Biodegradation of PAHs and PCBs in Two-Phase Partitioning Bioreactors Following Solid Extraction from Soil

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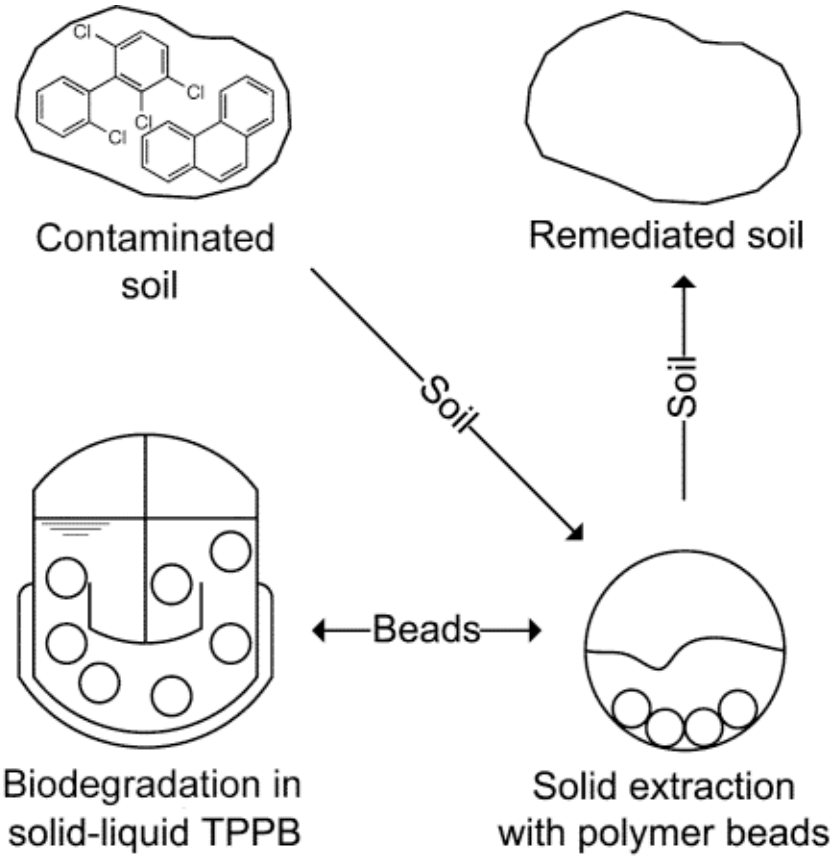
Schematic of Hydrocarbon Absorbing Polymer Technology (HAPT) for Soil Remediation



Polymer Beads as Absorbants of Soil Contaminants

- **Polymers Can be Tailored to Have High Affinity for Target Organics**
- **Polymers Remove Contaminants by Absorption (like Organic Solvents)**
- **Polymers Will Concentrate Contaminants Manifold in Reduced Volumes**
- **Polymers Can be Shaped into Many Sizes and Configurations**
- **Polymers are Biologically and Chemically Inert and non-Volatile**
- **Polymers Can be Easily Added to and Removed from Soil and Transported**
- **Polymers Can be Used in TPPB Bioreactors, and Reused**
- **Polymers are Inexpensive**

A 5L Two-Phase Partitioning Bioreactor (TPPB) with Polymer Beads

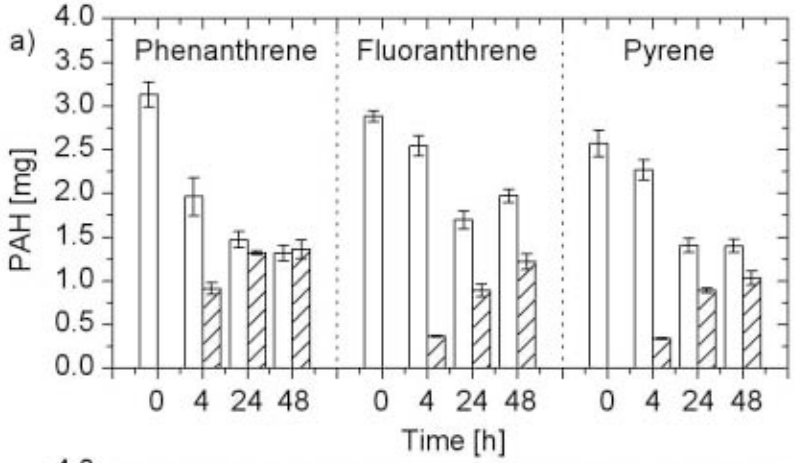
Biodegradation Under ***Controlled*** Conditions

Affinity for PAHs by Selected Commercial Polymers

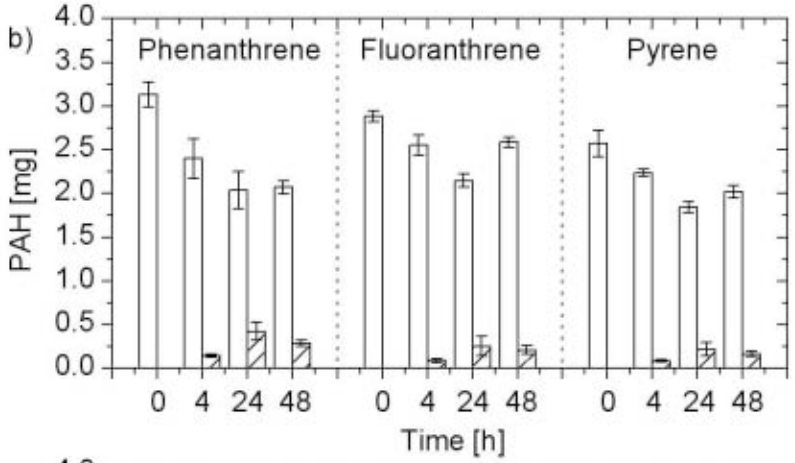
Polymer	Polymer/Water Partitioning Coefficient $K_{S/W}$		
	Phenanthrene	Fluoranthene	Pyrene
Desmopan	88,331 ± 697	237,060 ± 13,532	242,185 ± 12,420
Hytrel	23,923 ± 169	68,486 ± 600	72,350 ± 665
Polyethylene	10,827 ± 472	38,594 ± 1,892	30,553 ± 1,367

