EFFECT OF SURFACTANTS AND ELECTROKINETICS ON THE BIOREMEDIATION OF SOILS POLLUTED BY POLYCYCLIC AROMATIC HYDROCARBONS

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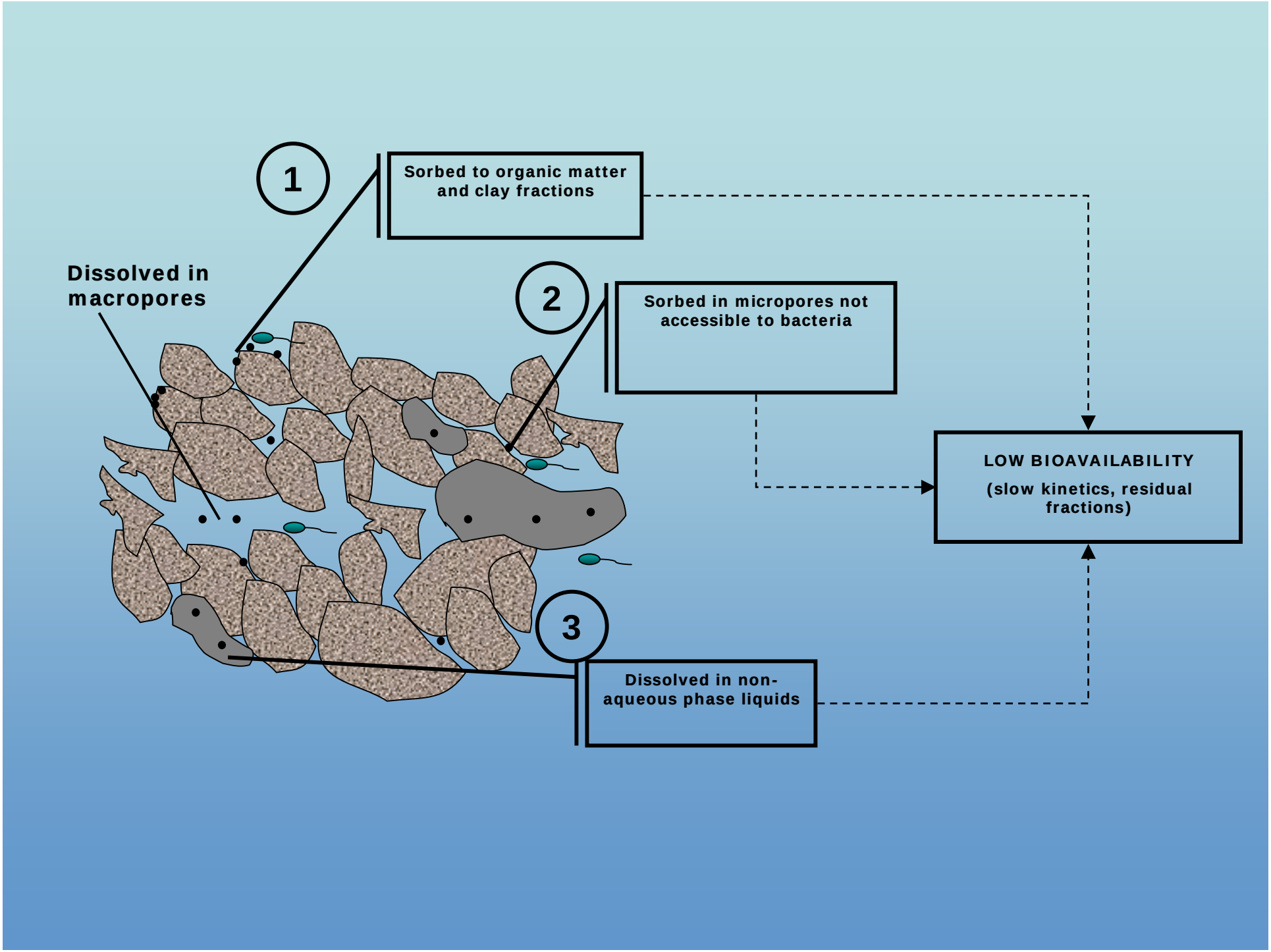
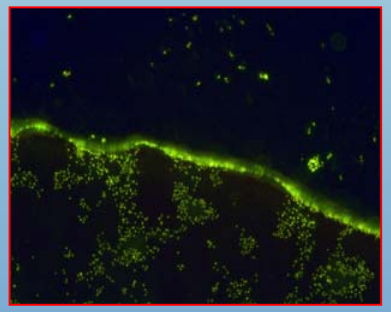
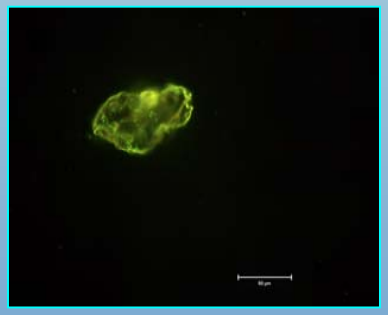

1
Sorbed to organic matter and clay fractions
Dissolved in macropores
2
Sorbed in micropores not accessible to bacteria
LOW BIOAVAILABILITY
(slow kinetics, residual fractions)
3
Dissolved in non-aqueous phase liquids

