

Potential of Biological Processes for Remediation of MTBE-contaminated Groundwater

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Introduction

- MTBE is being used frequently and in many areas
- MTBE is present in the environment
- Legislation for MTBE (TBA) exists in some countries (a.o. Belgium)
- Remediation of MTBE-pollution:
 - Adapted remediation technologies needed
 - Potential of biological processes?



MTBE-biodegradation potential in aquifers

Presence of MTBE-degrading bacteria in aquifer material?

→ Screening of Belgian soils/aquifers via batchtests:

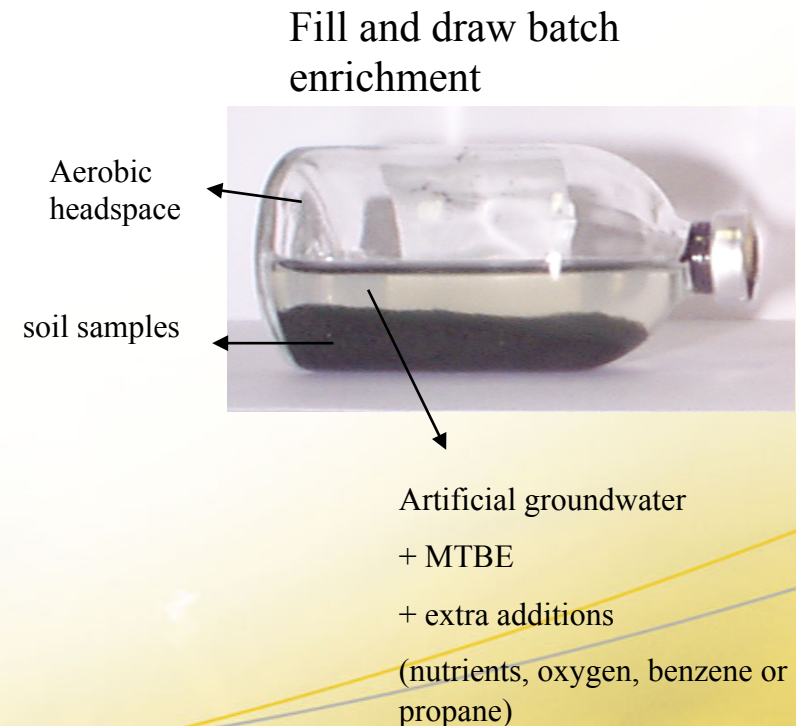
- 3 topsoils (2 locations)
- 8 aquifers (5 locations)

→ Different testconditions

- Abiotic condition, NA, + nutrient
- Cometabolic: Benzene & propane

→ Monitoring in time (> 200 days, 20°C):

- MTBE, Benzene (GC-MS)
- pH, dissolved oxygen

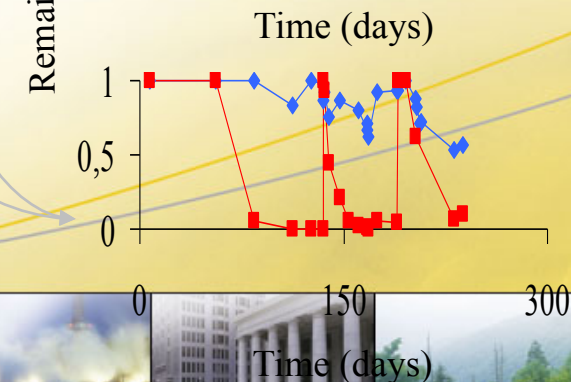
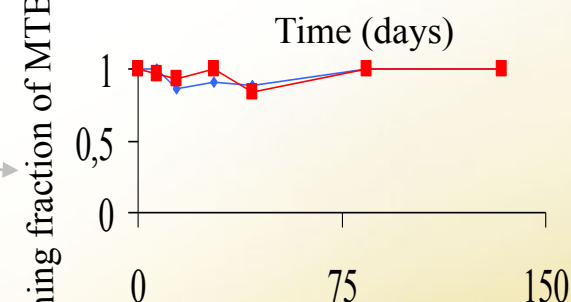
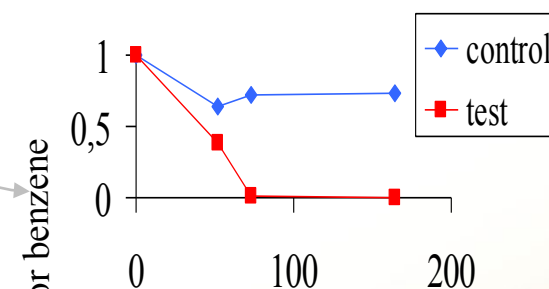


(Moreels et al., FEMS Microbiol. Ecol. (2004) 49:121-128)



