NORWEST LABS

Can Analytical Methods Predict Bioavailability?

Chris Swyngedouw

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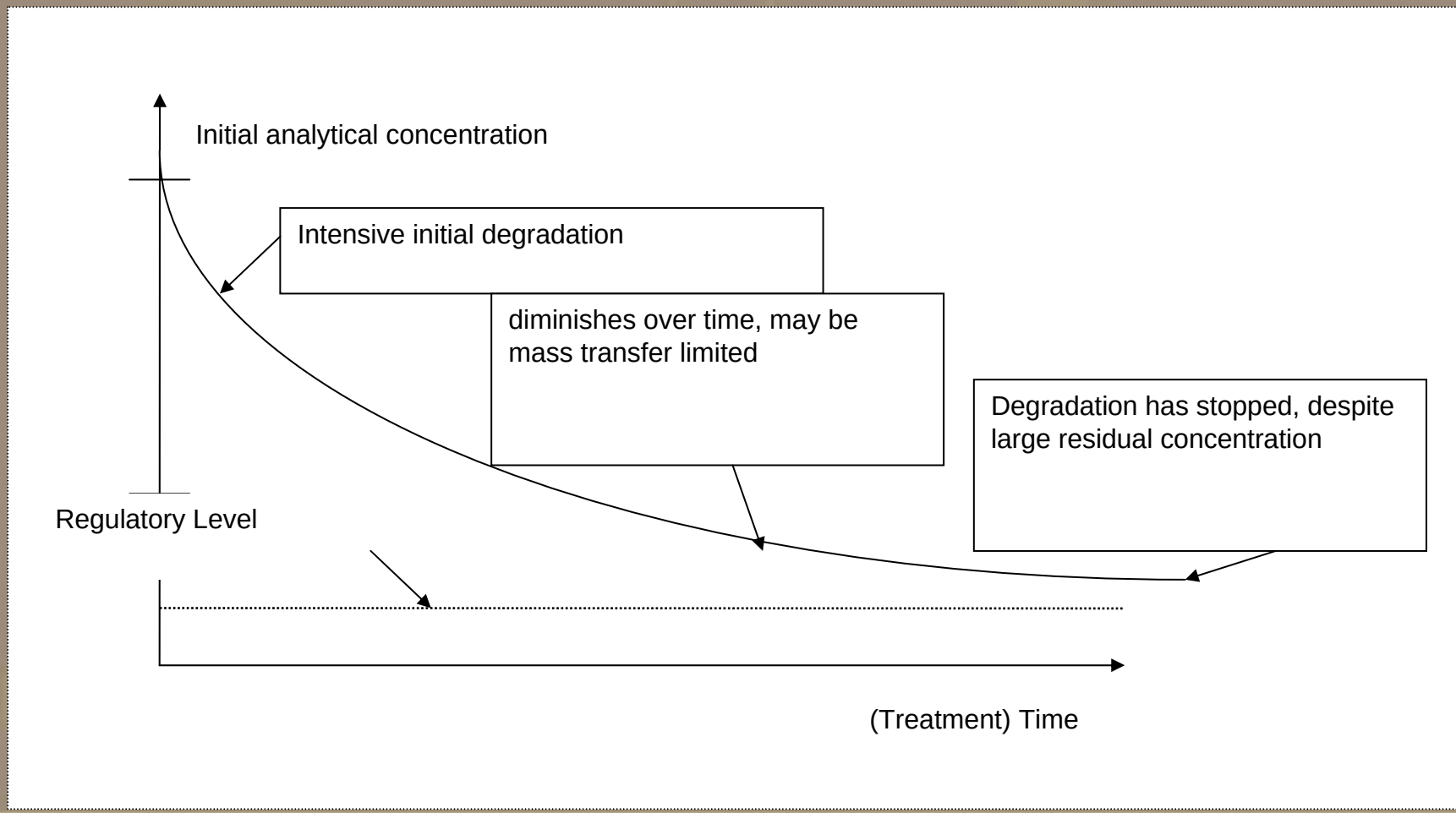
Outline

- Contaminant Bioavailability
- Current in vitro methods
- Mobility/bioaccessibility
- Results
- Conclusions

Bioavailability Issues

- Sorption to soil surfaces or organic matter.
- Complex residues, which are protected from microbiological (enzymatic) attack
- Reduced bioavailability
- Mass transfer limitations (e.g., pore diffusion)
- Slow leaching in sites that have been remediated.

Residual Concentration



Definitions

- **Bioavailability** represents the fraction of a chemical that is freely available to cross an organism's (cellular) membrane from the medium the organism inhabits.
- **Bioaccessibility** encompasses what is actually bioavailable plus what is 'potentially bioavailable' (Semple 2004)