MODES OF POLLUTANT ACQUISITION BY MICROORGANISMS

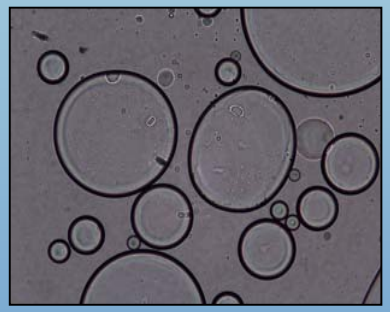
ADHESION



UTILIZATION OF MULTIPLE SUBSTRATES



BIOSURFACTANT PRODUCTION



PASSIVE TRANSPORT AND CHEMOTAXIS

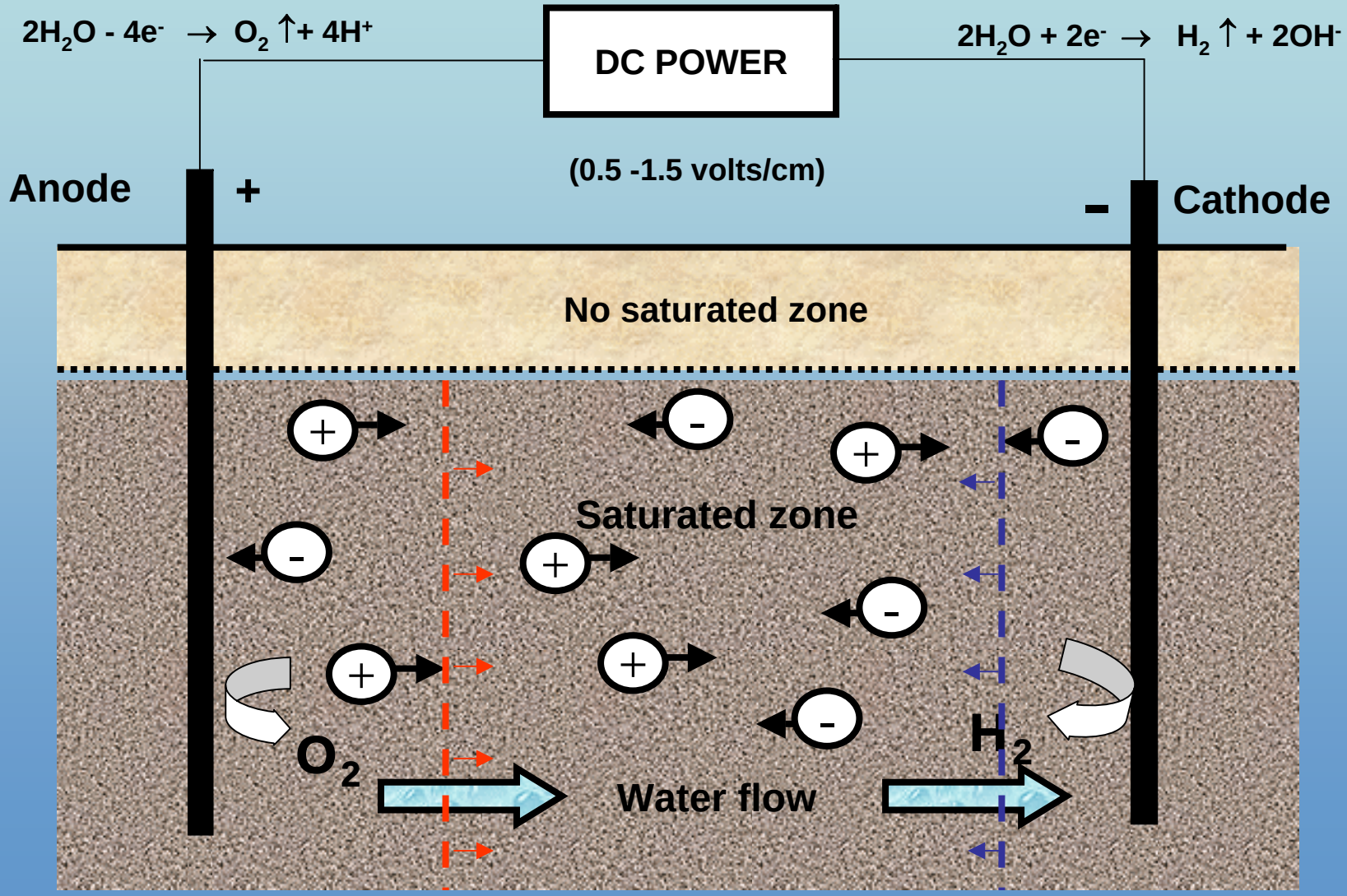
Bioremediation of creosote-polluted soil: low cost & reasonable time

Low bioavailability/bioaccesibility: limiting success

Clay soils:
+ Sorption
- Bacterial transport
- Oxygen & nutrients
+Physical problems (handling, excavation, clogging)

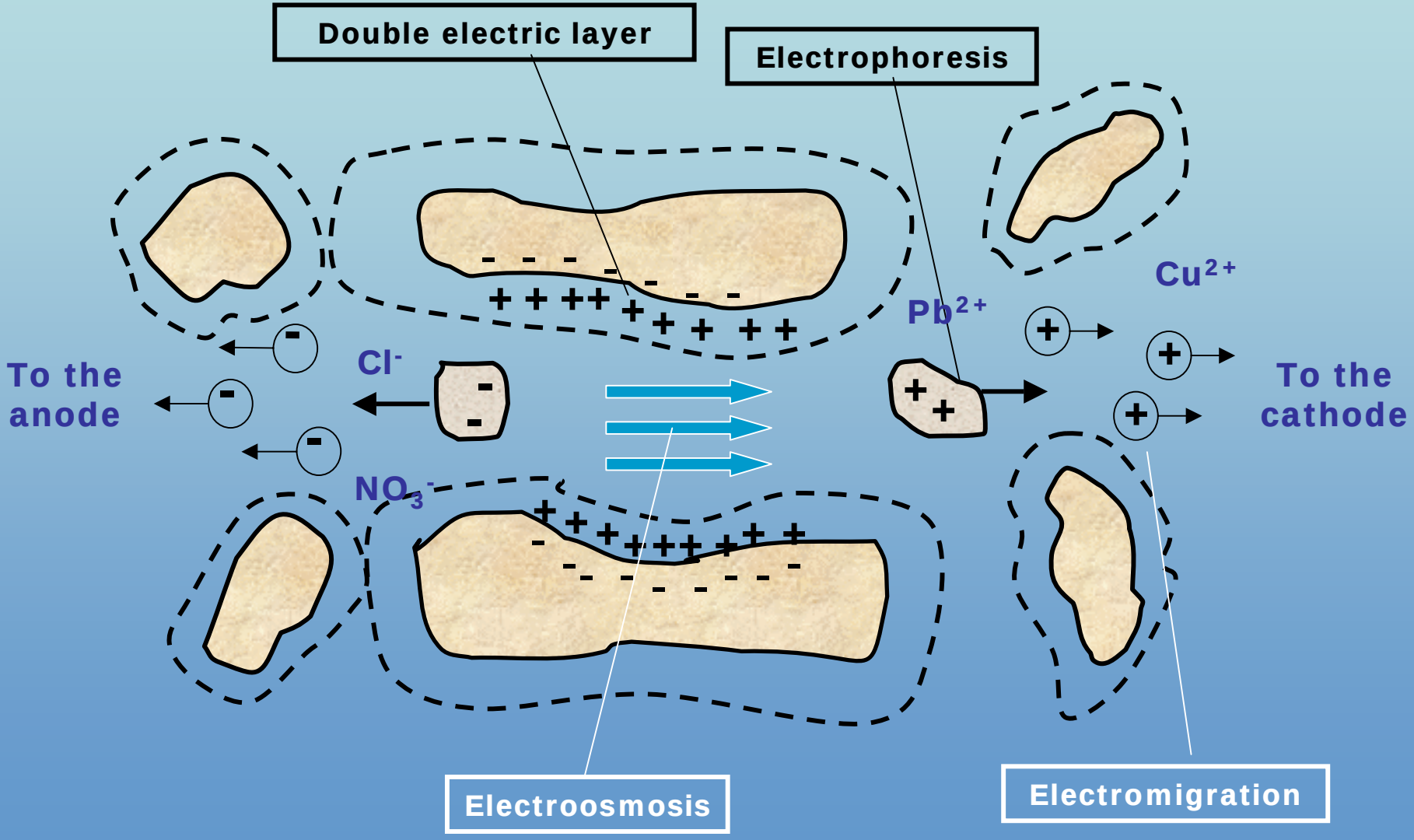
Electrokinetic bioremediation - an alternative?