Results screening biodegradation potential

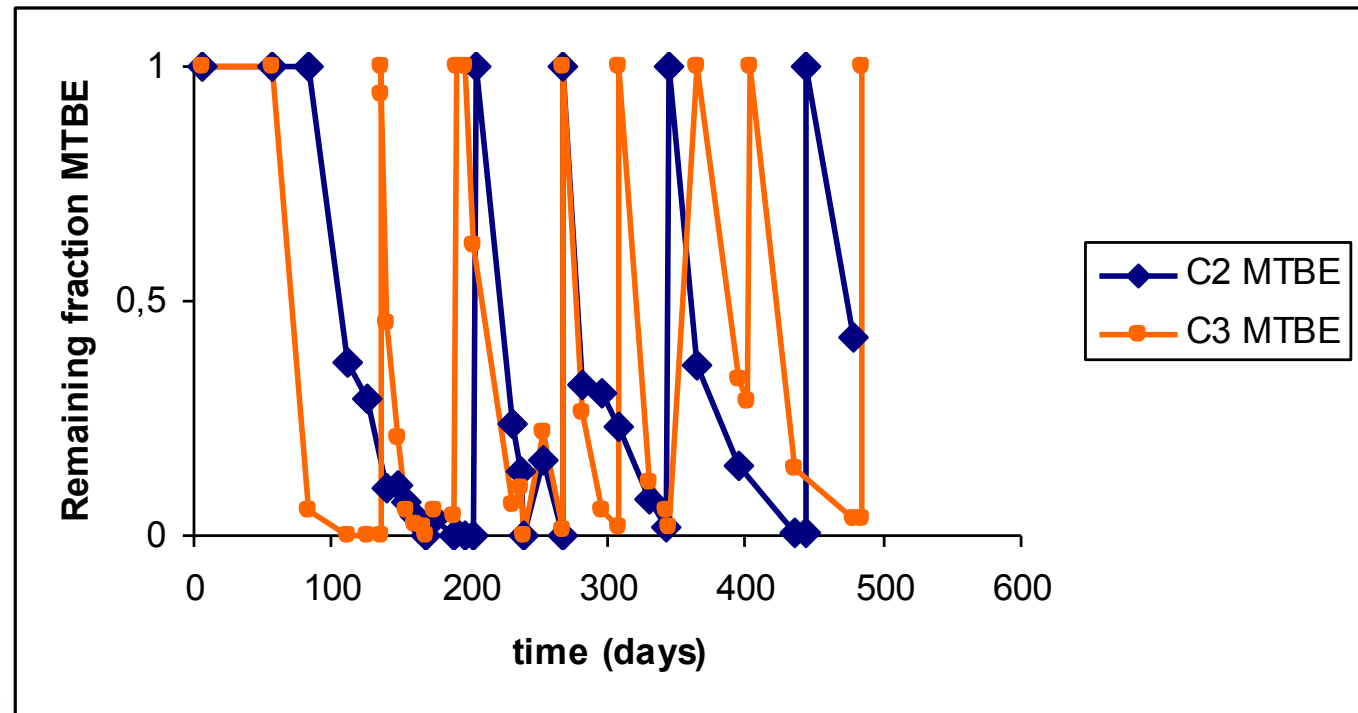
Soil		Degradation of	
Name	Origin of soil	MTBE	Benzene
T	Non-contaminated garden soil Flanders	-	+
G trunk		-	+
G canopy		-	+
351	Contaminated with BTEX Flanders	-	+
Z	Contaminated with MTBE containing fuel Flanders	-	+
M		-	+
H		-	+
P250		++	++
P300		++	++
P450		++	++
P600		++	++



