In-situ Dechlorination of Polychlorinated Biphenyls in Sediments Using Zero-Valent Iron

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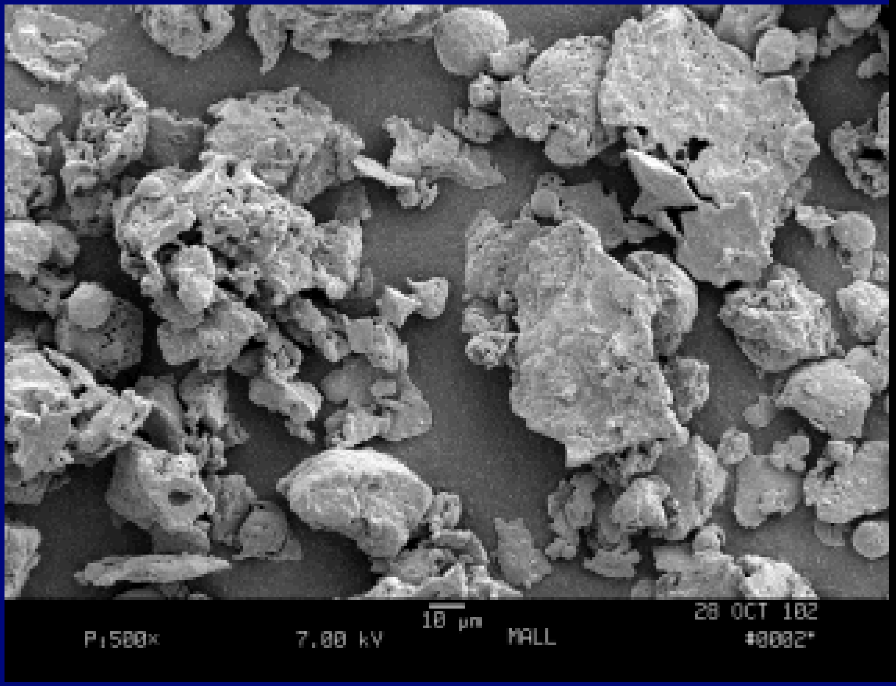
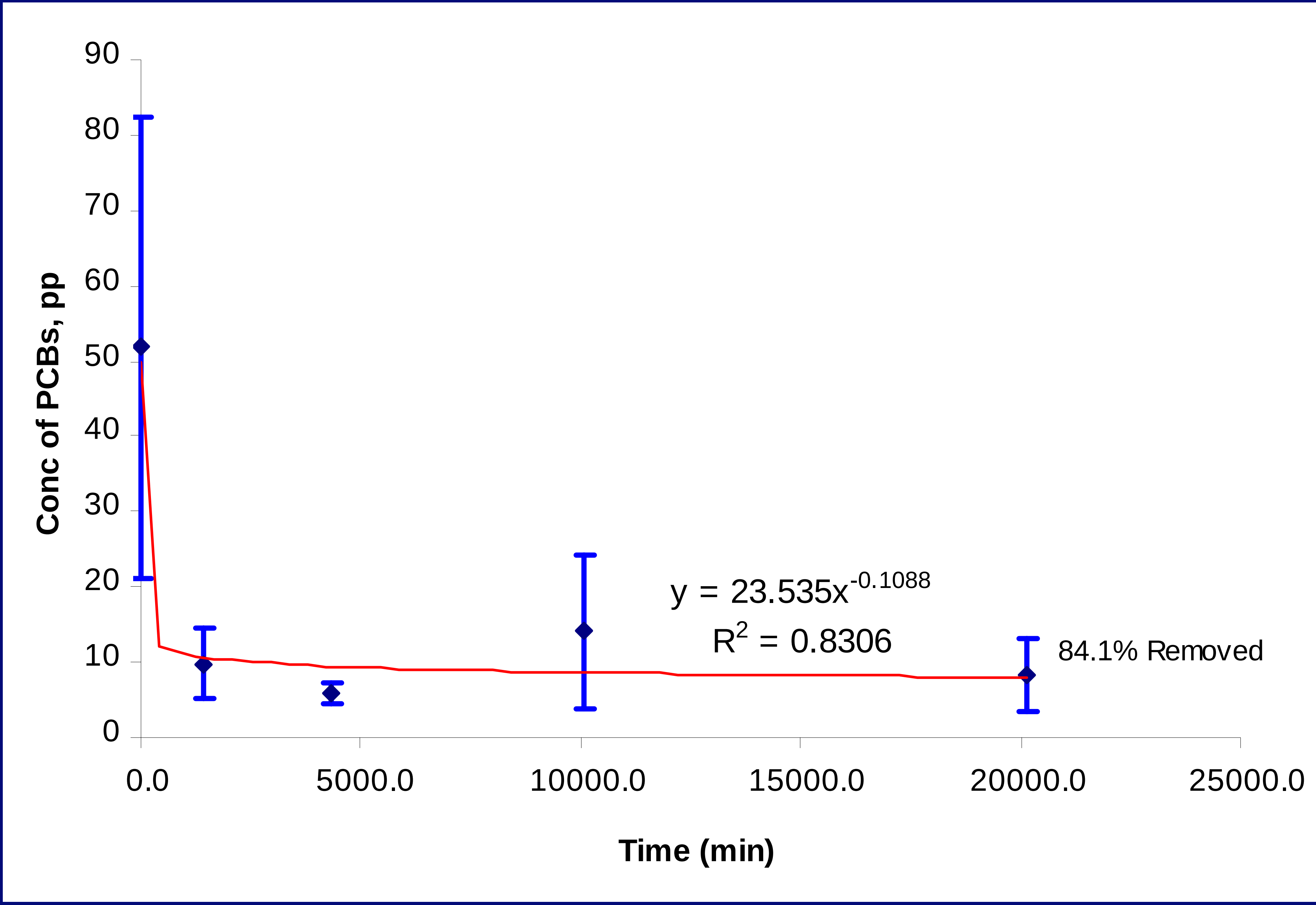


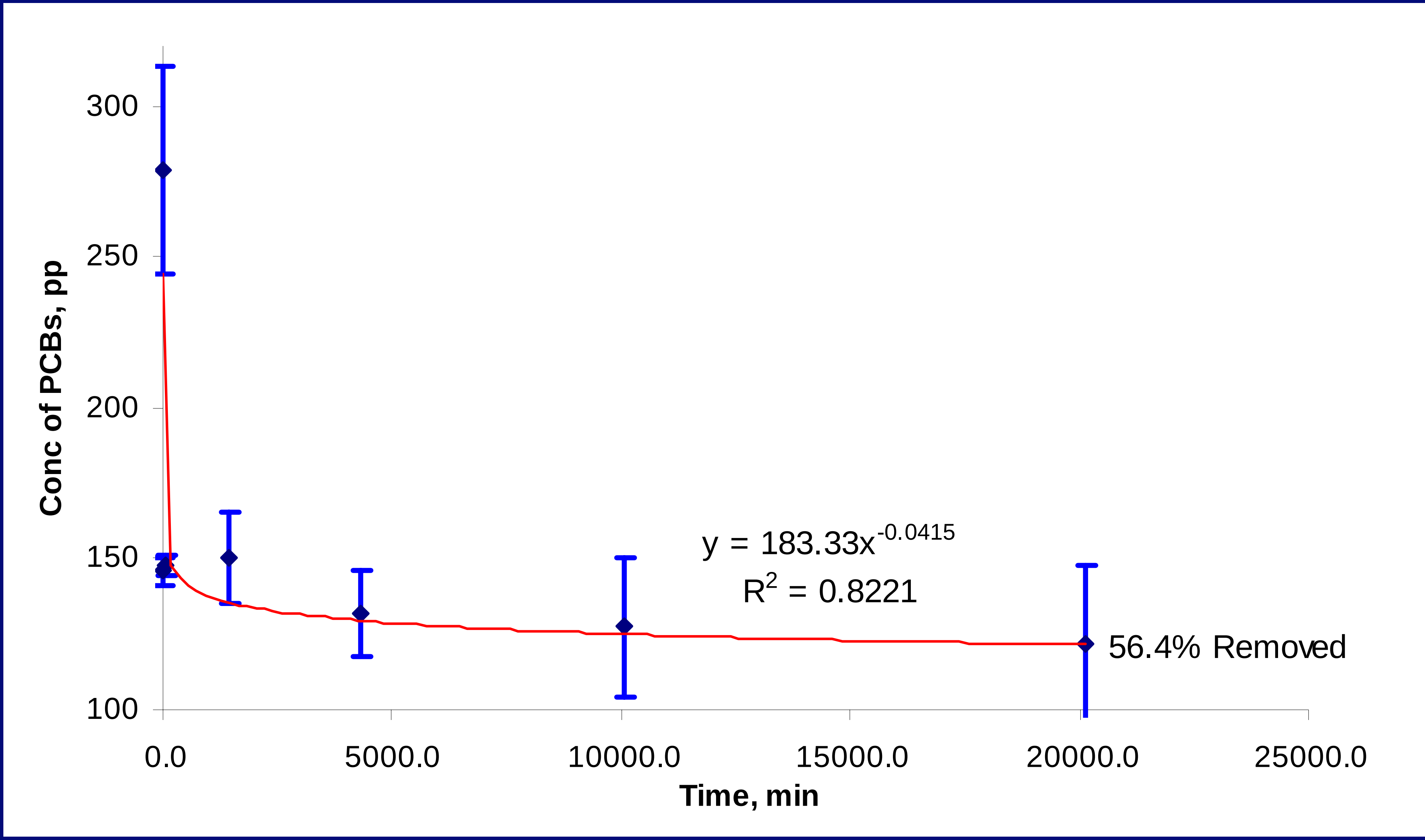
Overview

- ***In situ* remediation** or dredging accompanied with offsite treatment.
- Introduction of zero-valent iron (ZVI) – various sizes and manufacturing techniques
- Dechlorination of PCBs in PCB-contaminated sediments
- Relatively fast reaction and an economically viable process

