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Environmental consultant

**AECOM**

## DESIGN, DEVELOPMENT AND SCALE-UP OF AN AEROBIC *IN-SITU* BIOREACTOR FOR REMOVAL OF HCH IN GROUNDWATER

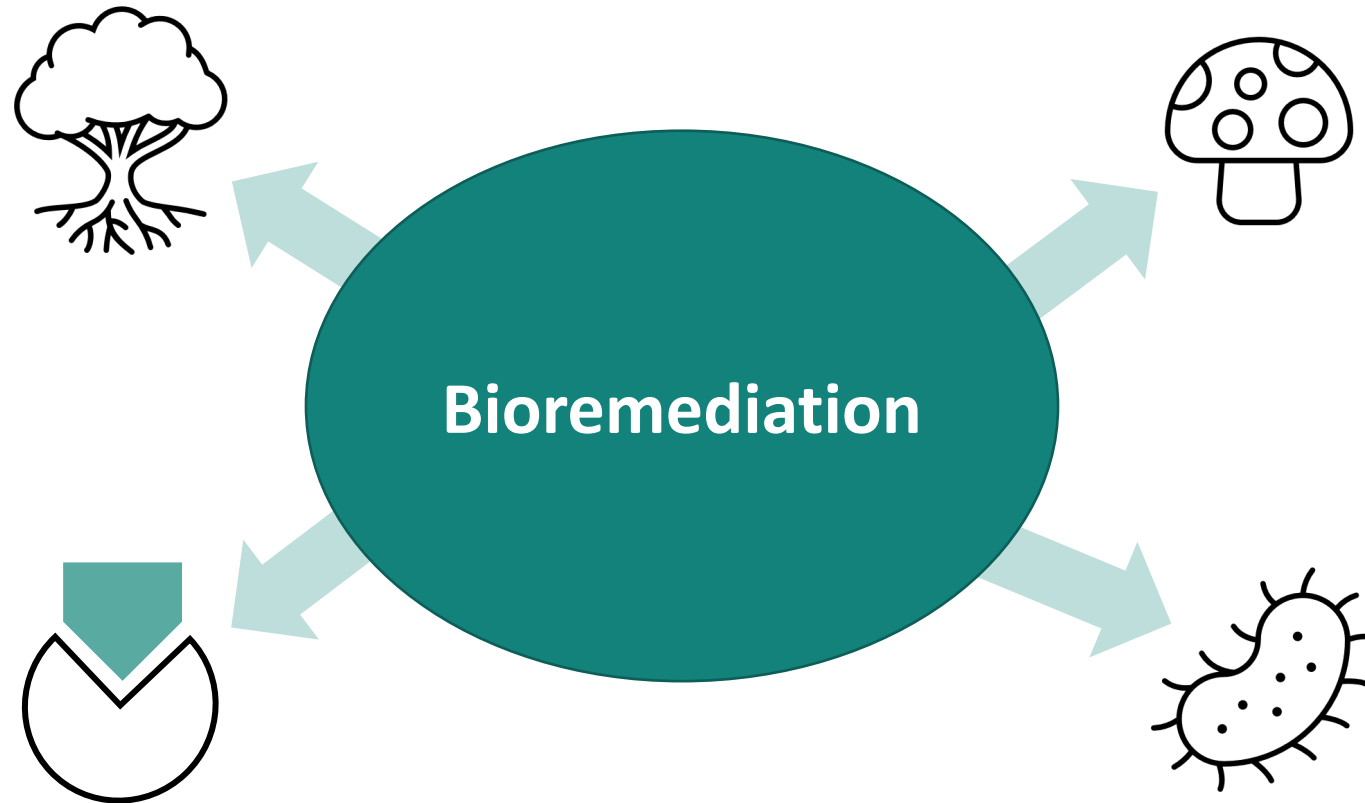
**Escobar-Arnanz J.<sup>1</sup>, Berganza J.<sup>2</sup>, Brettes P.<sup>2</sup>, Encinas R.<sup>1</sup>, Alonso T.<sup>1</sup>, Alcalde D.<sup>1</sup>, Fernández J.<sup>3</sup>**

<sup>1</sup>AECOM. Environment and Sustainability Department. Remediation. Madrid, Spain

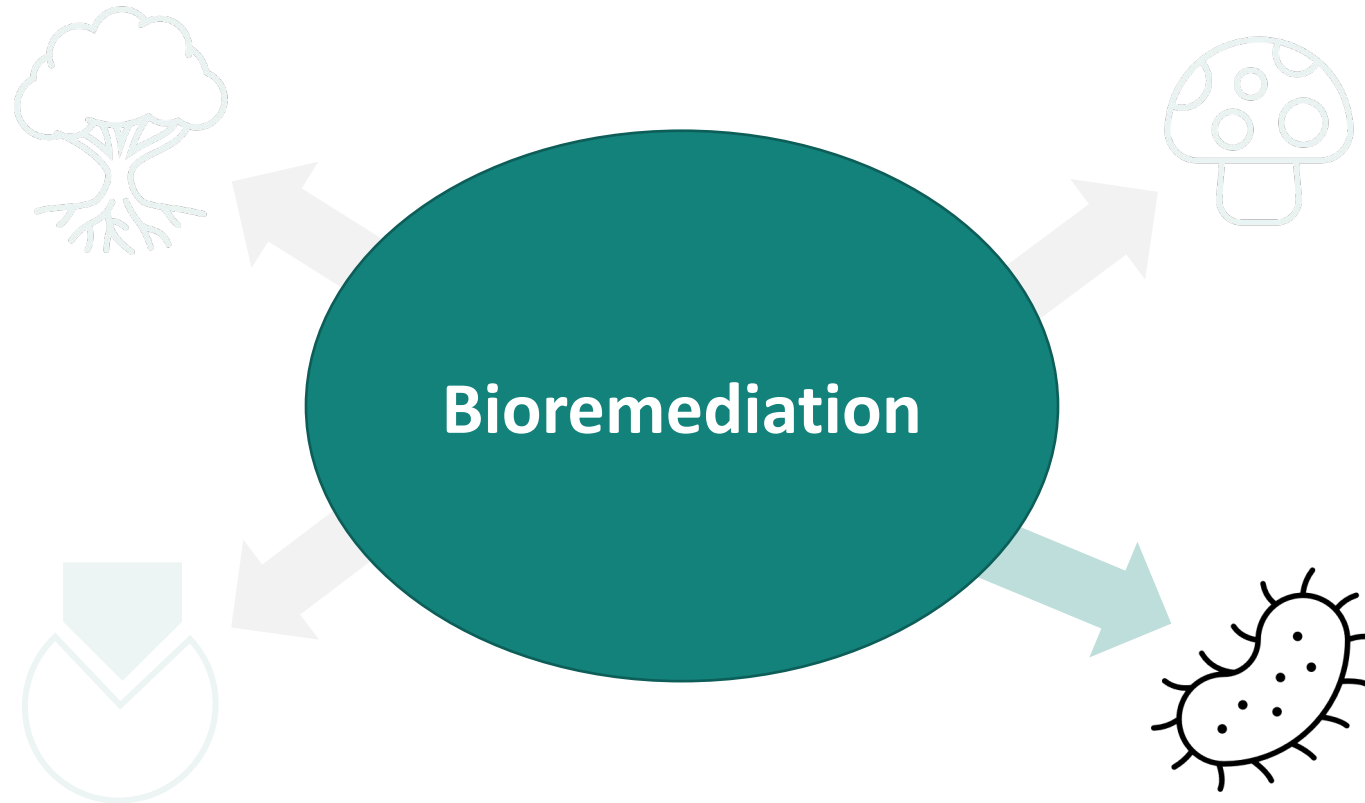
<sup>2</sup>GAIKER Technology Center. Zamudio. Spain

<sup>3</sup>Department of Agriculture. Livestock and Environment. Aragón's Government. Zaragoza, Spain