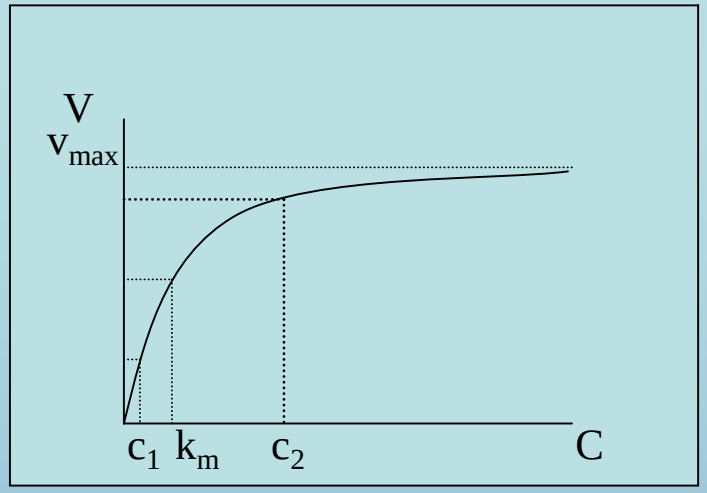
INTRODUCTION
(ELECTROREMEDIATION TREATMENT)

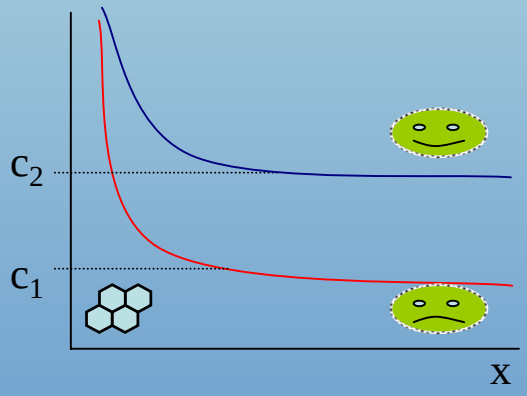


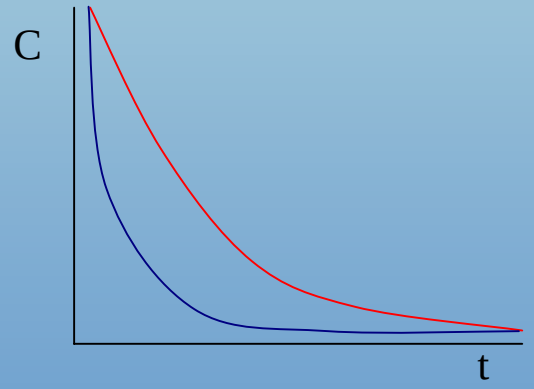
INTRODUCTION

(INDUCED ELECTROKINETIC PHENOMENA)




V
v_{max}
c_1
k_m
c_2
C


c_2
c_1
x


C
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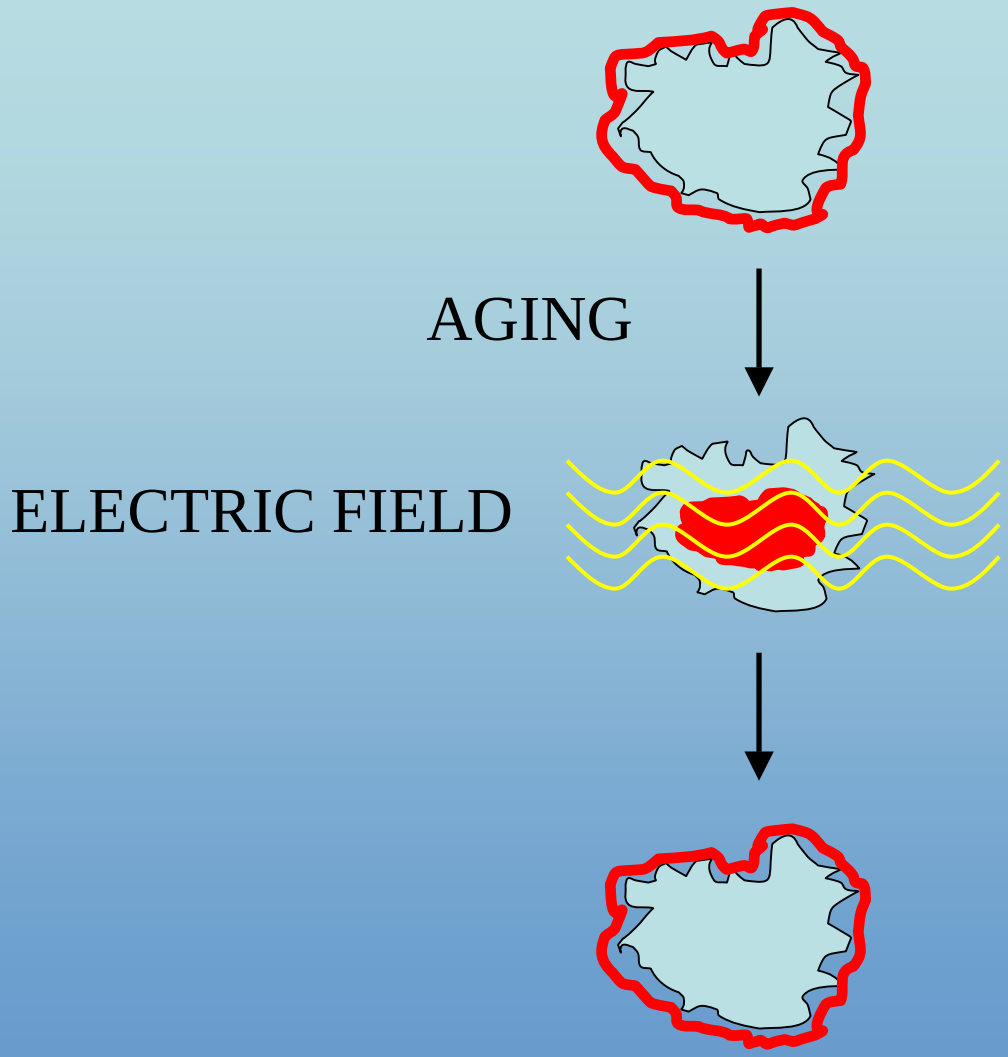

