Deltares
Enabling Delta Life

Quantification of microbial biodiversity and functionality in river sediments

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Introduction

Micro-organisms play a key role in many environmental processes

Micro-organisr

Biodiversity

Type of orga

Metabolic activity

Functions / processes

- **Denitrification**
- **Iron reduction**
- **Biodegradation of pollutants**

pH

ronment

Bioavailabilty

ential

Temperature

Oxygen

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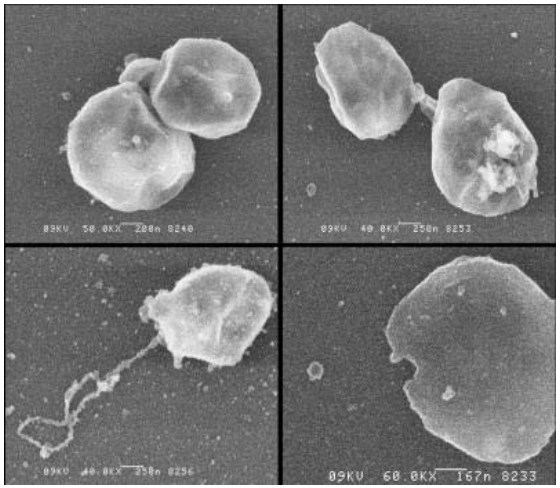
How to identify micro-organisms?



F. E. Löffler. 2006. AEM. 72:1980-1987

Microscopy

- Species identification on morphology (< 1%)
- Functions not by morphology
- Time consuming procedure

Microscopic picture of *Dehalococcoides* cells

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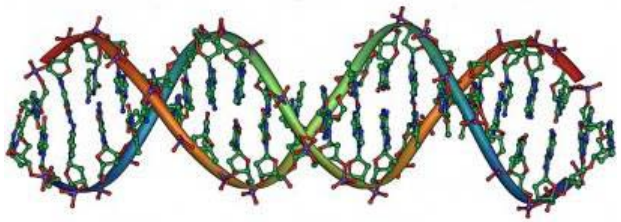
Molecular detection based on DNA



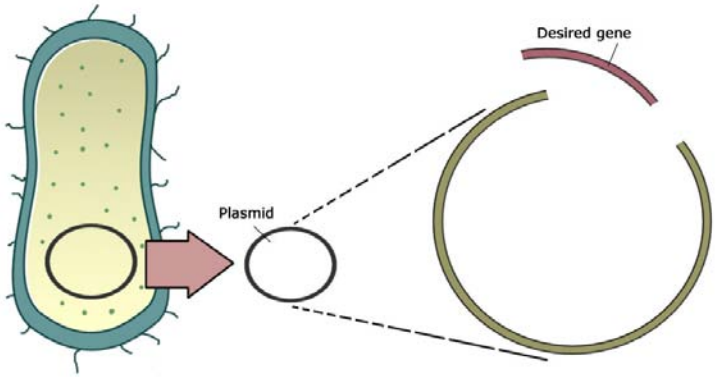
Which micro-organisms are present?

- Detection of specific “16S rRNA genes”

Which functions do they perform?

- Detection of specific genes coding for functional enzymes (e.g. pollutant degradation)

- Different micro-organisms , same function!
→ “Functional groups”



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Microbial diversity in the environment

Biodiversity is often very high

>1. 10^7 micro-organisms per g soil

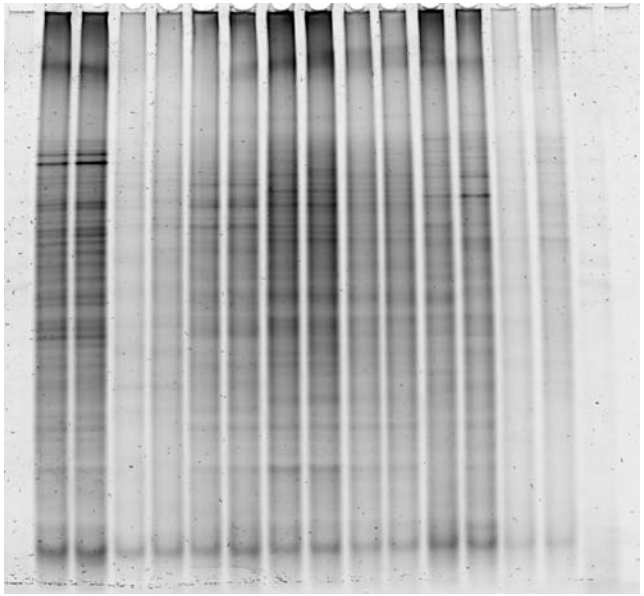
> 5 . 10^4 species per g soil

(Rouch et al, 2007, ISME J.)