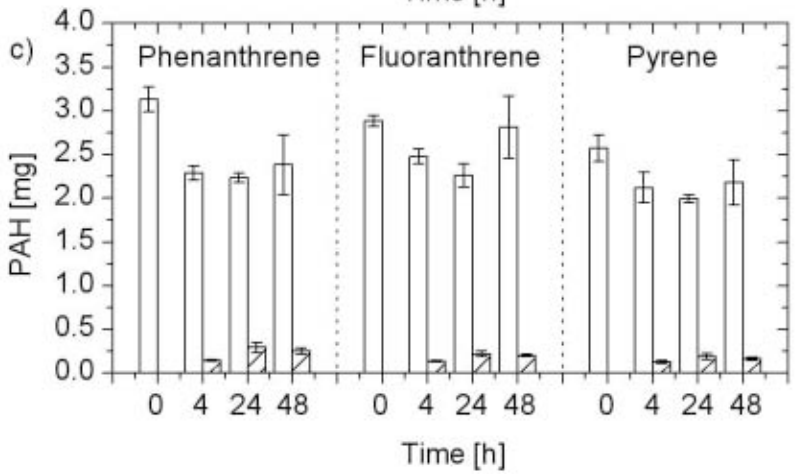
Uptake of PAHs from Soil by Desmopan

Dry Soil

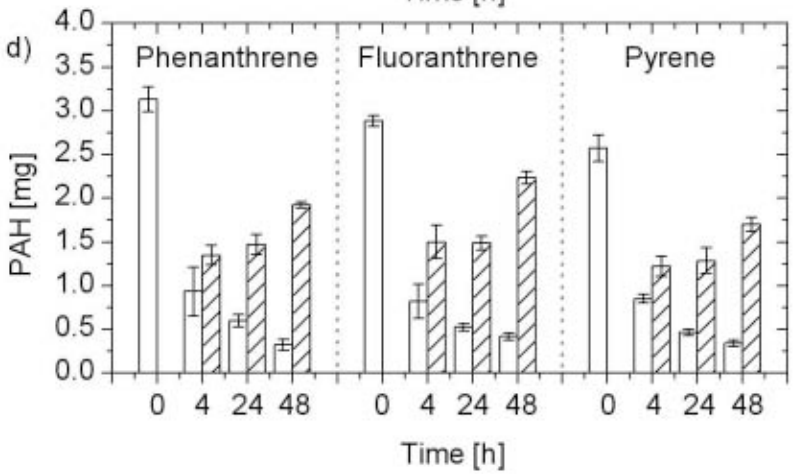


Wet Soil



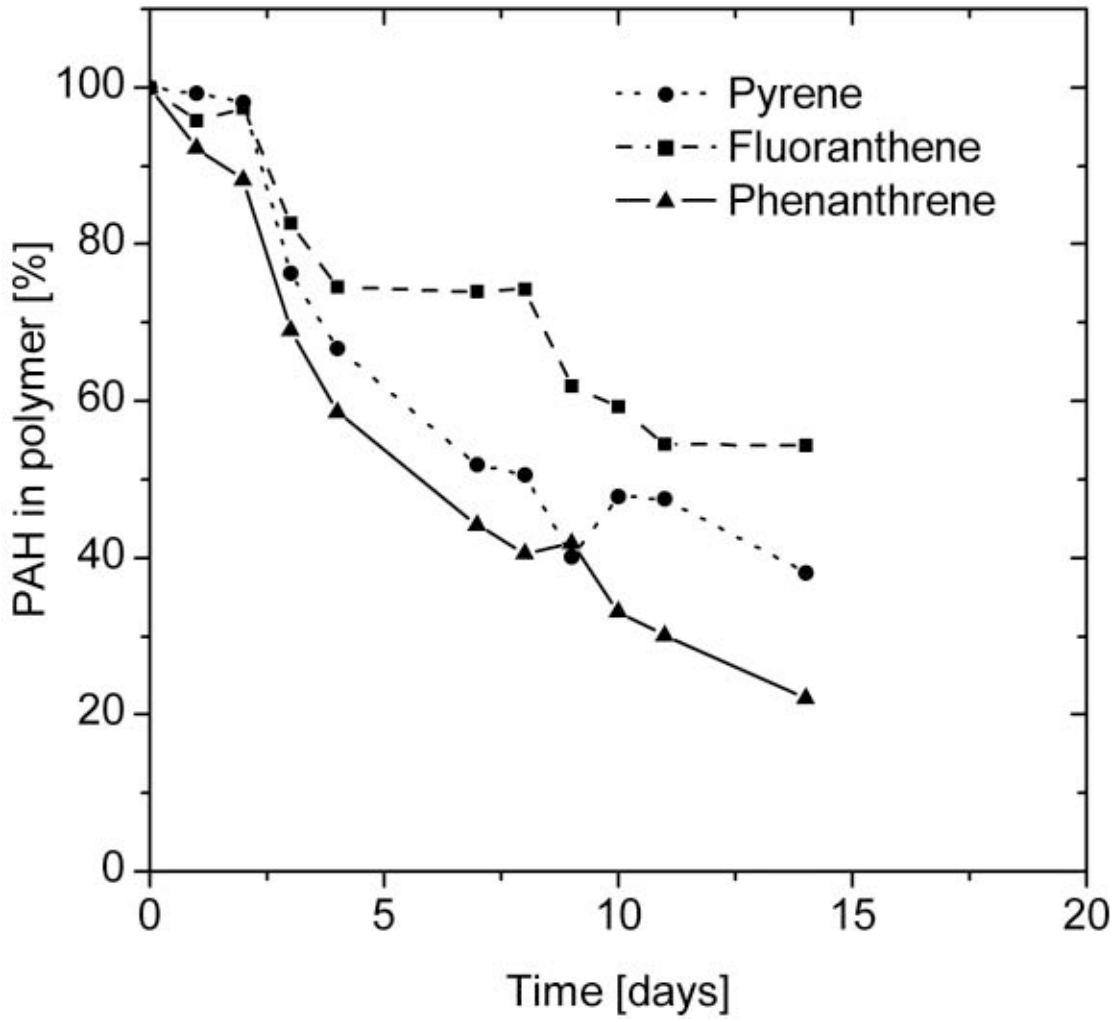


