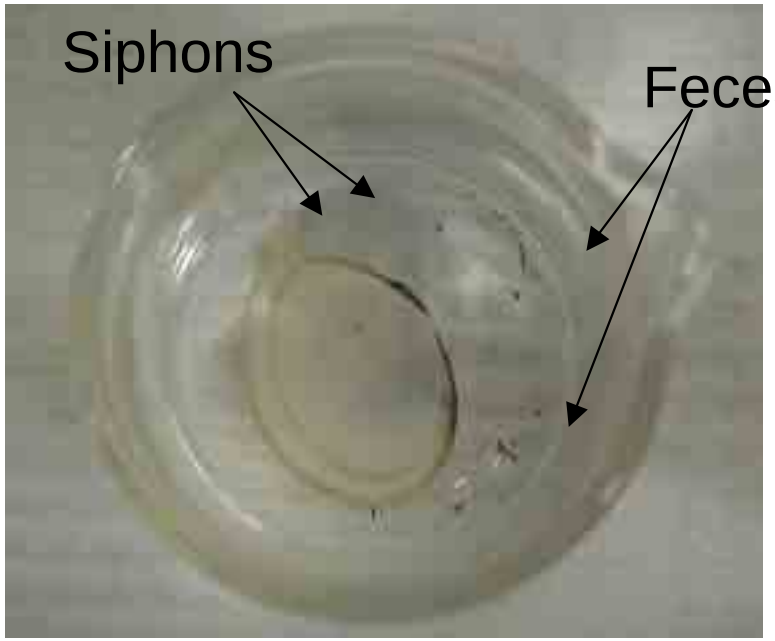


Feed clams

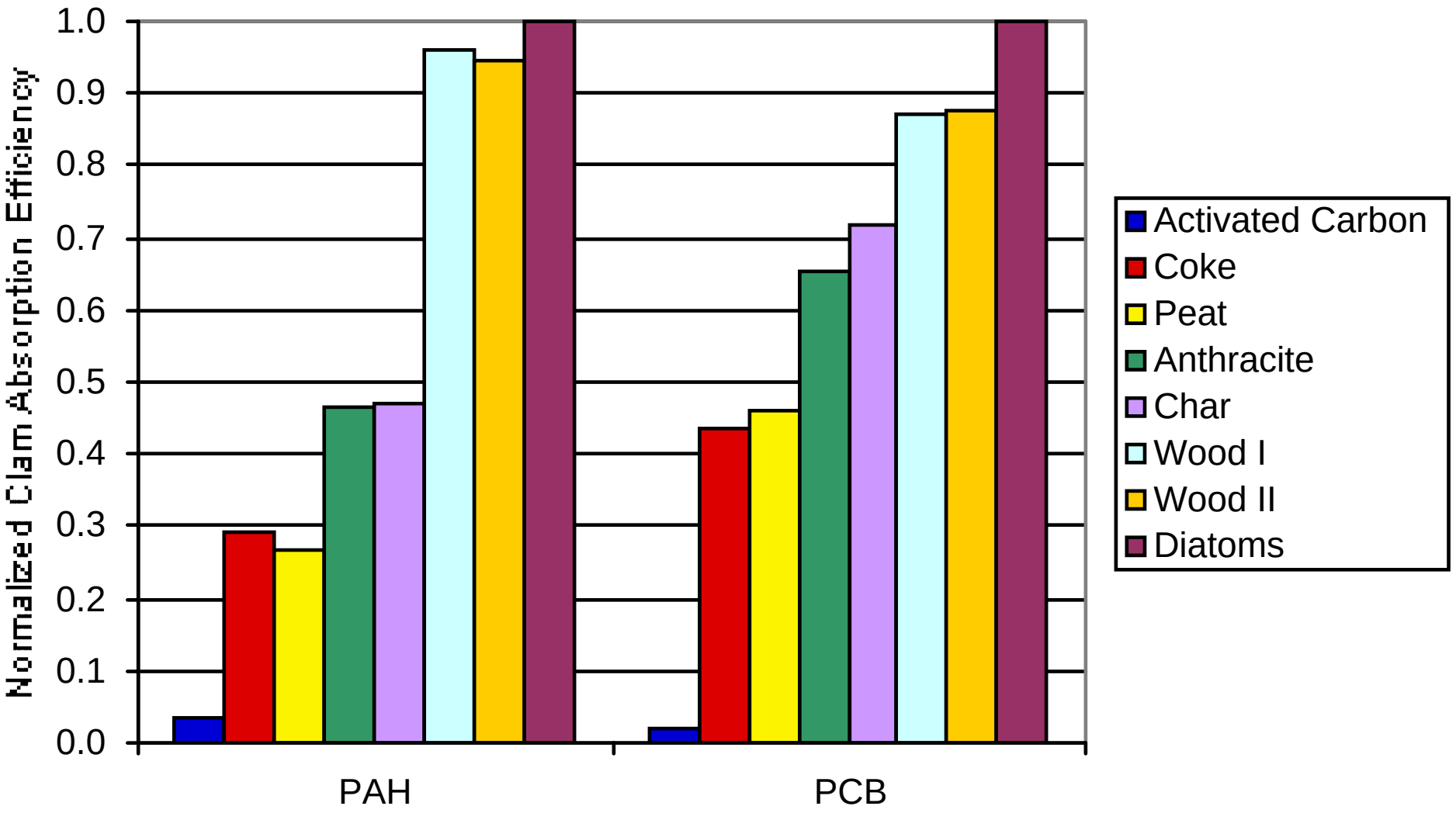
Depurate and analyze clam tissue and feces

Clam assimilation studies

- Track ^{3}H-BaP and ^{14}C-2,2',5,5' PCB through a clam
- Feed 8 hours
- Depurate 4 days
- Analyze clam tissue and feces



Assimilation efficiency



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University of Maryland Baltimore County

- Founded in 1966
- Newsweek's top 12 Hot College list for 2003

Engineering Research Center, CEE dept.

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