Fingerprint do not indicate functions

Need to focus on functionality!

- Mineralisation of nutrients
- Biodegradation of pollutants
- ….



Fingerprint of biodiversity in sediment

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Aim of the study

Can we monitor biodiversity and microbial functions by using molecular techniques?

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Different microbial functions, one sediment

Do environmental changes influence biodiversity and functions of micro-organisms in river sediment?

Ebro river sediment

Sediment mesocosm

(Van der Zaan et al, 2010, FEMS Microbiology Ecology 74, p. 72-82)

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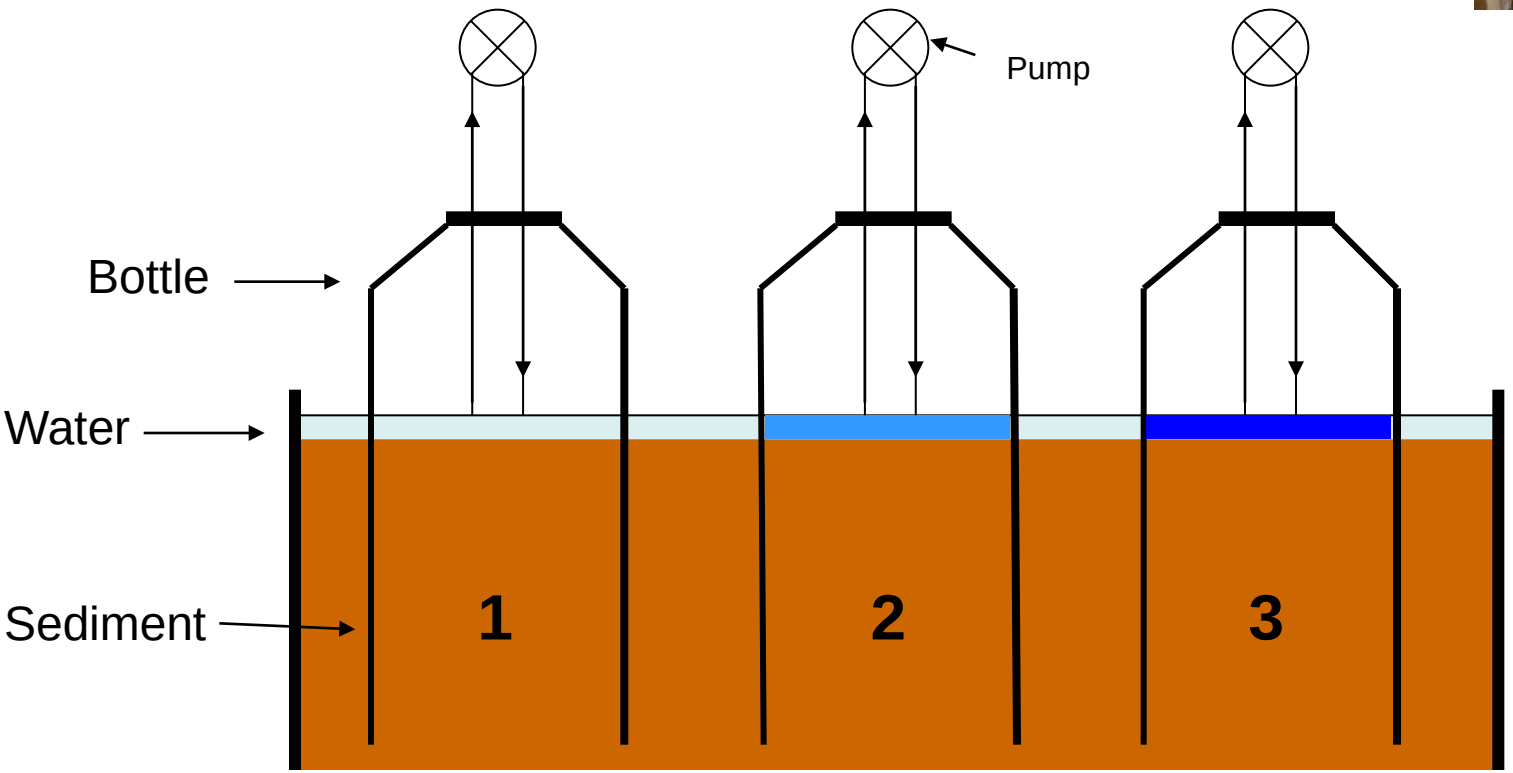
Experimental set-up