Biosolve plus Soil

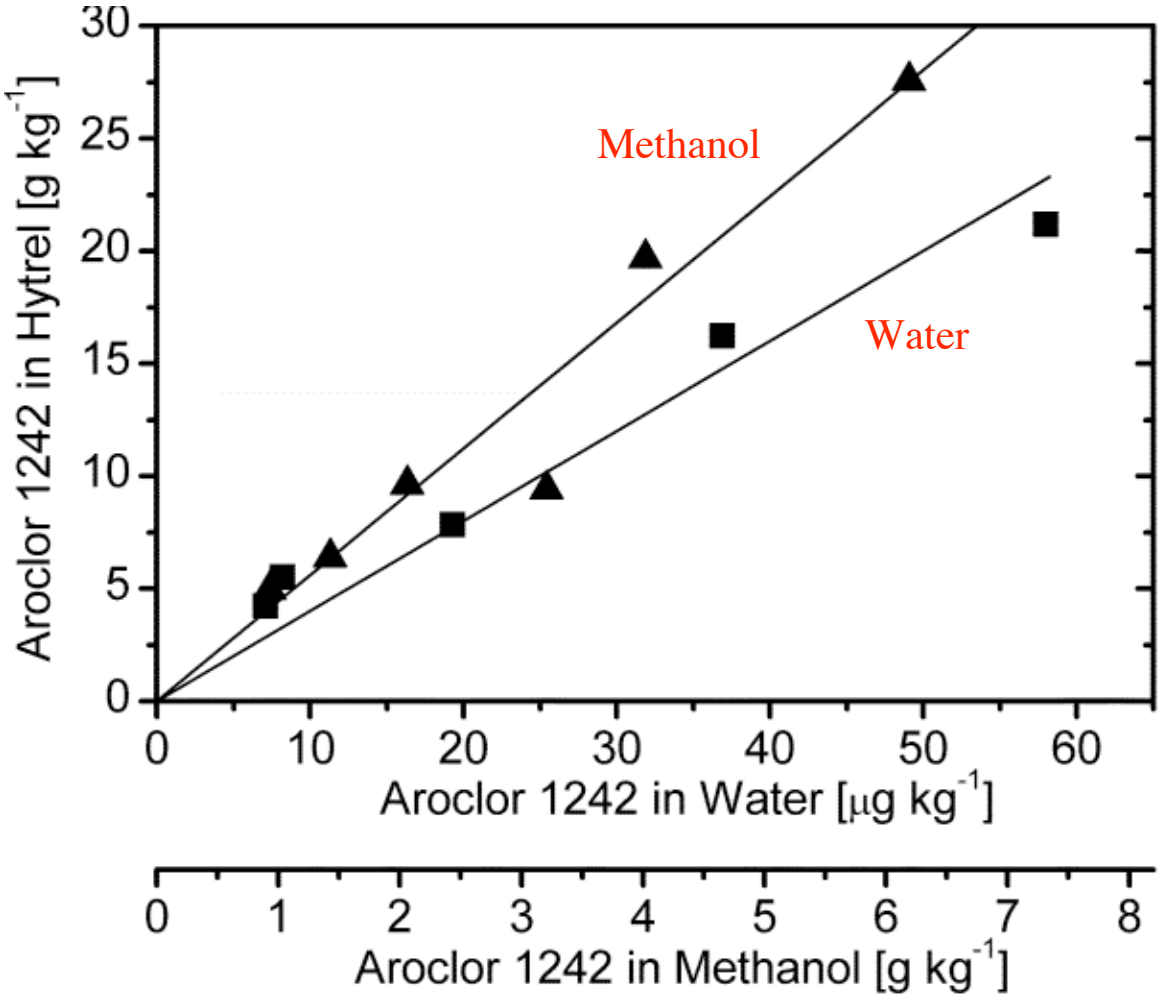


IPA plus Soil

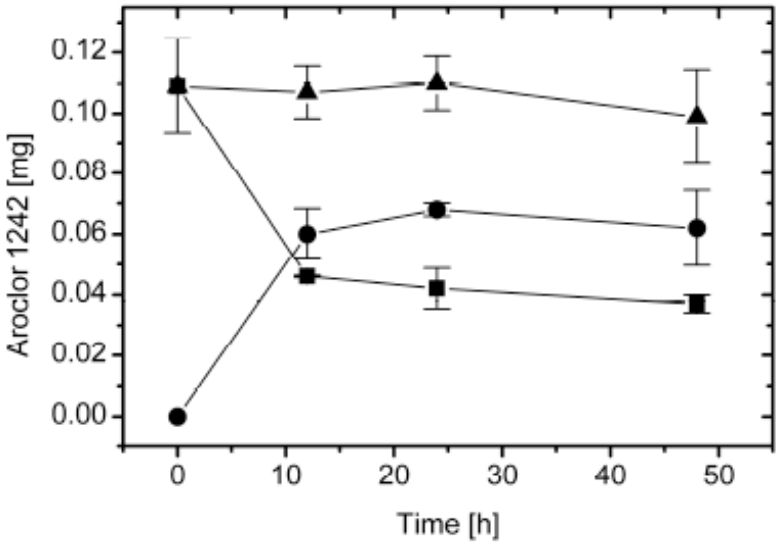
Biodegradation of PAHs in a Solid-Liquid TPPB



