

Constraints to Biodegradation of HOC in Soil - Does Bioavailability Really Matter?

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Contaminated Land Management

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Overview

- Requirements for biodegradation
- Limitations to bioremediation
- Bioavailability considerations
- Selected data
- Conclusions

Factors Influencing HOC Biodegradation in Soil

- Microbial degradation capability
- Environmental conditions

- Pollutant characteristics
- Soil and site characteristics

Microbial degradation capability

Pollutant Degrading Microorganisms

- Autochthonous microorganisms
- Bioaugmentation
 - Survival of added microorganisms?
 - Use of engineered organisms?
 - Cost/benefit considerations

Environmental Conditions

Requirements for microbial catabolism

- Moisture (40-70% WHC_{max})
- pH (3-9)
- Temperature ($>5^{\circ}C$)
- Nutrients (C:N:P:K=100:10:1:1)
- Electron acceptor (O_2 ...)
- Absence of inhibiting effects
- Electron donors
- Co-substrates

Pollutant Characteristics

Molecular structure & functional groups

- **Recalcitrance – not biodegradable**
- **Physicochemical properties**
 - **Water solubility**
 - **Octanol/water partitioning**

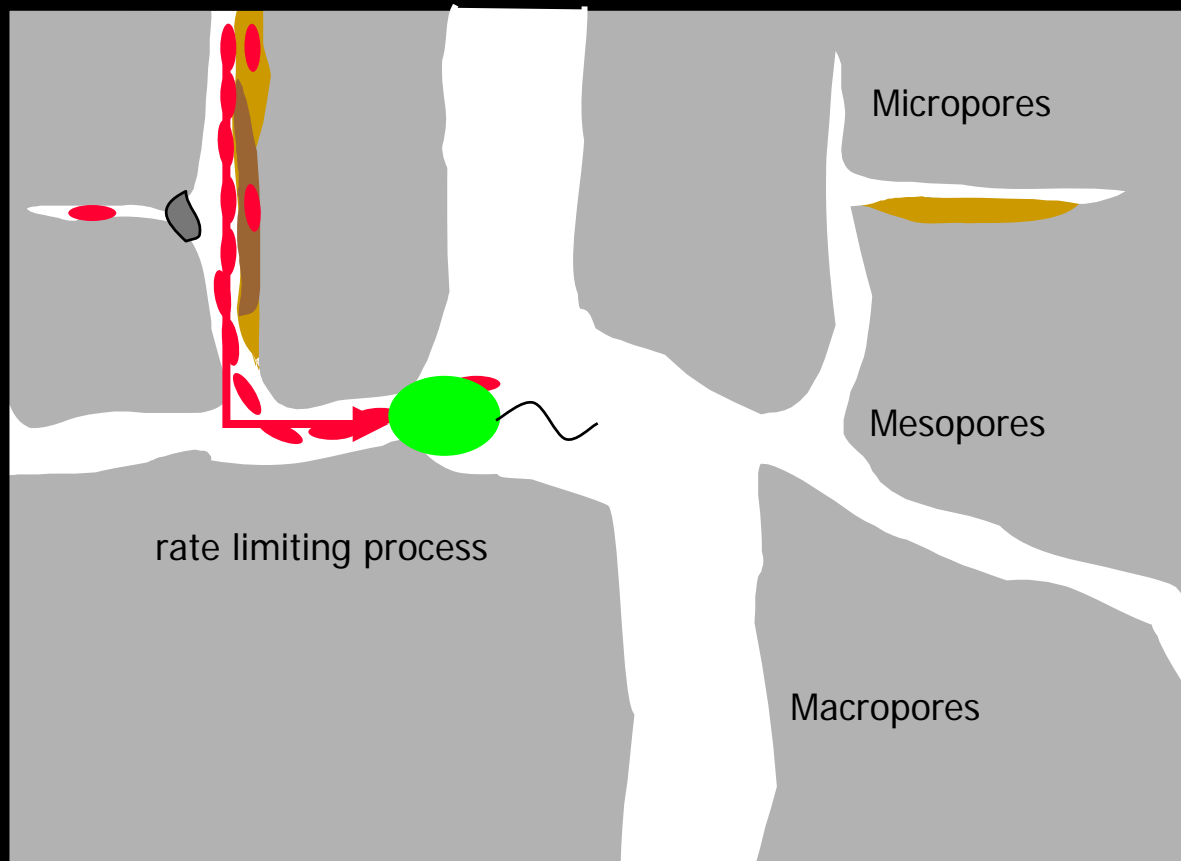
Pollutant Characteristics

Molecular structure & functional groups

- Recalcitrance – not biodegradable
- Physicochemical properties

Bioavailability

Sequestration of PAHs in Soil



- soil pores
- mineral particles
- oxides, carbonates
- PAHs
- flexible SOM
- condensed SOM
- combustion residues