⇒ The potential for MTBE biodegradation is not widespread

Enrichment of MTBE-degrading bacteria

Slurry enrichment



C2: MTBE + 8 ppm DO

C3: MTBE + nutrients + 8 ppm DO

→ Stimulation of degradation by nutrient addition



Enrichment of MTBE-degrading bacteria

Slurry enrichment



First transfers



Second transfers



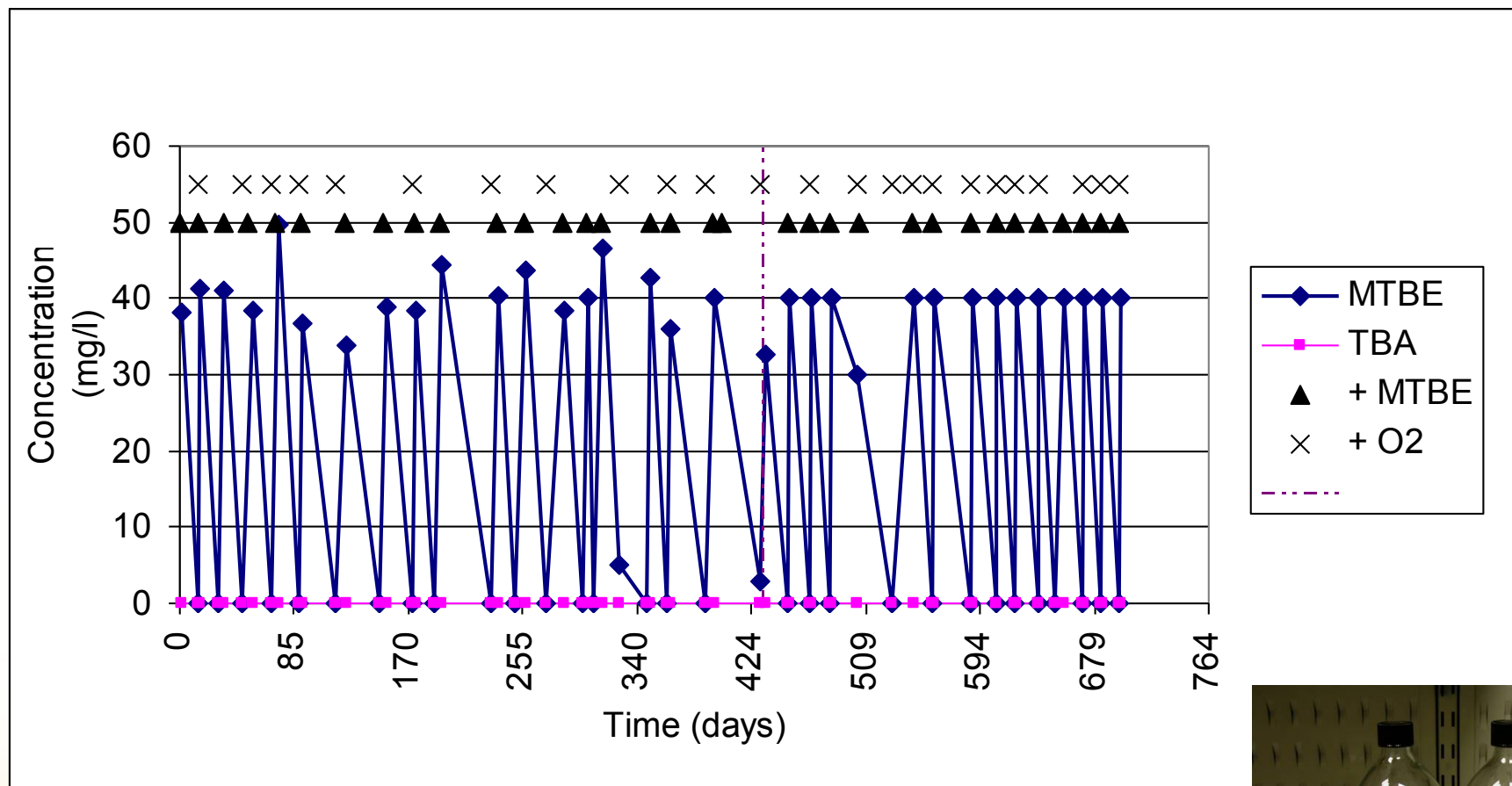
Vito MTBE/TBA-degrading culture



**Stable consortium
(PCR-DGGE based)**

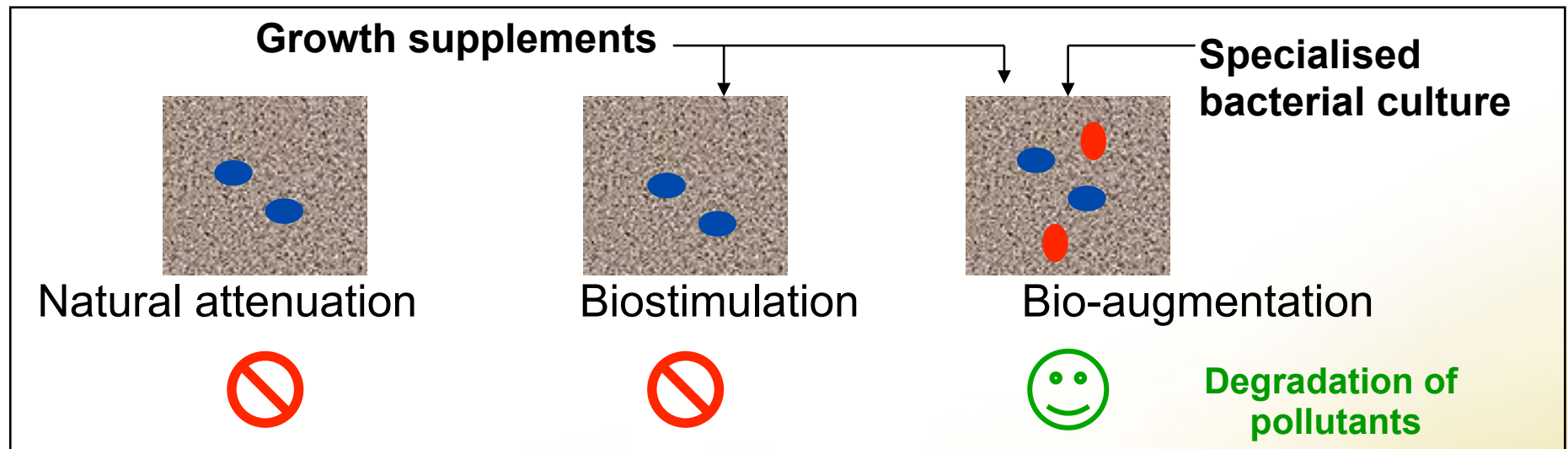