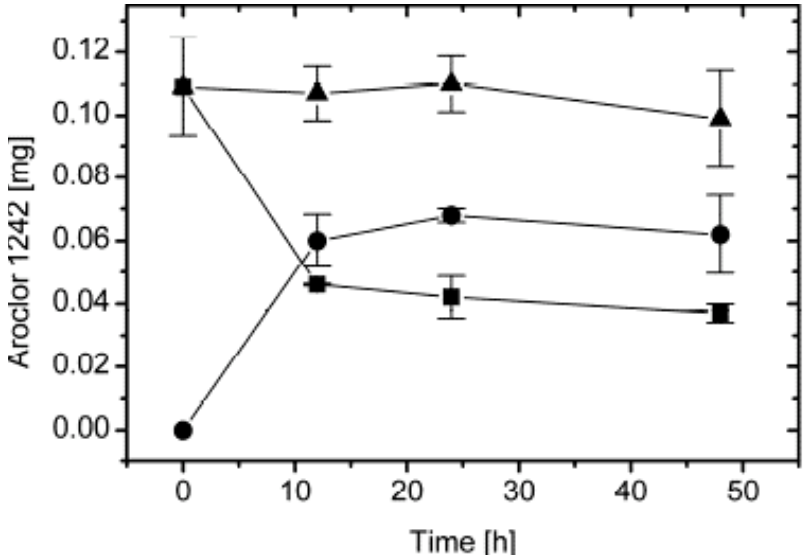
Affinity of PCBs by Hytrel



Uptake of PCBs from Soil by Hytrel



Initial PCB Concentration-100 mg/kg
Hytrel-to-Soil Ratio-10%

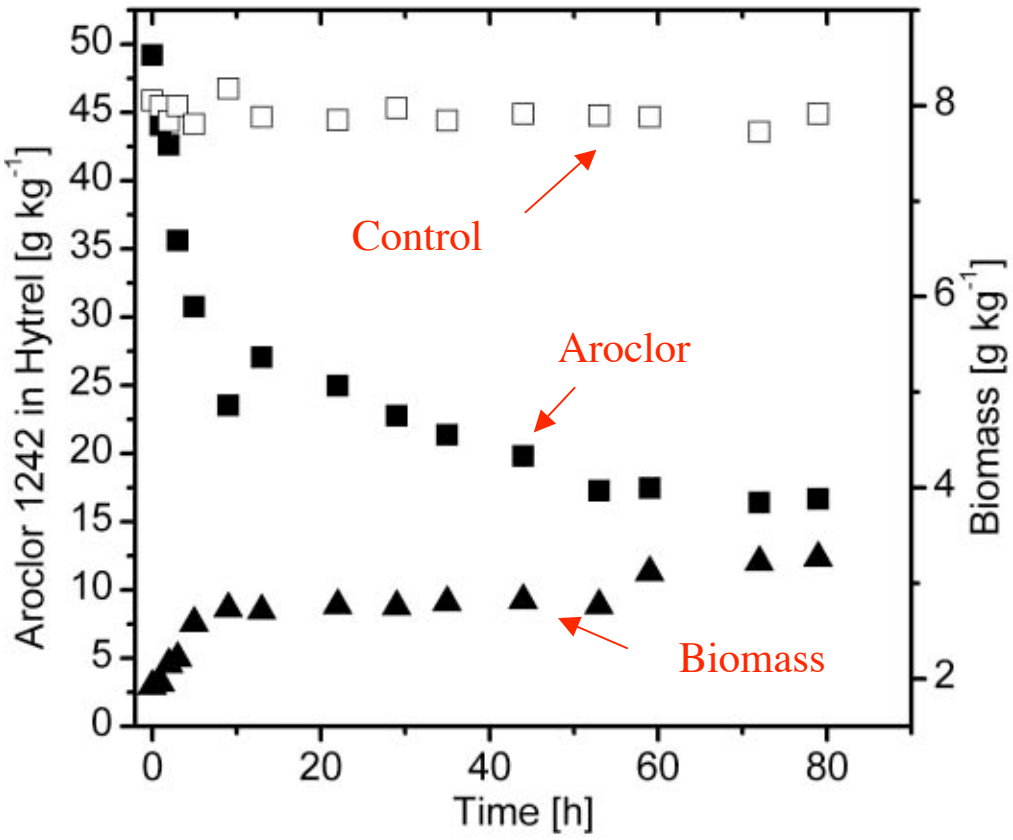


Initial PCB Concentration-1000 mg/kg
Hytrel-to-Soil Ratio-1%

Uptake of PCBs from Soil by Hytrel

Test series	Initial concentration in soil [mg/kg]	Bead/soil ratio [g/g]	Final concentration in soil [mg/kg]	Final concentration in polymer [mg/kg]	Residual in soil [%]	Amount extracted in polymer [%]
E1	100	0.1	37 ± 3	621 ± 124	34 ± 3	57 ± 11
E2	1000	0.1	271 ± 2	5,653 ± 641	32 ± 1	67 ± 8
E3	100	0.01	35 ± 6	4,039 ± 337	42 ± 7	48 ± 4
E4	1000	0.01	334 ± 27	68,036 ± 7,746	33 ± 3	68 ± 8

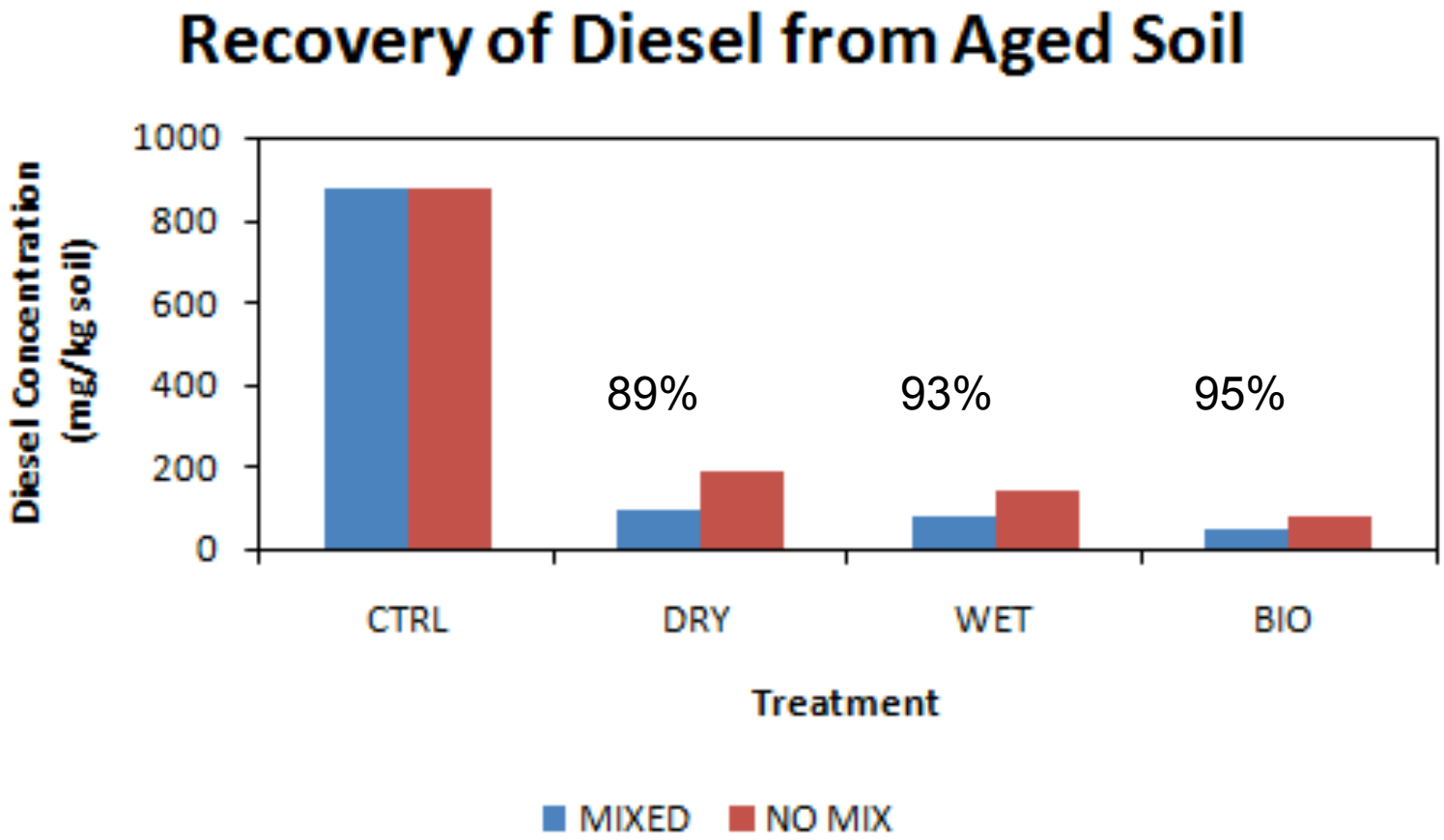
Biodegradation of PCBs in Loaded Hytrel Beads in a TPPB