PCB Dechlorination Kinetics with ZVI in Housatonic Sediment



New Bedford Harbor typical results

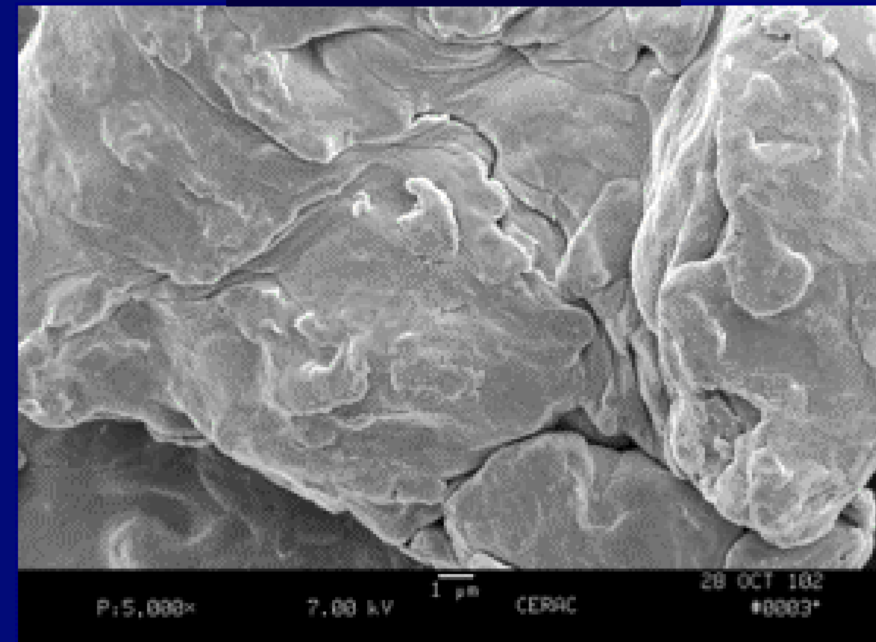


Different Types of ZVI Evaluated

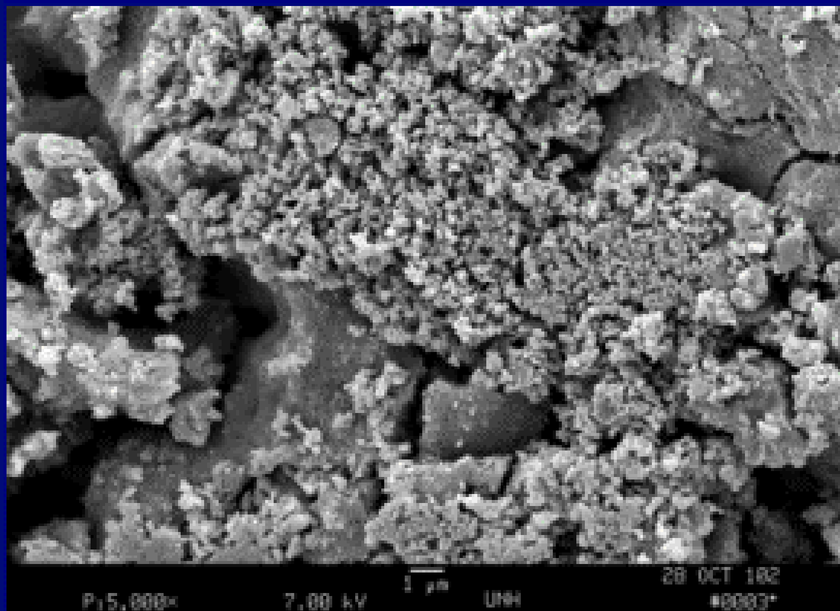
	UNH ZVI	RNIP	RNIP/Pd	Cerac	Mallinkrodt
Source	lab	Toda America	Toda America	Milwaukee, WI	St. Louis, MO
Cost	$N/A	$9/lb	$9/lb	$4.3/lb	$2.39/lb
Size	1-100 nm	30 nm	30nm	50 um	50 um
Water Content	79.9% water	52.5% water	52.5% water	25.0% water	25.5% water
Surface Area	33.5 m2/g	23.6 m2/g	23.6 m2/g	N/A	N/A
Characteristic	suspension	suspension	suspension	dry powder	dry powder

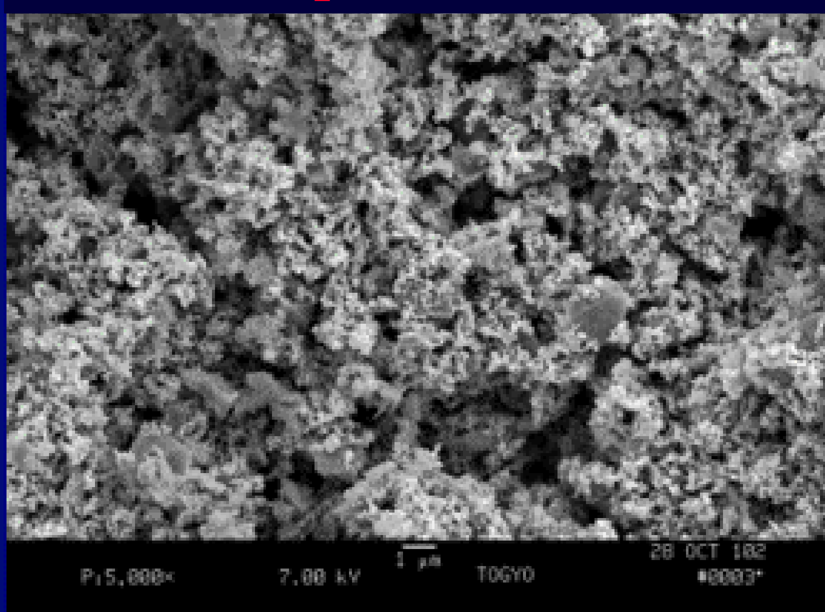
Scanning Electron Micrographs

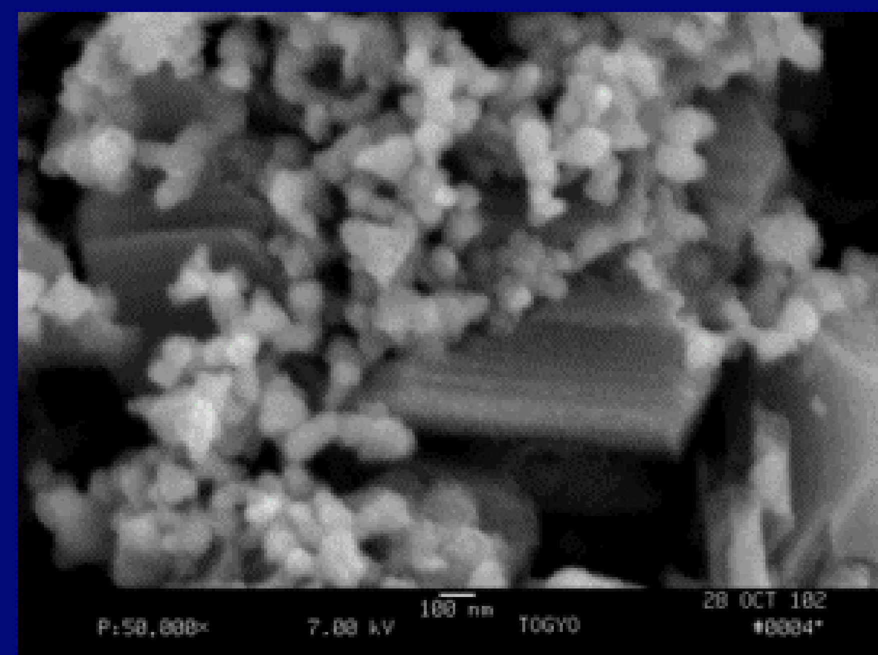
Micro-scale ZVI



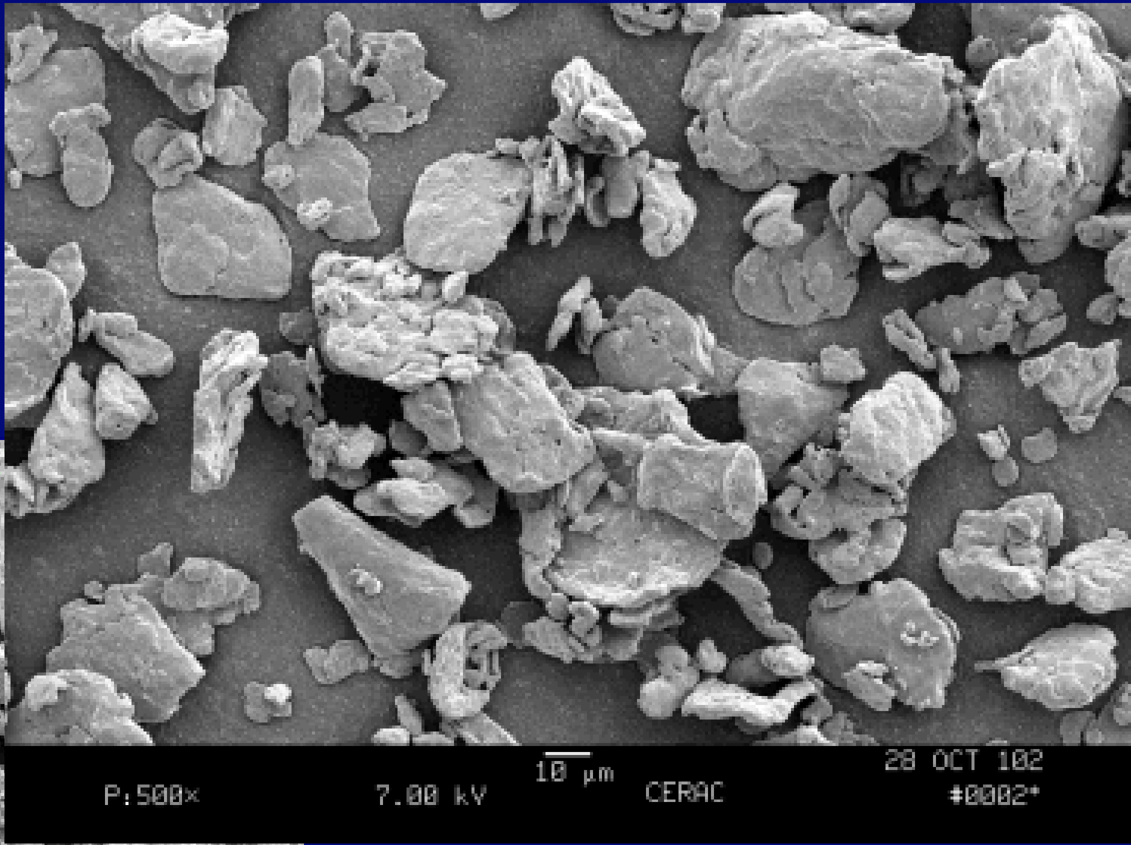
Nanoscale ZVI-the diameter of each particle ~ 50 nm