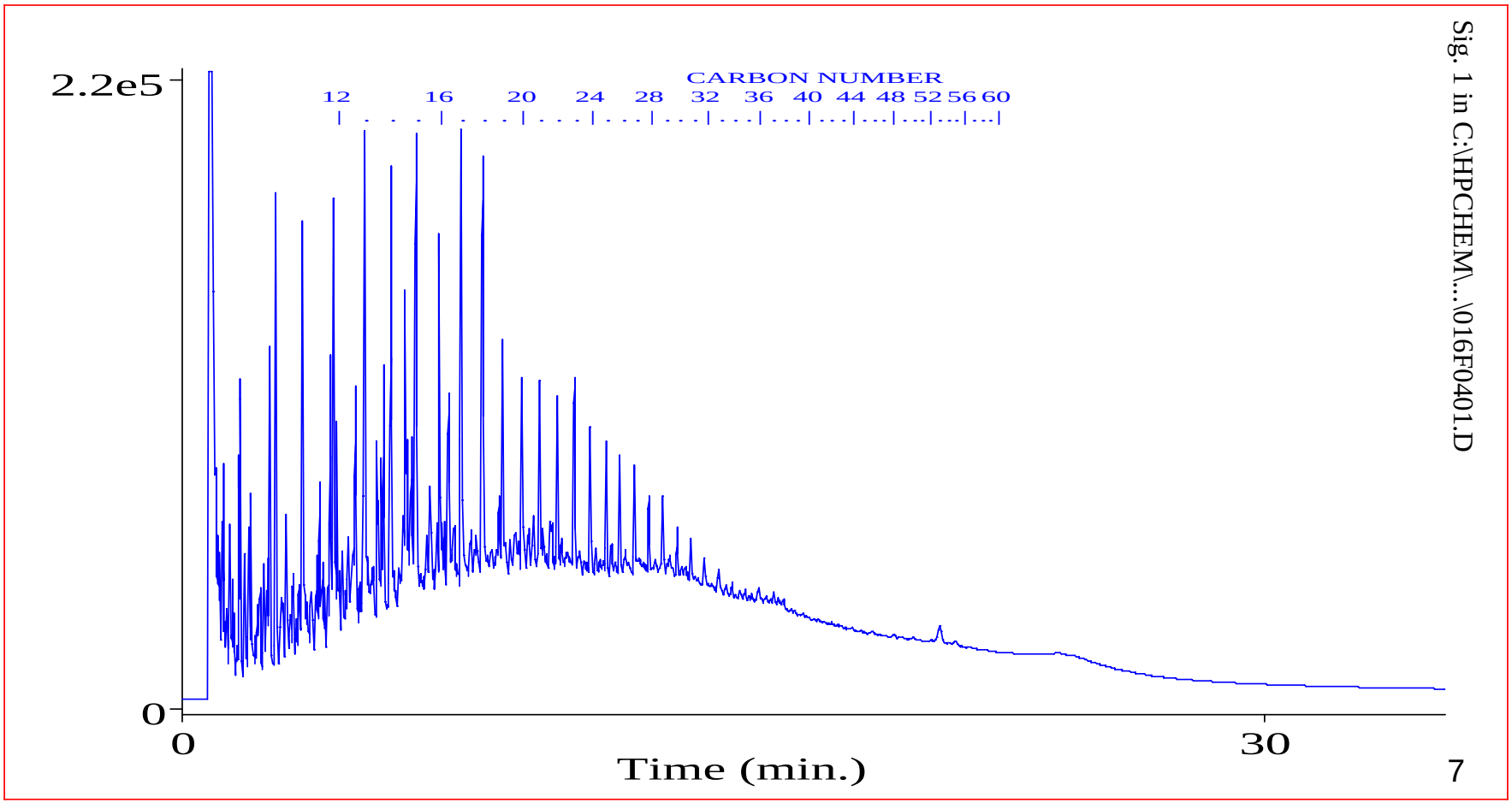




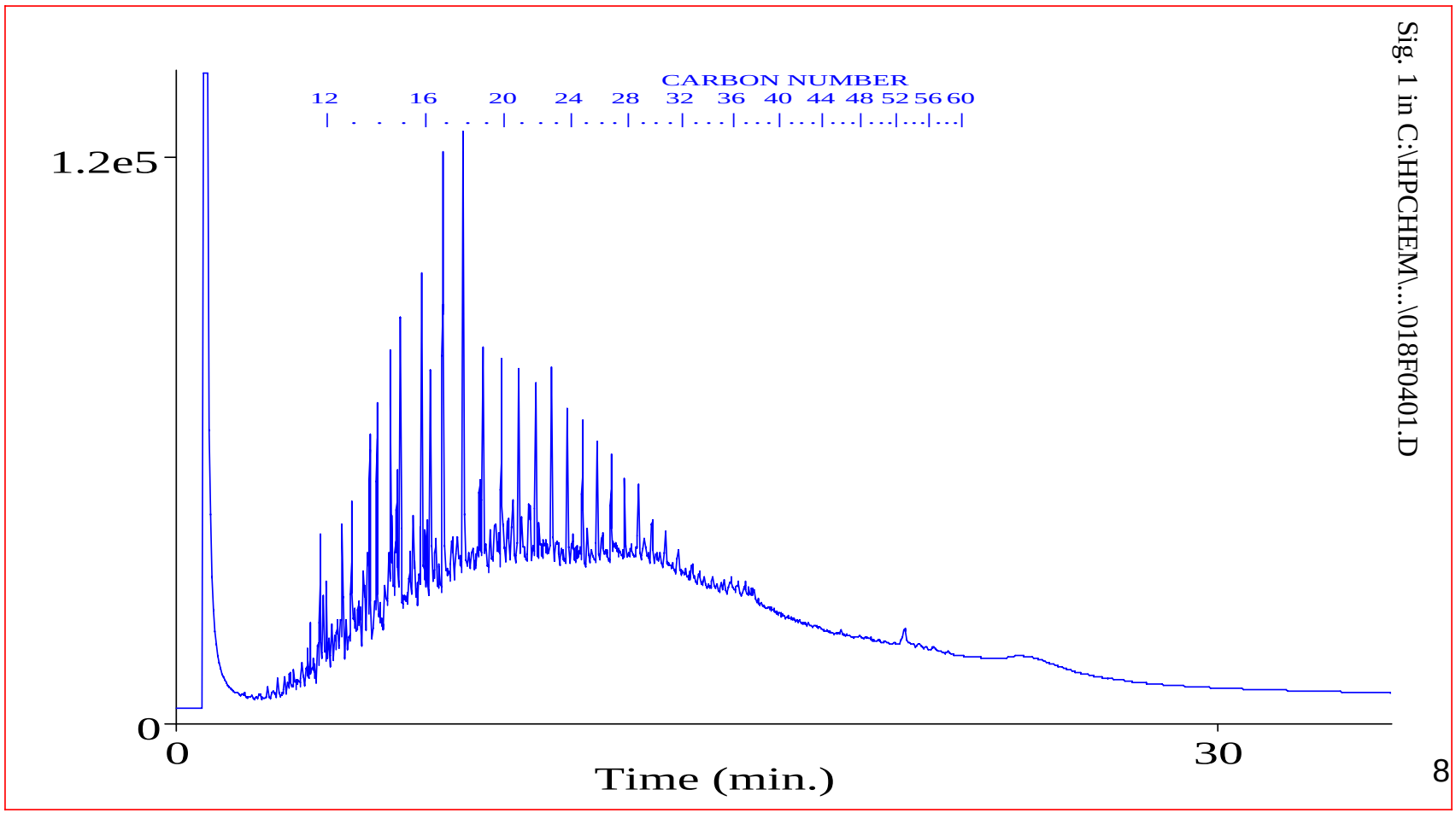
Variables

- Source of contamination
- Soil texture
- Moisture level
- Time
- Degree of contamination