Removal of Aroclor 1254 from Weathered Soil by Polymer Beads

Sample	Units	PCB Concentration Aroclor 1254
Control 24389	ug/g	3.1
RT dry	ug/g	2.3
RT slurry	ug/g	0.8
PU dry	ug/g	2.1
PU slurry	ug/g	0.4

Remediation of Diesel-Contaminated Soil by Polymer Beads

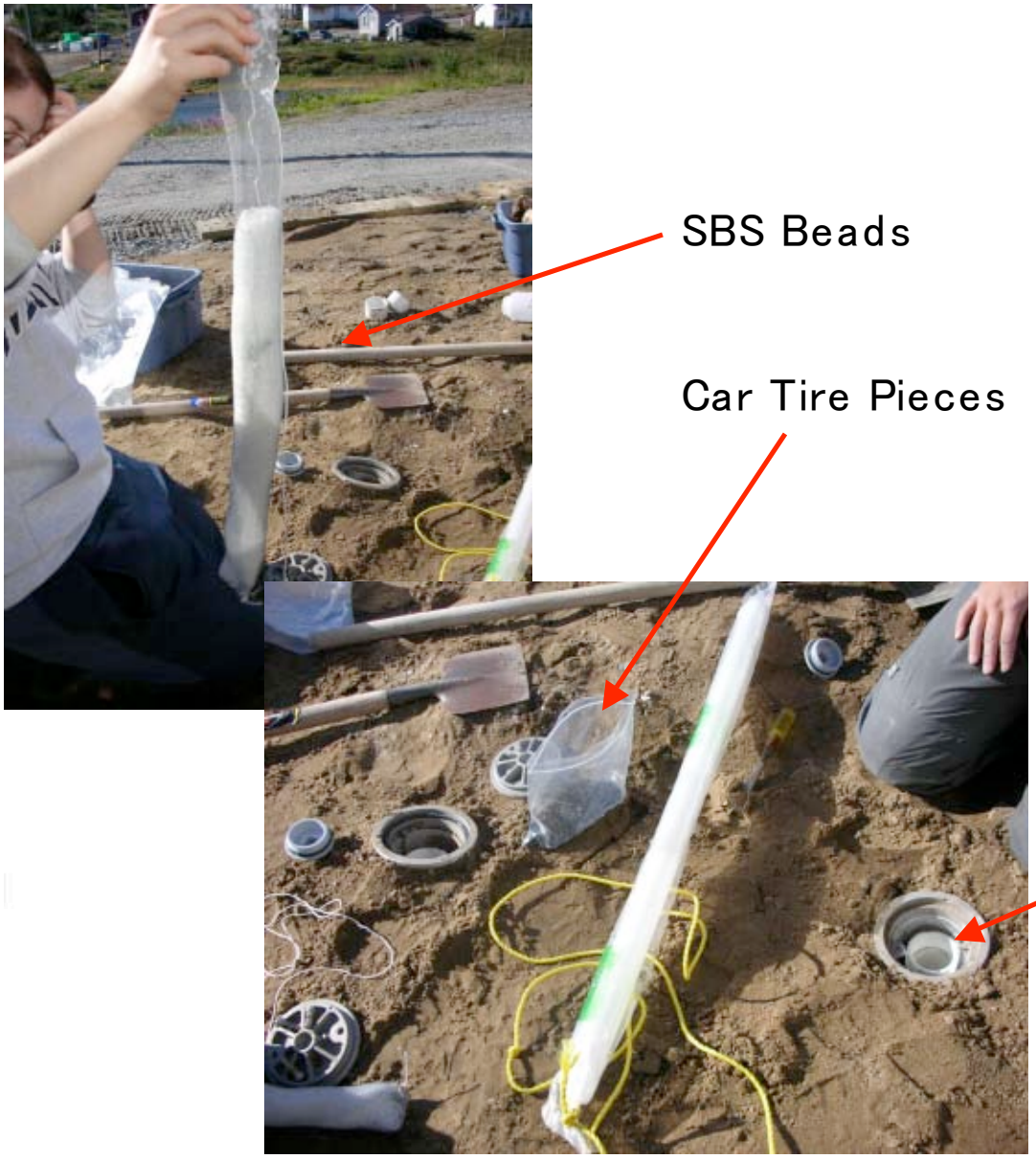


Removal of Diesel from Water by Polymer Beads

Site Applications

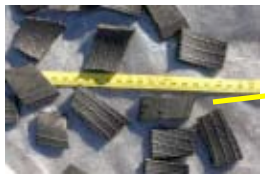
- Working with the Environmental Sciences Group at RMC we are applying our HAPT Technology to Remediate Contaminated Northern Sites:
- HAPT Technology has been applied at sites owned by several custodial departments
  - RCMP
  - Parks Canada
  - North Warning System Office (NWSO)