AGING
ELECTRIC FIELD

OBJECTIVES

- To determine bioavailability of native PAH
- To determine possible effects of electric field and surfactant on:
  - PAH biodegradation
  - Changes in desorption kinetics

MATERIALS AND METHODS

SOIL (B & E)

Location: Wood treatment facility. Andujar (Jaén, Spain)

Soil type: Calcaric Fluvisol

Pollutant: creosote

PAH concentration (Sample B): 4501 mg PAH/kg dry soil

Particle size distribution (%)	
Coarse-grain sand	73.3
Fine-grain sand	8.0
Silt	14.7
Clay	3.7

SOIL (Agricultural)

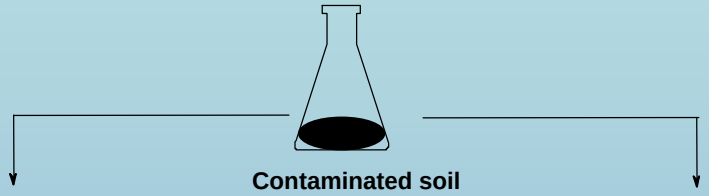
Location: Coria del Rio (Sevilla, Spain)

Soil type: Typic Xerochrepts

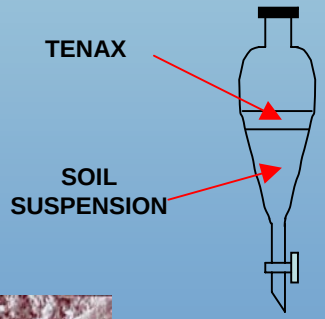
Pollutant: non contaminated soil

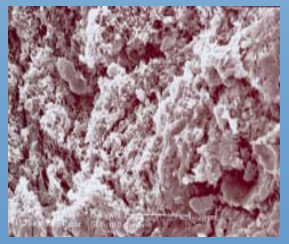
Moisture(%)	4.9
pH	7.92
Calcium carbonate (%)	23.4
Organic matter (%)	3.26
Organic matter (%)	3.26
Organic Nitrogen (Kjeldhal) (%)	0.106
Available phosphorous (mg/kg)	0.9