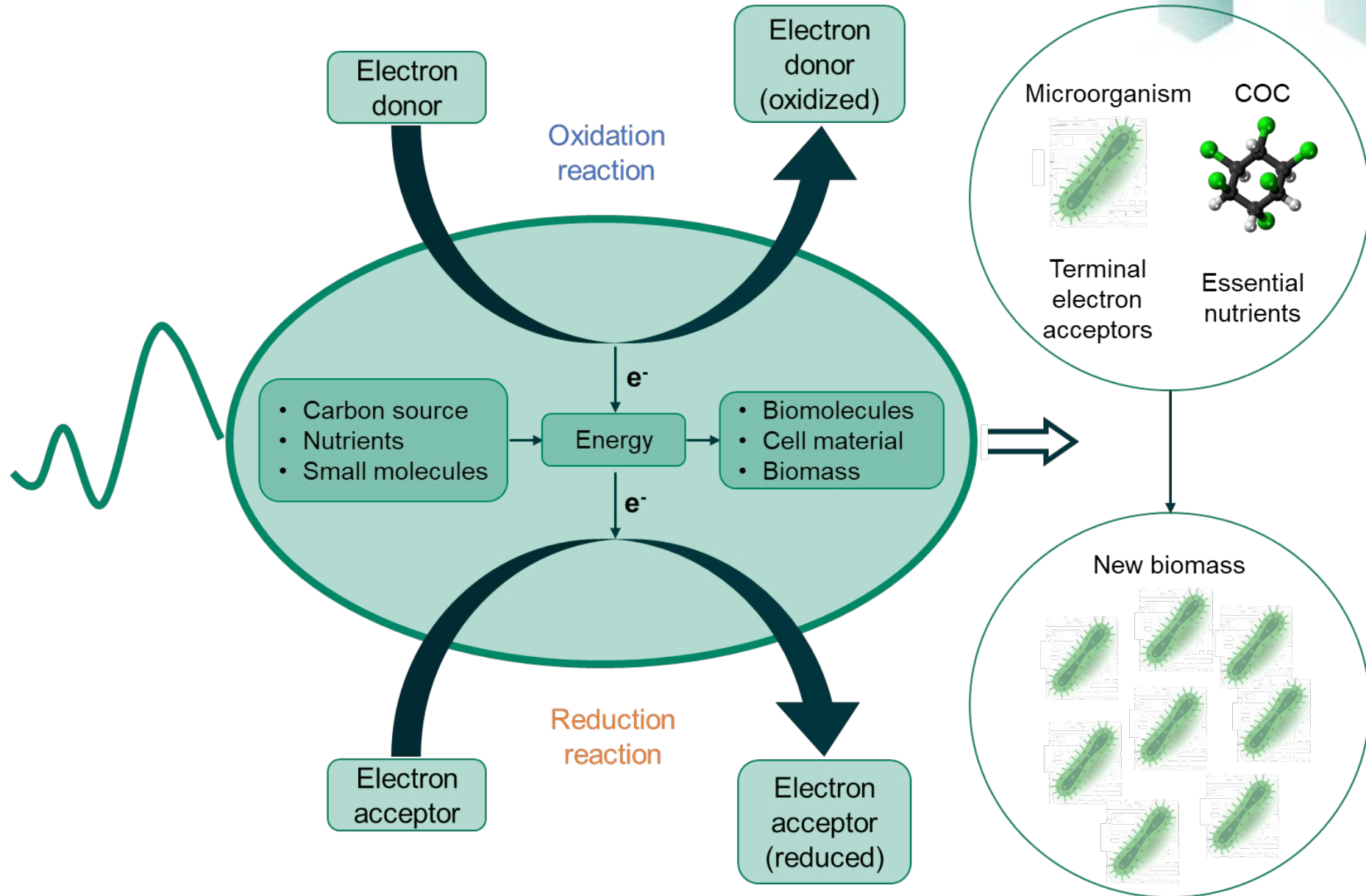
## POSSIBLE BIOREMEDIATION TECHNIQUES



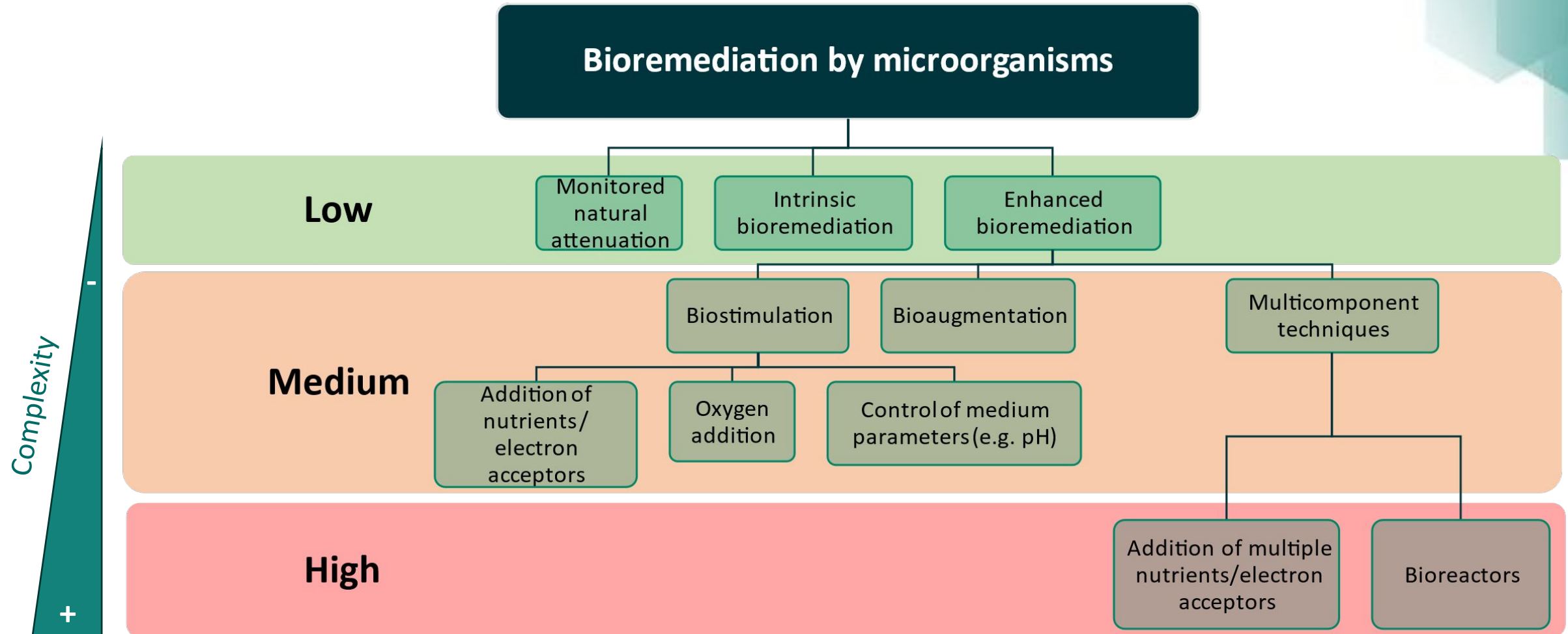
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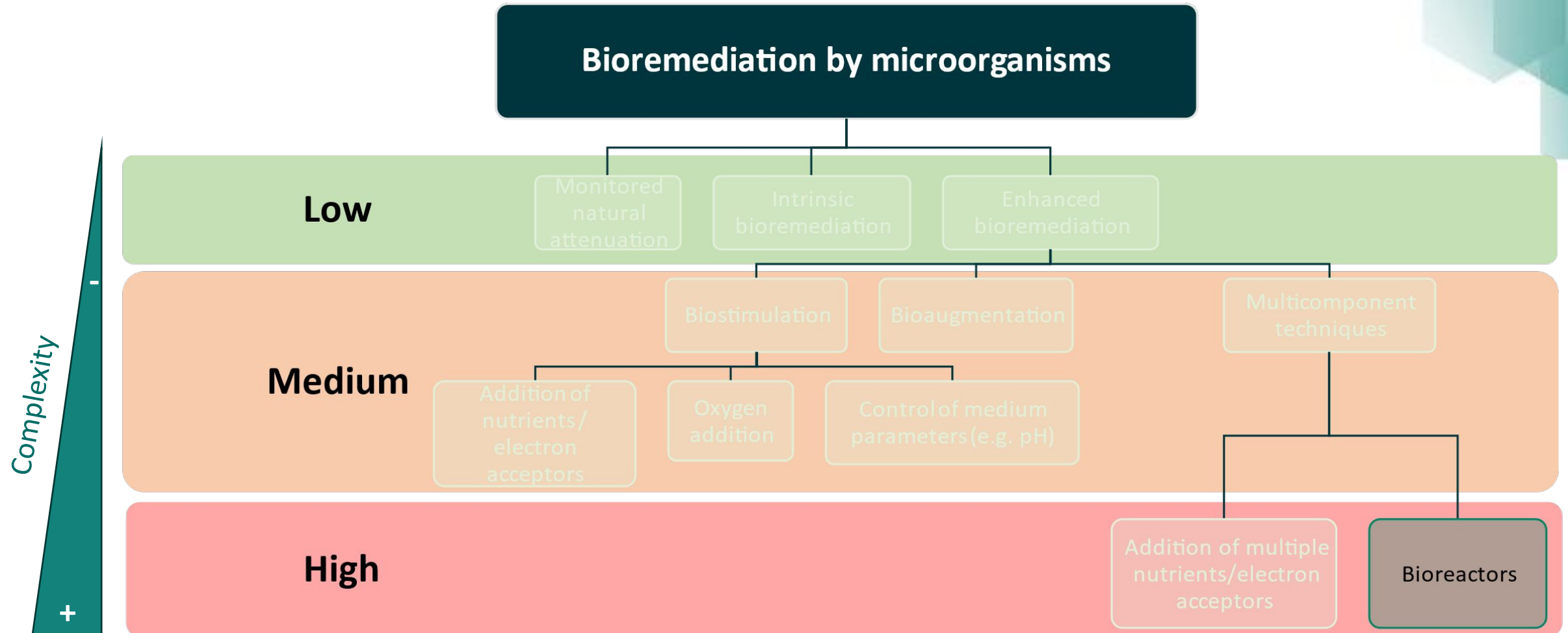
## METABOLISM OF MICROORGANISMS