RCMP



- Historical fuel release in Nain, Labrador
- HAPT Technology used as a monitoring tool for hydrocarbon migration
- Results pending (2008)

Parks Canada - Quitinirpaq National Park



Tire pieces

- Small areas of hydrocarbon contamination at Tanquary Fiord
- Contact time/mixing is a key component in HAPT soil remediation

Parks Canada – Stokes Point Yukon

- Small quantity of PCB contaminated soil
- HAPT Technology will be employed to absorb the PCBs from the soil
- Once remediated, the soil will be returned to the site

North Warning System Office

- A fuel-line leaked in the winter of 2007 resulting in large quantities of hydrocarbon-contaminated snow
- HAPT Technology demonstrated for its ability to treat contaminated snow
- HAPT Technology proposed as spill response measure for Northern Sites

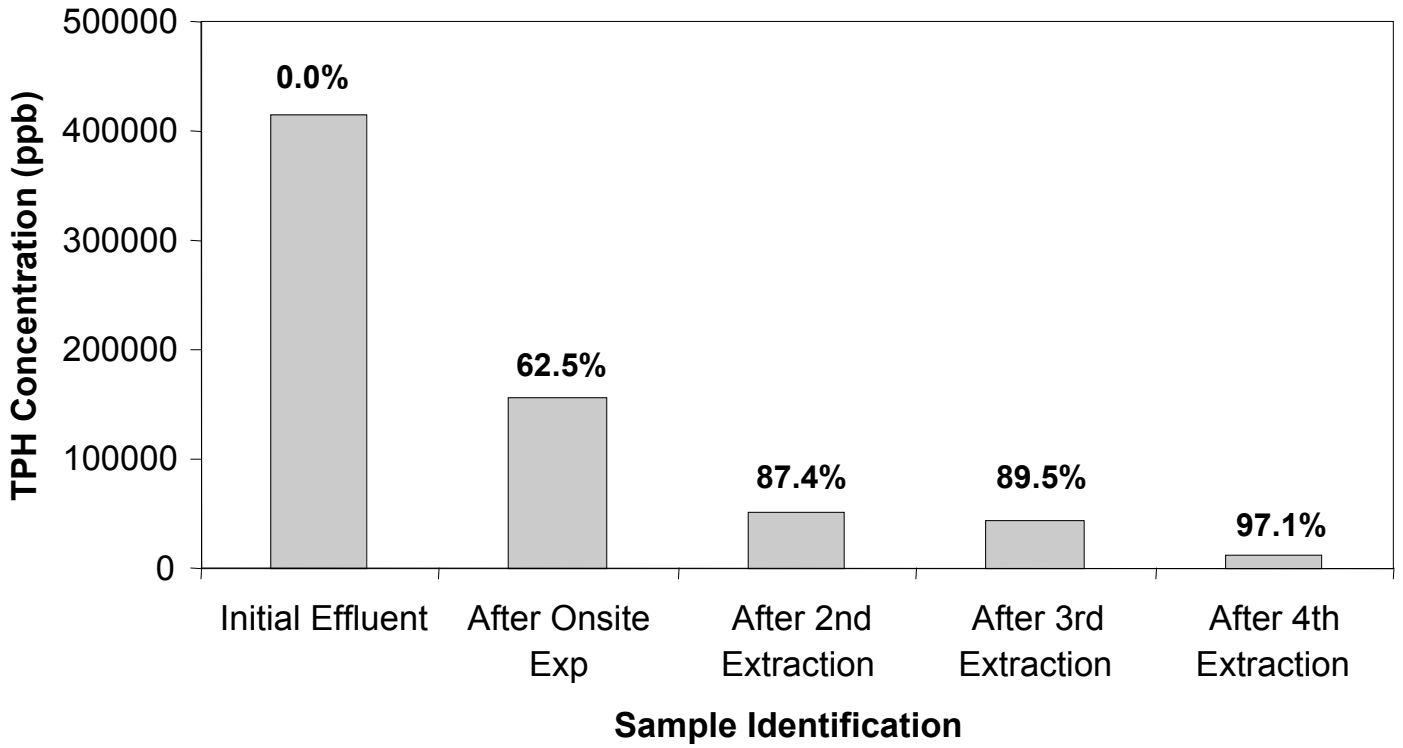
•Polymers contained within an aluminum mesh
•Suspended in contaminated water