Bioavailability of PAH sorbed to soils



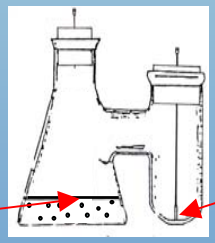
DESORPTION





- TENAX EXTRACTION
- HPLC ANALYSIS

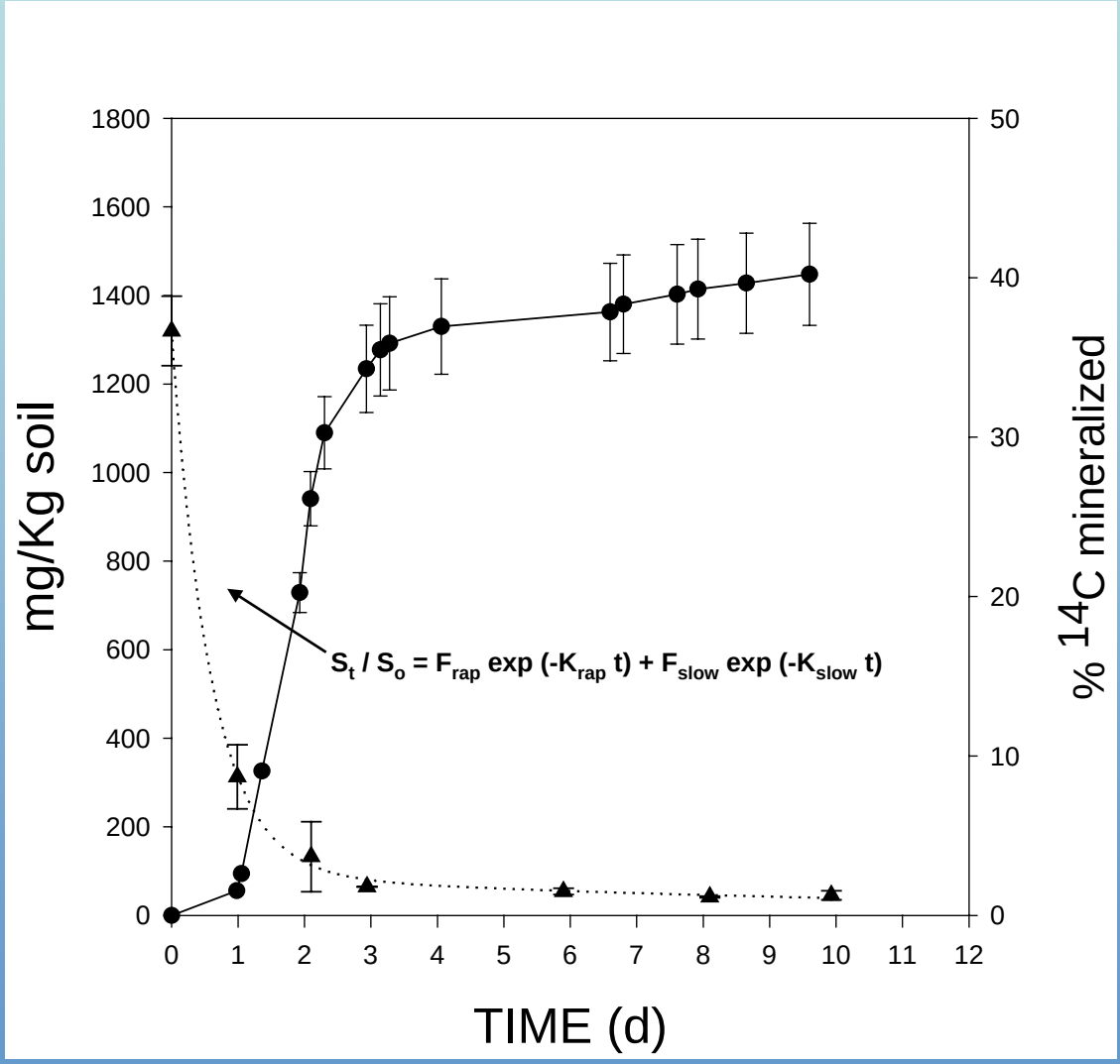
BIODEGRADATION



- MC EXTRACTION
- HPLC ANALYSIS
- $^{14}CO_2$ MEASUREMENTS

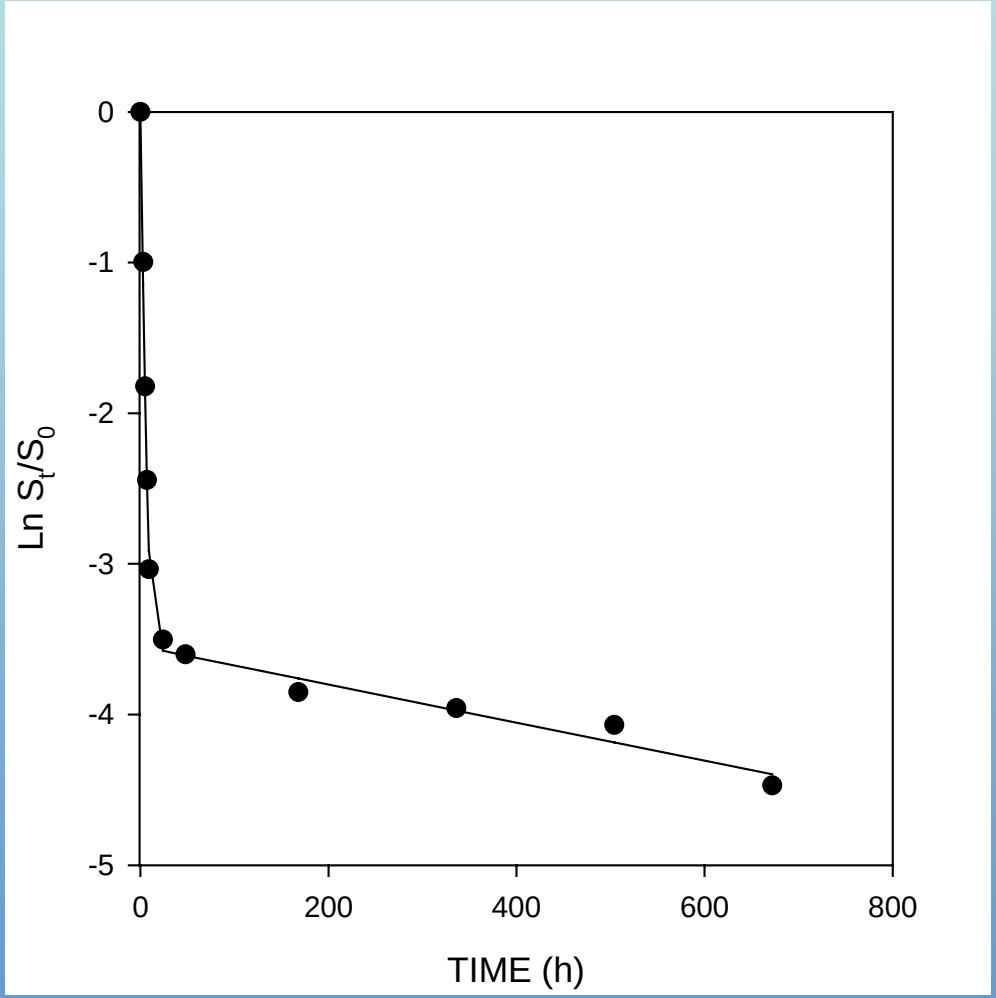
PHENANTHRENE BIODEGRADATION: SLURRY-PHASE

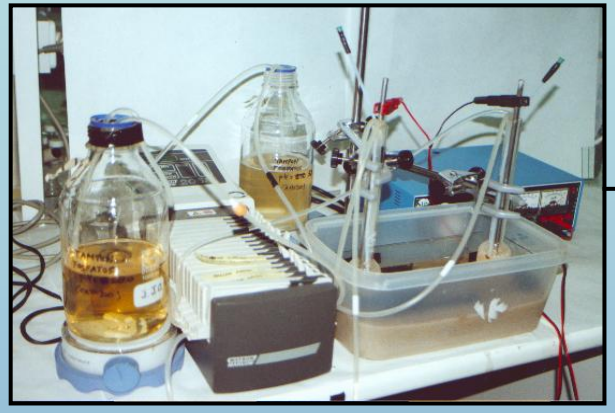
K_{rap} **0.046 h^{-1}**
K_{slow} **1.35 10^{-3} h^{-1}**
F_{rap} **95.4 %**