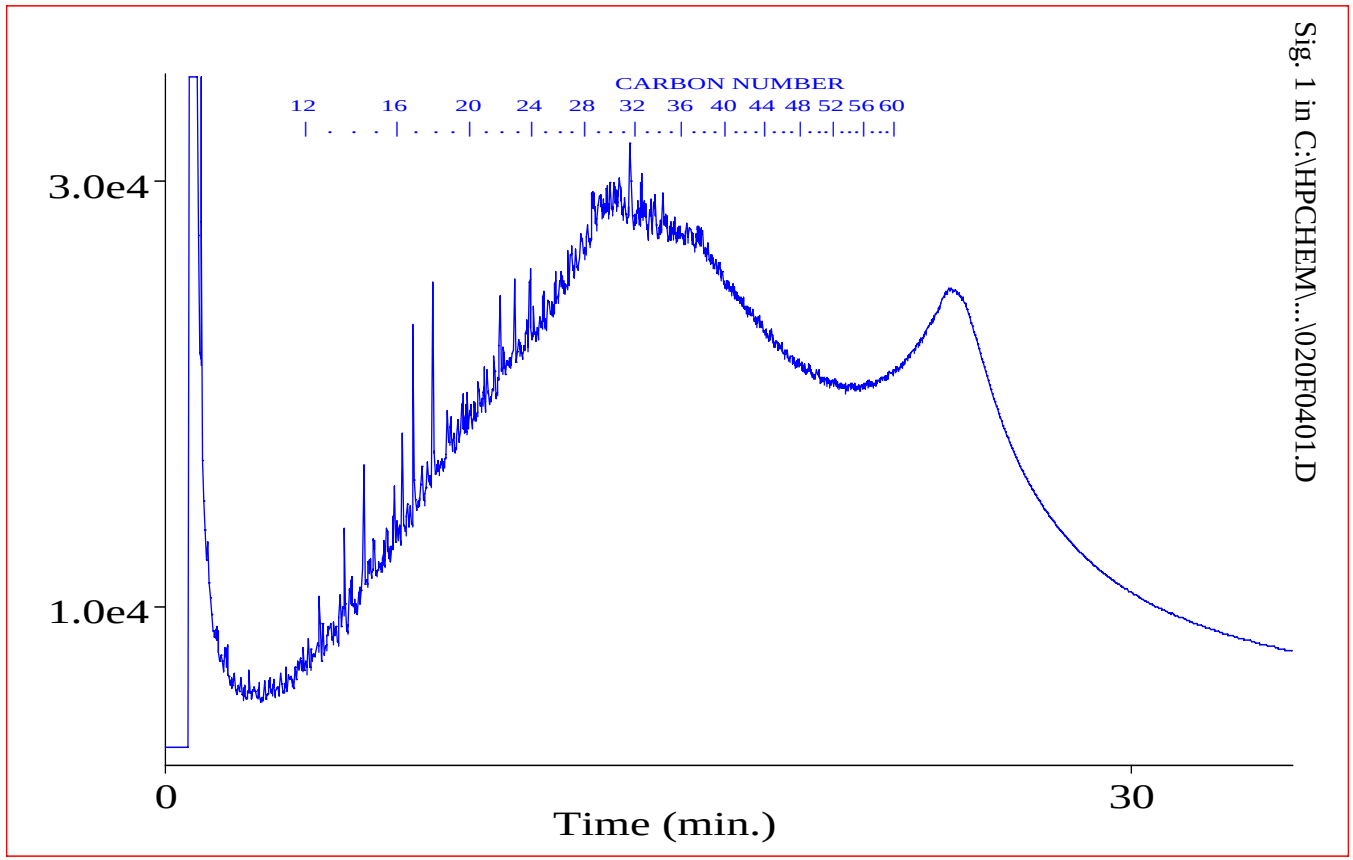
Example of Medium Crude - Unweathered



Example of Medium Crude - Weathered



Heavy Weathered Crude



Mild Extraction tests approaches

- solid with bound contaminant is extracted into a solvent phase: mild (methanol) extractions, subcritical water extractions, supercritical fluid extractions (CO2)
- solid or solid slurry is extracted into a solid phase sorbent: Tenax, XAD, C-18 or SPME, or cyclodextrin (Puglisi 2003)
- solid slurry is extracted through a membrane into a solvent phase (PBET, Ruby 1996)
- solid or solid slurry is extracted through a membrane into a solid phase sorbent (resin capsules)

Extraction tests --issues

- Overestimate the bioavailability of contaminants.
- Milder extraction tests may correlate more
- Extractions are never specific
- Comparison of extraction tests to those from an in vivo model (e.g. piglets) are very costly
- Could be used in Tier 2 assessment





Leachate tests