## BIOREMEDIATION BASED ON MICROORGANISMS

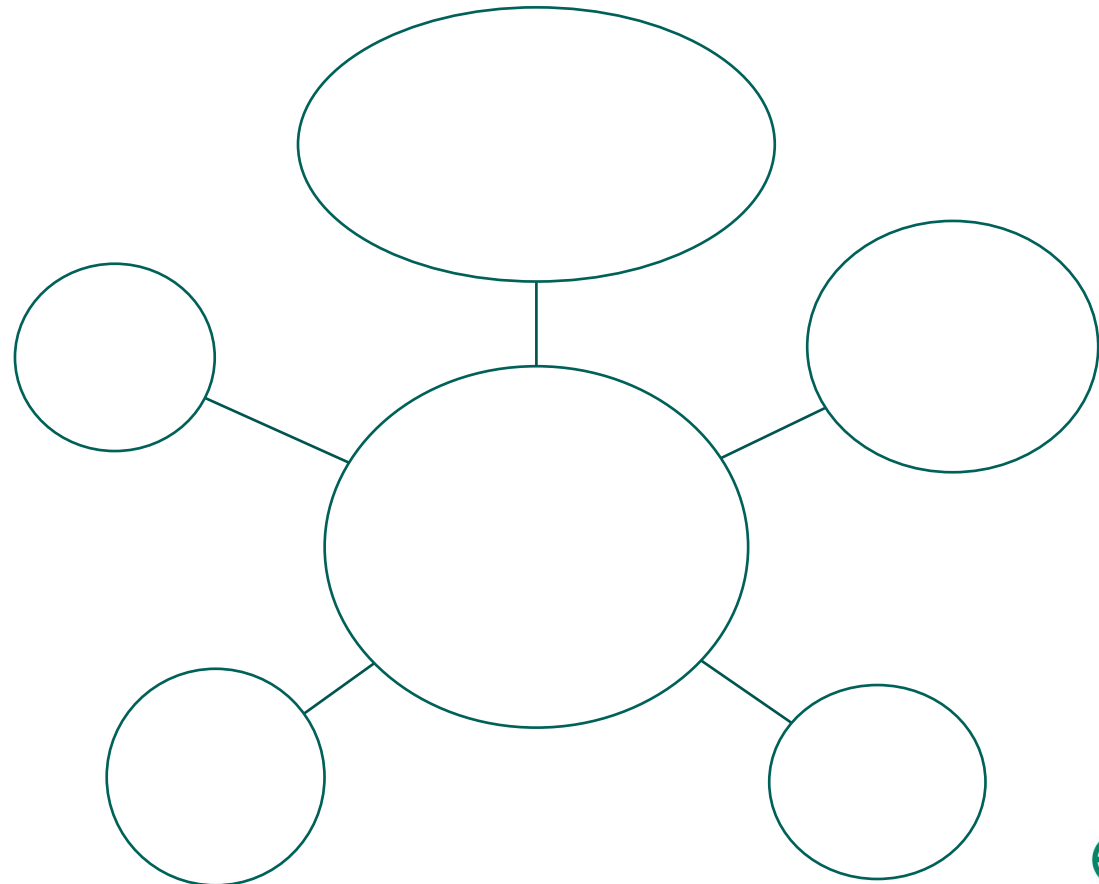
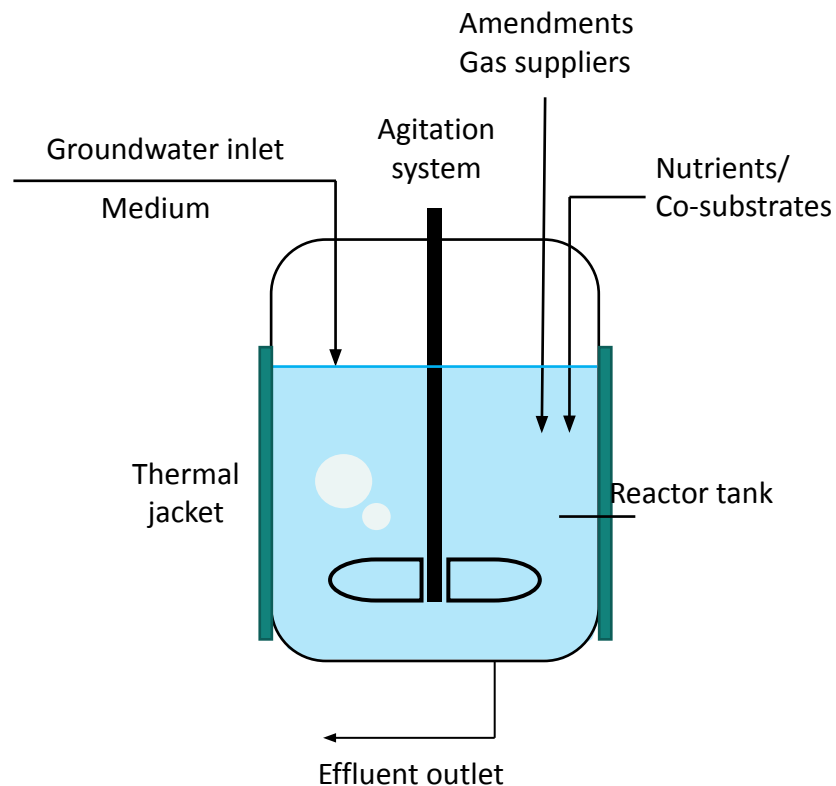


## BIOREMEDIATION BASED ON MICROORGANISMS



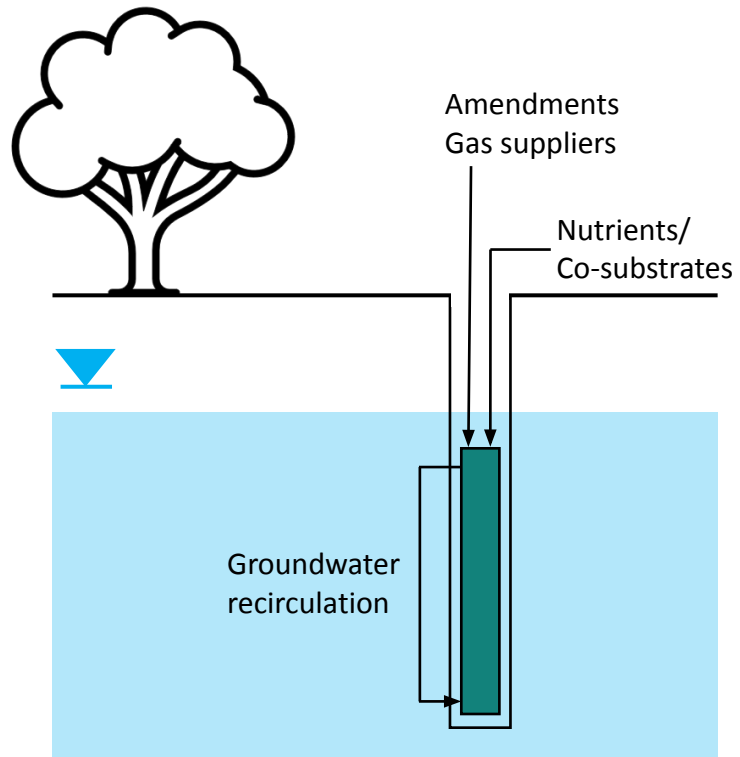
## BIOREACTOR AS REMEDIATION SYSTEM

A bioreactor is a biotechnological device capable of producing a controlled and isolated environment that guarantees and maximizes the growth of a culture of microorganisms that carry out the degradation of the contaminants of interest in the aquifer