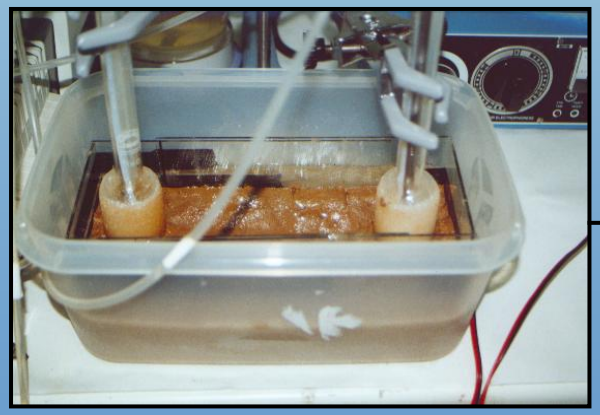


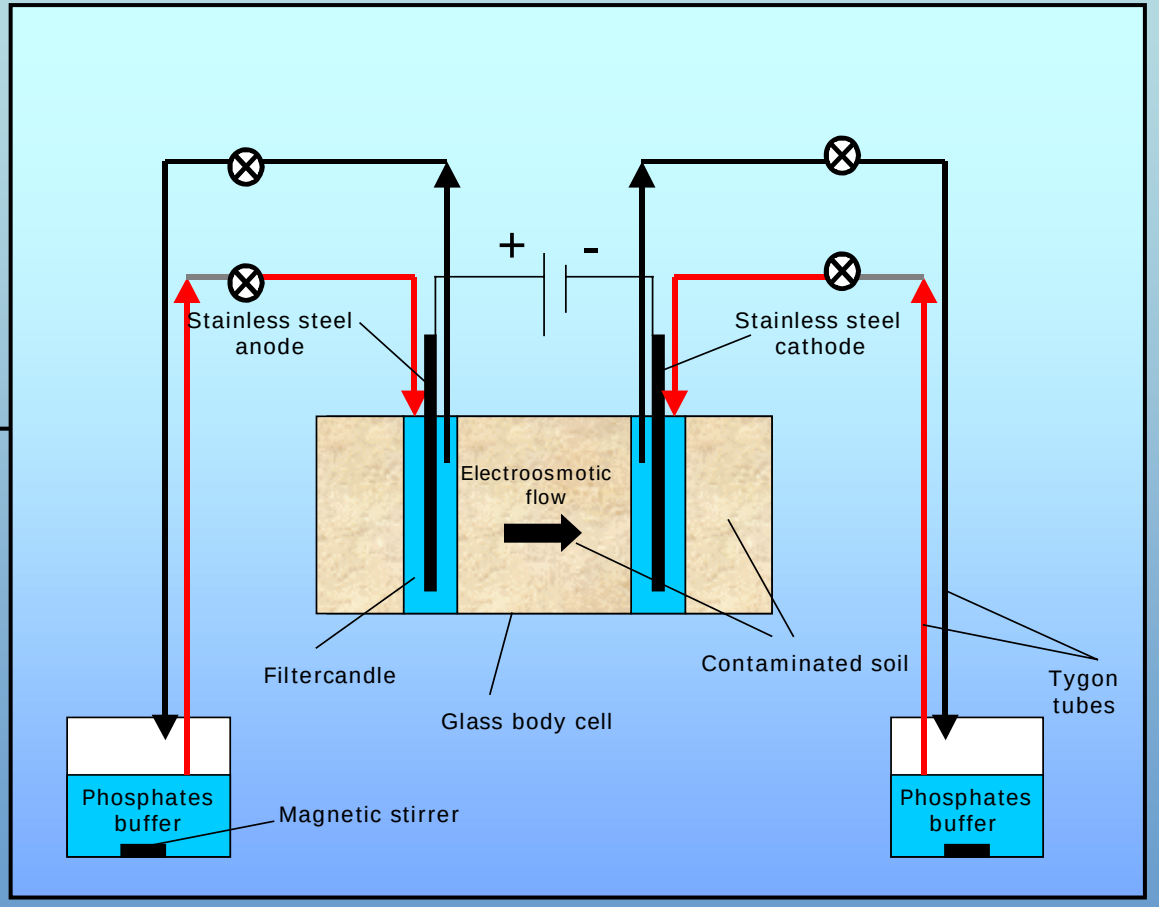
PHENANTHRENE DESORPTION: TENAX EXTRACTION

K_{rap}	**0.37 h^{-1}**
K_{slow}	**2.23 10^{-3} h^{-1}**
F_{rap}	**95.6 %**








+
-
Stainless steel anode
Stainless steel cathode
Electroosmotic flow
Filtercandle
Glass body cell
Contaminated soil
Tygon tubes
Phosphates buffer
Magnetic stirrer
Phosphates buffer

ELECTROKINETIC BIOREMEDIATION EXPERIMENTS

EXPERIMENTAL CONDITIONS

Soils: Andujar B & E (clay-rich soils)
Agricultural soil (loamy soil)

Treated soil mass: 200 – 700 g (as appropiate)

Strains: *Novosphingobium* sp. LH 128 (Phe degrader)
Mycobacterium gilvum VM552 (Phe, Ftne, Pyr degrader)

CFU: 10^7-10^8 /ml inoculum (10^6-10^7 cells/g)

Surfactant: BRIJ 35 (non-ionic; 35000 μg/g dry soil)

Potential drop: 0.7 – 1.1 volts/cm (as appropiate)

Treatment: 1-2 weeks (as appropiate)

Buffers: Phosphates buffer (pH 5.80 and 8.00; 1.0 and 0.1 M; 12 ml/min)
Tris-acetate buffer (pH 7.00; 0.05M; 12ml/min)

- ELECTROKINETIC BIOREMEDIATION EXPERIMENTS -

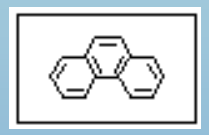
EXPERIMENTAL CONDITIONS

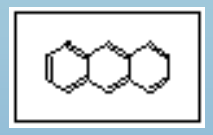
Cell A: inoculated soil + electric field

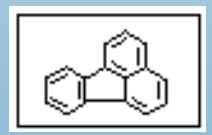
Cell B: inoculated soil – electric field

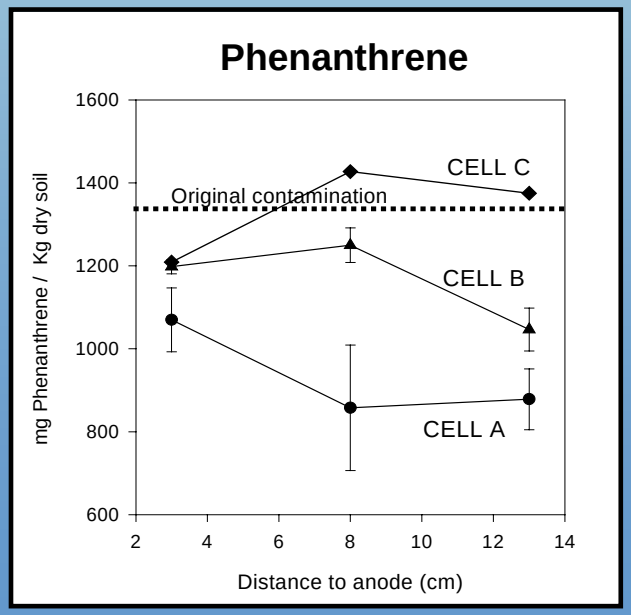
Cell C: sterilized soil + electric field