- Simple regulatory leaching test, such as the TCLP, EPA method 1311, or the SPLP, method 1312 have been used to determine the bioaccessibility of metals from soil.
- They were designed to simulate leaching in a landfill environment or leaching in rainwater.
- They are only useful for evaluating the mobility of the contaminants in soils.
- Their use as a first level, commercially available test to evaluate the mobility in soils may be appropriate for particular situations.

LBTEX Precision

Effect of moisture

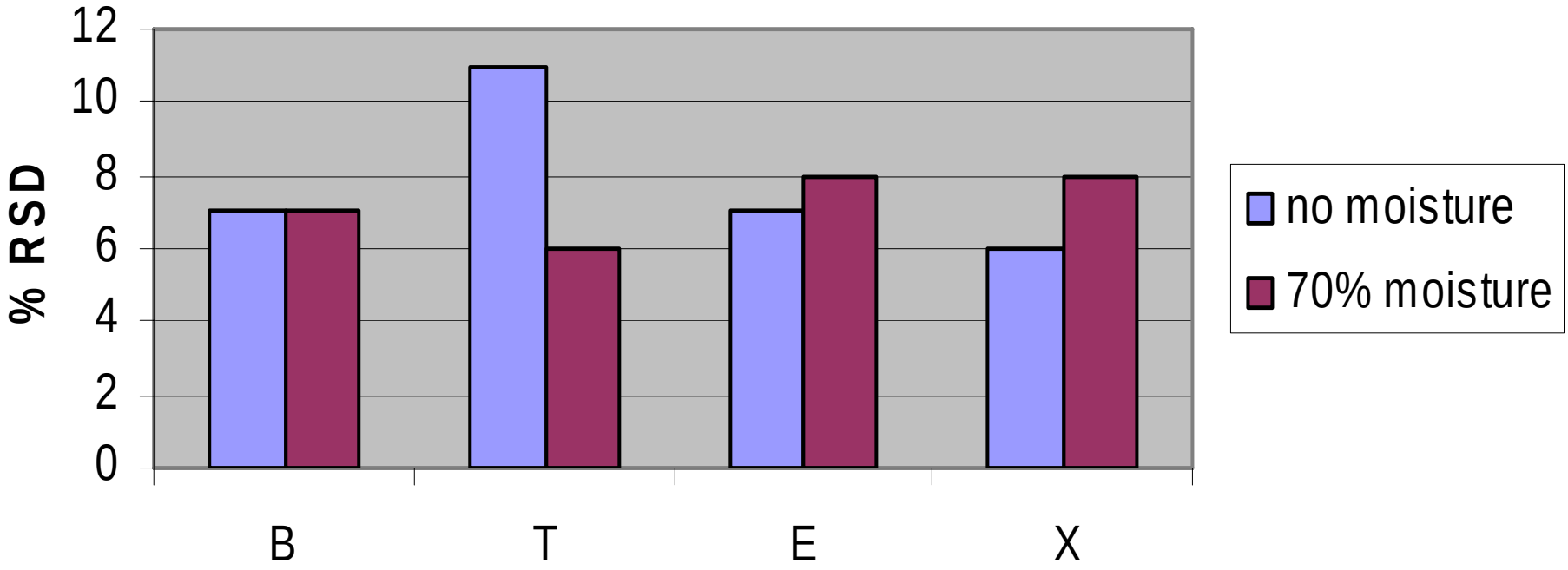






Table 1. leachate extraction efficiency of fresh spikes in sand (%)

Benzene	Toluene	Ethyl benzene	Xylenes	Average
89	92	84	82	87





Table 2. Leachate extraction efficiency of fresh spikes in loam (%)

(average from duplicates at each concentration)

Concentration	Benzene	Toluene	Ethyl benzene	Xylenes	Average
Low (1 mg/L)	58	54	40	33	46
Med (20 mg/L)	56	52	44	42	48
High (200 mg/L)	55	55	51	48	52
Average	56	54	45	41	49

Lab spikes -- Loam

(Average from duplicates at each conc. Level)