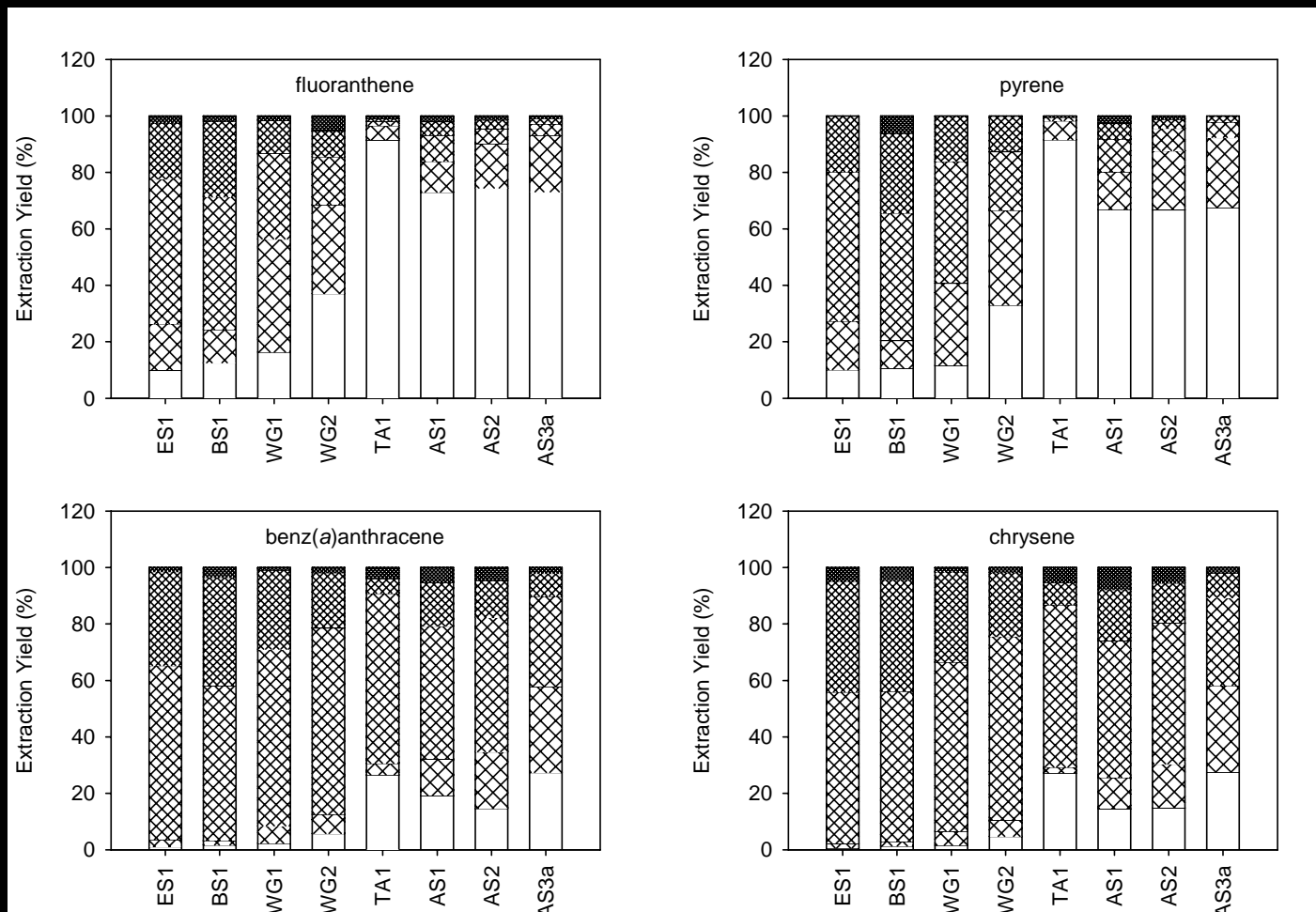
Pollutant Availability in Soil

Dependent on

- pollutant characteristics (structure, concentration)
- soil characteristics (om, ms, 3d-structure)
- co-pollutants (solubilizer, competition)