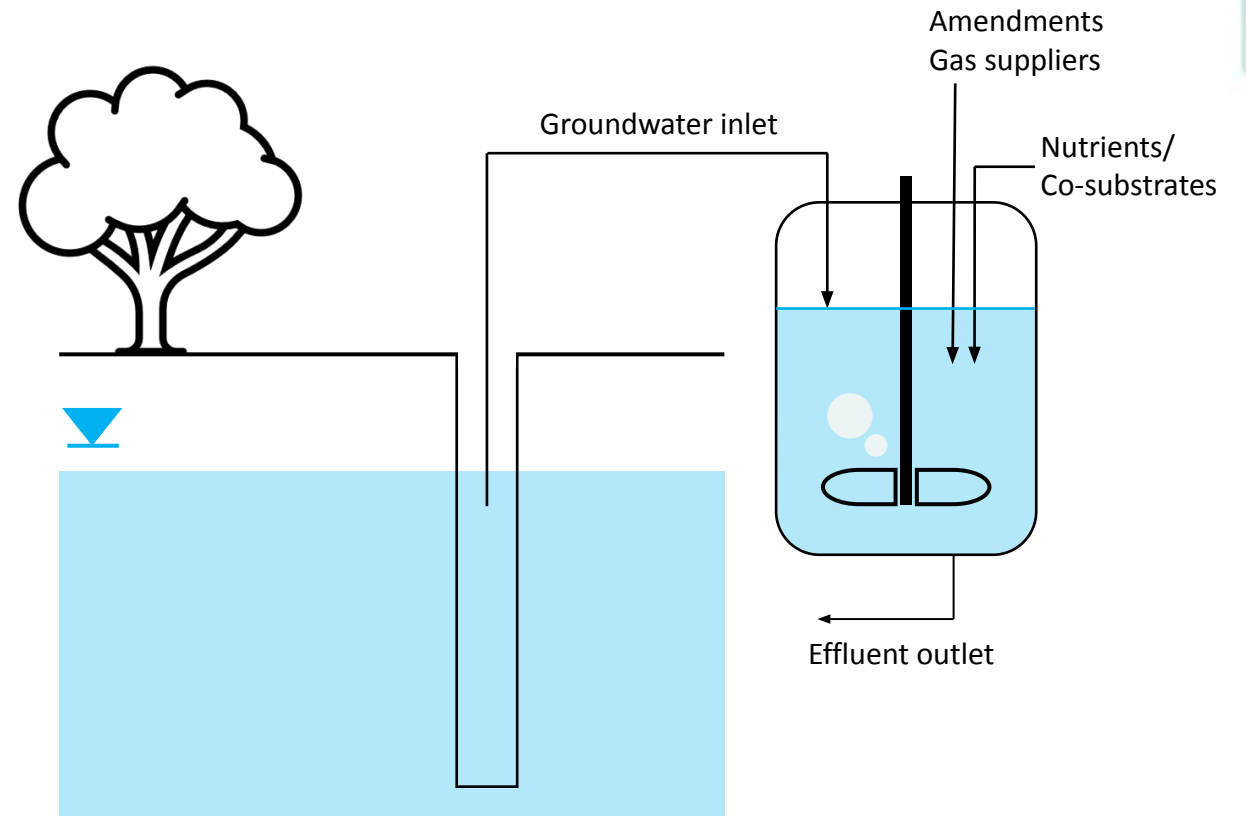
## BIOREACTOR CONFIGURATIONS

### *In-situ* bioreactor



Key. K. C. et. al. – RS – 23 (2013) 55-84

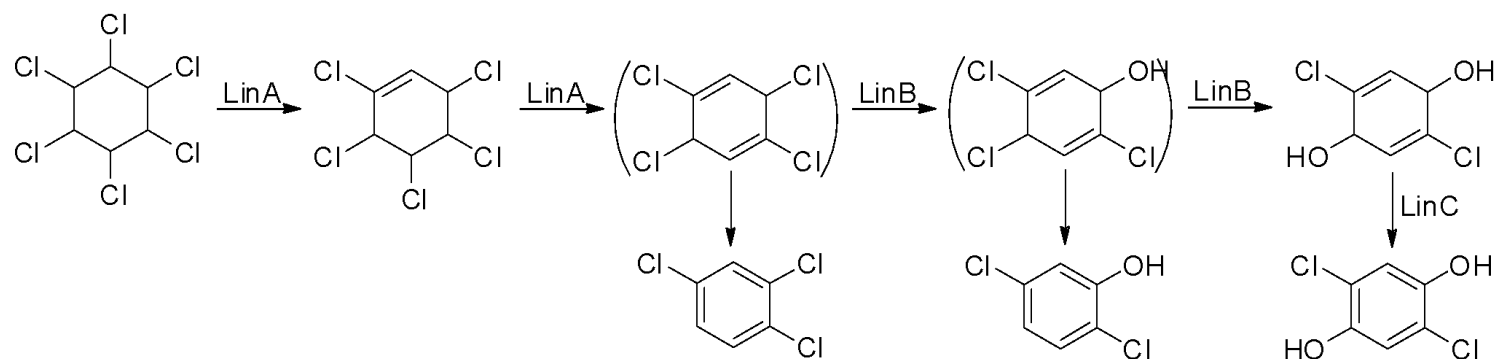
### *Ex-situ* bioreactor



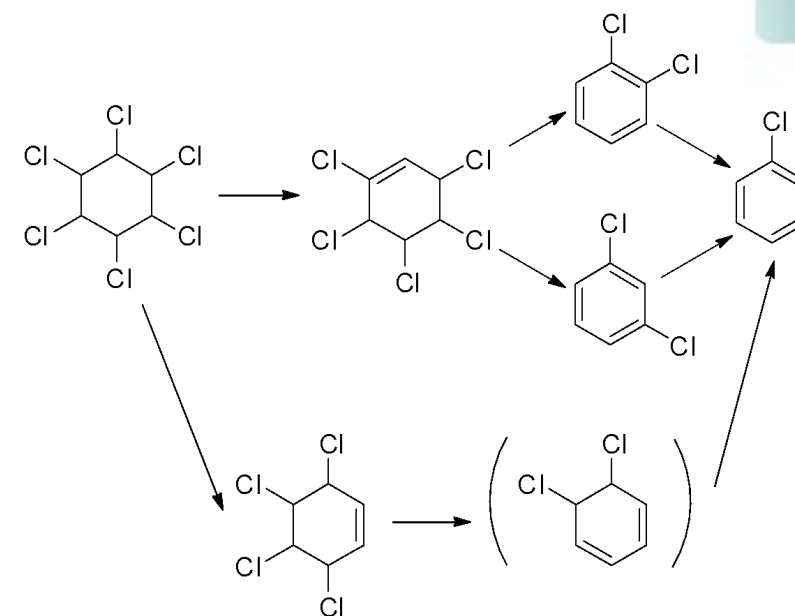
Quintero. J. C. – Chemosphere – 60 (2006) 319-326