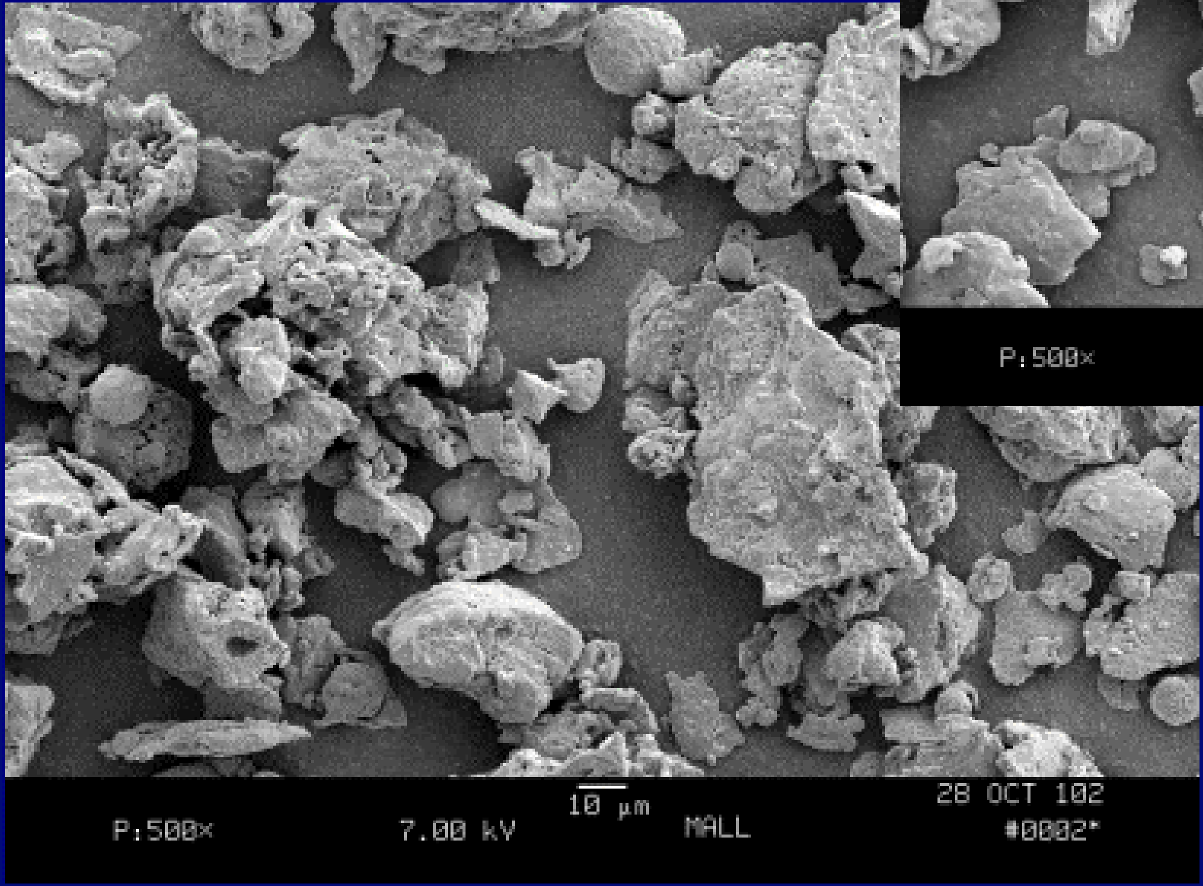




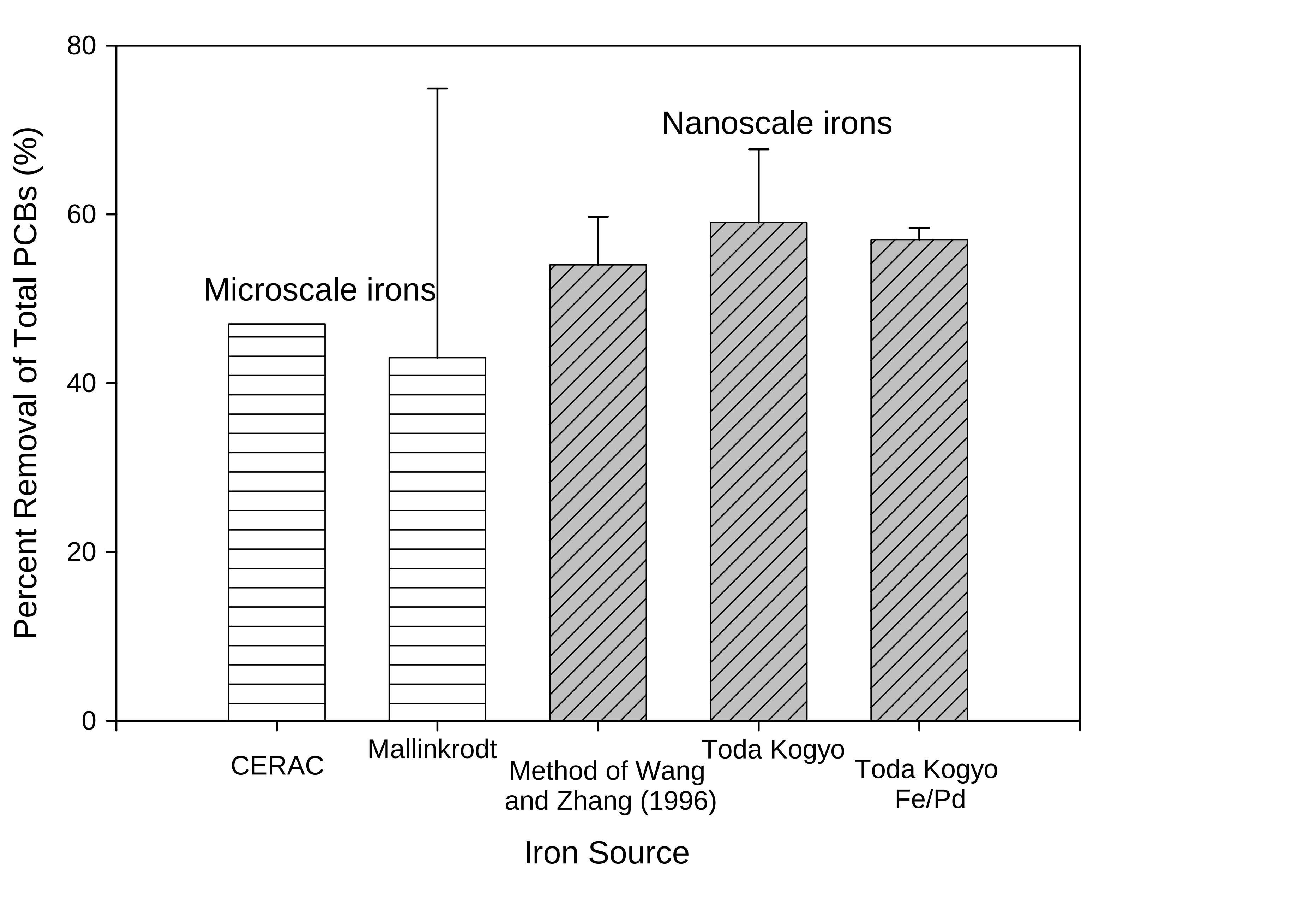


50-um iron materials





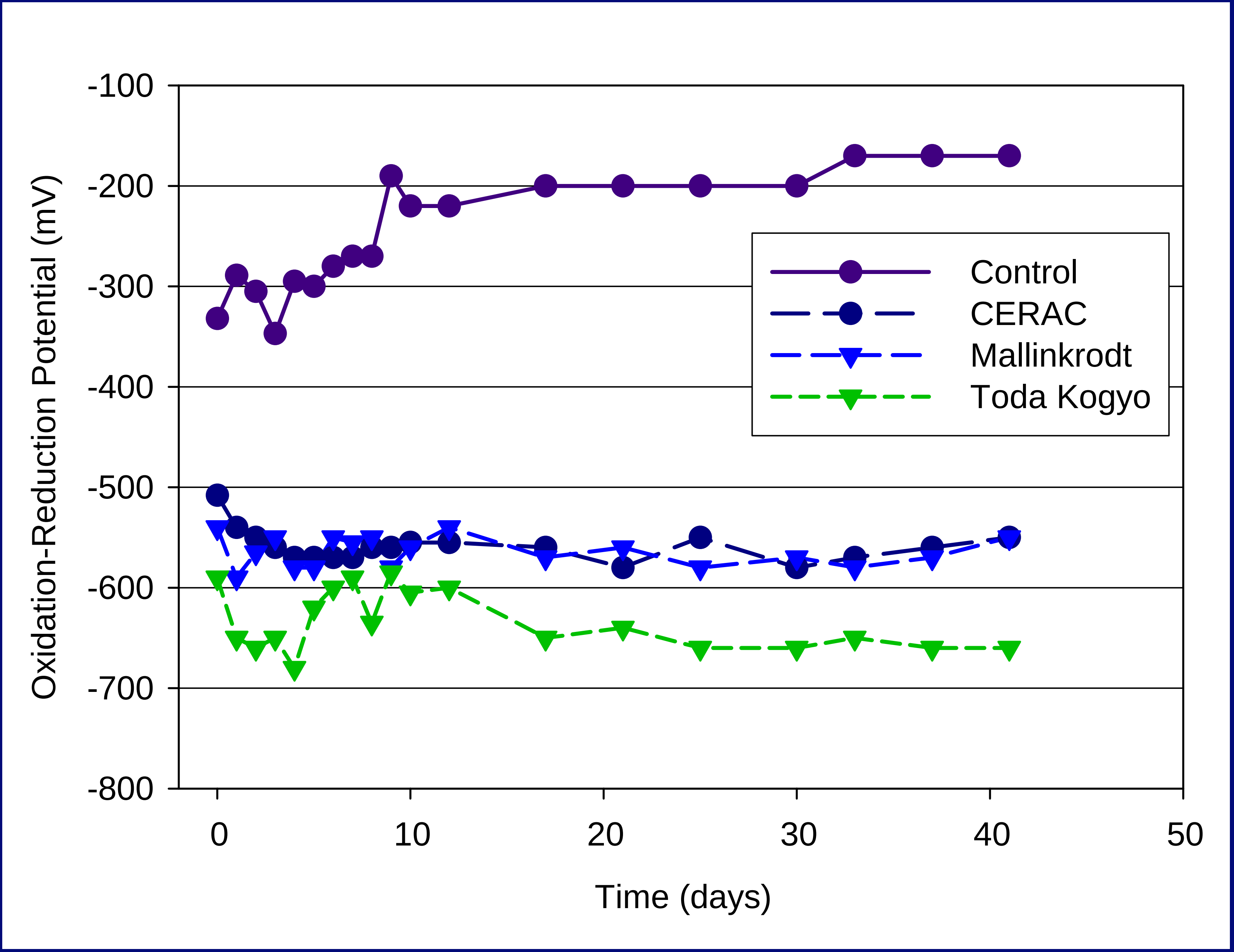
PCB dechlorination with different iron types



Why does degradation level off?