MTBE-degradation by Vito consortium



Bioaugmentation

- Bioremediation with bacteria



- Opportunities:
 - MTBE: degradation potential is not omnipresent

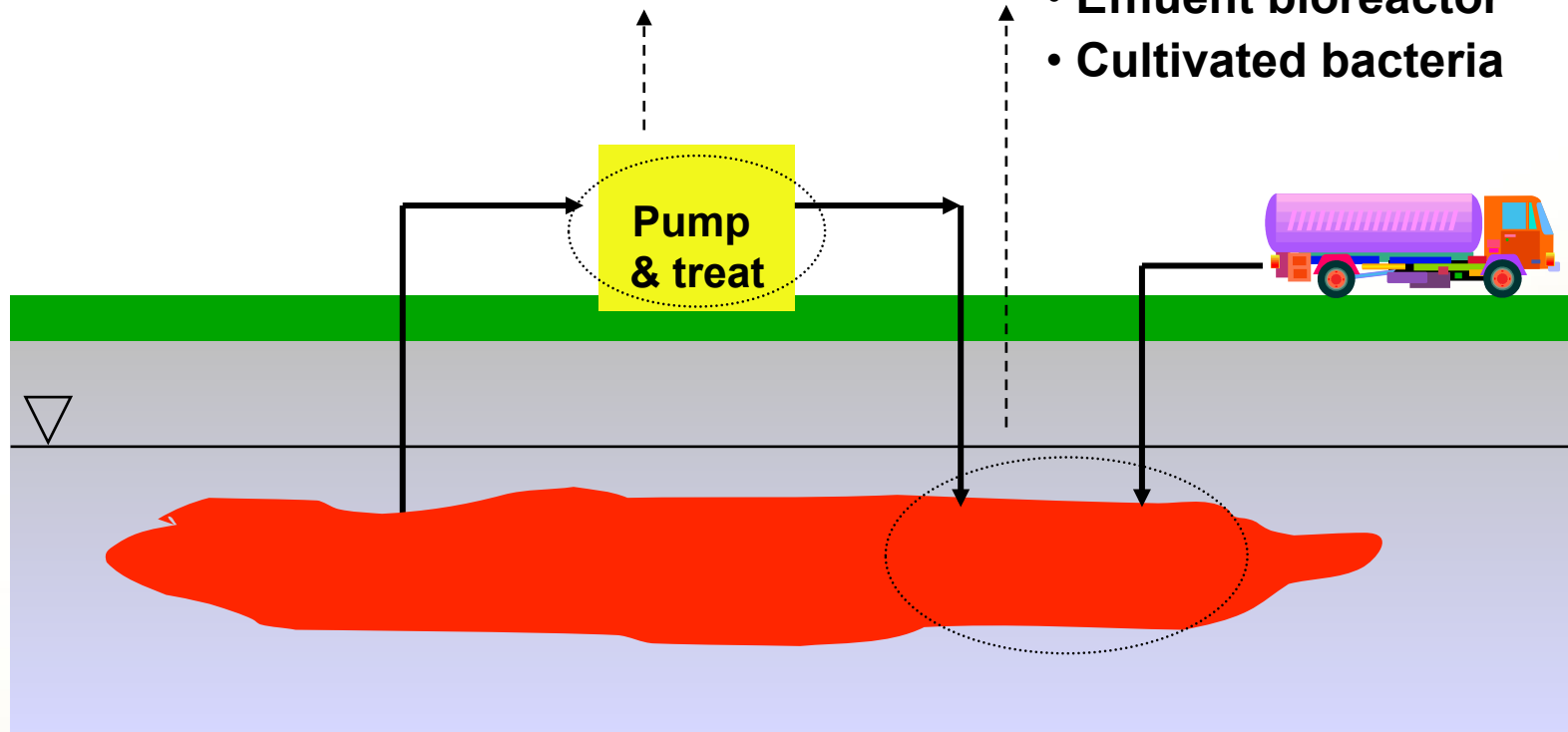


Bio-augmentation

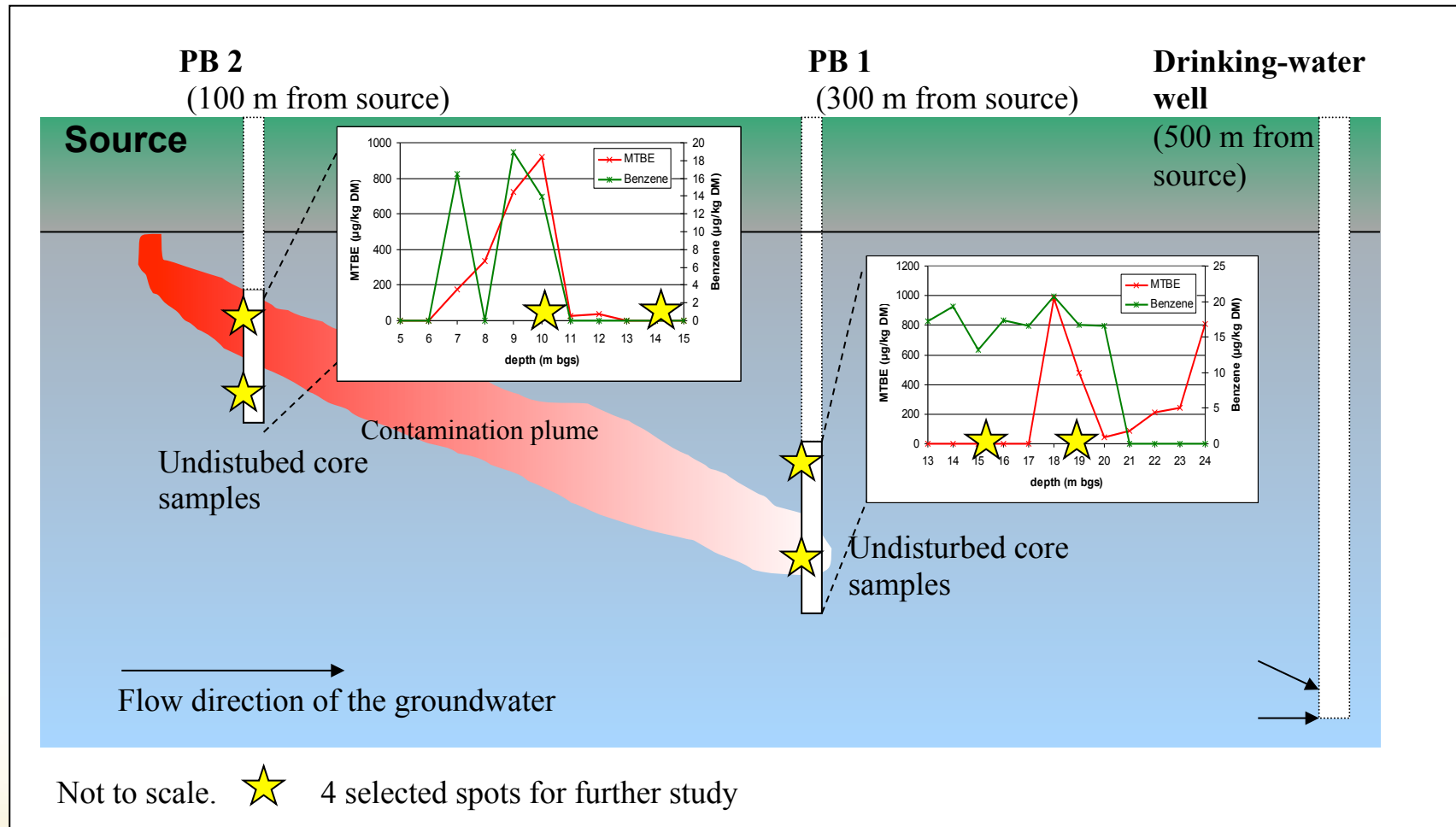
1. Inoculated bioreactor

2. In situ bio-augmentation

- Effluent bioreactor
- Cultivated bacteria



Schematic overview site Z



Enrichment cultures

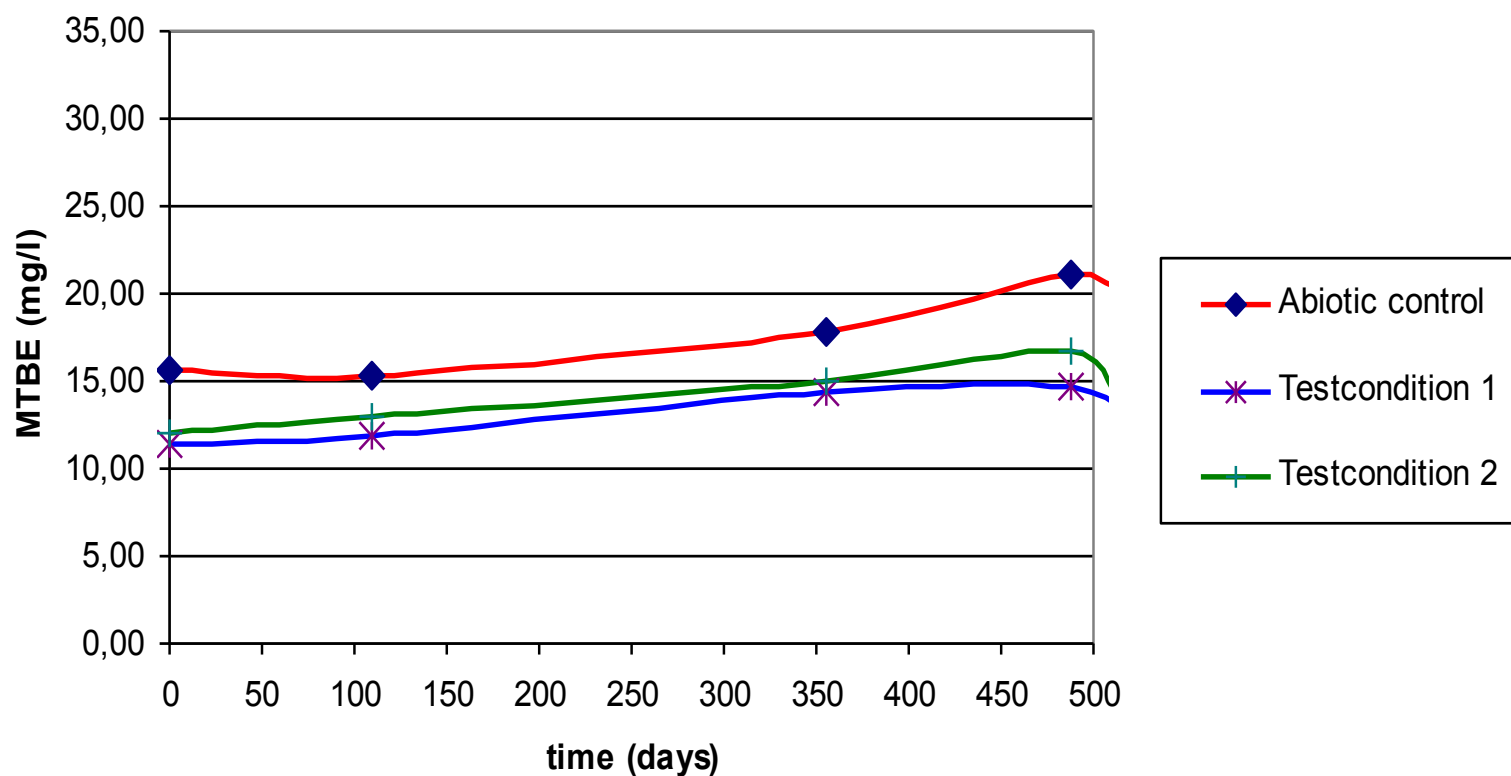
- Batch-experiment:
 - Aquifer: B1-in, B1-above, B2-in, B2-beyond
 - Minimal mineral medium
- Test-conditions (duplo):
 - Abiotic control
 - No additions
 - Addition of nutrients
 - Additions of co-substrates: benzene, TBA, propanol, propane, n-heptane, MSBE, pyruvate, yeast extract
 - Anaerobic enrichments: denitrifying, sulfate reducing, iron reducing conditions
- Incubation: 20°C, static
- Monitoring: during >2 years
 - MTBE, TBA, benzene, pH, DO