Observations

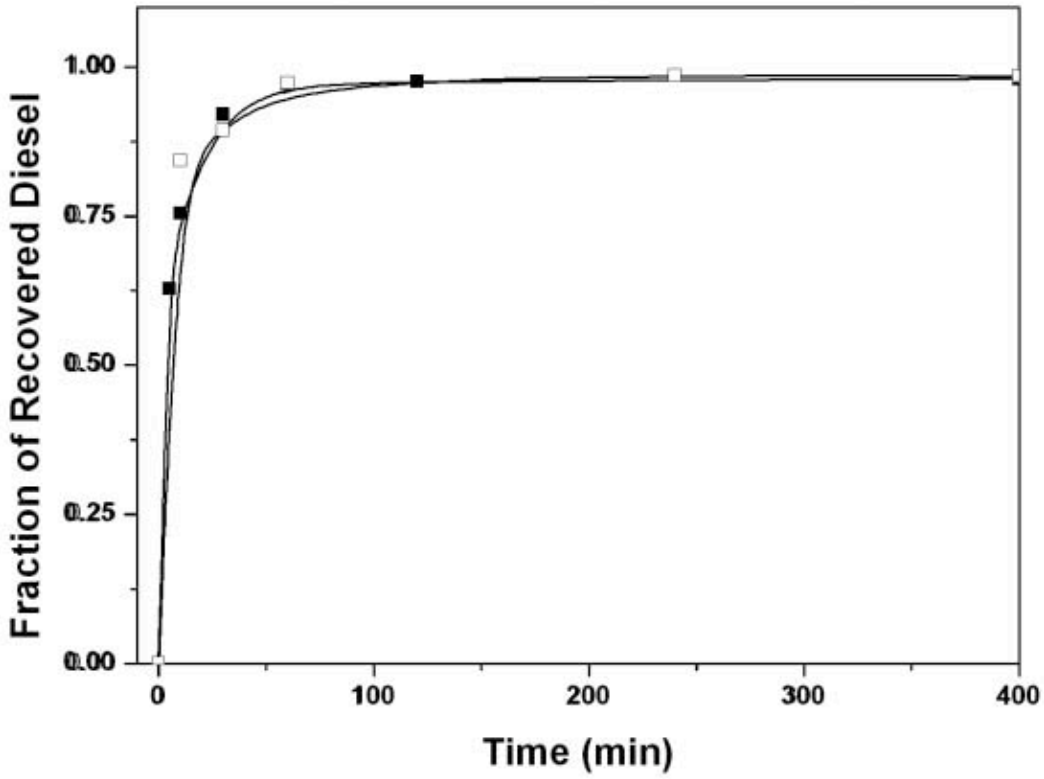
- Oil sheen reduced over a 24 h period
- Visual inspection (and via absorbent towel) confirmed the reduction of TPH over this period of time
- Polymeric material became more malleable (indication of TPH sorption)
- Contact of beads and contaminants important for TPH recovery

Results – TPH Reduction

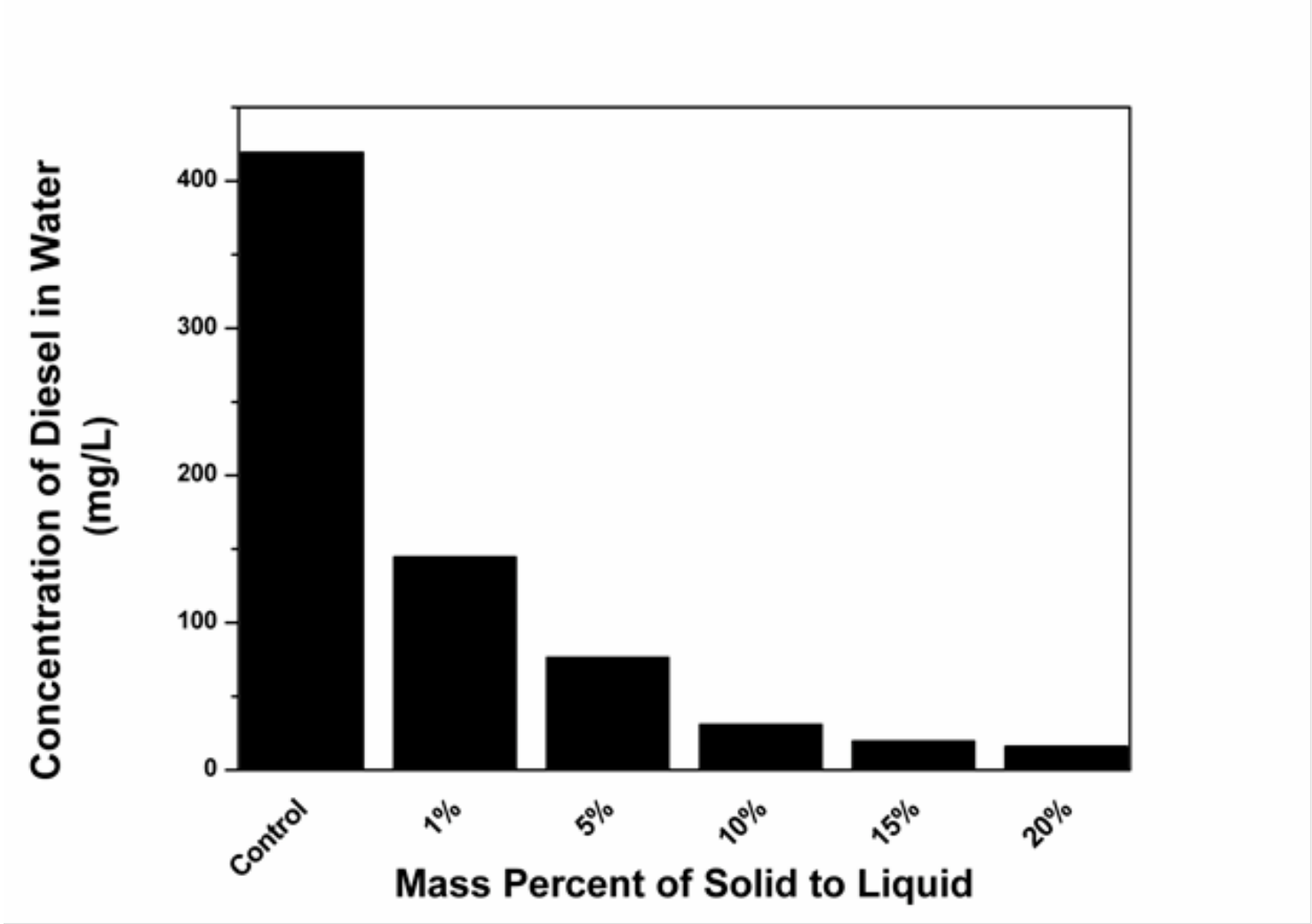
Removal of TPH, including *dissolved* TPH, from contaminated water onsite, followed by multiple extraction stages performed in the laboratory