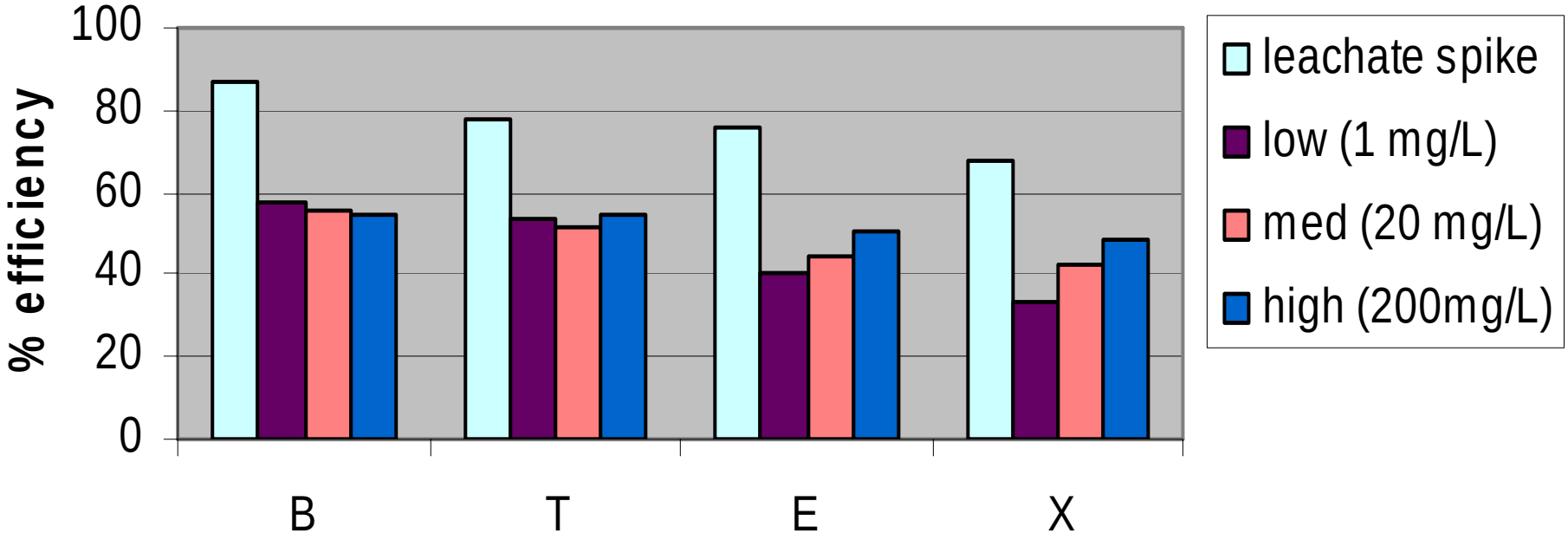






Table 3. Leachate extraction of an oil (n=1)

	Total concentration mg/kg	Leachate concentration mg/L	% efficient
Benzene	0	<0.01	-
Toluene	516	1.01	4%
Ethylbenzene	99	0.009	2%
Xylenes	566	0.50	2%