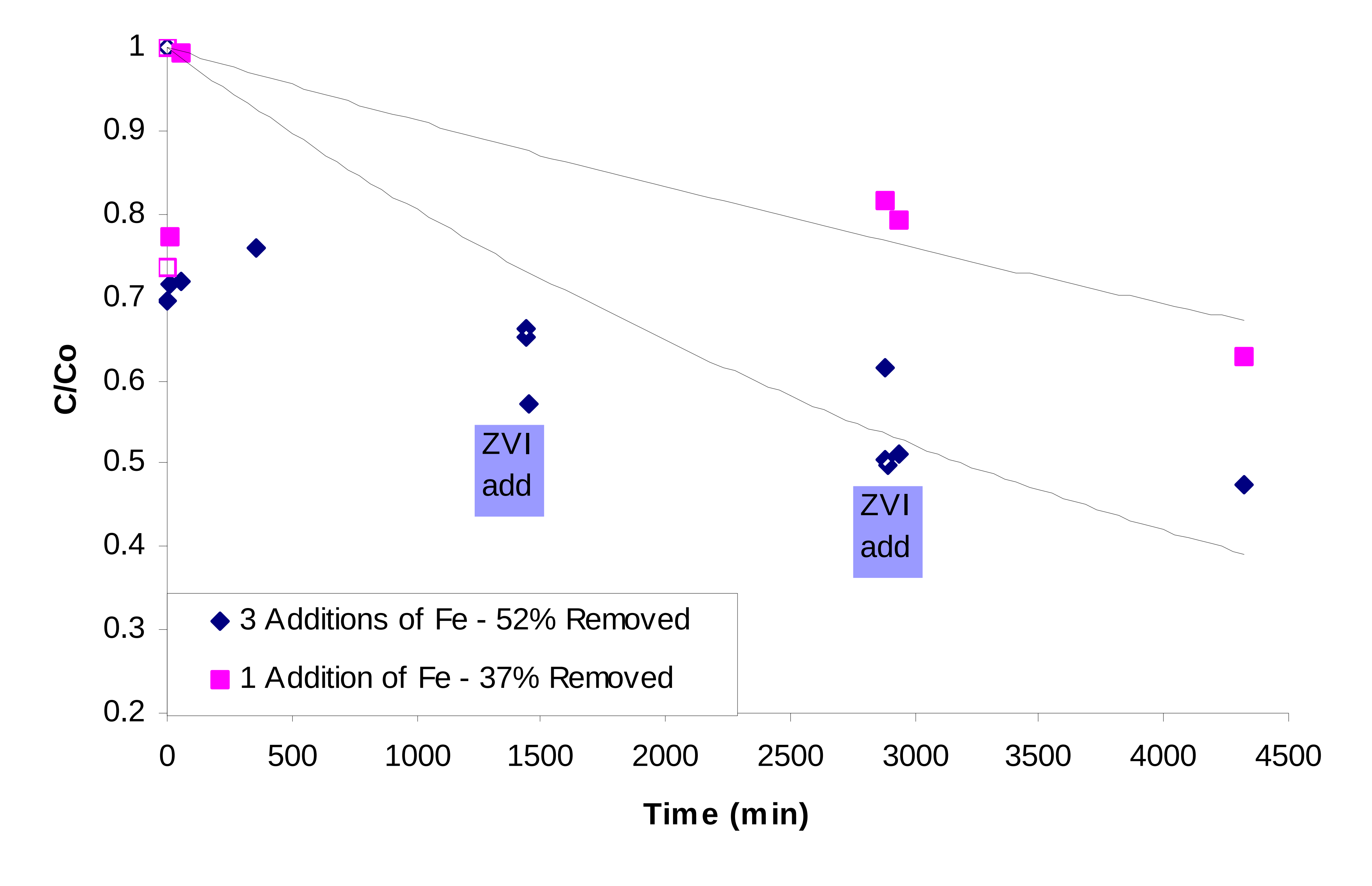
- Iron degradation faster than PCBs
- Passivation of iron surface
- Desorption of “slow” PCB fraction