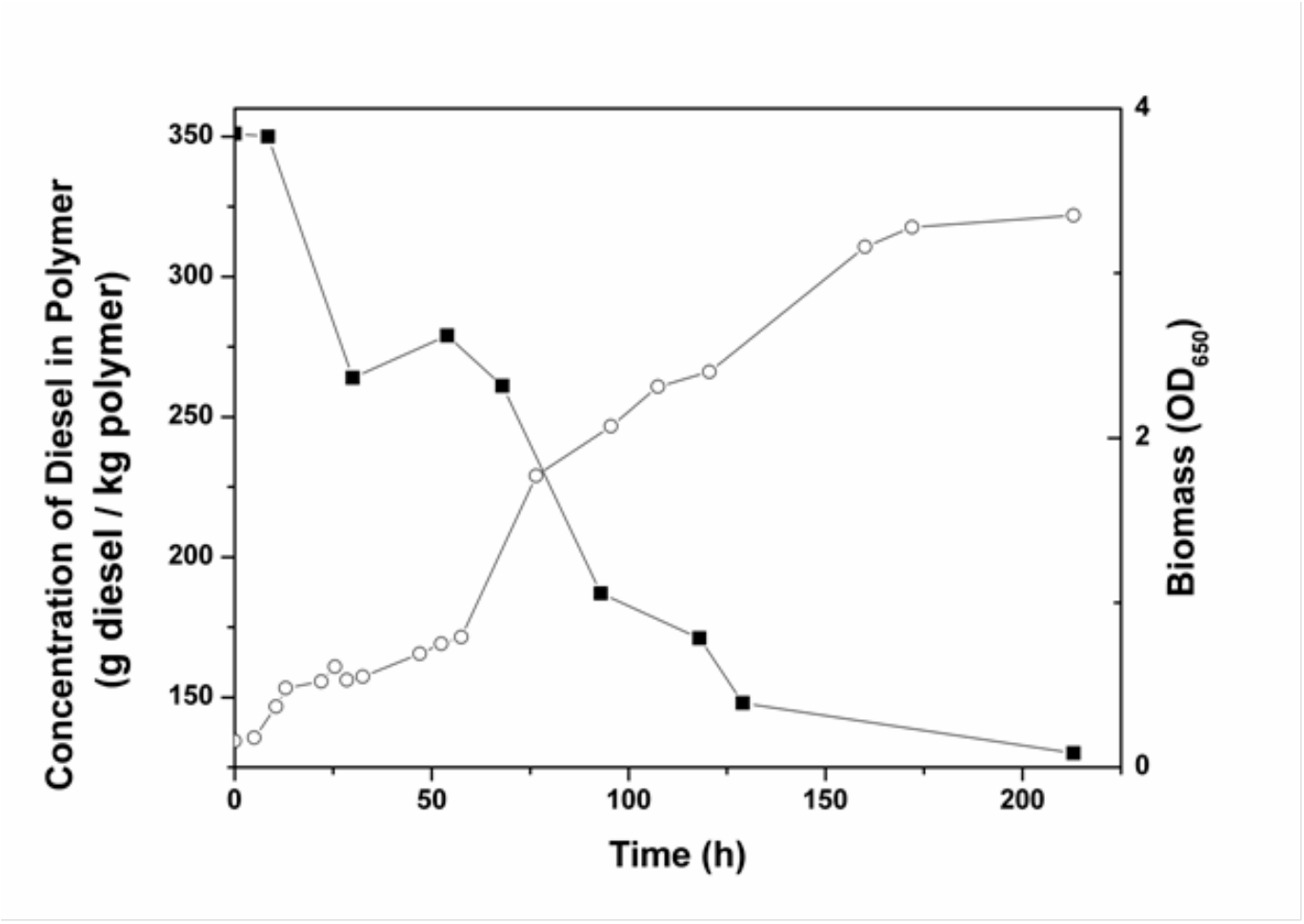
Removal of Diesel from Water by Polymer Beads



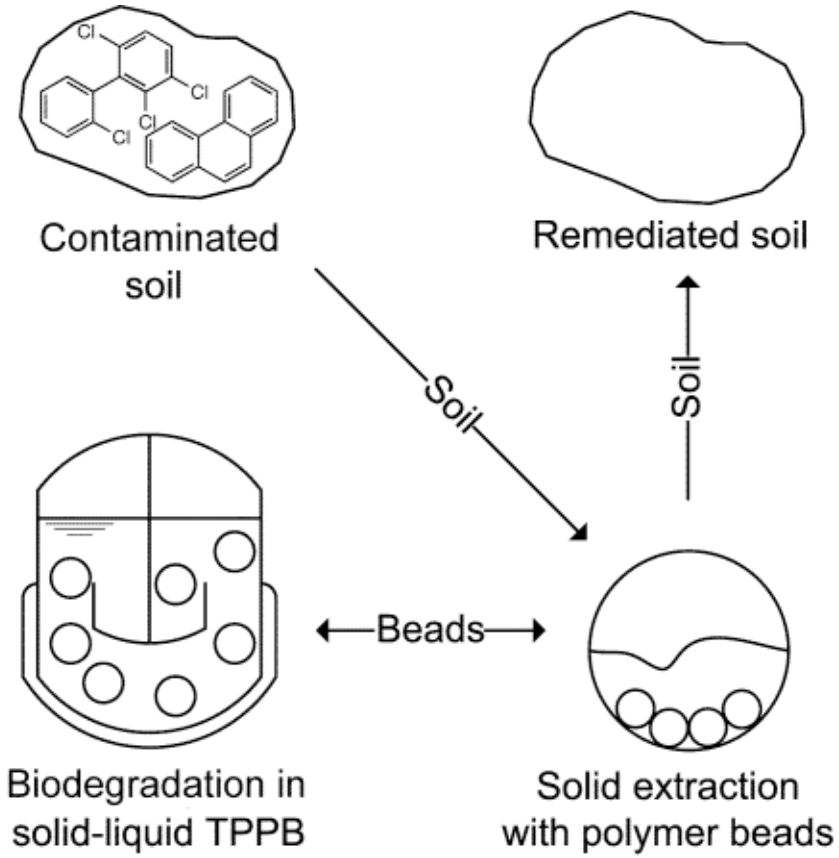
Removal of Diesel from Water by Polymer Beads



Biodegradation of Diesel from Loaded Polymer Beads in a TPPB



Summary of Hydrocarbon Absorbing Polymer Technology (HAPT) for Soil Remediation



Conclusion

- Polymers can be used to effectively absorb recalcitrant organic contaminants from soil significantly reducing the volume of material to be treated
- Treated soil can be returned
- Polymers can be tailored to specific contaminants, and include very inexpensive materials (including rubber tires)
- Contact times are short, and remediation is at ambient conditions
- Contaminant-loaded polymers can be transported for remediation in TPPBs *under controlled conditions*, allowing for polymer reuse
- HAPT Polymer technology continues to be demonstrated "on-site"