Oily waste

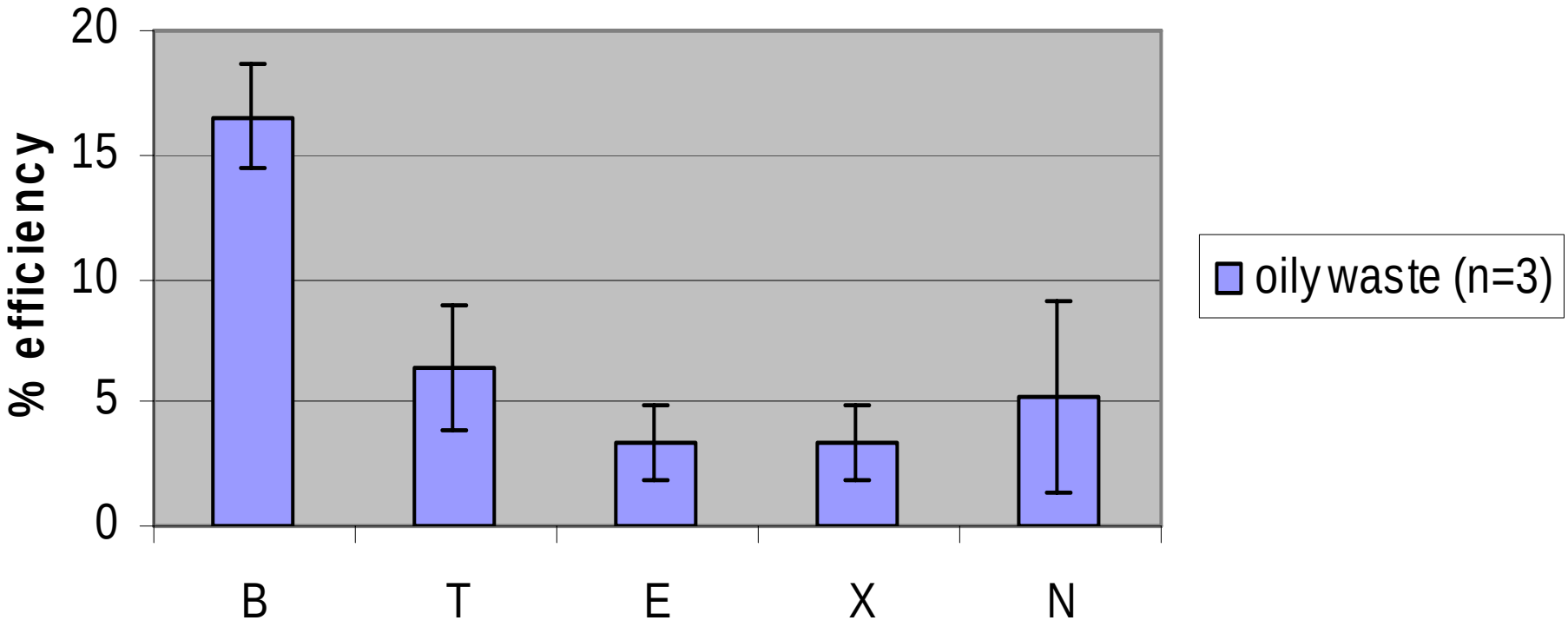






Table 4. Leachate extraction efficiency as a function of texture (%)

(n=4 for each soil type)

texture	Benzene	Toluene	Ethylbenzene	Xylenes
Coarse (sand)	37	42	38	35
Fine (clay)	35	18	20	22

Soil type

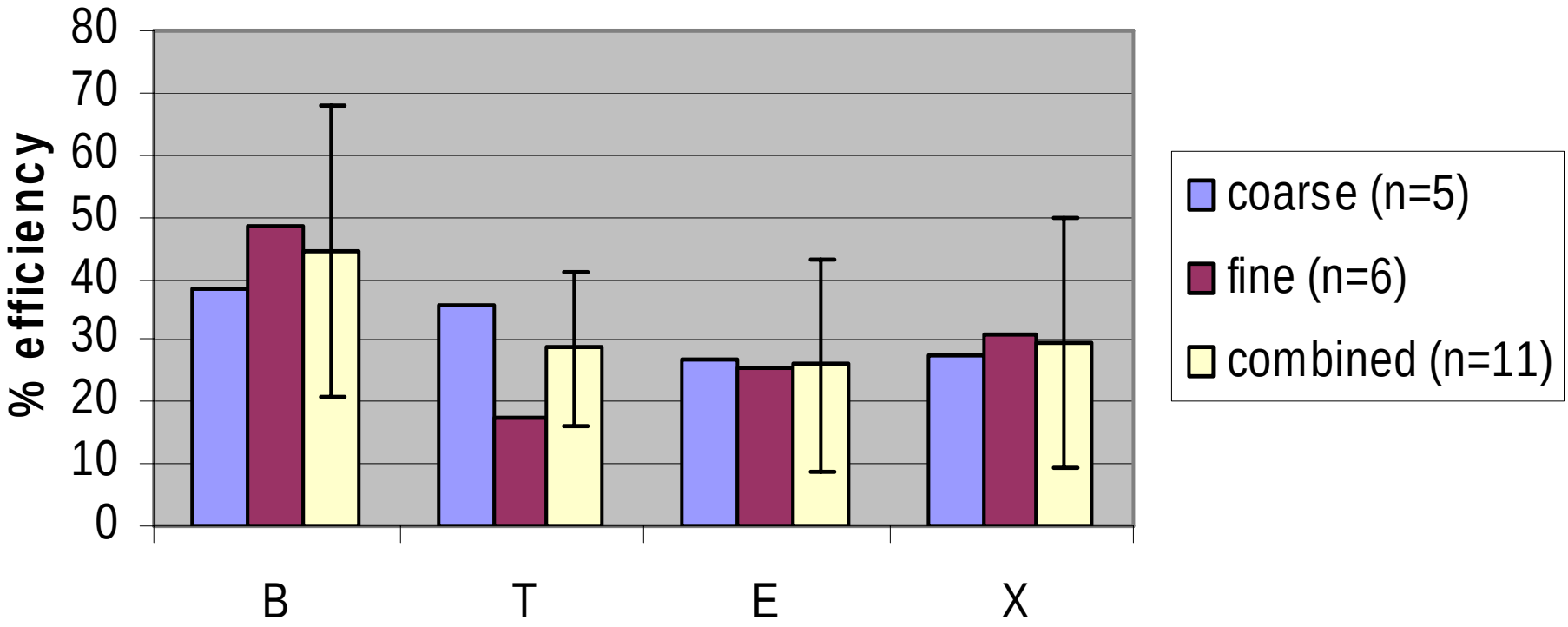

% efficiency
80
70
60
50
40
30
20
10
0
B
T
E
X
coarse (n=5)
fine (n=6)
combined (n=11)





Table 5. Leachate extraction efficiency as a function of depth (%) (n=6 for each depth).