ORP over time

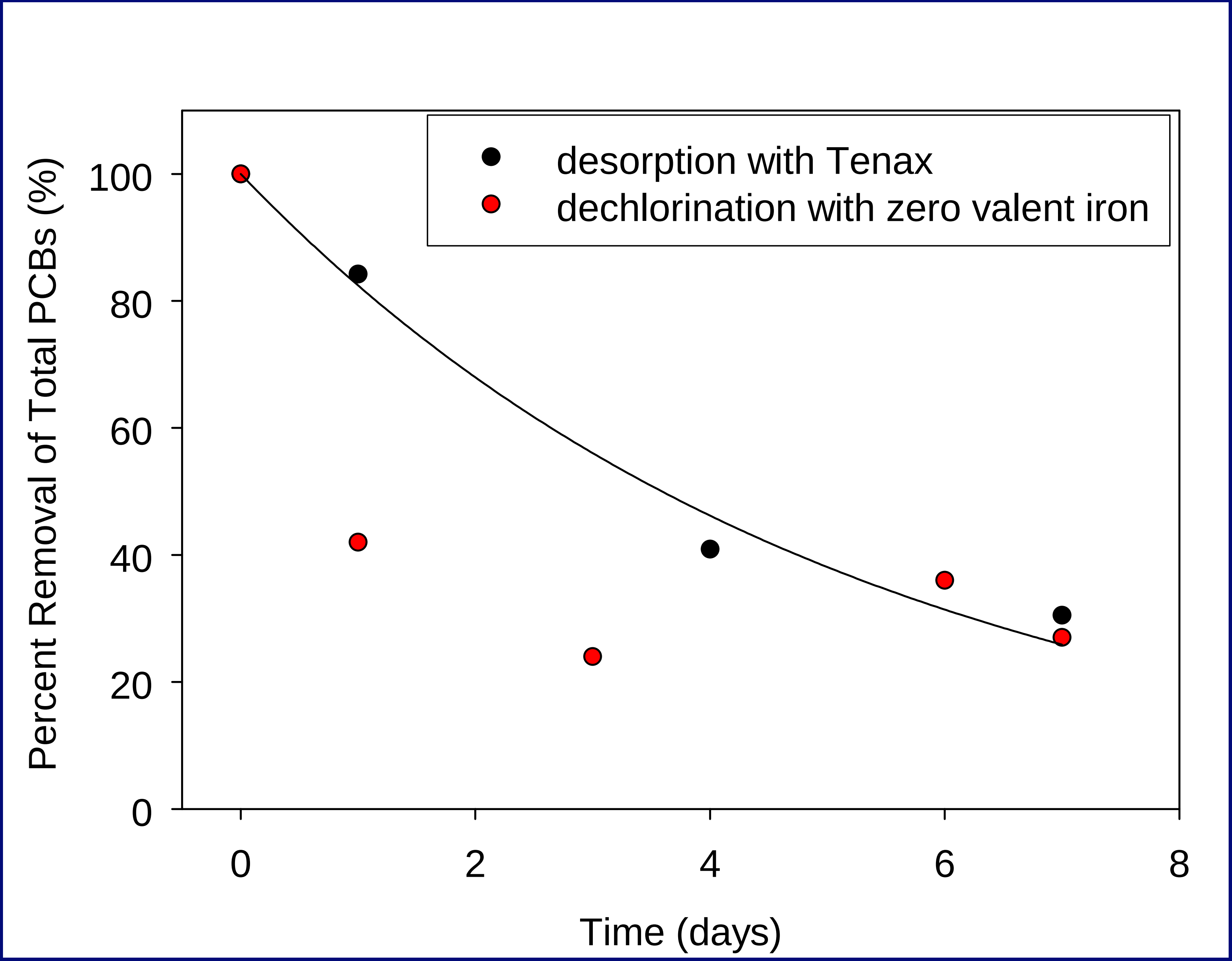


Sequential Fe additions

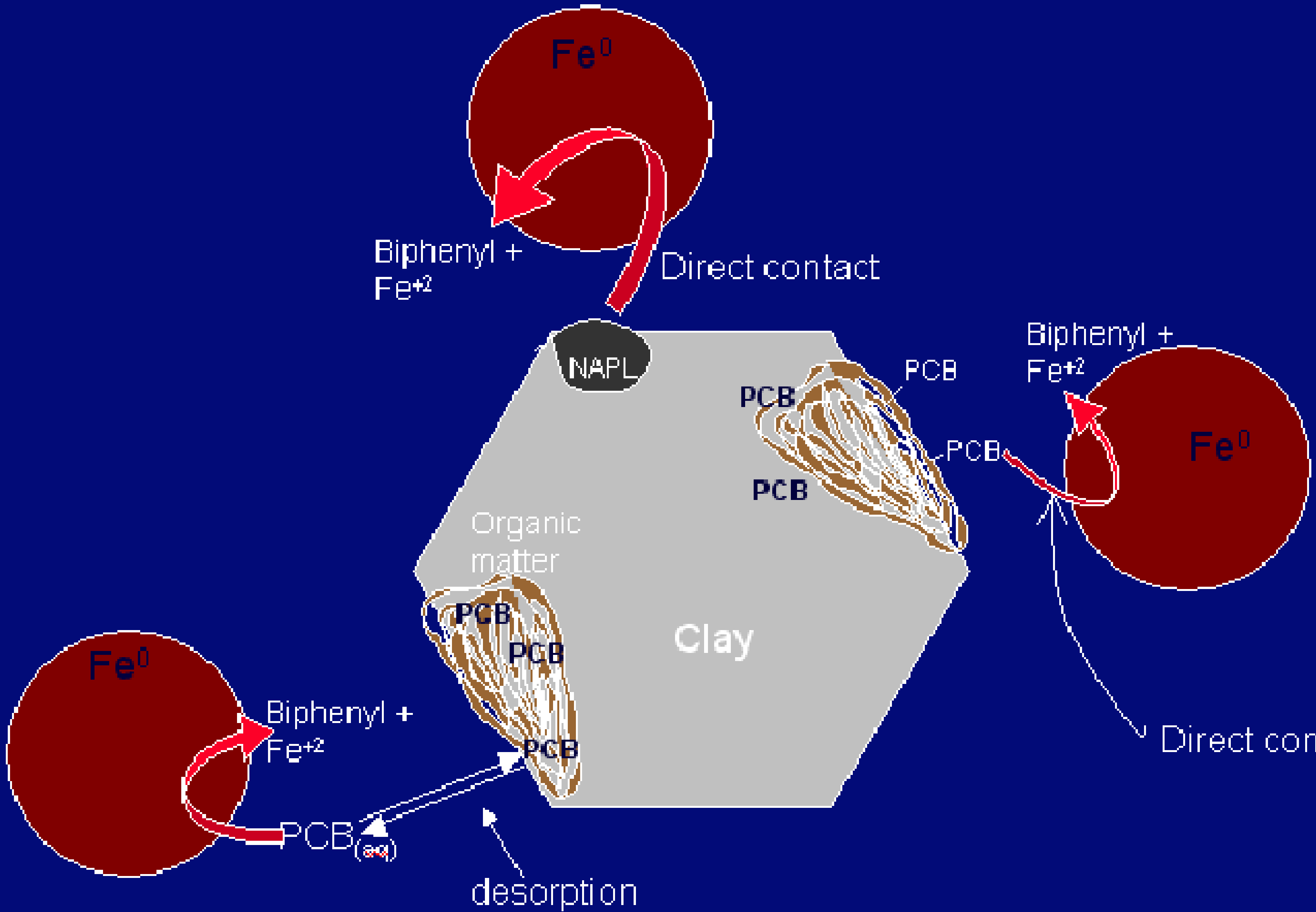
Static experiment – initial mixing only



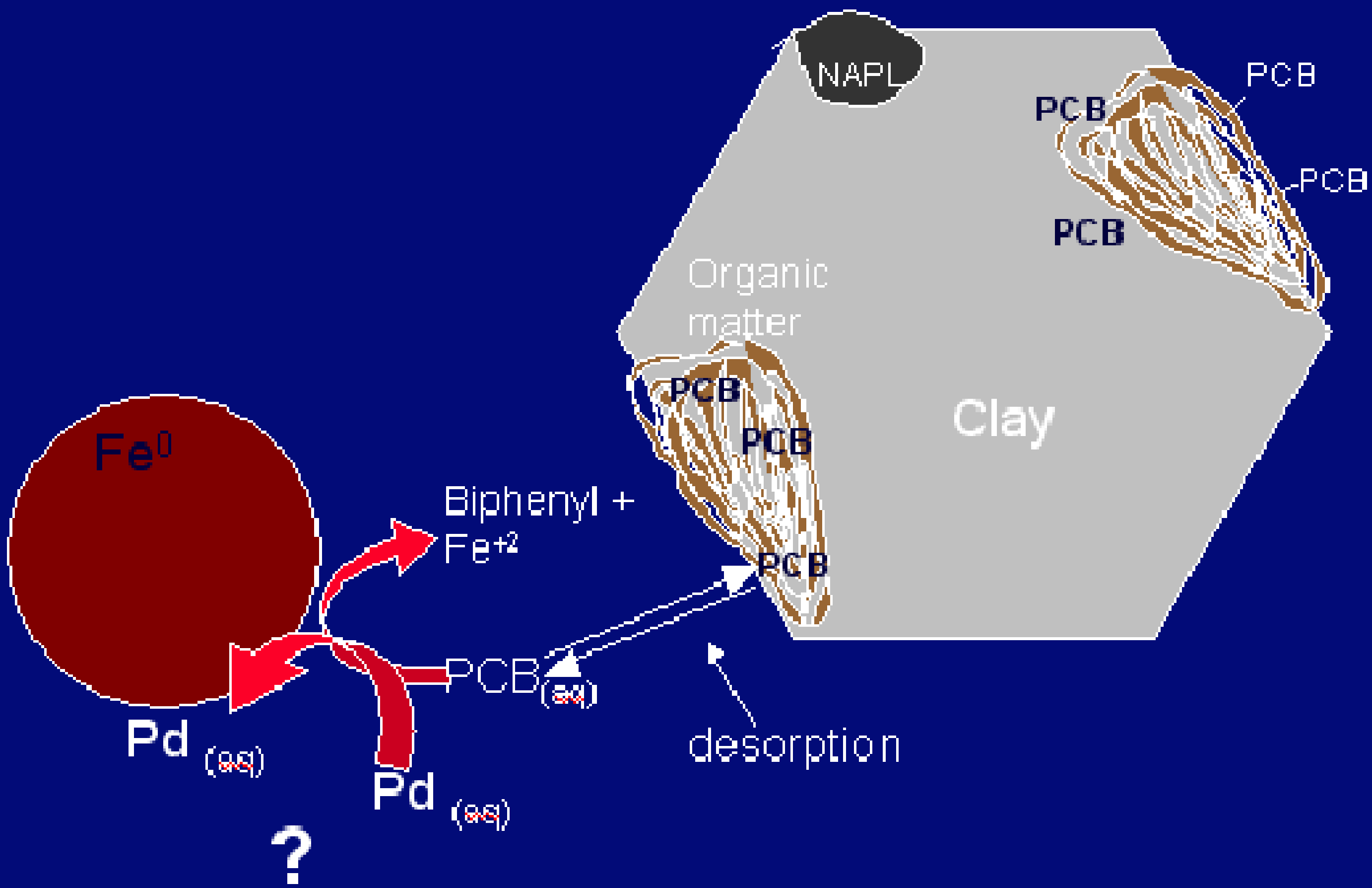
PCB desorption and dechlorination kinetics - NBH sediments



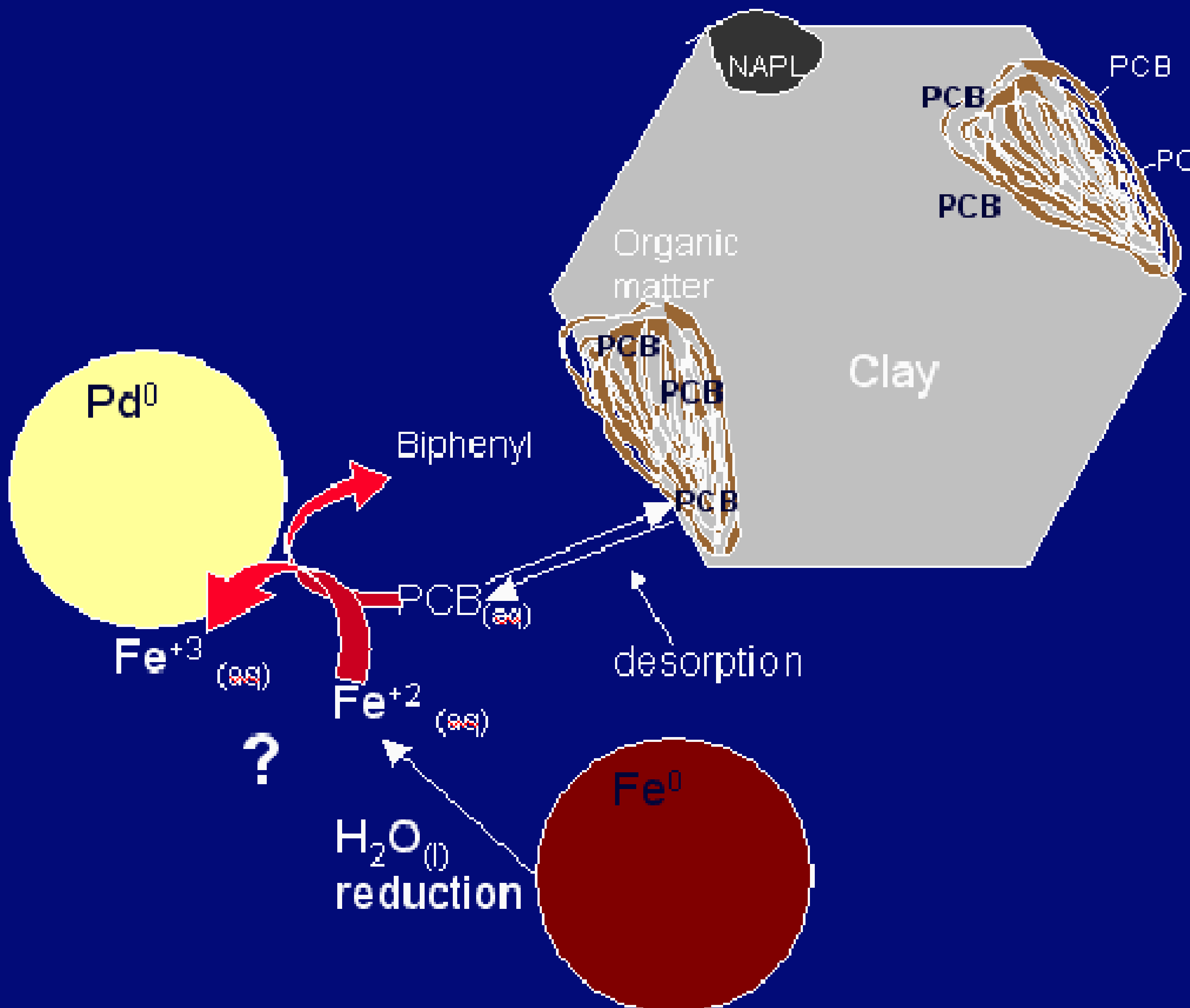
Direct reduction and desorption/reduction scenarios