1 = Reference sediment

2 = Sediment + 250 µM PCE and 1,2-DCA

3 = Sediment + extra nutrients (N/P/K)

Mesocosm



Incubation for 6 months

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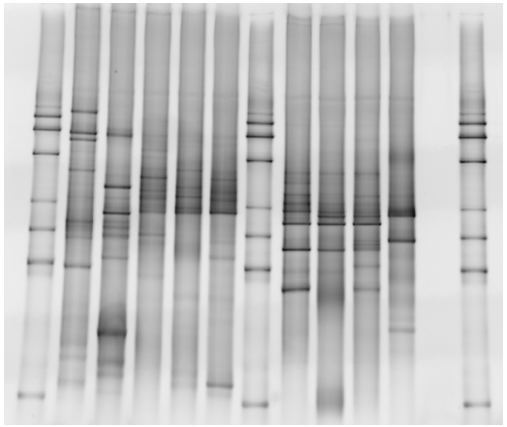
Analyses on mesocosms

Geochemical conditions

- pH / Redox / oxygen
- Nutrients
- TOC

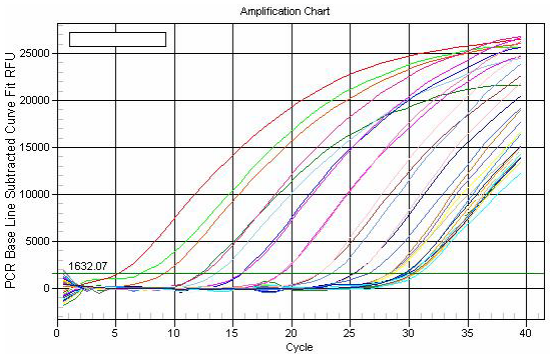


Biodiversity: different species of micro-organisms

Different functional groups of micro-organisms

- Denitrifiers
- Sulfate-reducers
- Iron-reducers
- Methanogens
- Dechlorinators

DNA



MPN

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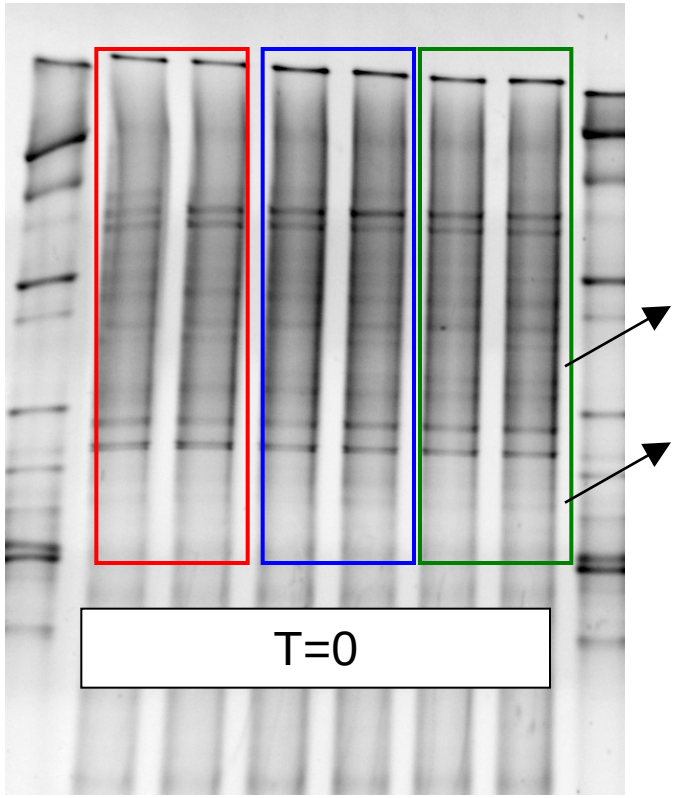
Results – Biodiversity

DGGE fingerprint

Vertical lane = sample Band = individual micro-organism



Some micro-organisms disappaer, some not

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Results - Biodiversity

Shannon-Weaver index → H = -• Pi log Pi

Mesocosm	t = 0	t = 6 months
Reference	1.12	1.08
Chlorinated organic pollution	1.13	1.13
Extra Nutrients	1.12	0.90

Conclusion:

- Individual species of micro-organisms are affected species
- Nutrient addition → Biodiversity decrease significantly ($p < 0.05$)

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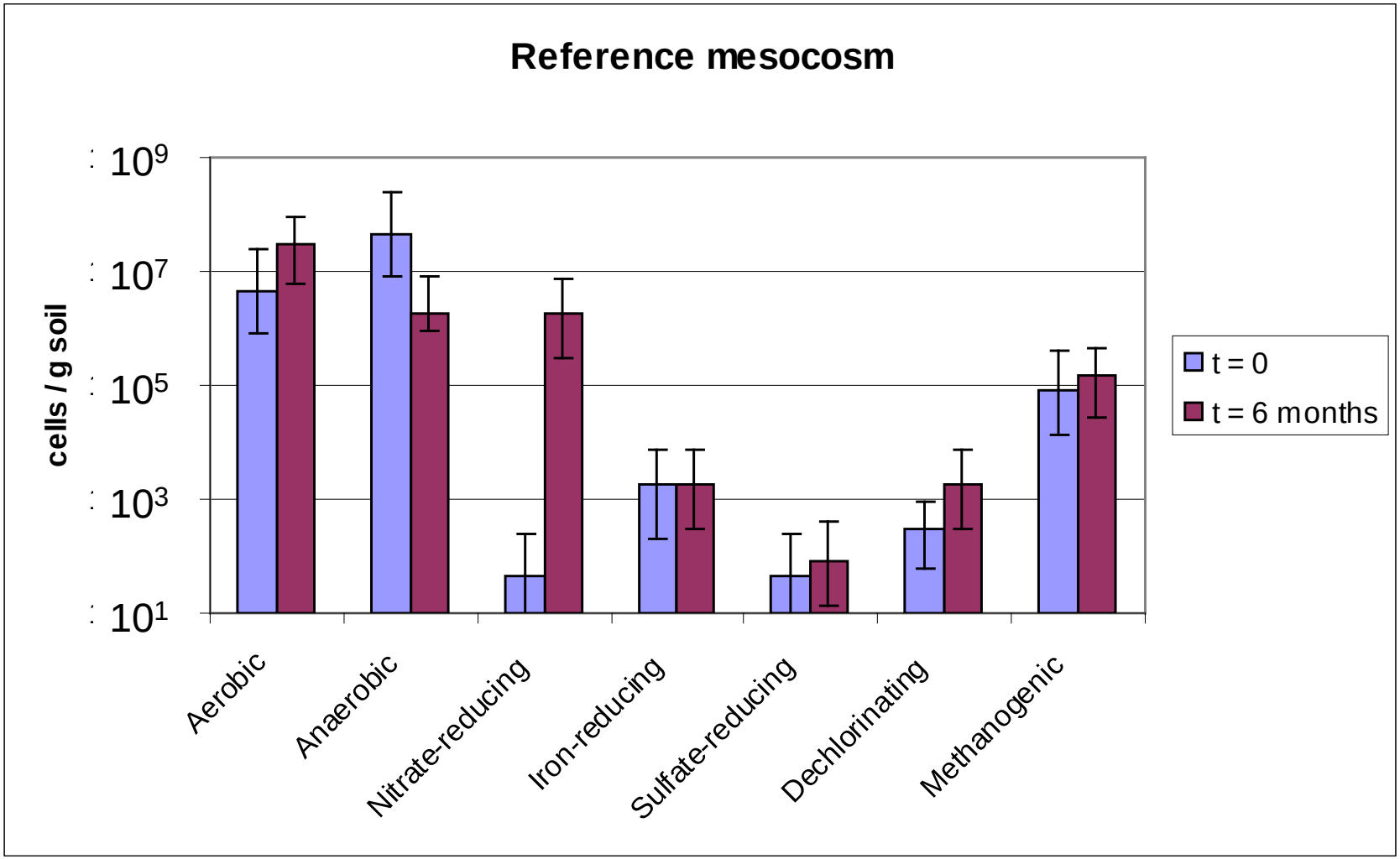
Results – MPN in specific media