- environmental factors (pH, temperature, salinity)
- retention time in soil (ageing)
- receptor organism (uptake, metabolism)

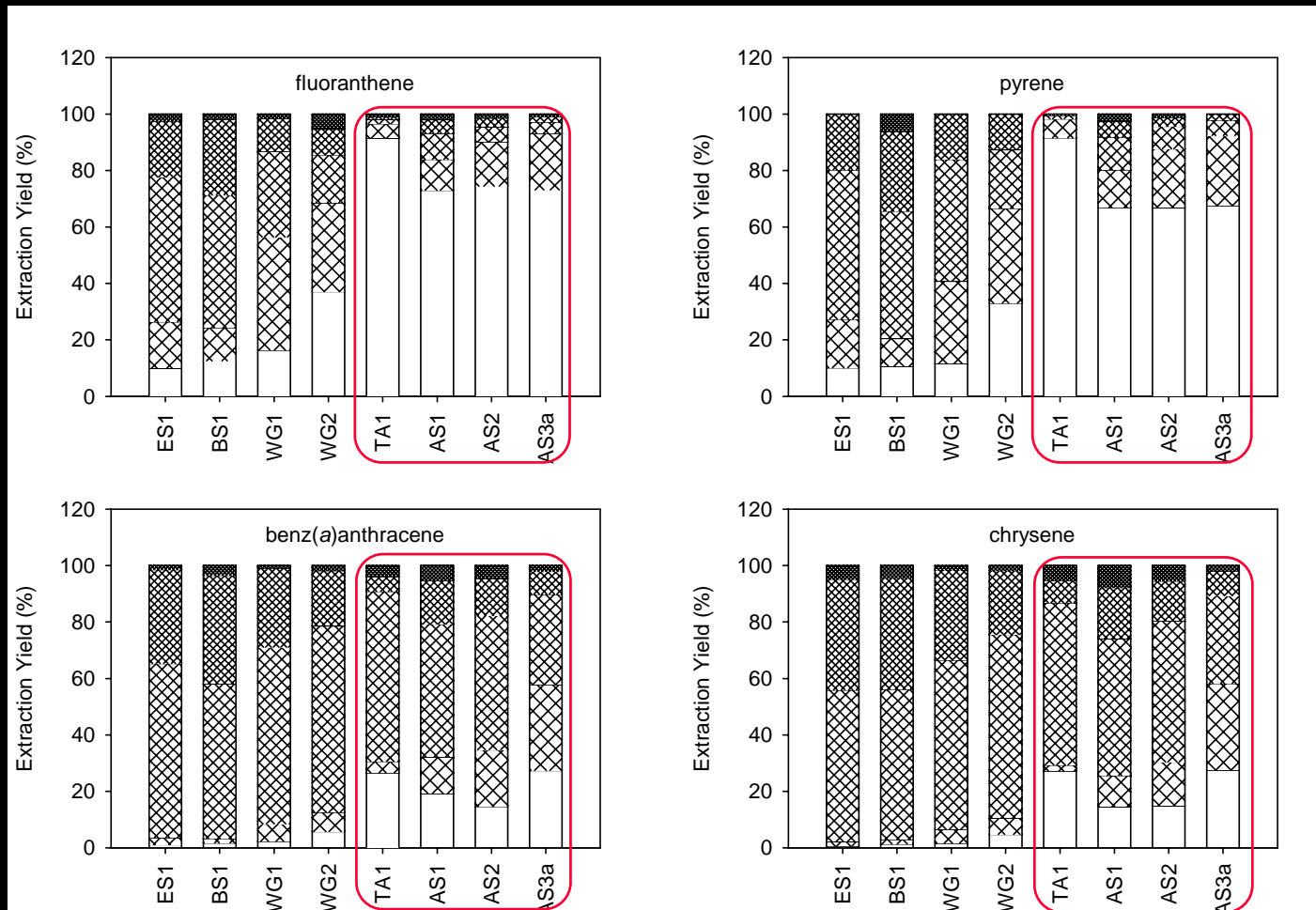
Sequential Supercritical Fluid Extr.