## BIODEGRADATION PATHWAYS OF HCH

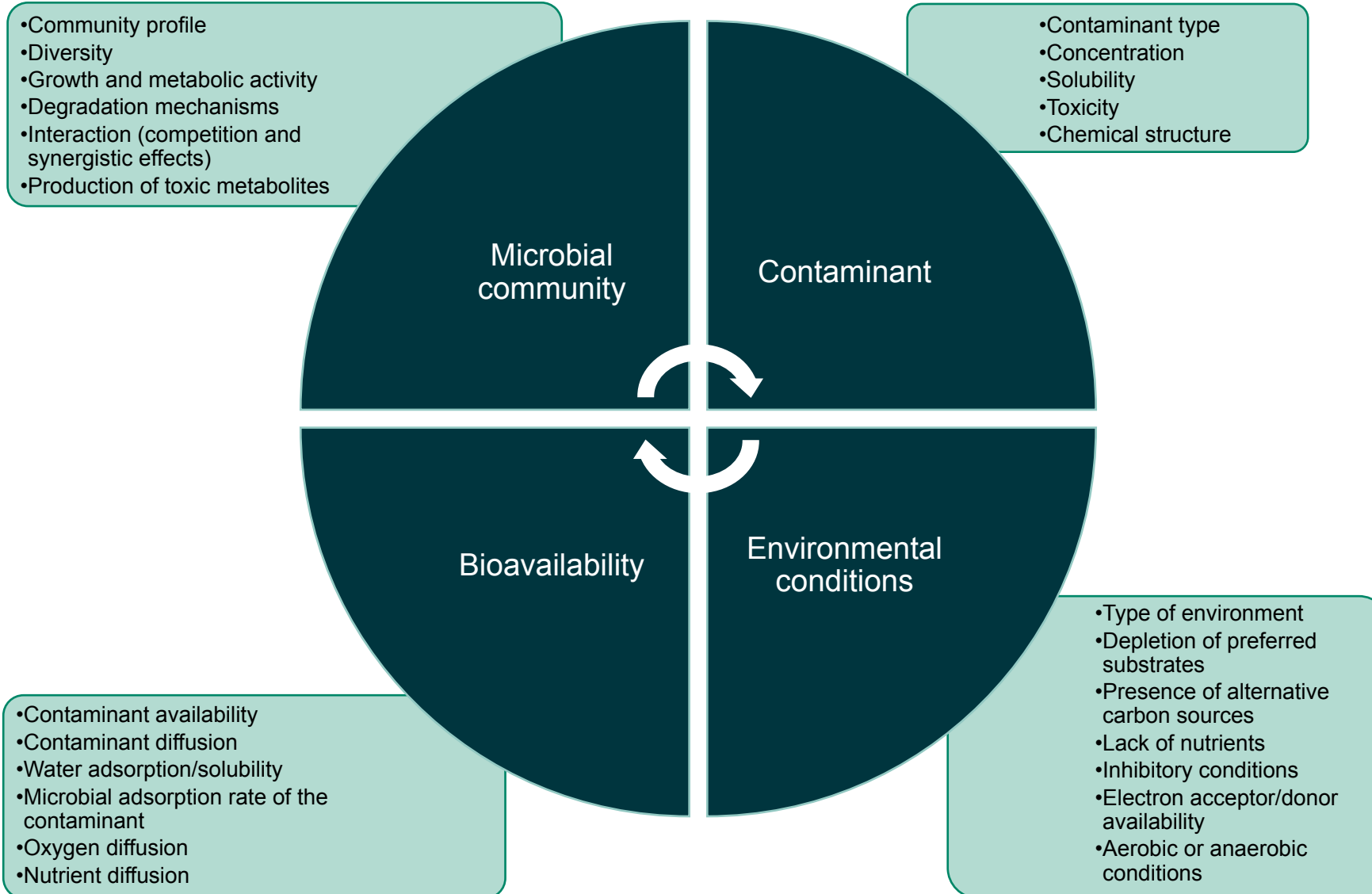
### Aerobic degradation pathway



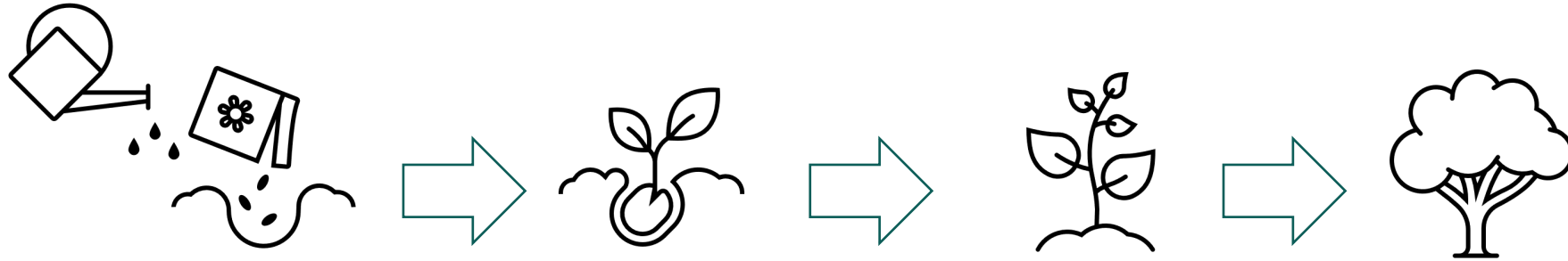
### Anaerobic degradation pathway



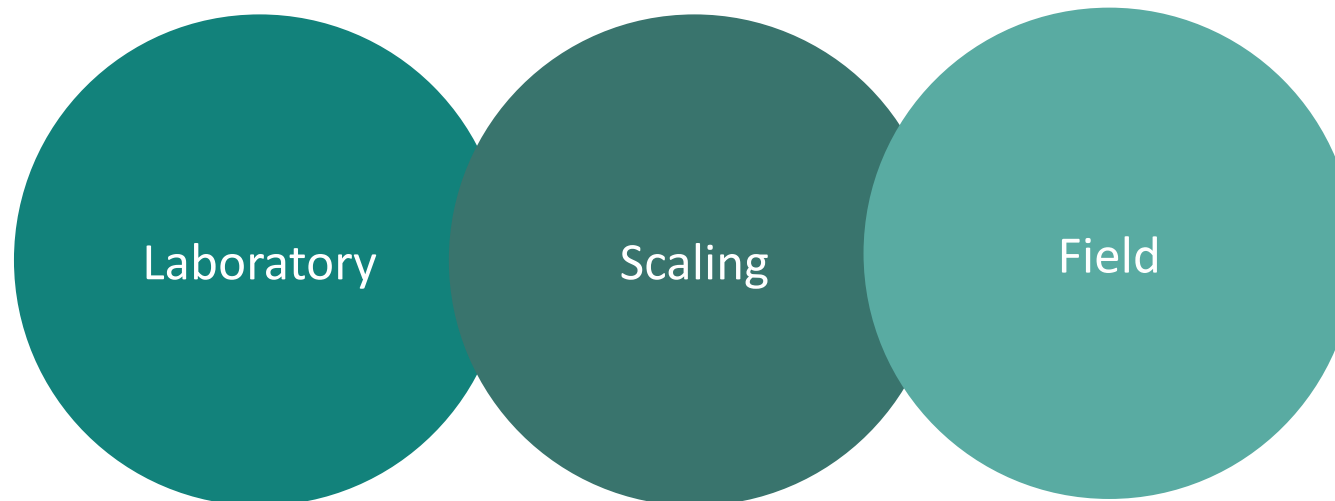
## FACTORS AFFECTING BIOREACTOR PERFORMANCE



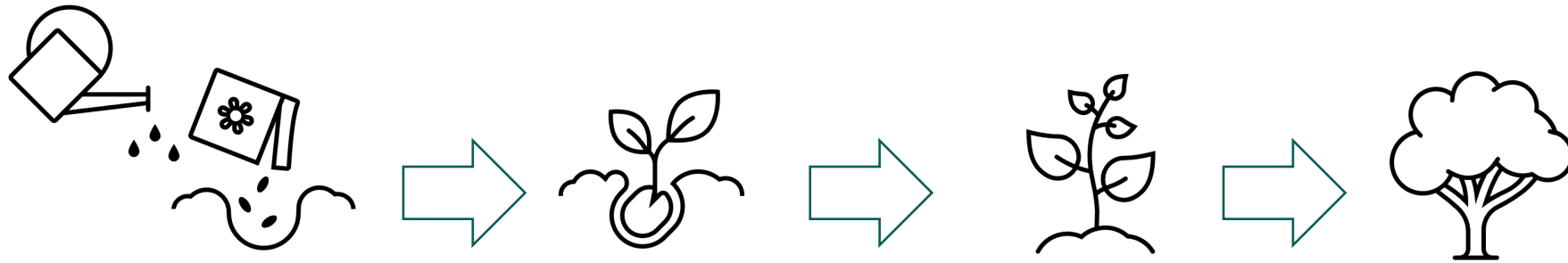
## SCALING PROCESS



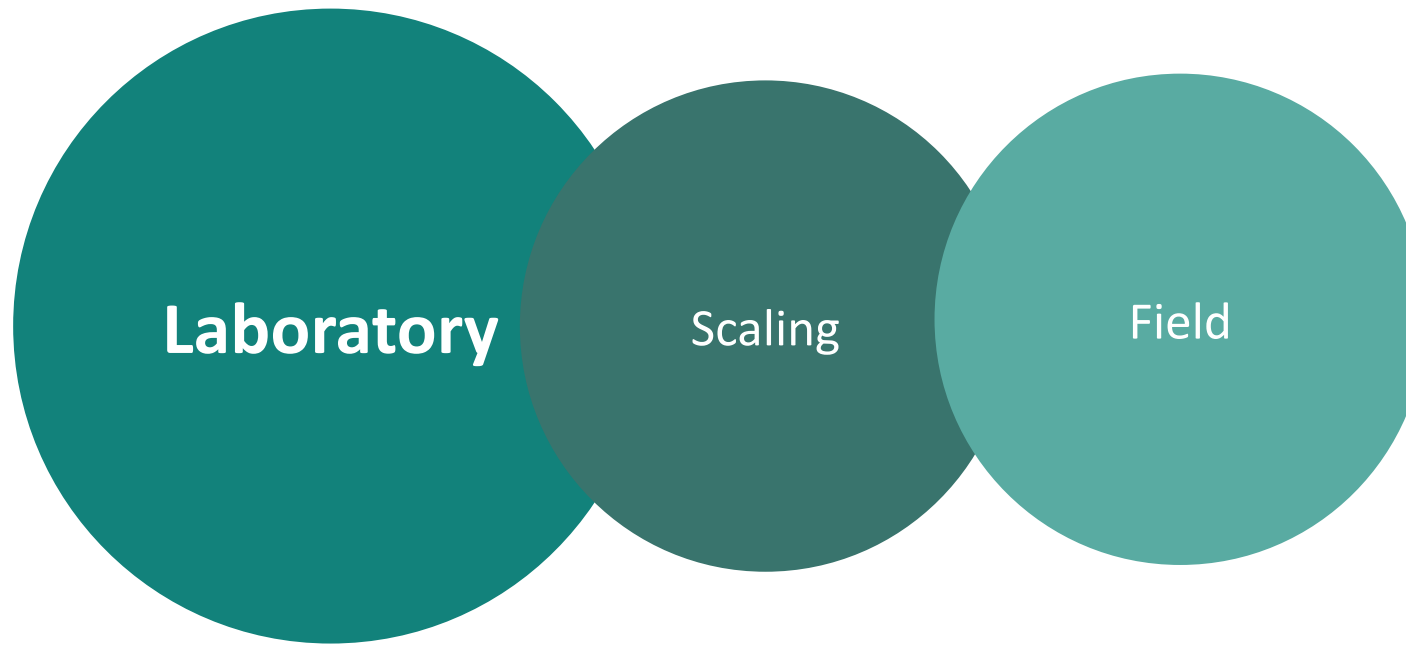
Increasing volume and sequential optimization of parameters...



## SCALING PROCESS



Increasing volume and sequential optimization of parameters...



## OBJECTIVES

Study, design and development of bioreactor for the *in-situ* remediation of groundwater in the Bailin aquifer

2021

2024



1



2



3



4



5



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Study, design and development of bioreactor for the *in-situ* remediation of groundwater in the Bailin aquifer

2021

2024

1

### Characterization of inoculum candidates

- ☐ Sample collection
- ☐ Sample preparation
- ☐ Sample characterization
  - Total biomass
  - Specialized biomass
  - Diversity and activity
  - Toxicity

2

### Additional characterization of inoculum candidates

- ☐ Specialized biomass
- ☐ Mixed cultures (Candidate + P168)

3

### Biostimulation and bioaugmentation experiments

- ☐ Biostimulation
  - P168 abiotic control
  - P168 biotic control
  - P168 + nutrients/amendments
- ☐ Bioaugmentation
  - P168 + Pool1 + nutrients/amendments
  - P168 + Pool2 + nutrients/amendments

4

### Lab-scale bioreactor

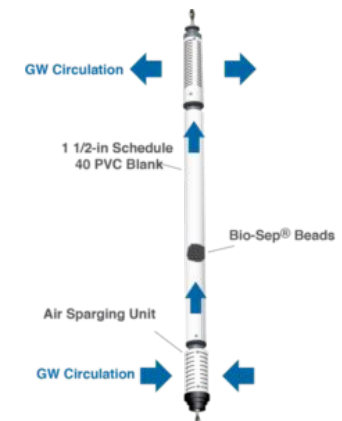
- ☐ Design
- ☐ Variable adjustment
- ☐ Optimization