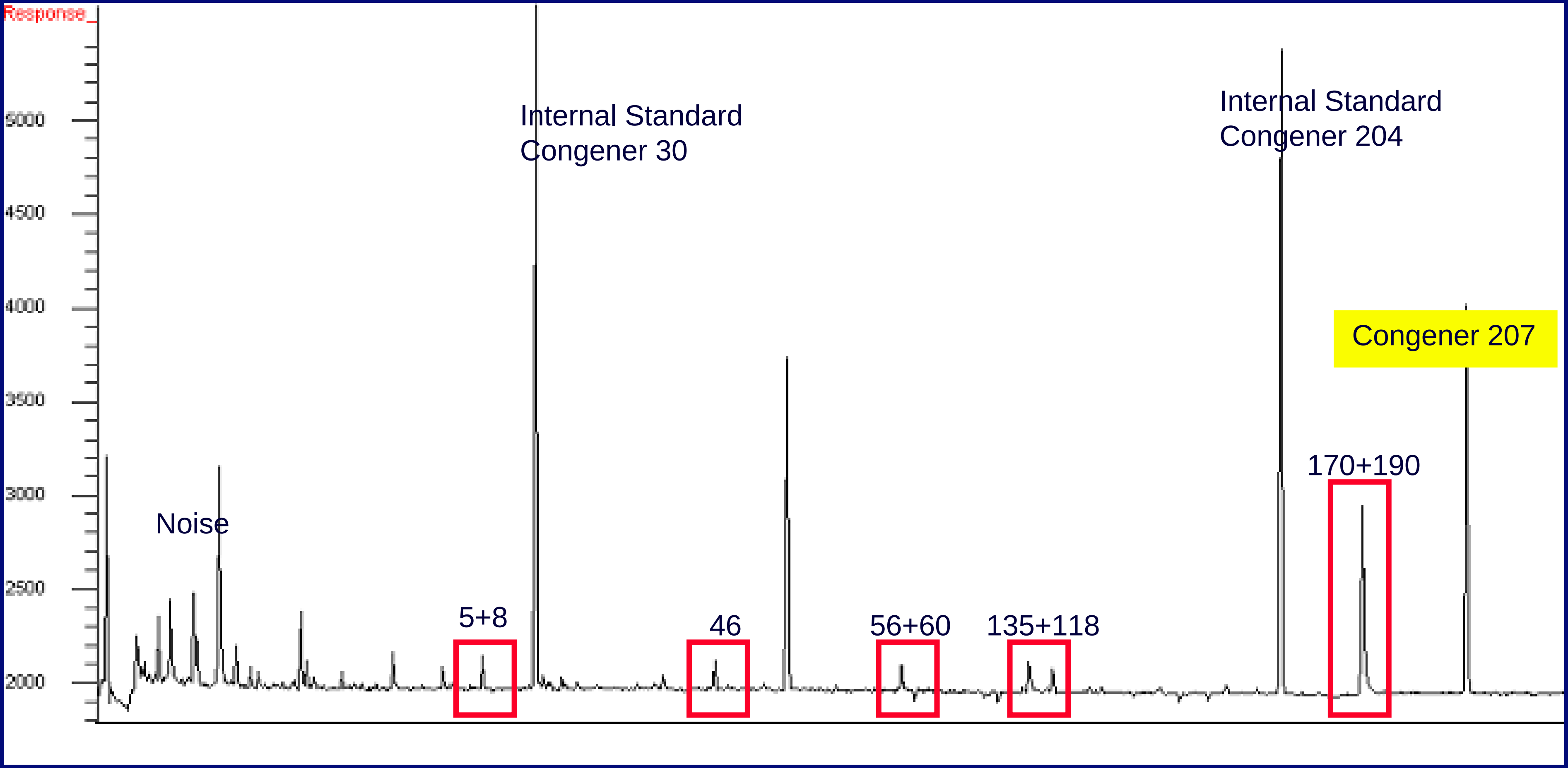
Catalysis by aqueous phase constituent?



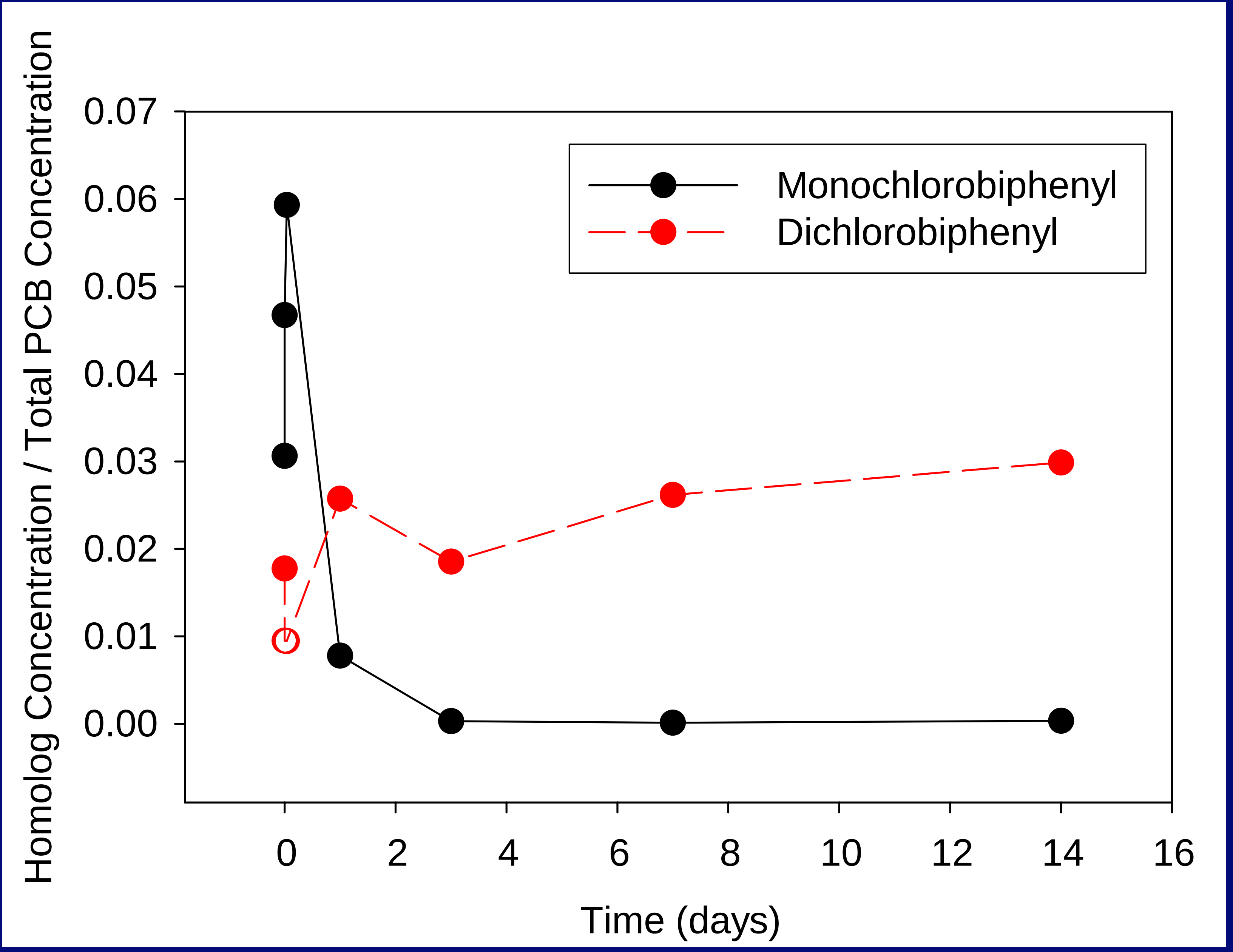
Catalysis by solid phase?



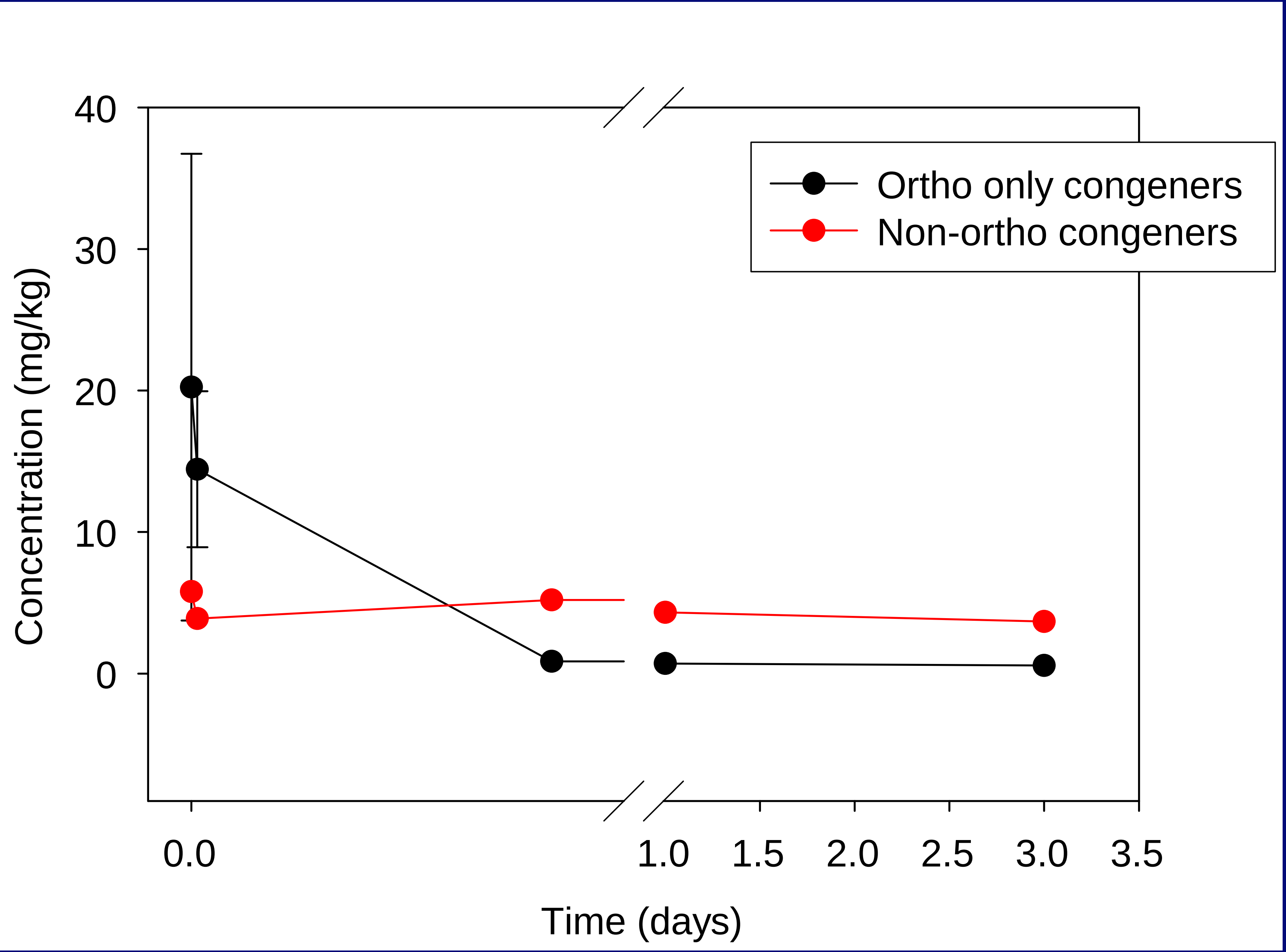
What are the Breakdown Products??
7 Day Breakdown of Congener 207