depth	Benzene	Toluene	Ethylbenzene	Xylenes
<1.5 m	46	44	28	23
>1.5 m	87	60	52	42

Depth

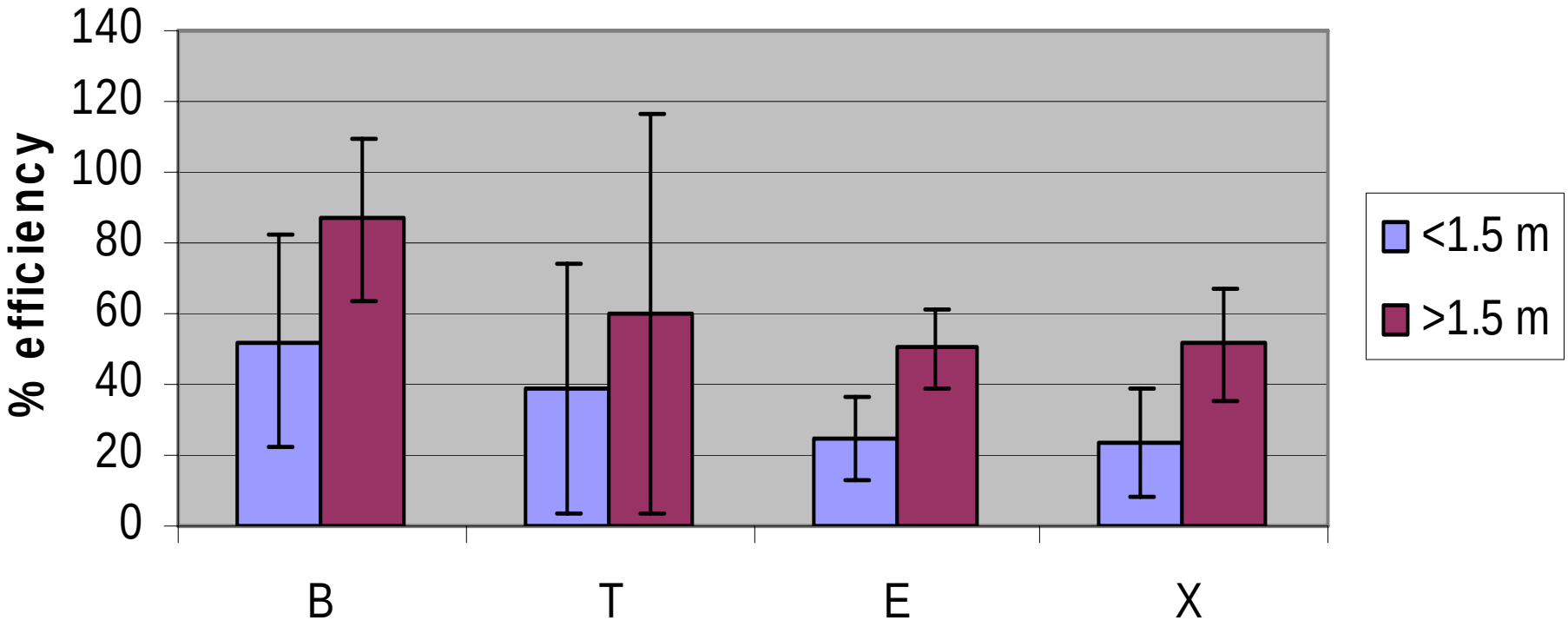






Table 6. Leachate extraction efficiency in windrows (%)

(n=4)