5

### Field bioreactor

- ☐ Design
- ☐ Construction
- ☐ Field test optimized inoculum



Laboratory

Aerobic



Anaerobic

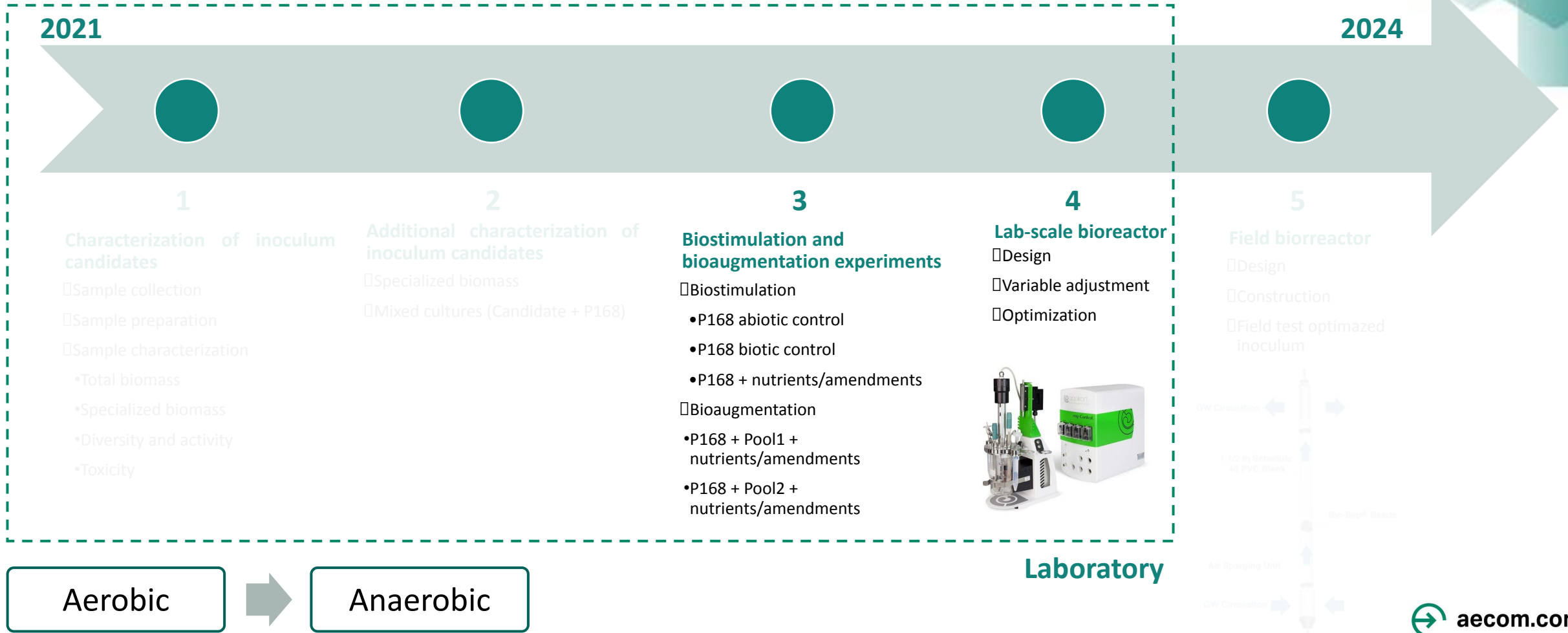
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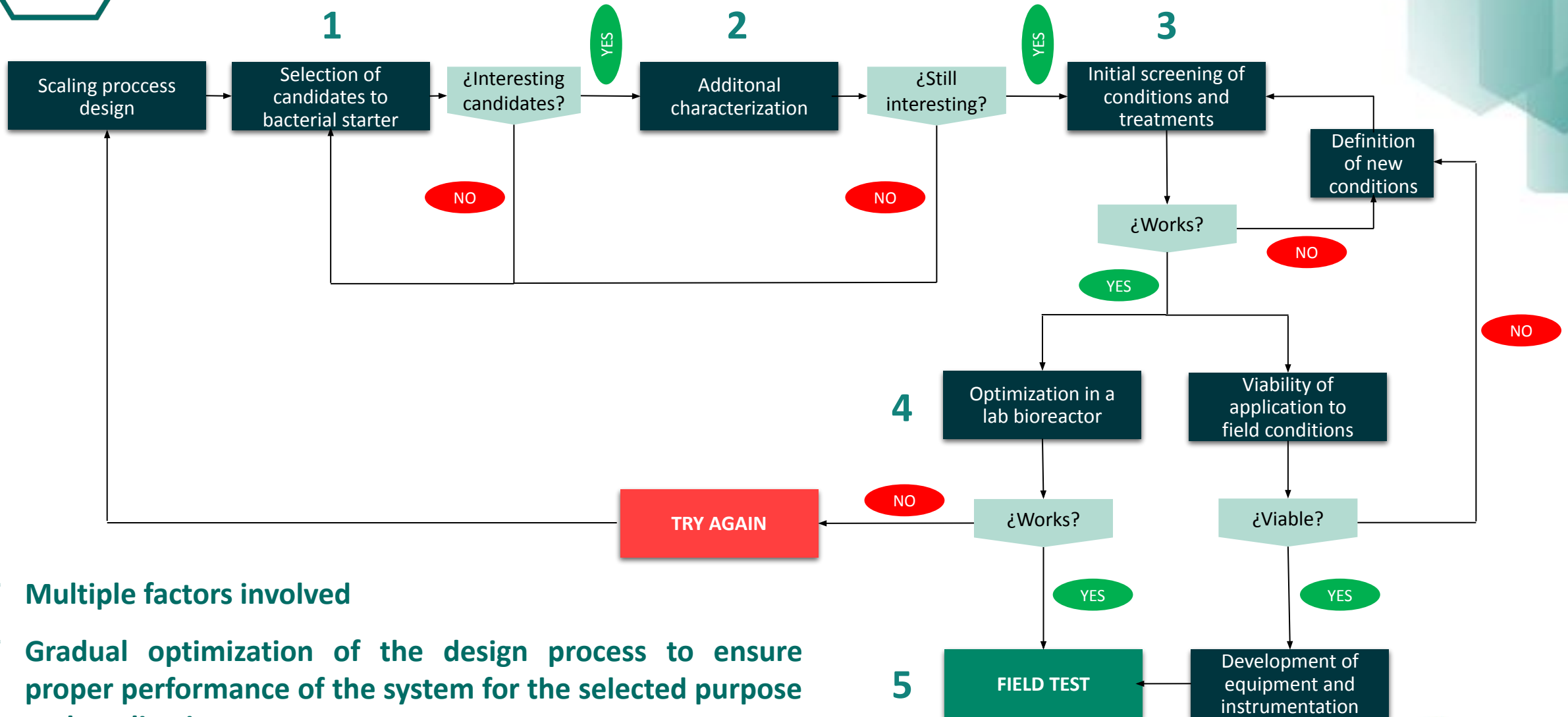


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Study, design and development of bioreactor for the *in-situ* remediation of groundwater in the Bailin aquifer



## BIOREACTOR DEVELOPMENT: WORKFLOW

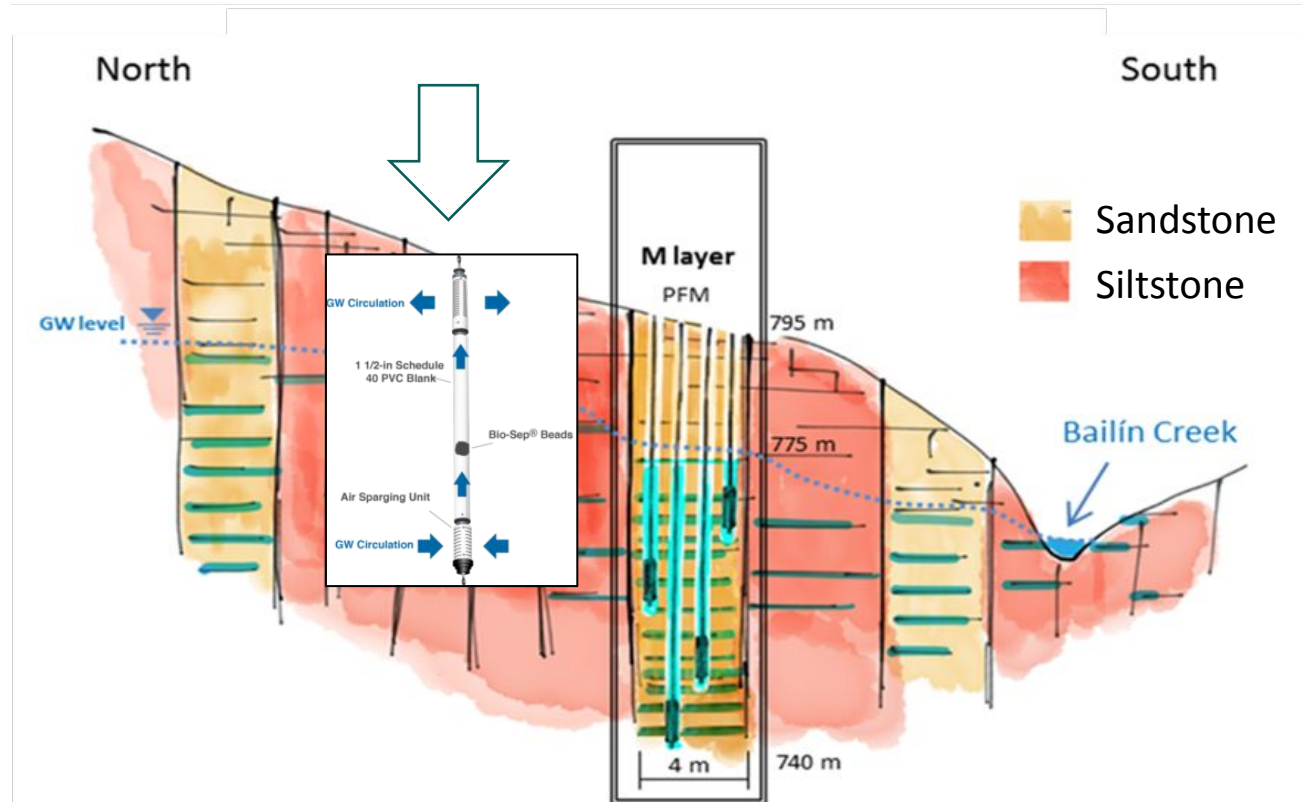


- ✓ Multiple factors involved
- ✓ Gradual optimization of the design process to ensure proper performance of the system for the selected purpose and application