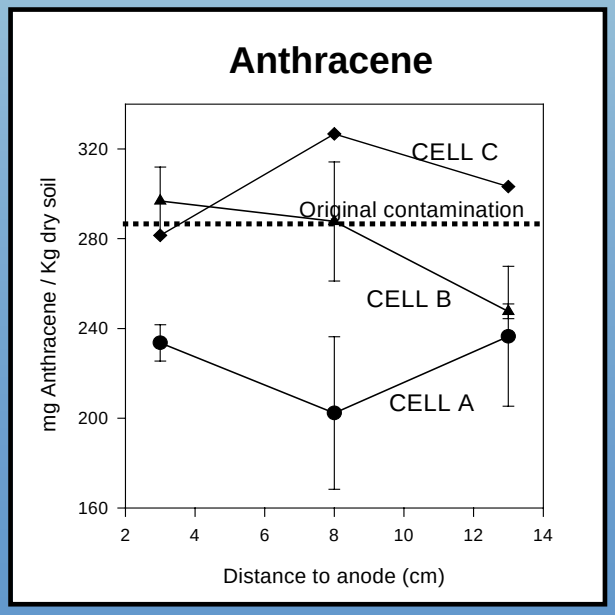
Strain: *Novosphigobium sp* LH128WT (Phenanthrene-degrading strain)

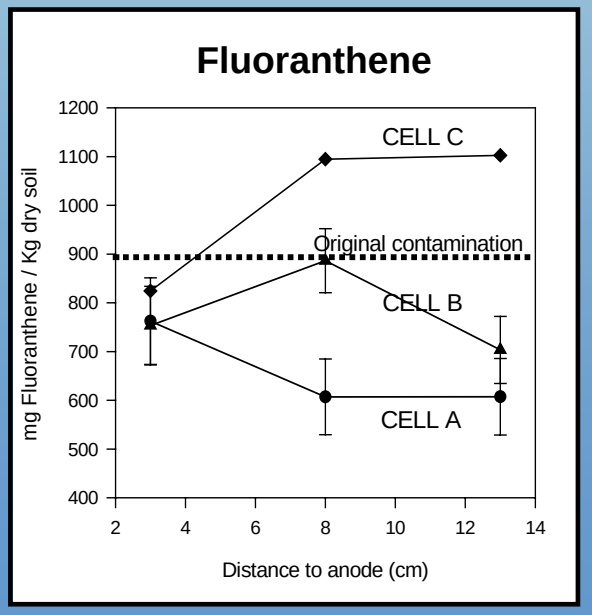








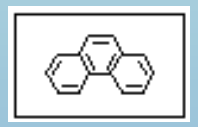


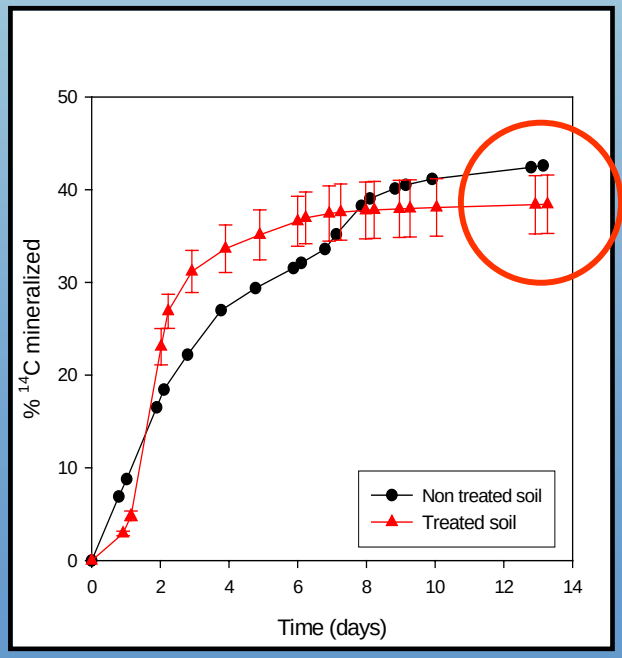


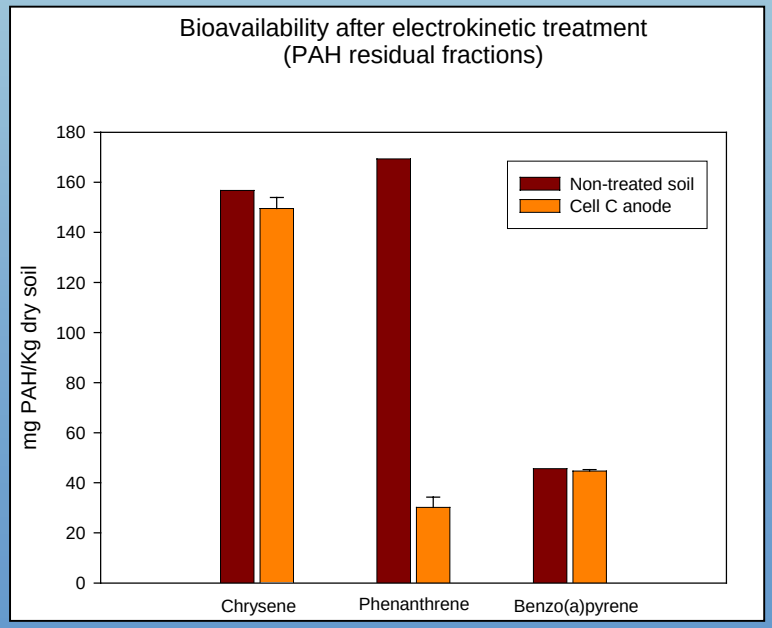
BIOAVAILABILITY AFTER ELECTROKINETIC TREATMENT