Szolar et al. 2004, JEQ



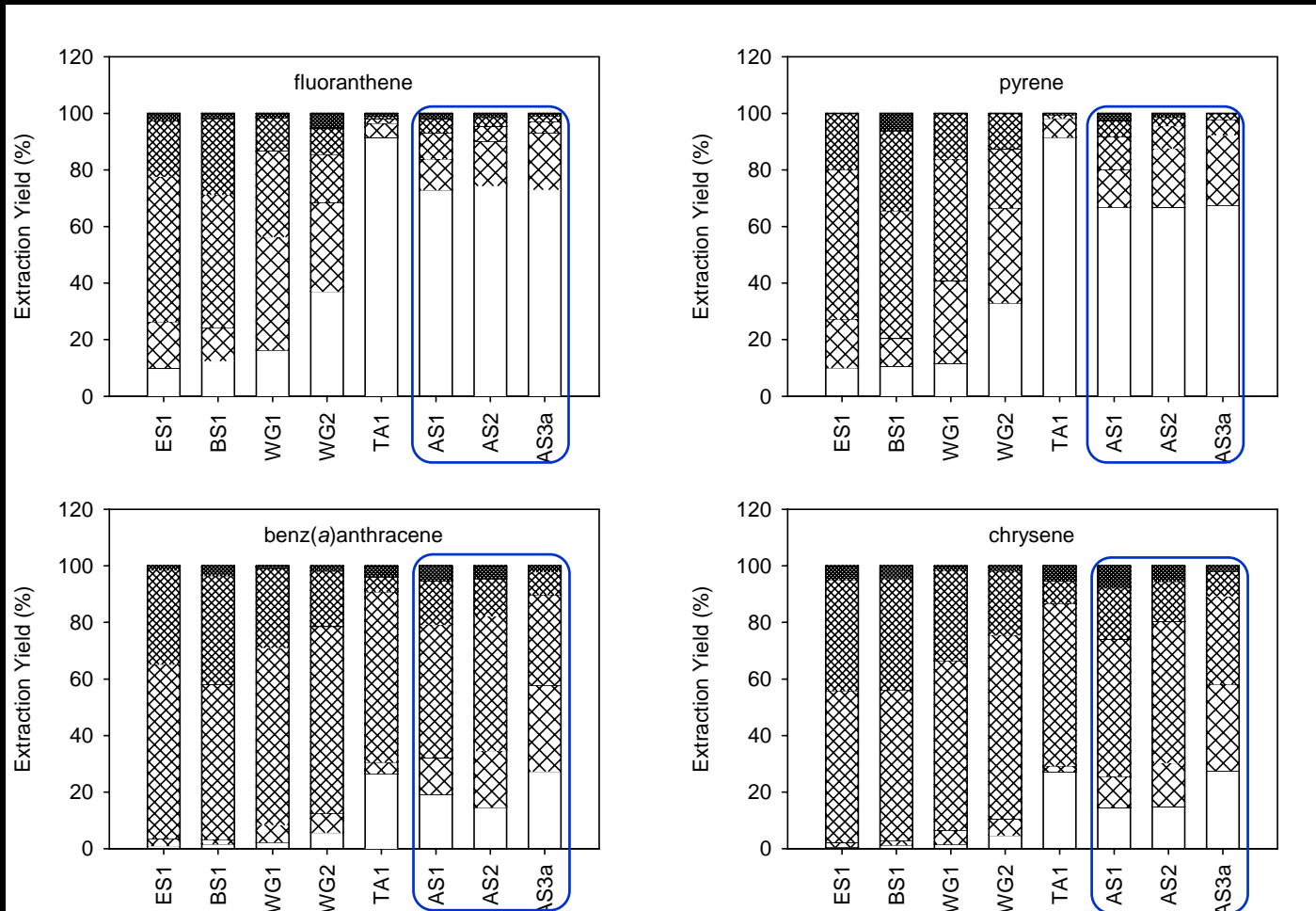
High Extractability

Szolar et al. 2004, JEQ



Biodegradation

Szolar et al. 2004, JEQ



SSF Extractability - Degradation

	WG	TA	AS
extractability	low	very good	good
degradability	no	no	yes
Total PAH (ppm)	380	250	620