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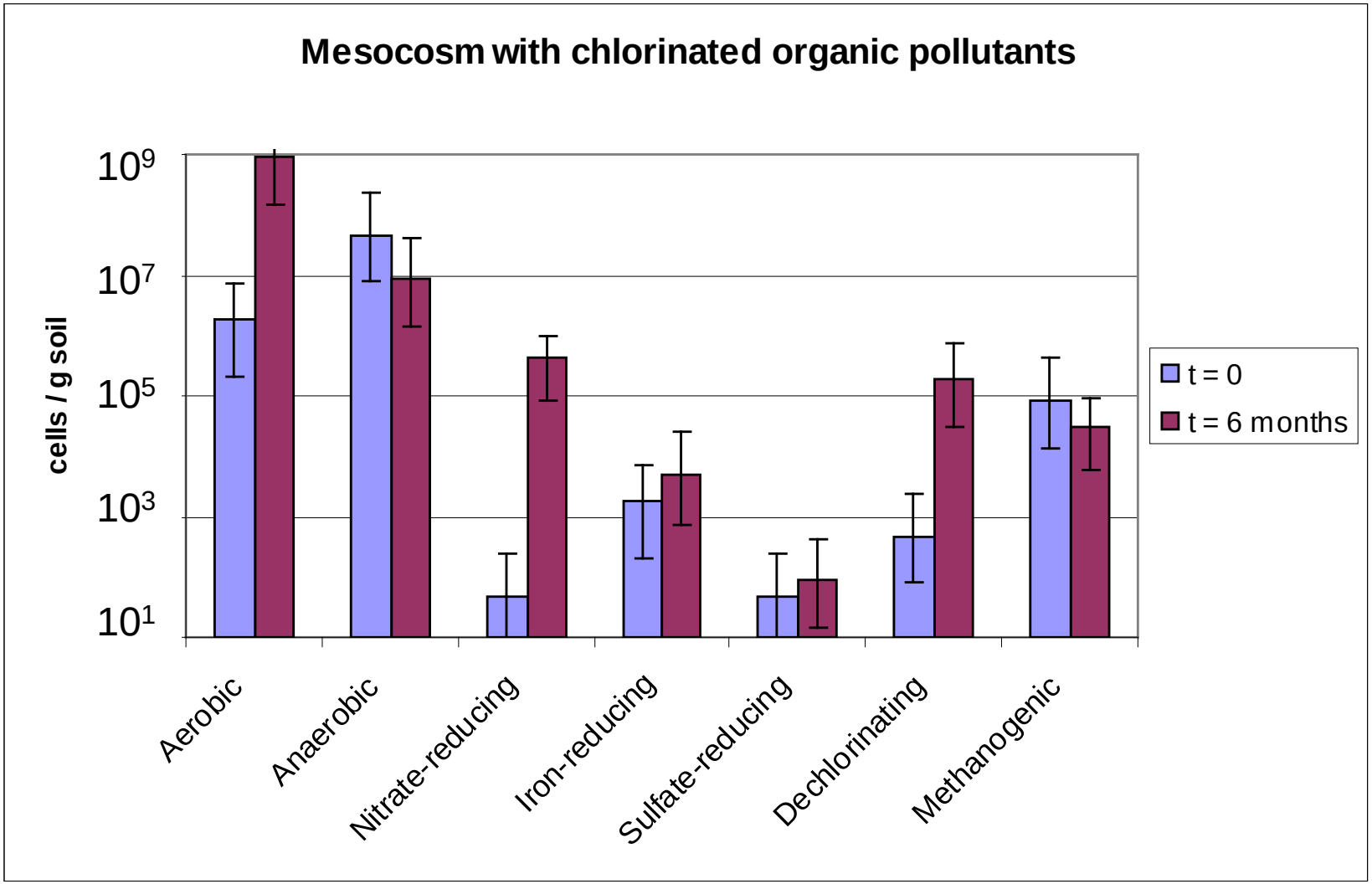