EXPERIMENTAL CONDITIONS

- Previously electroremediated soil (*Mycobacterium sp* VM552)
- Slurries: 15 g soil / 100 ml inorganic salts solution
- Re-inoculated with *Mycobacterium sp*. VM552 strain
- Room temperature
- Rotary shaker at 150 rpm

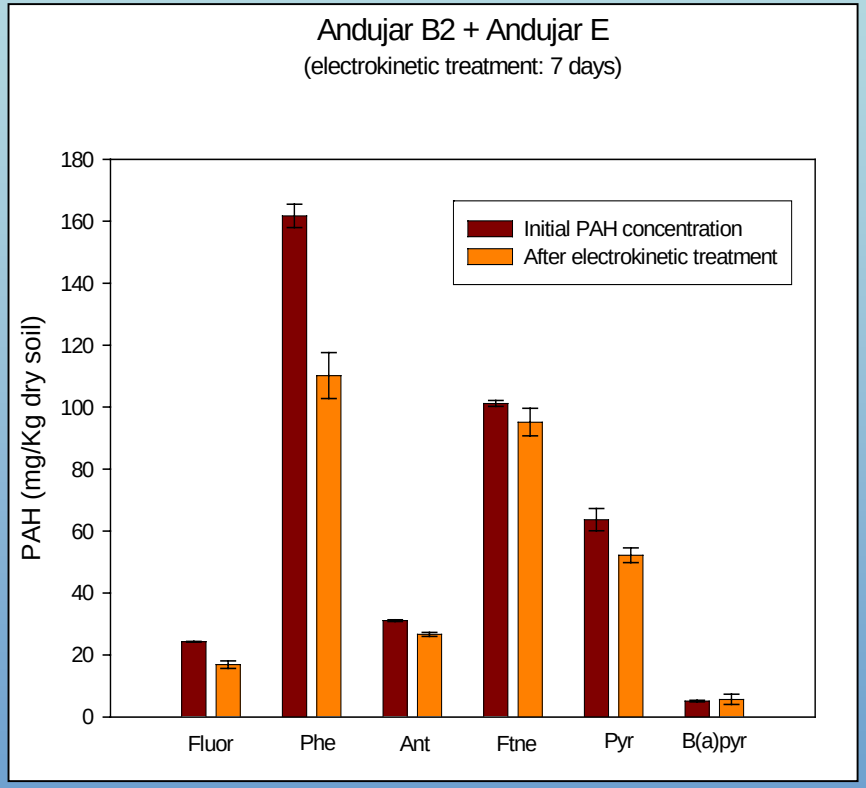


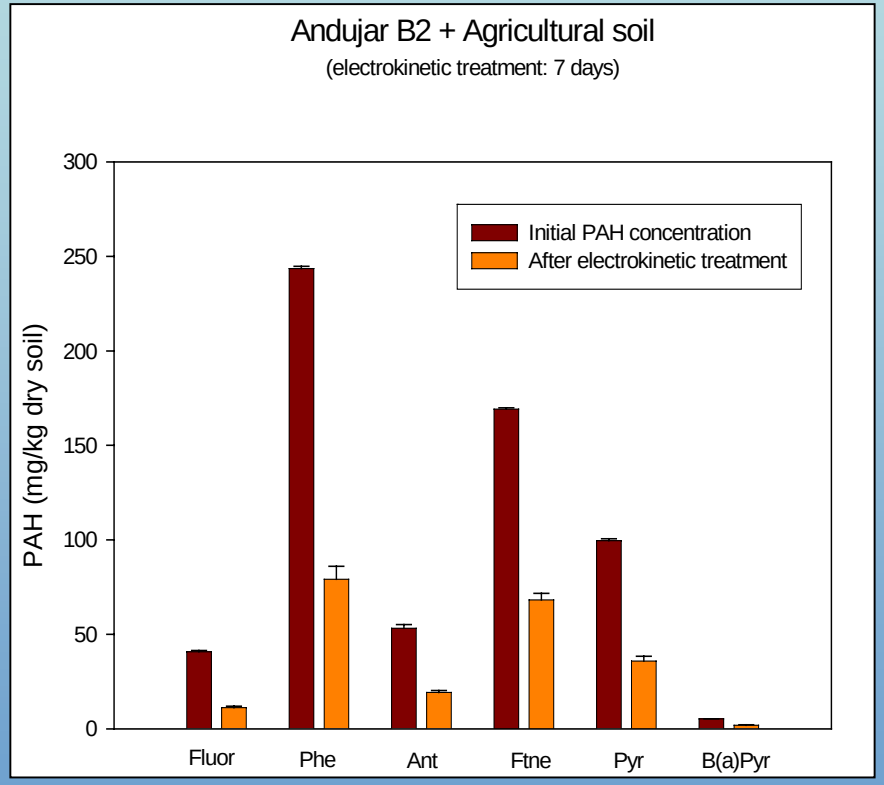




14C-PHENANTHRENE

- ELECTROKINETIC BIOREMEDIATION EXPERIMENTS (+BRIJ 35)-





CONCLUSIONS

- The enhancement effect of applied electric fields on PAH biodegradation can be explained by: a) the mobilisation of PAH and/or bacteria through soil, which would have caused a higher mass transfer b) an additional supply of nutrients (phosphorus present in the electrode buffers) and dissolved oxygen through electroosmotic flow.

- In spite of using optimal conditions for microbial activity, biodegradation in slurries was not complete but often stopped or occurred at very slow rates after the fast biodegradation of a significant fraction of the initially present PAH. This lead to low but significant residual concentrations after treatment. Our results suggest that electrokinetic treatment could be able to reduce the slow desorption-PAH fractions.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Use of bioavailability promoting organisms to decontaminate PAH-polluted soils: Preparation towards large scale field exploitation
(BIOSTIMUL)
EU contract QLK3-1999-00326
BIOSTIMUL

4th INTERNATIONAL WORKSHOP
BIOAVAILABILITY OF POLLUTANTS AND SOIL REMEDIATION
Sevilla, Spain 10-13 September 2006

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BIOAVAILABILITY OF POLLUTANTS AND SOIL REMEDIATION
Sevilla, Spain 10-13 September 2006

Major themes:
1) Methods to measure bioavailability (organic & inorganic)
2) Physico-chemical and biological processes determining bioavailability
3) Bioavailability and biodiversity
4) Land management practices to improve contaminated sites
5) Bio/phytoremediation techniques

Special issue of Environmental Pollution

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