Benzene	Toluene	Ethylbenzene	Xylenes	Naphthalene	Overall
16	7	8	9	6	~10%

Windrows

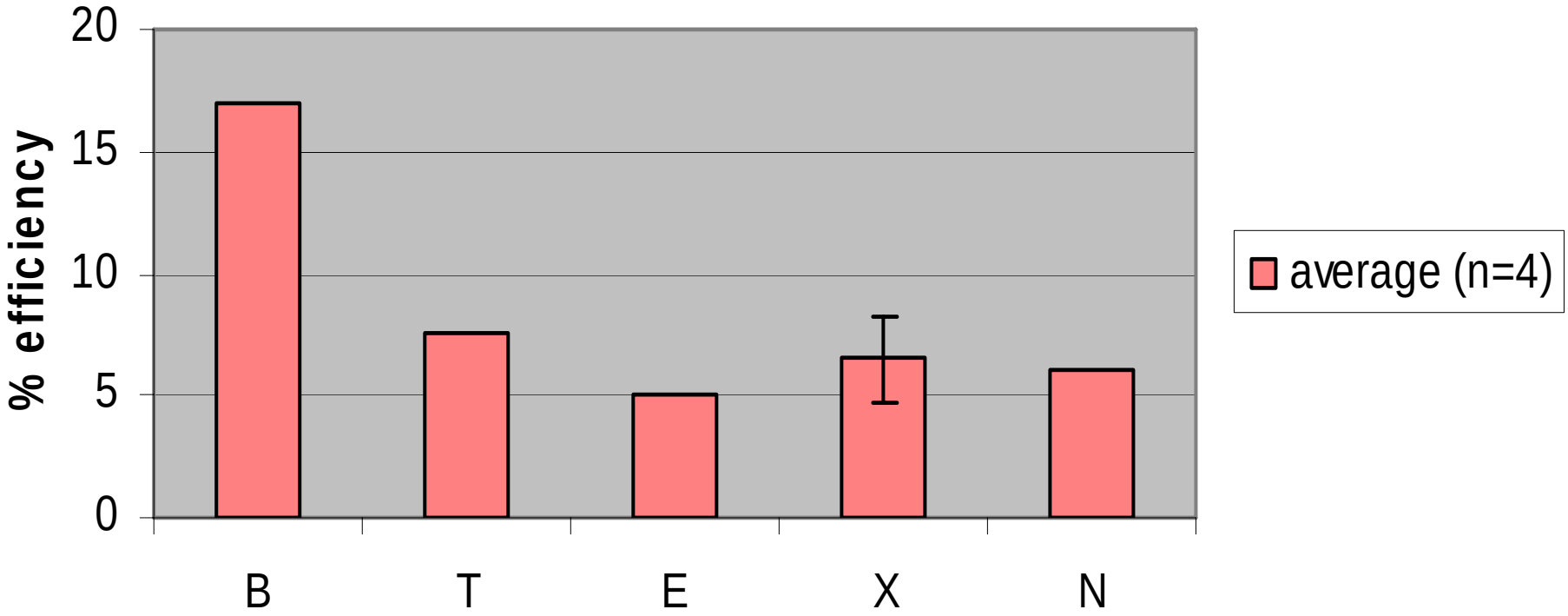


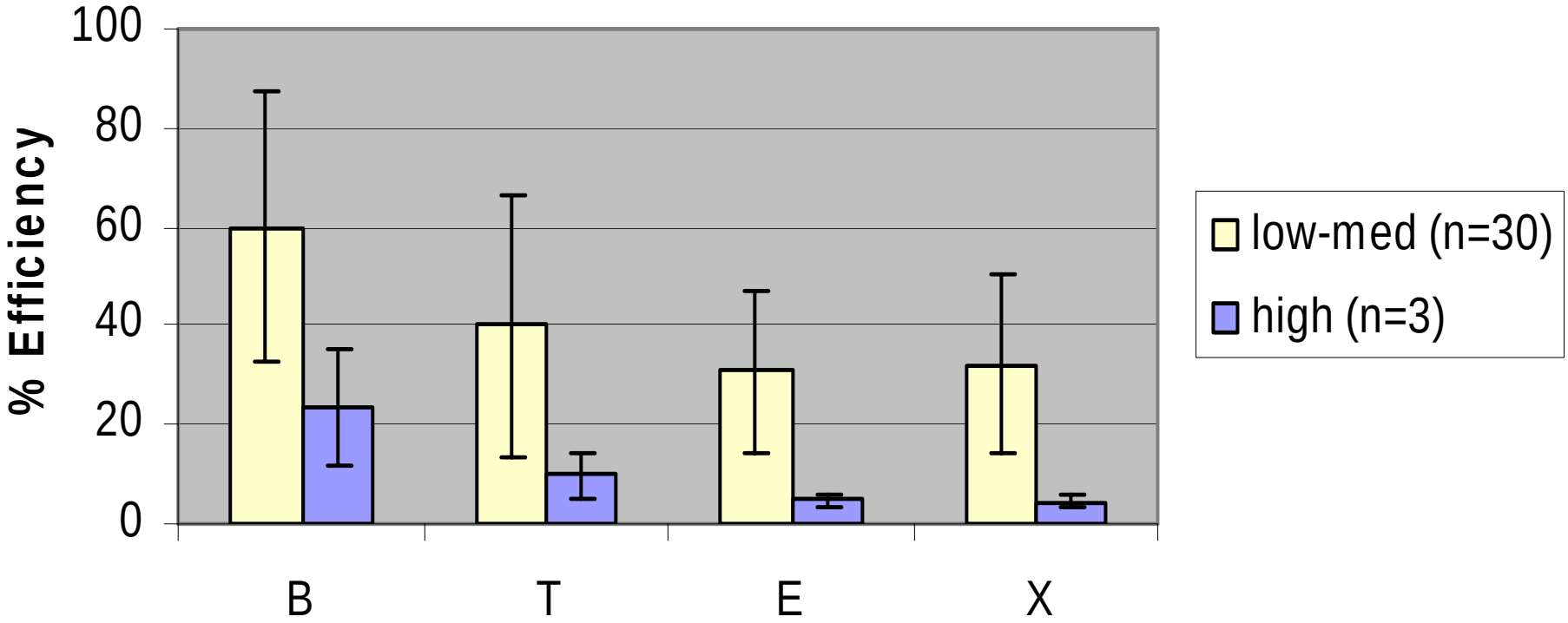




Table 7. Leachate extraction efficiency as a function of concentration level (%) (n=6 for each level)

Concentration	Benzene	Toluene	Ethylbenzene	Xylenes
Low	37	36	44	32
Med	62	52	34	38
High	22	21	14	14

Concentration Level



Conclusions

- The leachate extraction efficiency results indicate that at a first level, a commercially available test such as the leachate test can be used appropriately to evaluate, not only the mobility, but also the bioaccessibility of contaminants in soils.

Examples of research studies

- Bioavailability studies that have the aim of developing standardized in vitro bioavailability methods
- Investigating the effects of mixtures of substances and determining whether these substances show additive, synergistic or antagonistic properties
- Re-evaluating the toxicity of PCBs, petroleum hydrocarbons (PHCs), PAHs, etc. with the aim of revising the toxicological reference value (TRV) for these substances

References

- Stantec Consulting Ltd. (2004). Framework Foundation and Guidance for Tier 2 Site-specific development of Soil Contact Standards for PHC-contaminated Sites: Literature review. ERAC Soil and Groundwater Project 2002.
- ERAC (2004). Environmentally Acceptable Endpoints for Weathered and Aged Petroleum Hydrocarbons Fraction F3 in Soil. Report on 2004 Research Projects. Environmental Research Advisory Council





Can analytical methods predict bioavailability?