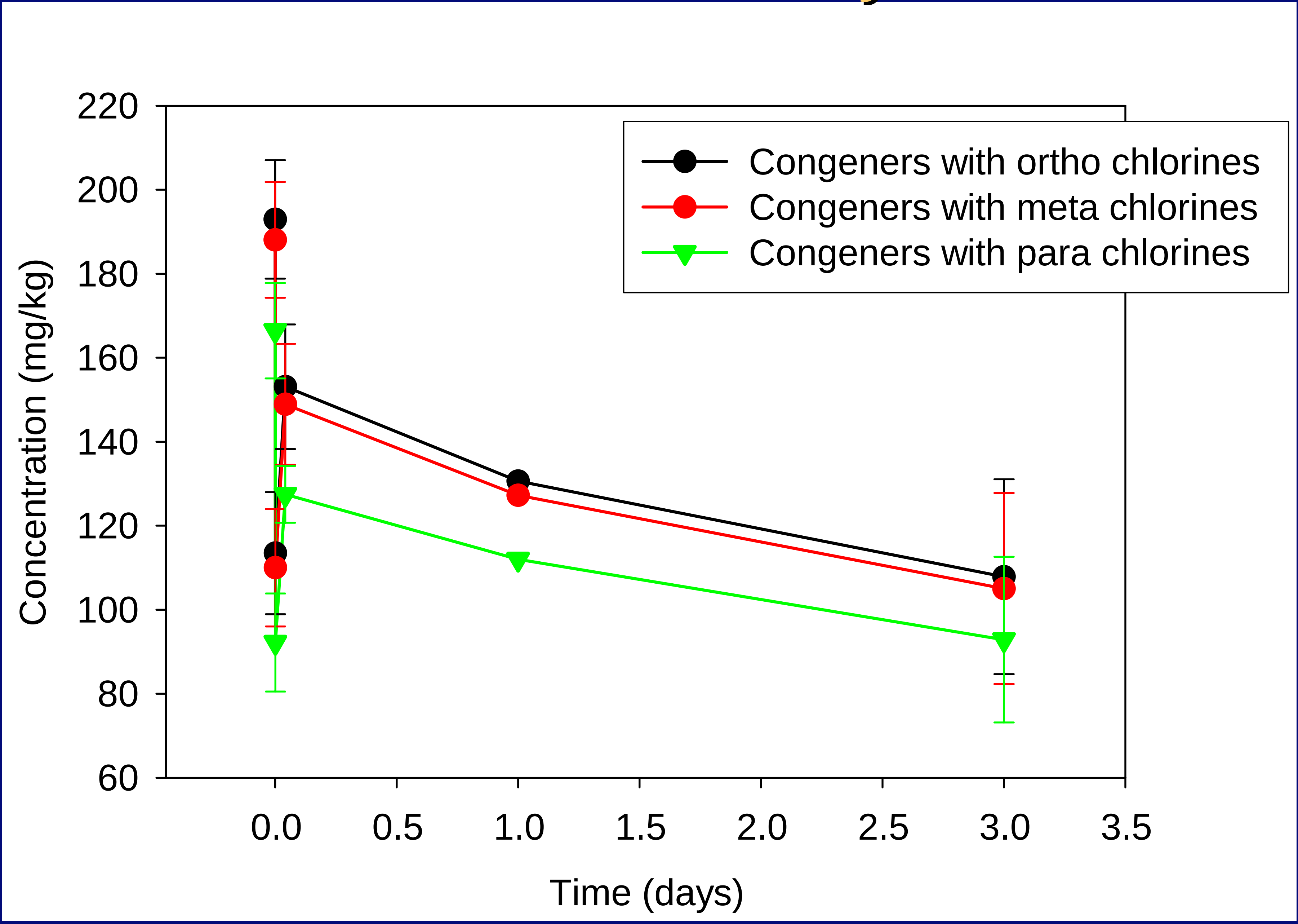
Transient behavior of 1-CB, 2-CB



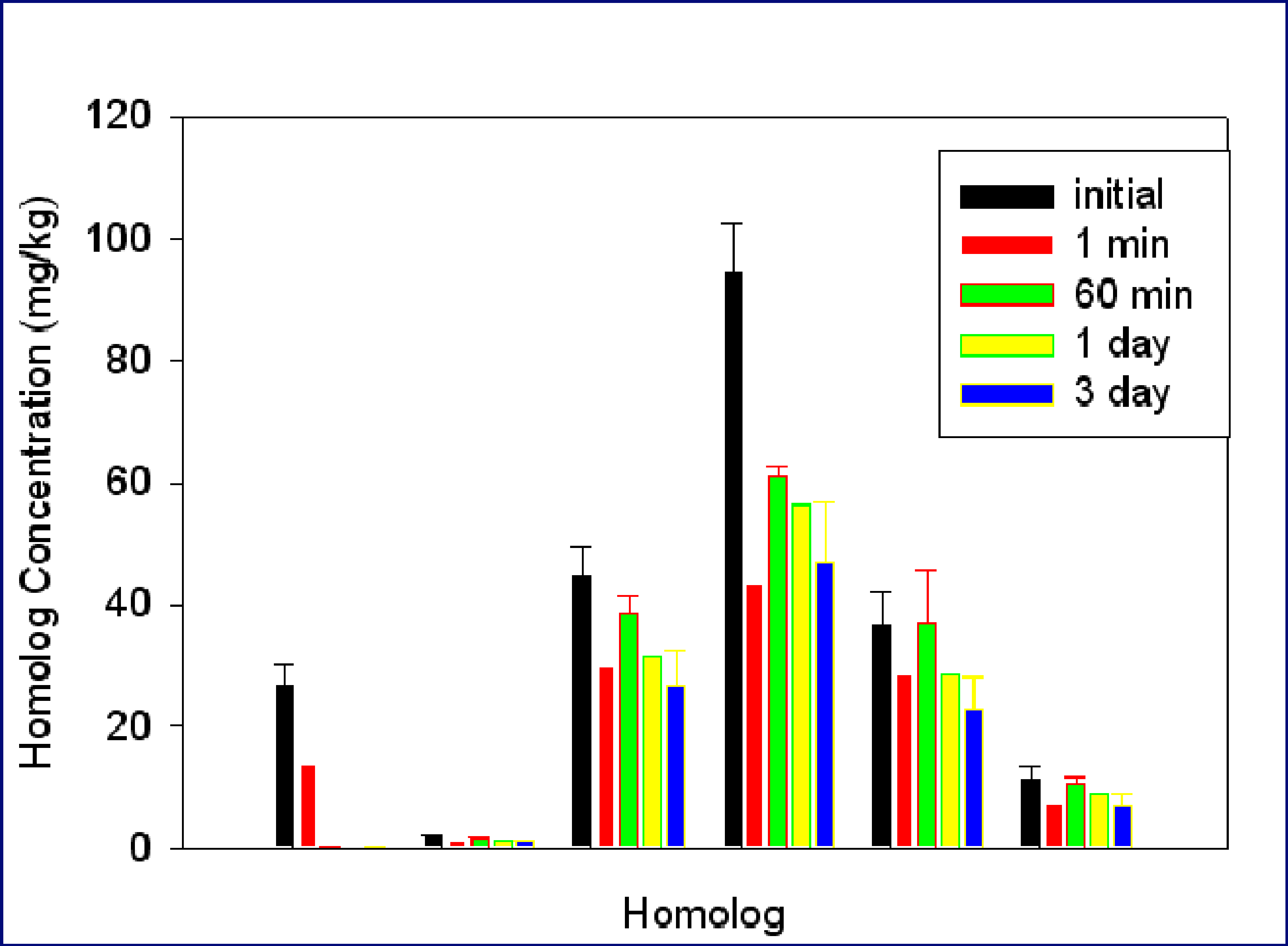
Ortho dechlorination



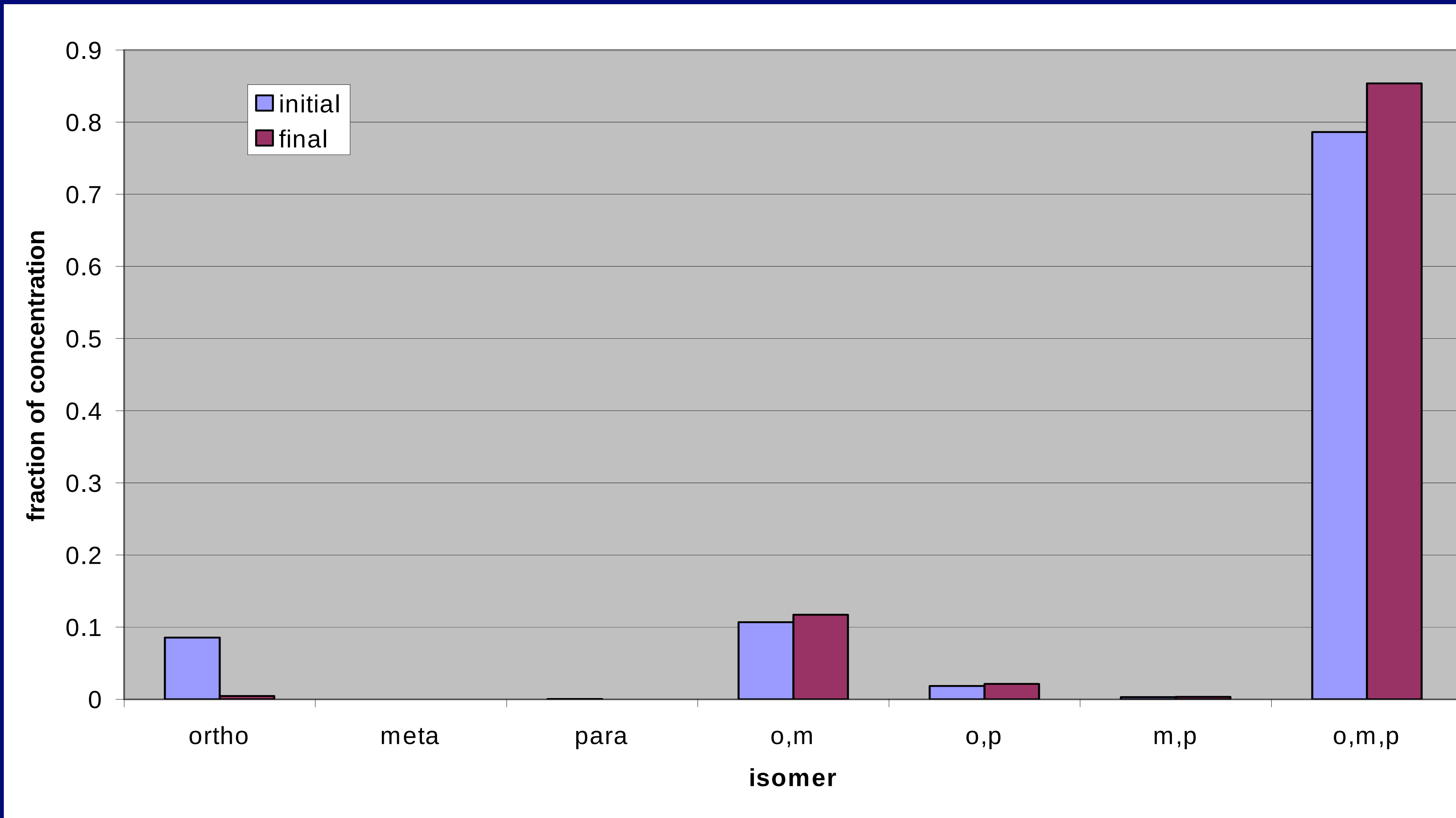
Positional analysis



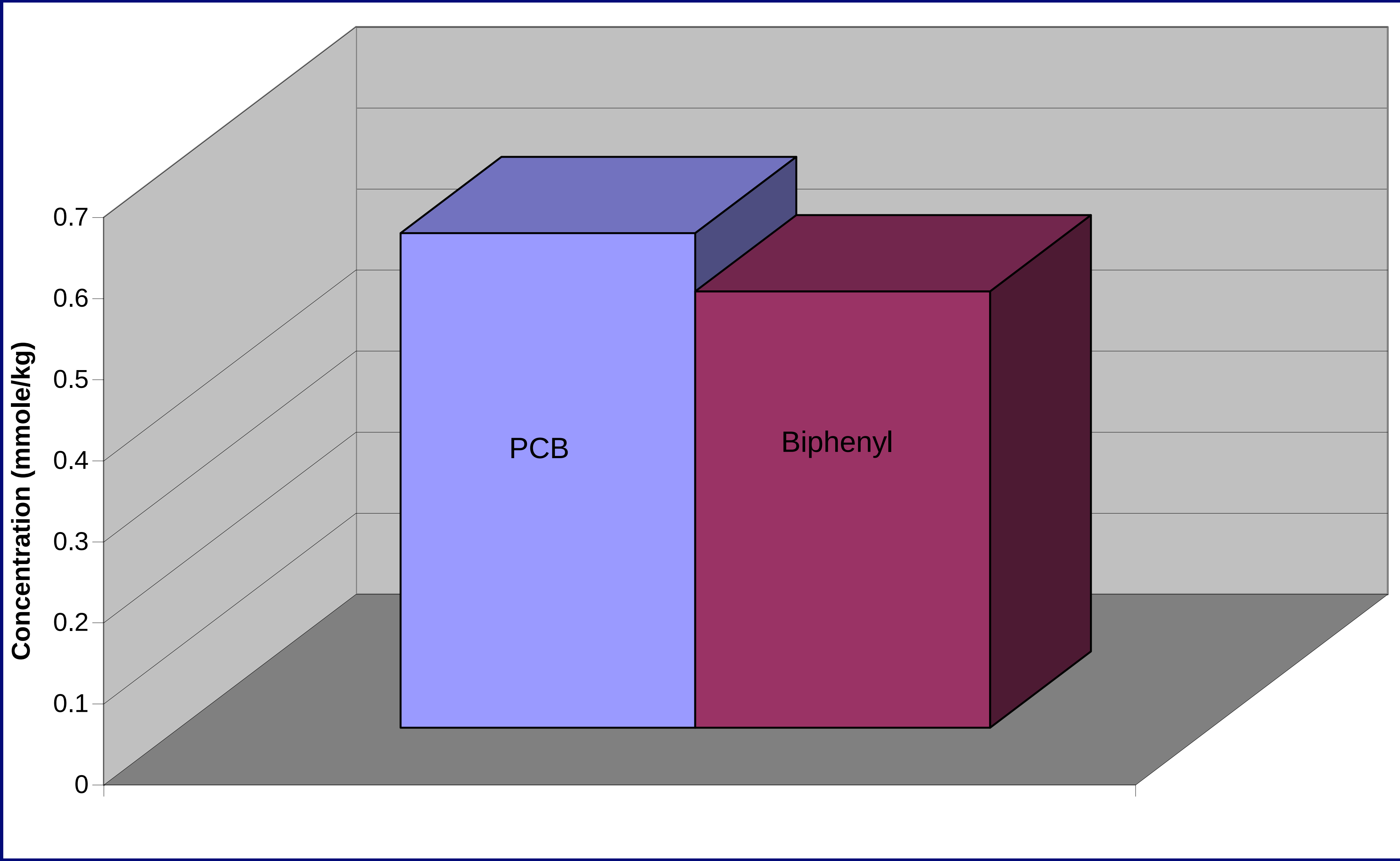
Homolog-specific dechlorination



Specificity of degradation



Mass Balance

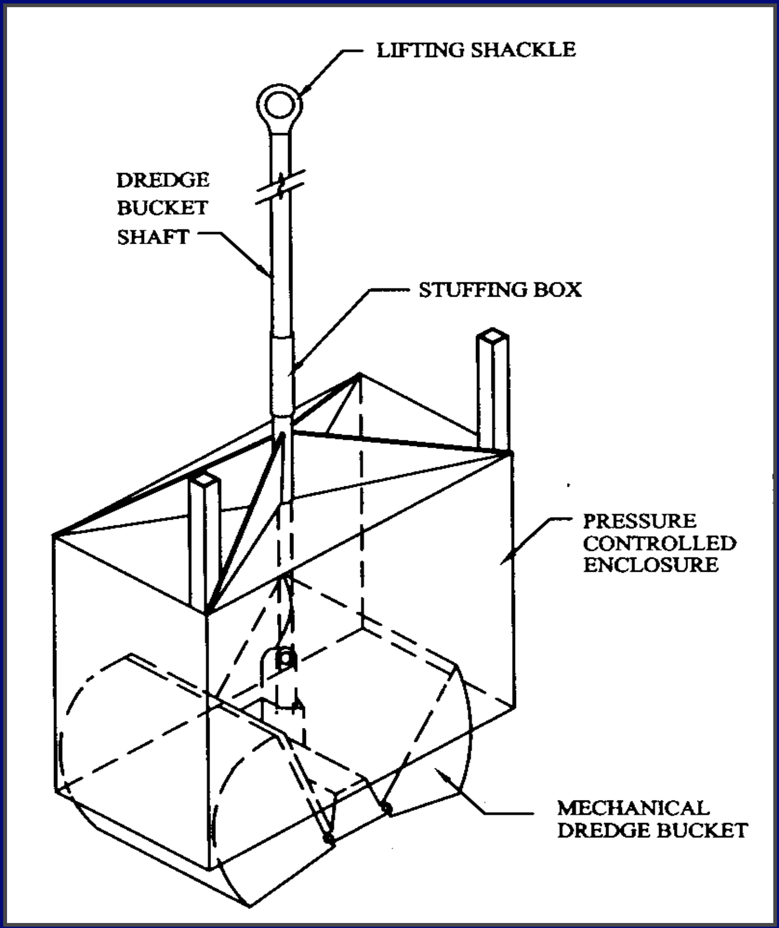


In-Situ Treatment Technology: Reagent Delivery

- Deliver reagent(s) to contaminated subsurface strata
- Provide adequate mixing of reagent in strata
- Maximize yield – minimize reagent dispersion
- Minimize dispersion of contaminated sediment

Seaway Systems - Field Examples

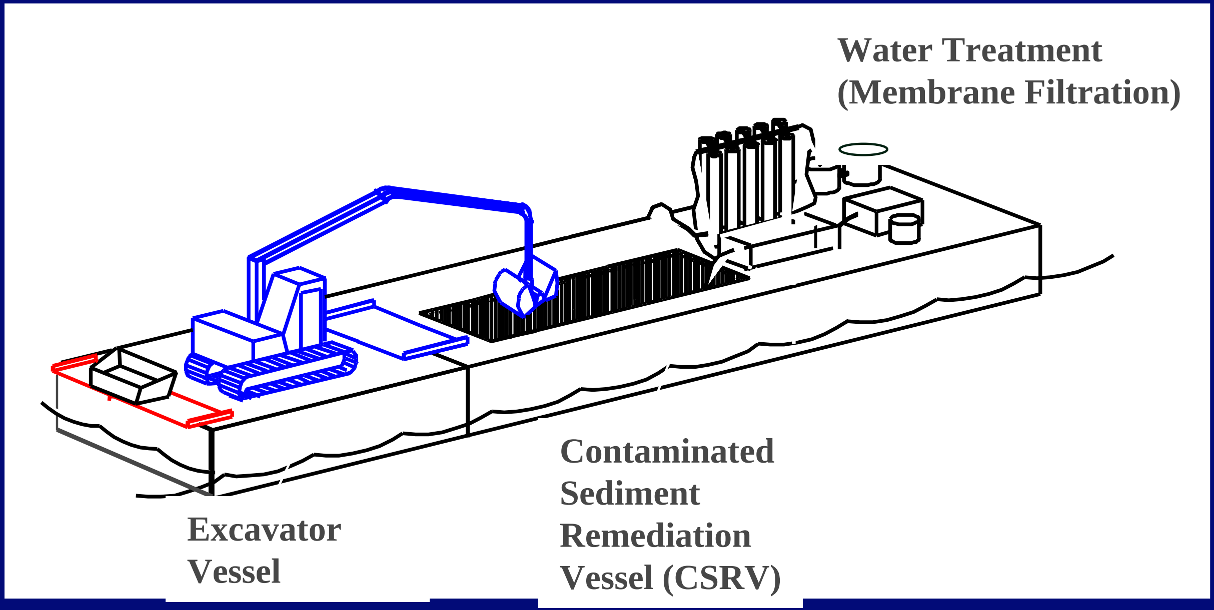
Contaminated Sediment Excavator



- **Pressure-controlled housing provides a dry environment around the mechanical bucket or mixing in-situ treatment zone**
  - **Sediments are prevented from mixing with the water**
  - **Pressure-control subsurface technology permits mixing in dry environment for in-situ treatment**

Seaway Systems - Field Examples

Contaminated Sediment Remediation Vessel



- **CSRV establishes a containment area within the river**
  - **Prevents migration of contaminants**
  - **Operator can work quickly and efficiently**
  - **Progress can be easily monitored**
- **Low pressure within containment area prevents water from escaping**
- **CSRV applicable for in-situ treatment technology**

Deploying shrouds

Conclusions

- Cost? ~ $50/cubic yard in materials (for ~2-3% iron addition)
- 50 micrometer size iron works well and may be more cost-effective, easier and safer to handle
- Remediation endpoint – high organic carbon results in slow desorption kinetics (addition of surfactant/cosolvent to enhance PCB availability is currently being investigated)
- Implementation
  - Reactive cap or mixed into sediment
- Why does this study show results so different from others?
  - Catalysis (by Ti, Mn oxides, Pd, Pt?)

End