Flow = 200 ml/day = 0.5 PV/day



Results site Z



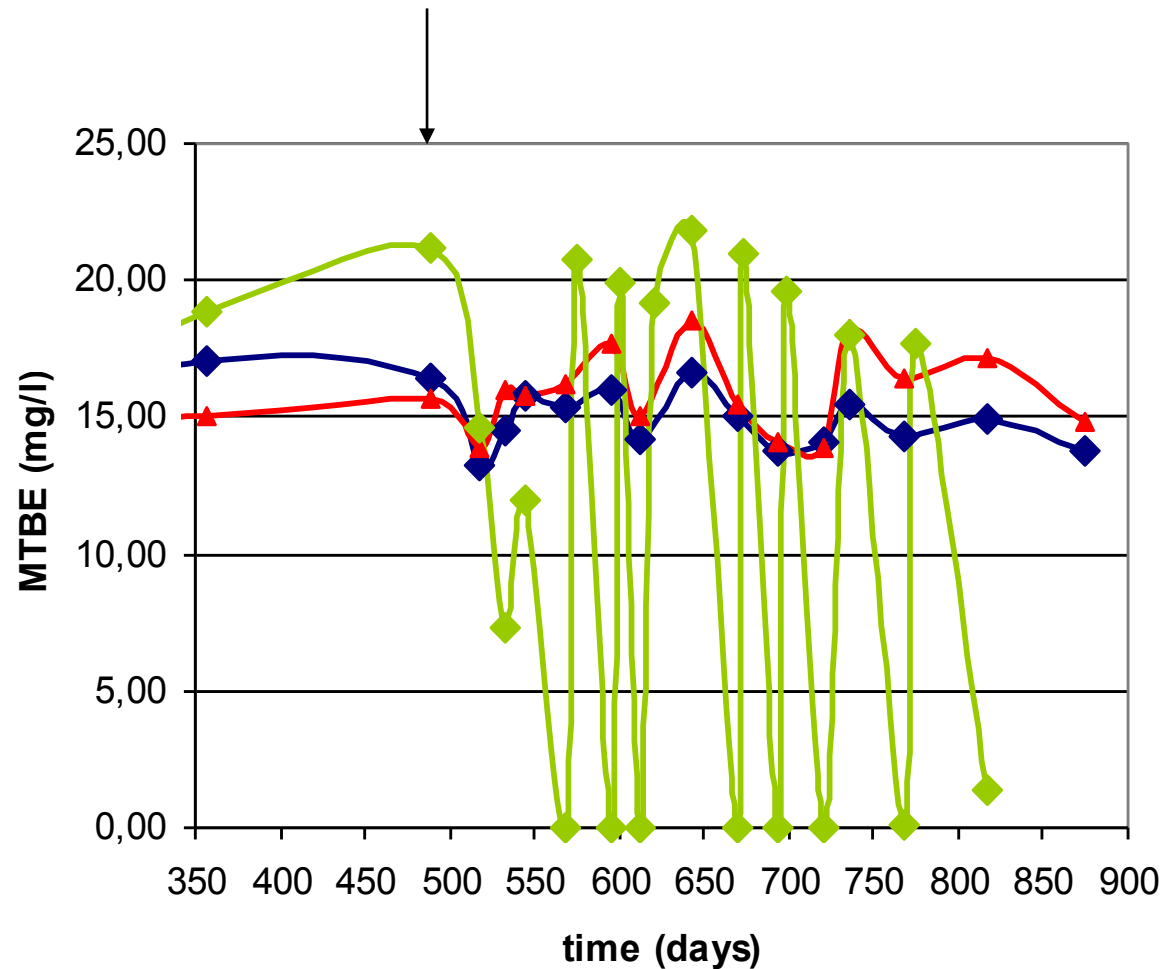
→ No MTBE biodegradation potential is present?

→ An inhibiting factor is present?



Results bio-augmentation

+ Vito MTBE-degrading inoculum



- ◆ abiotic control
- ▲ non-bioaugmented control
- ◆ + MTBE-degrading inoculum



Bio-augmentation in continuous systems

Column fillings:

- Aquifer material
- 4 other filling materials

Column conditions per filling:

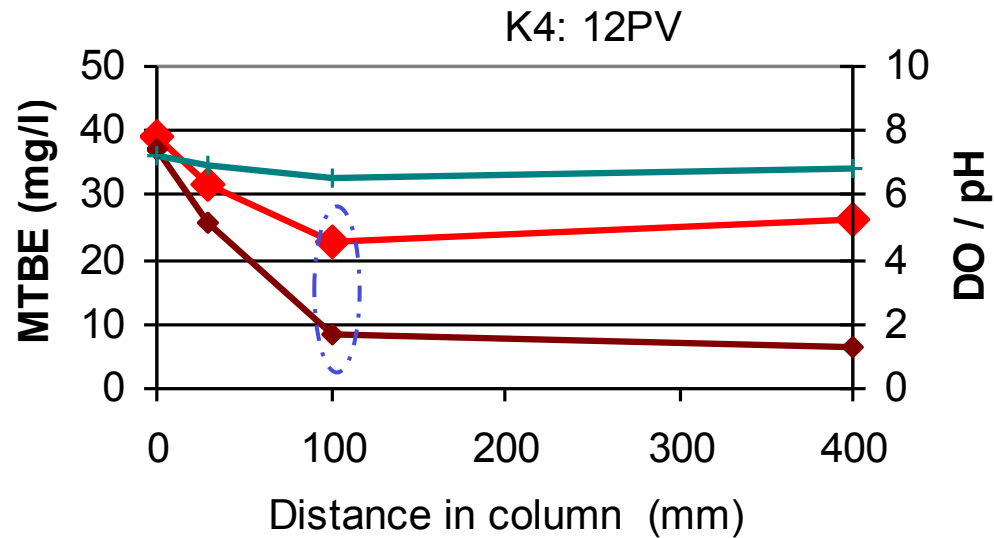
- Non-inoculated column
- Inoculated column
- (Abiotic column)

Artificial groundwater:

- Phase 1: 40 mg/l MTBE
- Phase 2: 10 mg/l MTBE
- Phase 3: 10 mg/l MTBE + 5 mg/l BTmX



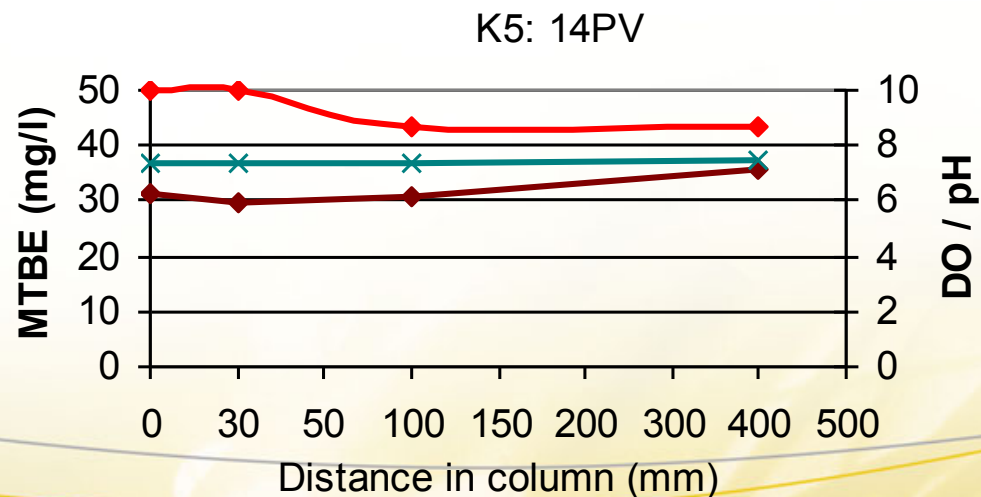
Results phase 1 (column with carrier material B)