## LOCATION



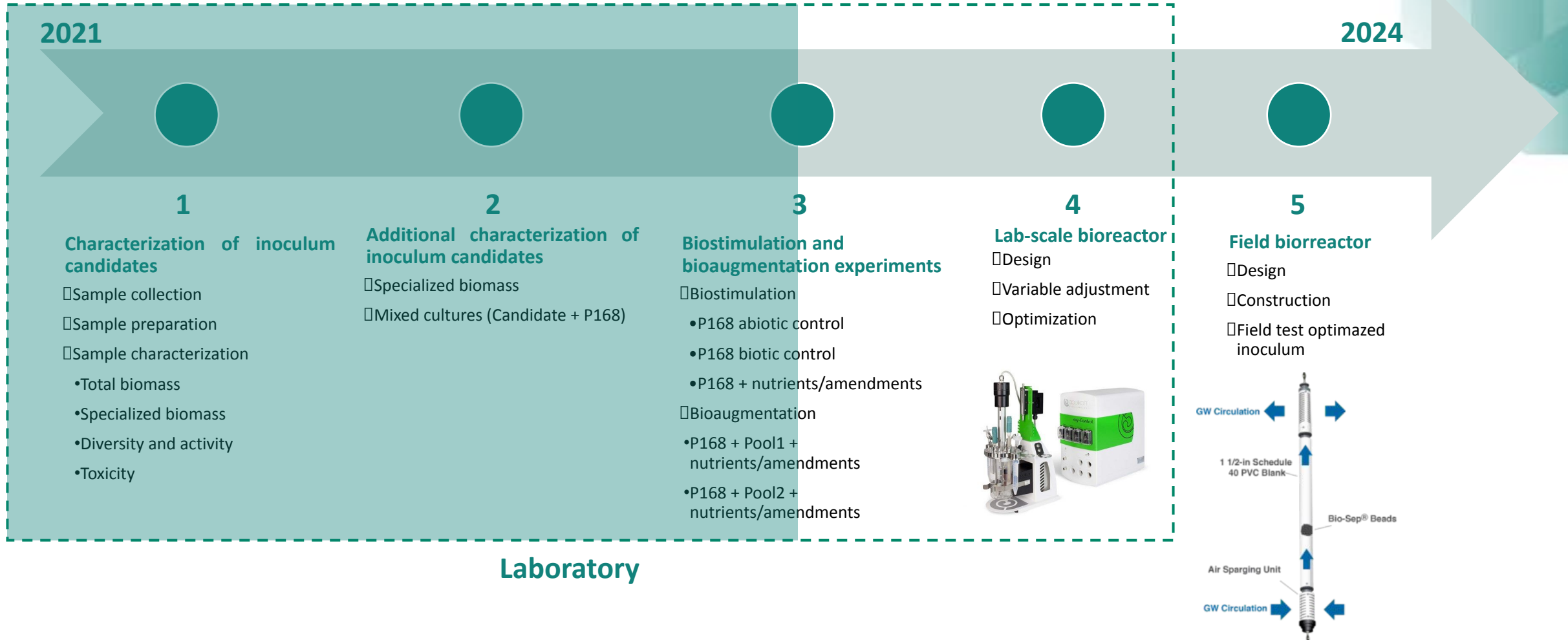
## BIOREACTOR CONFIGURATION



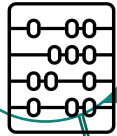
### ¿Why an *in-situ* bioreactor?

- Fractured bedrock, impact in groundwater
- Areas with ↓ contaminant concentrations
- Low hydraulic connectivity of siltstone layers
- More stable environment

## BIOREACTOR DEVELOPMENT: TIMELINE



## STEP 1: CHARACTERIZATION OF INOCULUM CANDIDATES



13 indigenous samples

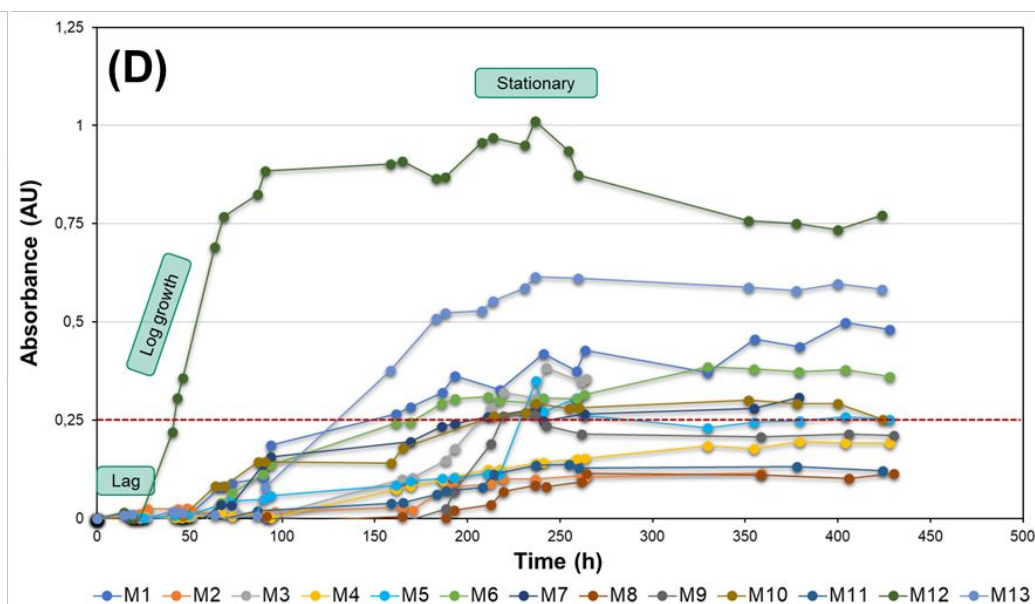
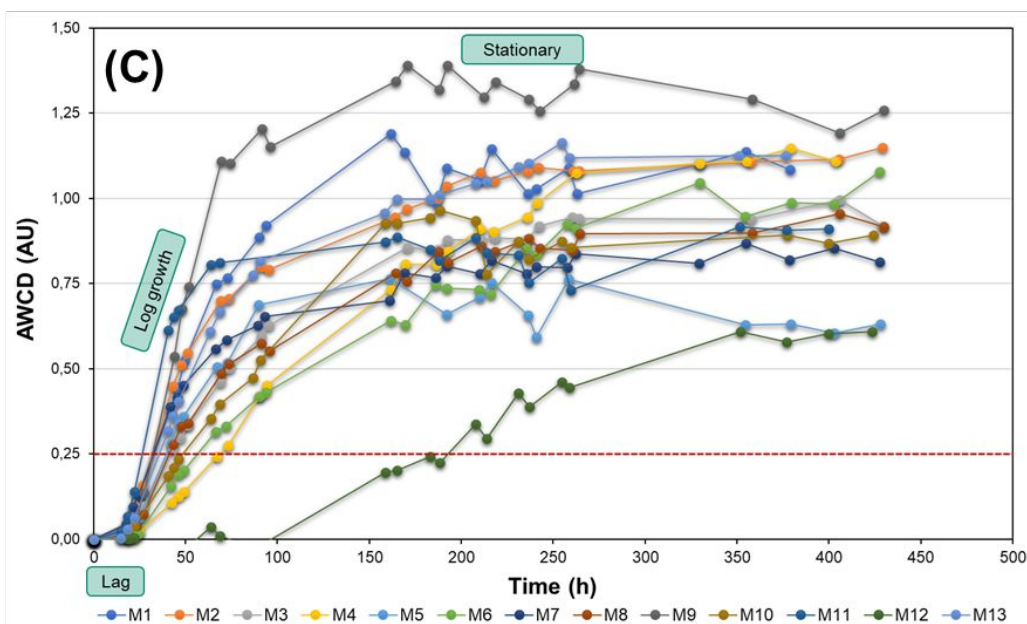
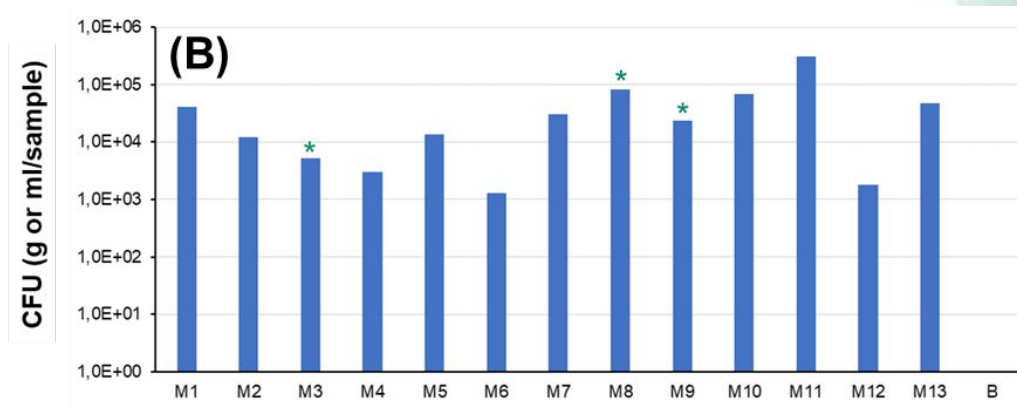
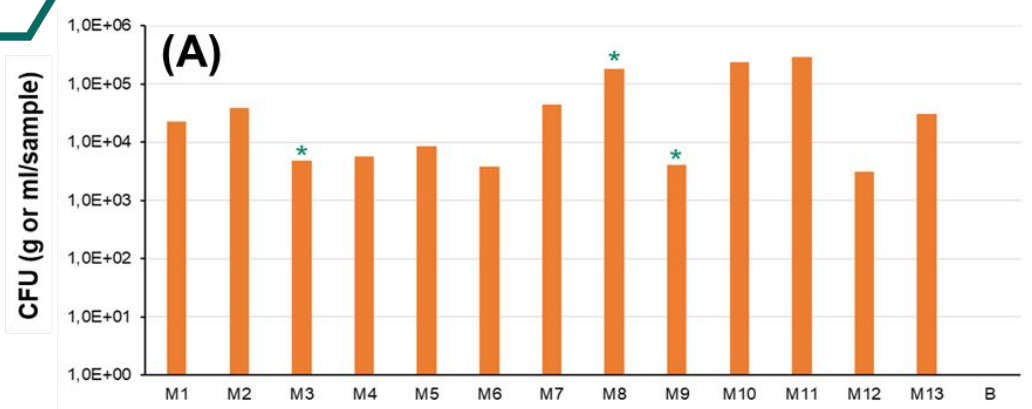