Toxicity - Bioassays

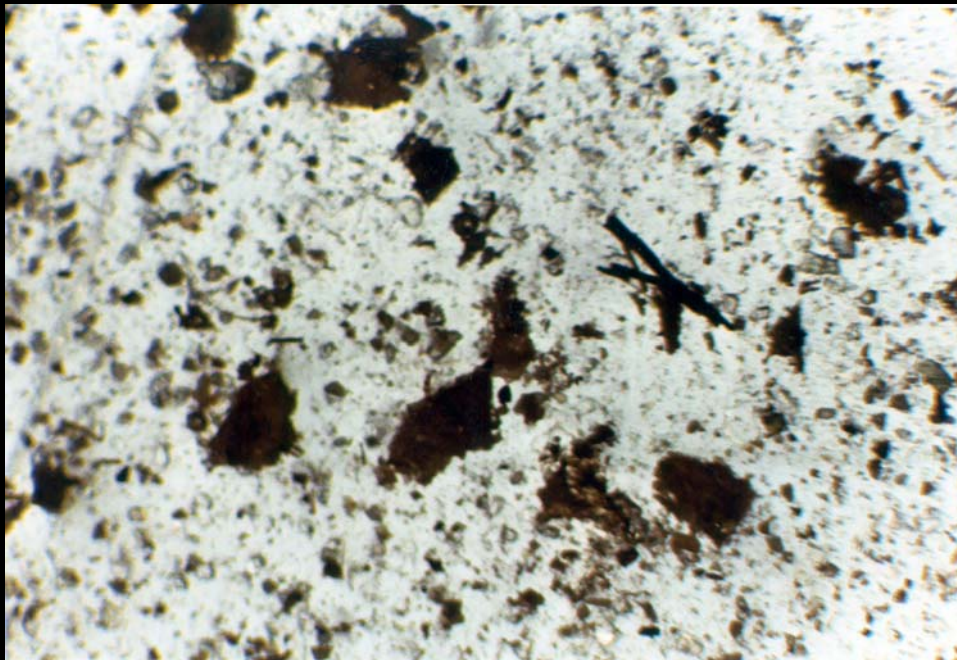
	WG	TA	AS
extractability	low	very good	good
degradability	no	no	yes
toxicity	low	very high	medium

SOM Content

	WG	TA	AS
extractability	low	very good	good
degradability	no	no	yes
toxicity	low	very high	medium
Soil Texture	sandy loam	loamy sand	silt loam
TOC (%)	2.1	0.2	4.9