Inoculated column

MTBE-biodegradation

Oxygen limited

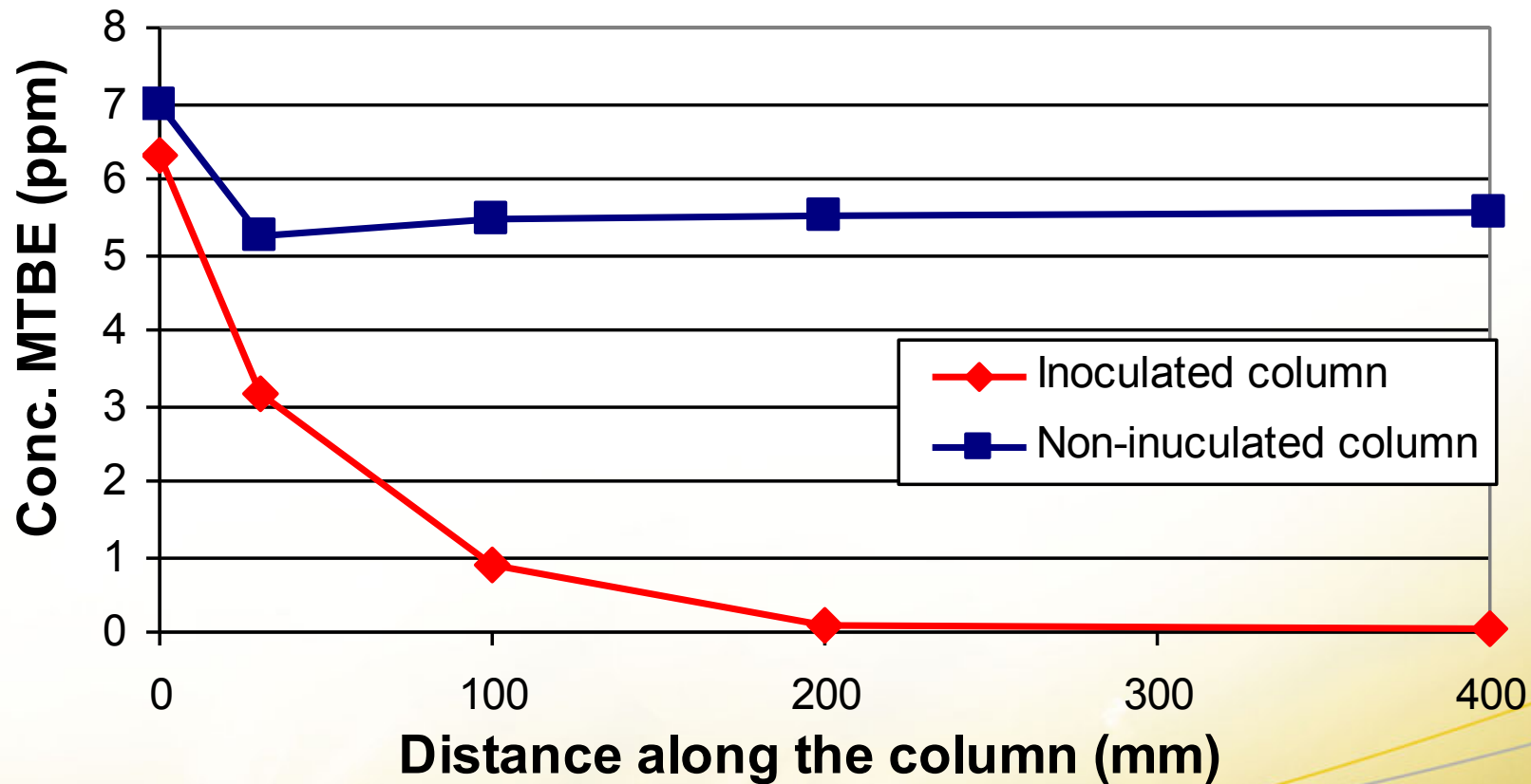


Non-inoculated biotic column

No biodegradation of MTBE

Flow = 200 ml/day = 0.5 PV/day

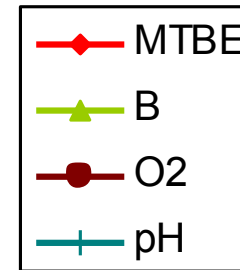
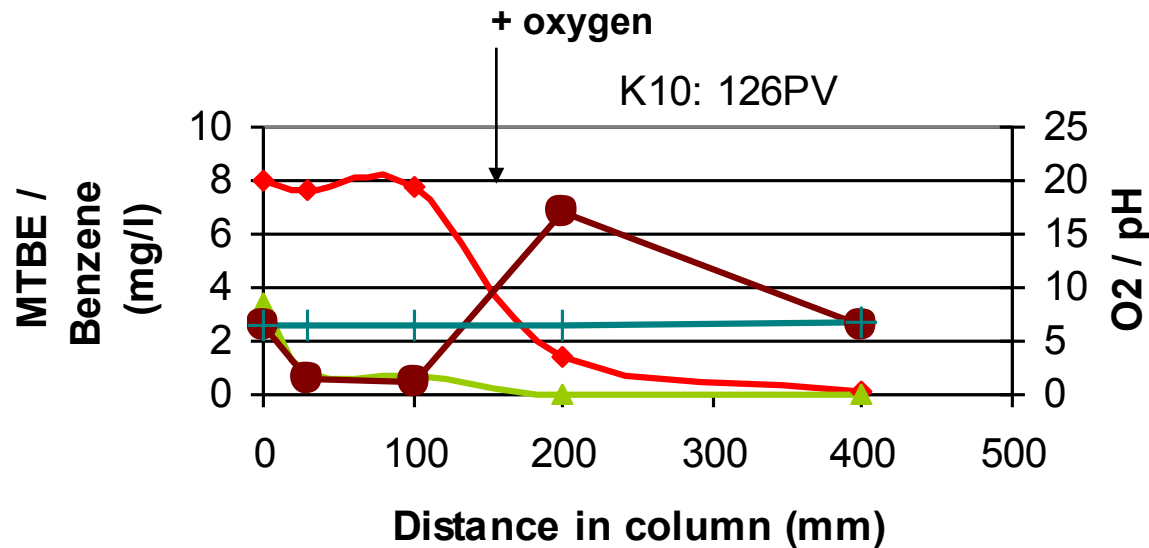
Results phase 2 (Column with carrier material D)