Different nature (water, soil, sediment and sludge)

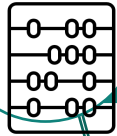


Creation of internal library for comparison

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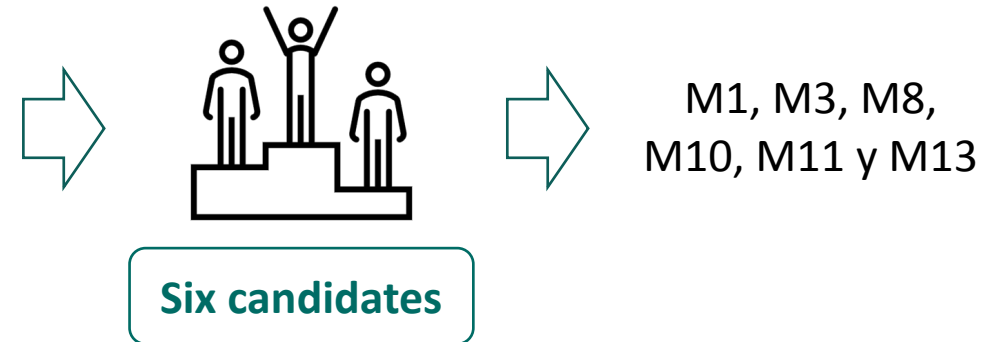
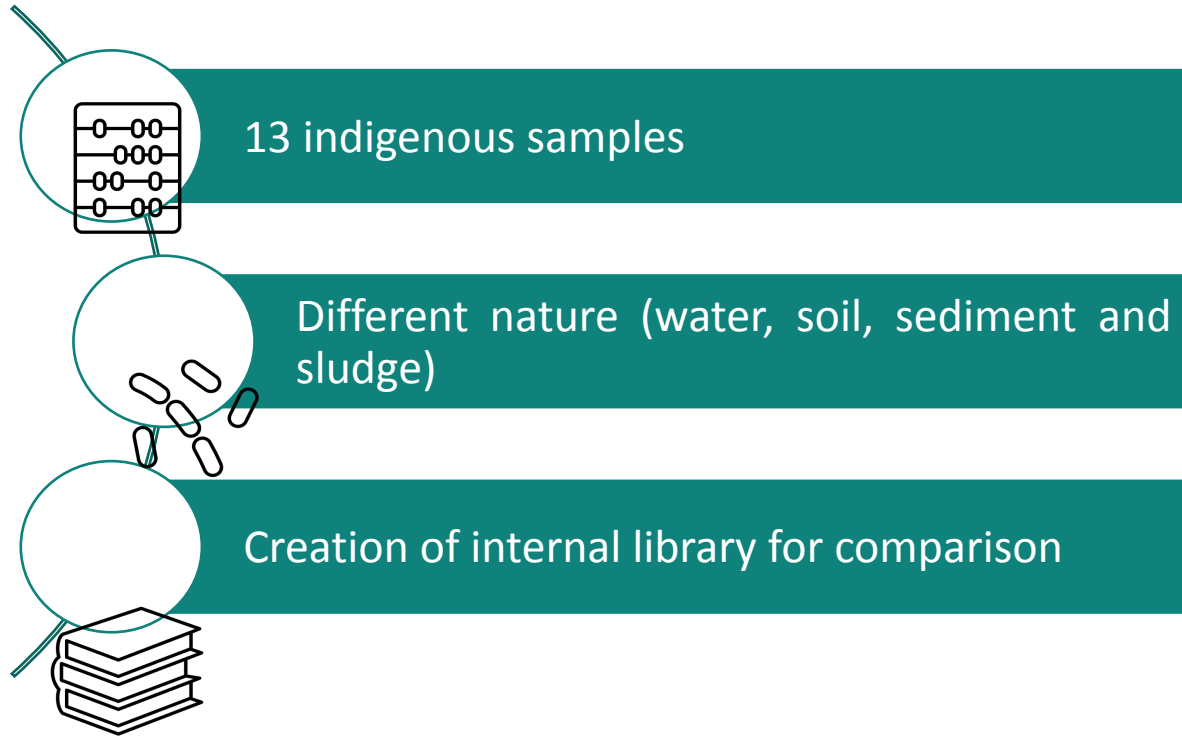


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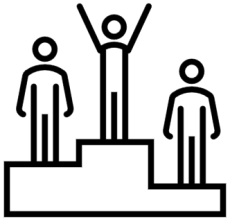


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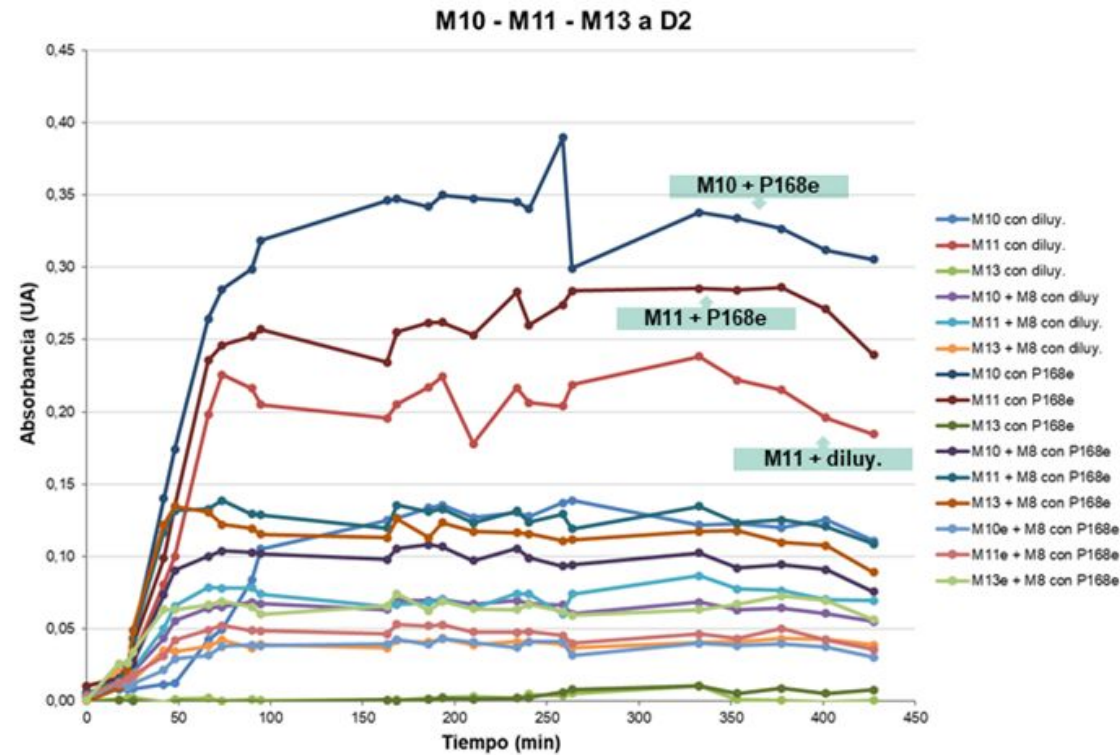


## STEP 2: ADDITIONAL CHARACTERIZATION OF INOCULUM CANDIDATES



Six candidates

Co-inoculation  
experiments



Samples selected for  
biostimulation experiments

Samples selected to be  
used as co-inoculants

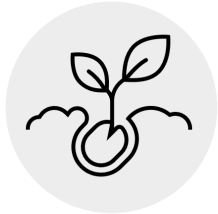
## STEP 3: BIOSTIMULATION AND BIOAUGMENTATION EXPERIMENTS



## CONCLUSIONS



Implementation of a bioreactor as remediation system is **not a straightforward process** that requires a deep understanding of the medium and factors affecting bioreactor performance



The design of a bioreactor accounts for a **sequential scaling process** where **parameters may be carefully optimized and controlled** to ensure a proper system efficiency



The development of an efficient bioreactor is a **long-term process** where microbial communities may be **gradually adapted to environmental site conditions** in order to ensure microbial growth and improve rates of biodegradation



**Interesting samples** have been found in the Bailin aquifer to **continue with the scaling process** for the potential implementation of a field bioreactor



THANK YOU FOR YOUR ATTENTION

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