SOM in Sand Fraction

	WG	TA	AS
TOC (63 - 2000 μm) (%)	1.9	0.0	7.8
TOC (< 63 μm) (%)	2.1	0.5	3.6

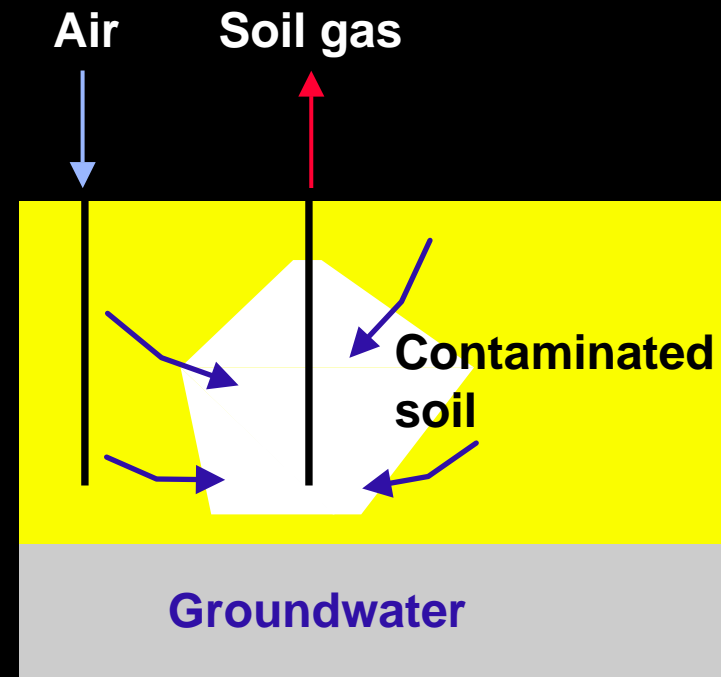


particulate
organic matter
in sand fraction

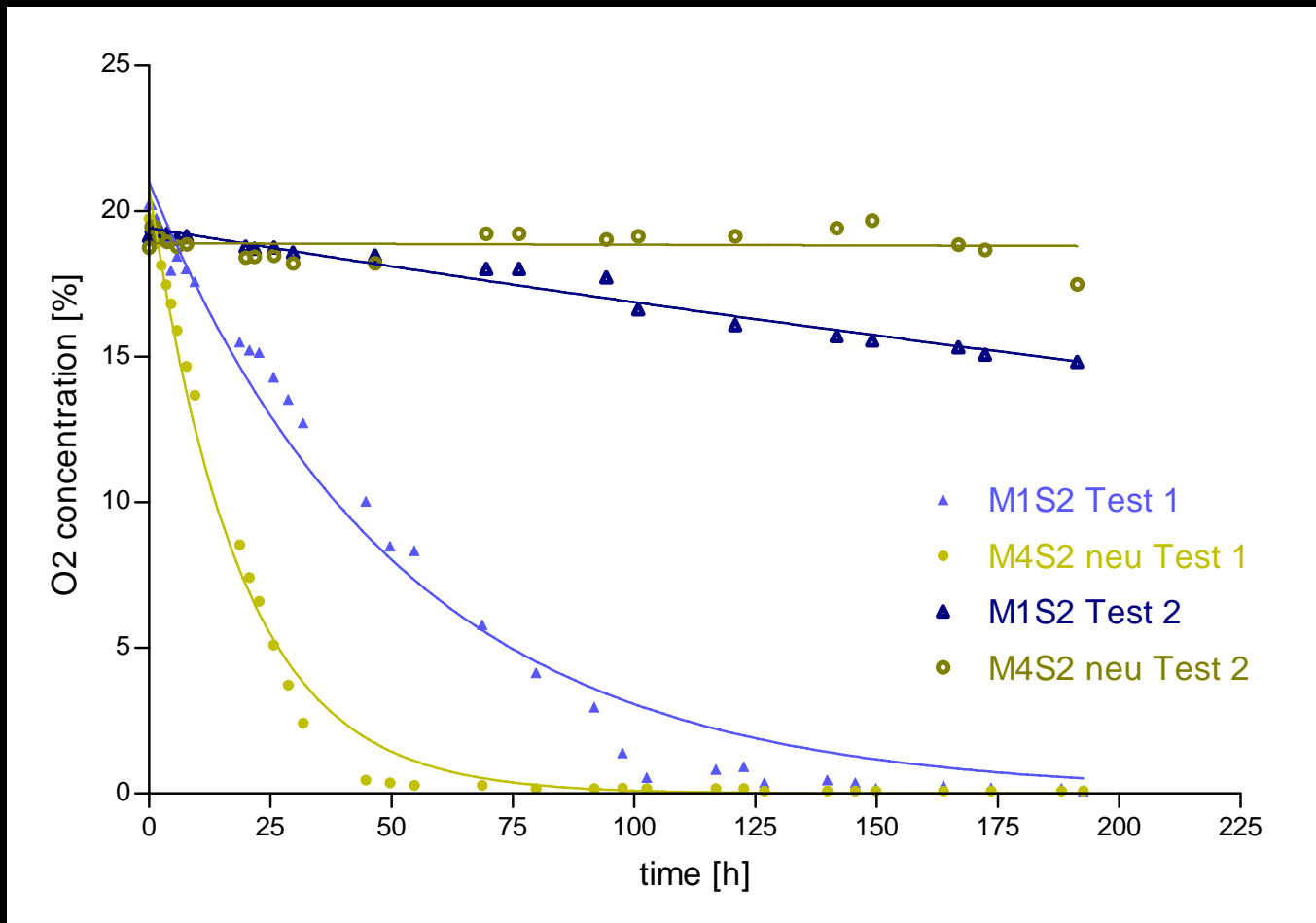
Site Factors - *In Situ* Remediation

Providing favorable degrading conditions at field

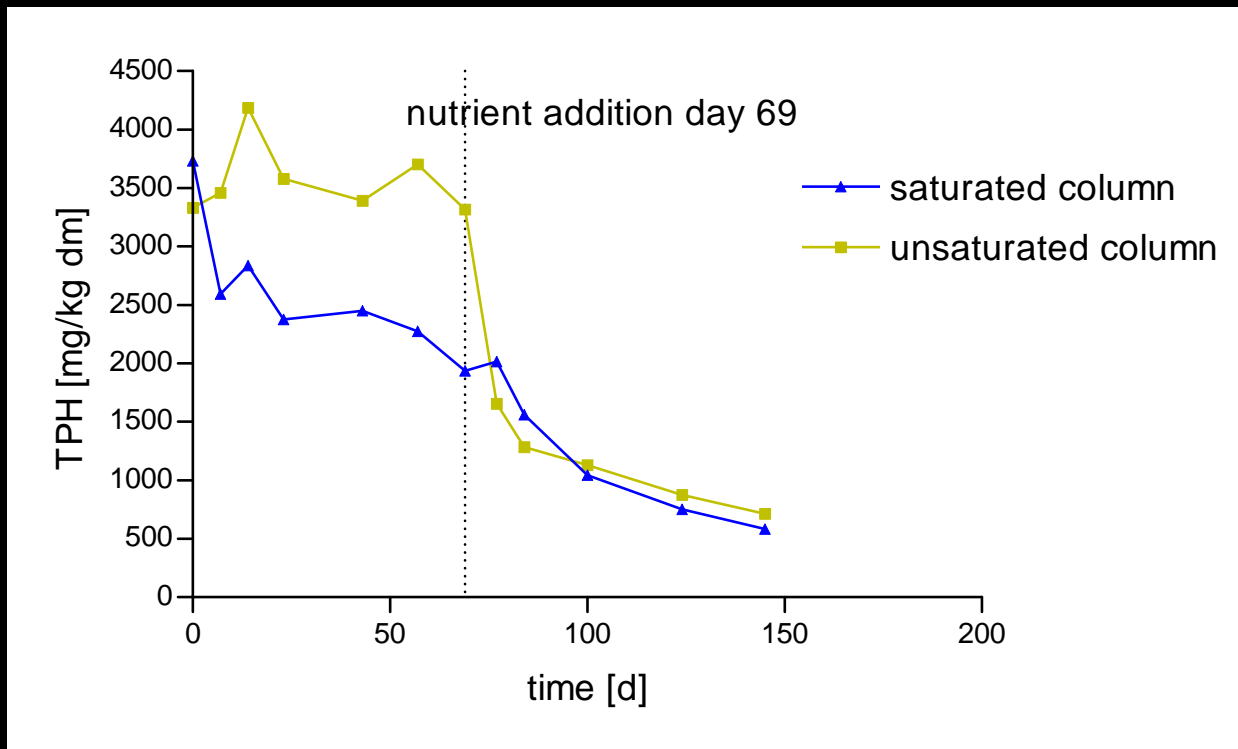
- Permeability
- Heterogeneity
- Vadose zone
- Saturated zone



Bioventing - Respiration Test



Degradation in Soil Columns



Conclusions

- HOC availability in soil is a potential constraint to biodegradation – investigate it!
 - Log K_{OW} of the contaminant is above 4 - 5
 - (Condensed) SOM is above 0.01 - 0.2 %
- Possibilities to enhance availability?
- Don't forget to check for degradation favouring conditions

Acknowledgements

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