Flow = 200 ml/day = 1 PV/day



Results phase 3 (column with carrier material C)

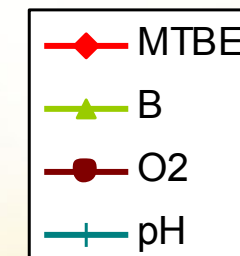
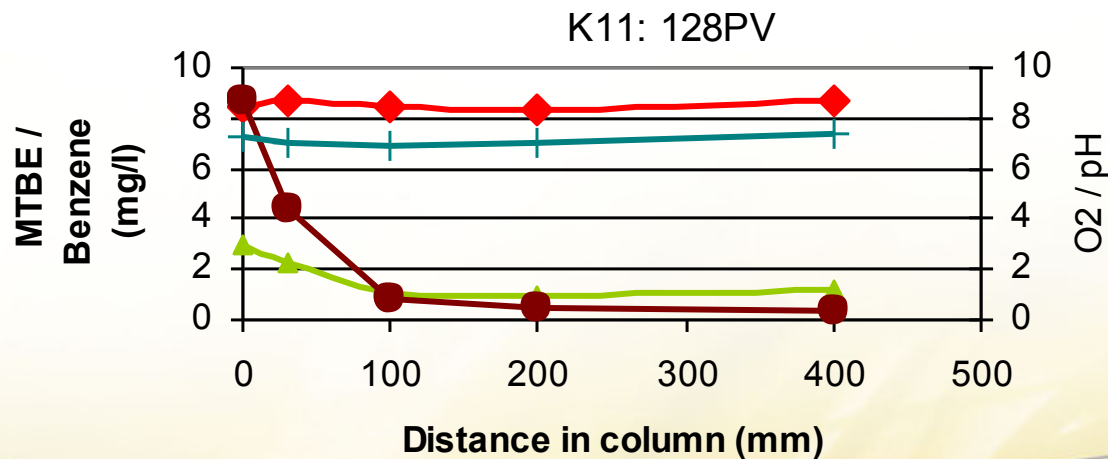


Inoculated column:

MTBE-biodegradation

Preferential substrate use

Competition for oxygen



Non-inoculated biotic column:

No biodegradation of MTBE

Flow = 200 ml/day = 1 PV/day



Conclusions biodegradation studies

- MTBE biodegradation potential is not widespread in aquifer material
 - bio-augmentation may offer a solution
- Vito enriched a stable MTBE/TBA-degrading consortium
- Successful use of consortium as inoculum for bioaugmentation:
 - Batch-systems with aquifer: active more than 1 year after the inoculation
 - Continuous systems with aquifer & carrier materials:
 - MTBE-biodegradation in inoculated columns, up to 8 months after the inoculation
 - Oxygen is limiting factor
 - BTEX are degraded before MTBE → preferential substrate use



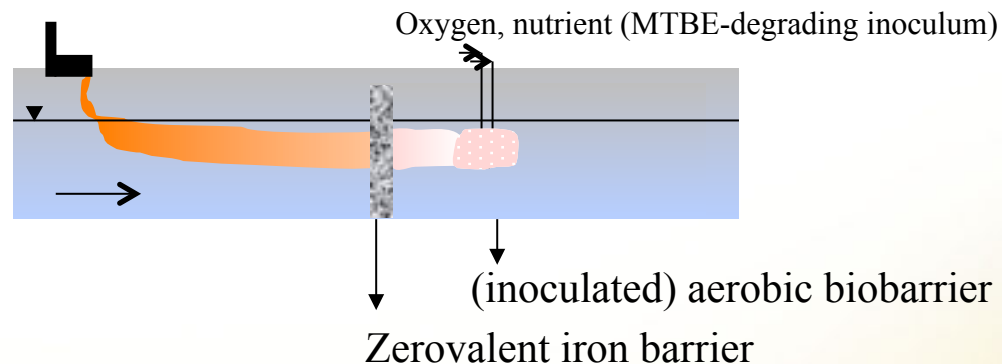
Future

- More in depth scientific study (PhD L.Debor)
 - Composition of consortium
 - Monitoring tools for consortium
 - Modelling of growth and MTBE/TBA degradation in bioreactor
- Optimisation of inoculated bioreactor:
 - Shorter HRT
- Demonstration of the inoculum in the field:
 - Growth of consortium at larger scale
 - Pilot demonstration inoculated bioreactor
 - Vito/OVAM-project



Future (II)

- Contract research for the industry:
 - Site contaminated with mixed pollution (VOCs, BTEX, mineral oil and MTBE): → in-situ treatment



- Labtest & pilot demonstration in the field (BTEX, MTBE):
 - MTBE-biodegradation potential present?
 - In situ remediation via aerobic degradation (ISOC)
 - Biostimulation or bioaugmentation

→ Needs for remediation of MTBE are actual