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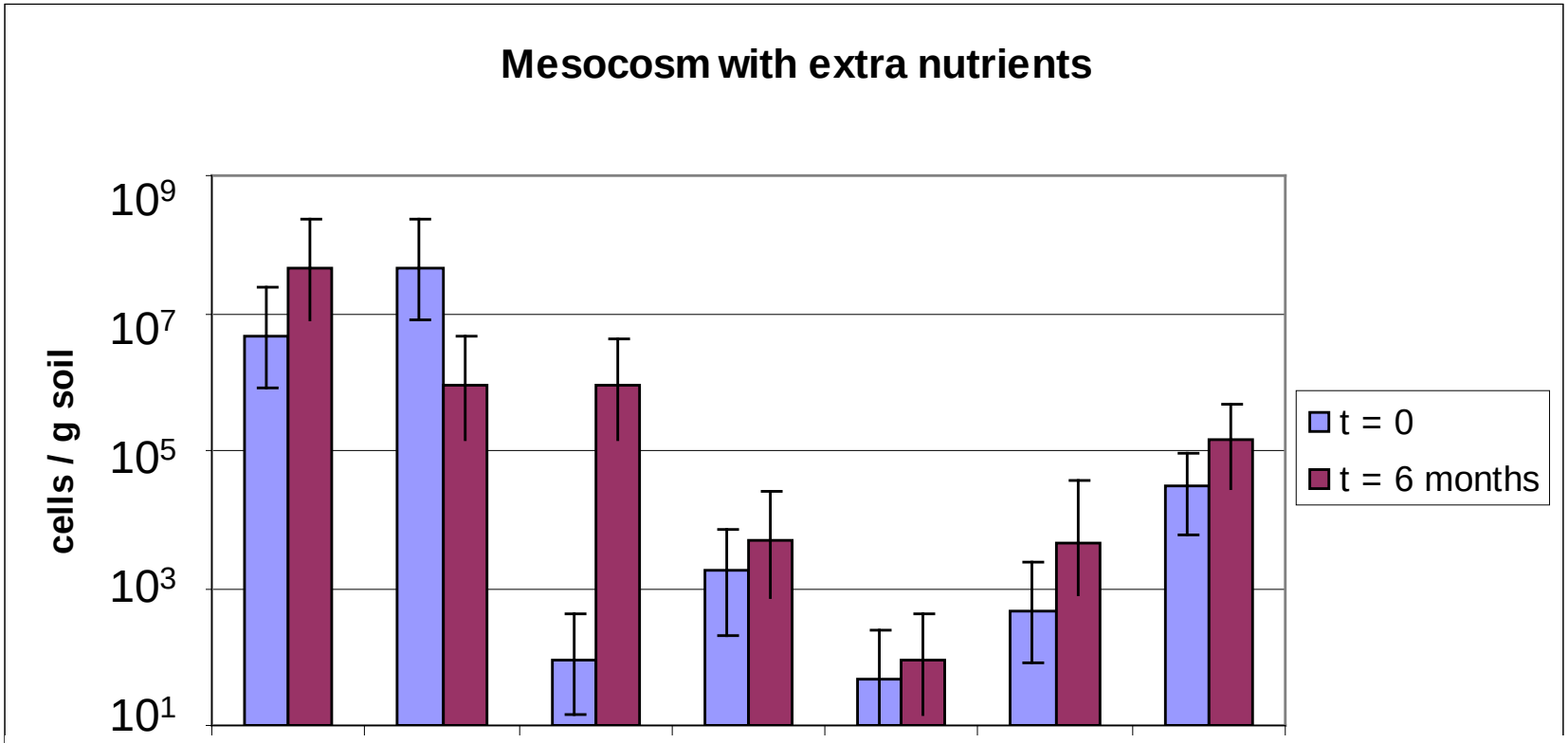

Conclusion:

- Specific microbial functional groups are stimulated
- Other functional groups of micro-organisms are robust

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One functional group, different sediments

Sediment of 3 European rivers

- Ebro (Spain)
- Danube (Various countries)
- Elbe (Czech Republic / Germany)

Are there differences on biodegradation capacity of 1,2-DCA?

Monitor dechlorinating micro-organisms and activity

- Sediment *vs* water phase
- Various redox conditions
  - e.g. Aerobic, iron-reducing, methanogenic

(Van der Zaan et al, 2009, Water Research 43, p. 3207-3216)

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Results

Water	Biodegradation?	Dechlorinating micro-organisms
Ebro	-	-
Danube	-	-
Elbe	-	-
Sediment		
Ebro	Denitrifying + Methanogenic	+
Danube	Iron-reducing + Methanogenic	+
Elbe (fresh sand)	-	-

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Conclusion:

- Sediment is essential for biodegradation

- Functional group present under various environments
  - Redox
  - Geographic location

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General Conclusions

- Individual species of micro-organisms may increase or lost, without effect on biodiversity
- Chlorinated pollutants caused specific selection of micro-organisms, but biodiversity was not influenced
- Nutrient addition caused specific selection and lost of biodiversity
- Functionality of the microbial community is robust
- Sediment is essential for dechlorinating micro-organisms in river systems

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Remaining questions and outlook

- Are all microbial functions always present, or not?
- How fast can microbial community adapt to environmental changes? (Hours, weeks, years?)
- Can we indentify “indicator species” for good sediment quality by molecular (DNA) methods?

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