USING HYDROGEOBIOCELLS FOR THE IN-SITU BIOLOGICAL TREATMENT OF CAH CONTAMINATED GROUNDWATER IN AREAS WITH LOW HYDRAULIC GRADIENTS

Tom Claes (LVM), Ine Arits (RSK), Luc Lebbe (Ugent),
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Contents

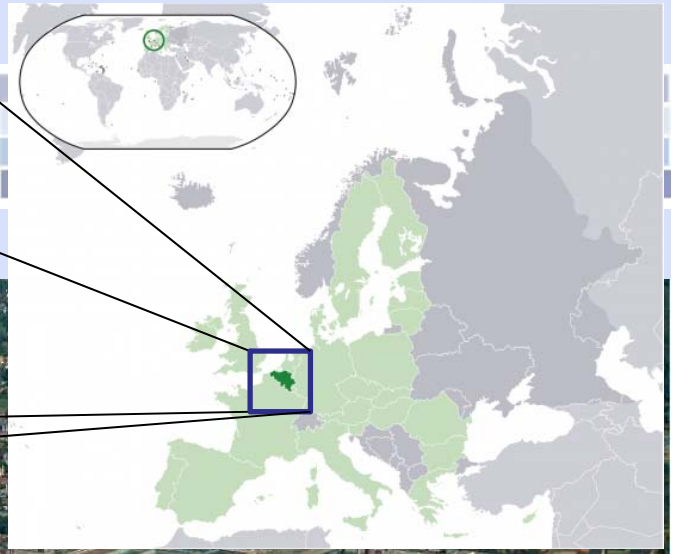
- Background
- History / Research
  (2 technological innovations)
- LIFE+ project
  (Financial support EC)
- Expected results

BACKGROUND

- Production plant of MVC: soil and groundwater are contaminated with chlorinated CAHs with an emphasis on 1,2-dichloroethane (12DCA)
- CAHs: the most difficult and expensive group to remediate because of their physical and chemical characteristics (depth > 50m)
- Low groundwater flow velocities
- High Fe-conc in aquifer: up to 150 ppm
- Traditional remediation techniques are often inadequate, time-consuming and expensive

Project Location:

- Tessenderlo (Belgium)



HISTORY / RESEARCH

- **DEVELOPMENT OF A 'MULTIDECHLORINATING' CULTURE**

- DEVELOPMENT OF THE 'HGB-CELL'

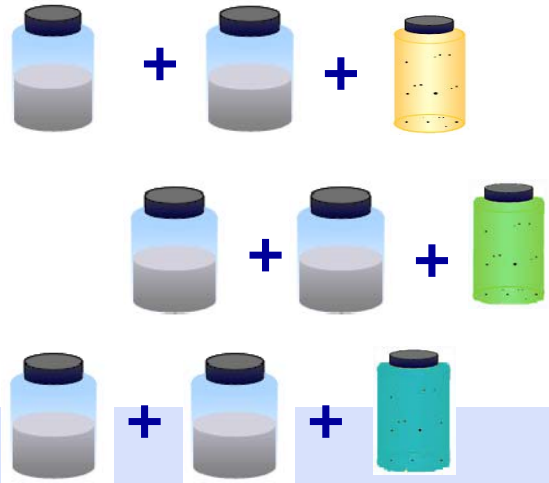
SEARCH FOR AN APPROPRIATE BIOAUGMENTATION CULTURE:

MULTIDECHLORINATING ANAEROBIC CULTURE:

LABSCALE ENRICHMENT EXPERIMENTS

SEARCH FOR AN APPROPRIATE BIOAUGMENTATION CULTURE

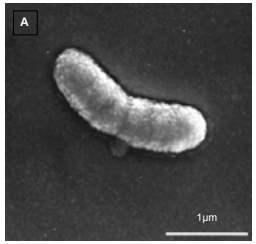
- COMBINATION OF DIFFERENT CULTURES WITH DECHLORINATING CAPACITY
  - PURE CULTURE *Desulfitobacterium dichloroeliminans*
  - AQUIFER MATERIAL FROM CONTAMINATED SITES
- DEVELOPMENT OF APPROPRIATE NUTRIENT SOLUTION



1,2-DCA → ETHENE
PCE → ETHENE

ANAEROBIC

KEY PLAYERS IN THE MIXED CULTURE:

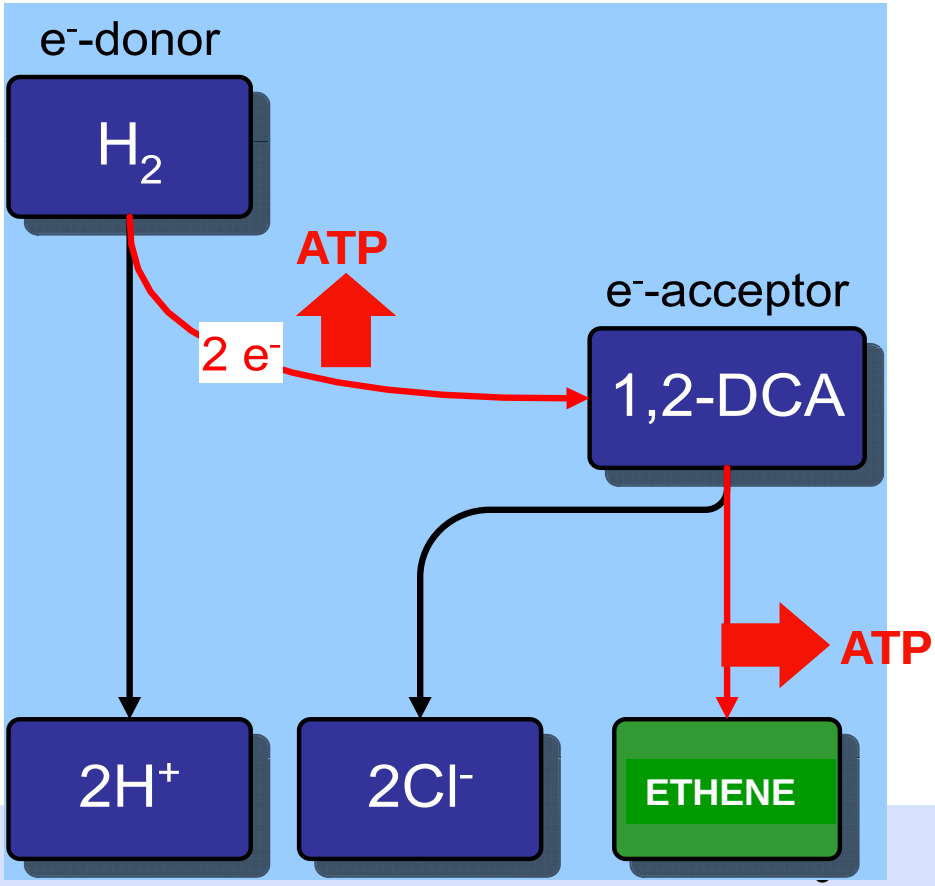


De Wildeman et al., 2003

- *DESULFITOBACTERIUM DICHLOROELIMINANS* STRAIN DCA1: DEGRADATION OF **1,2-DCA**
- *DEHALOCOCCOIDES* SPECIES: STEPWISE DEGRADATION OF **PCE AND TCE**
- ACCOMPAGNYING BACTERIA FOR PRODUCTION OF VITAMINS, HYDROGEN ...

KEY PLAYERS IN THE MIXED CULTURE:

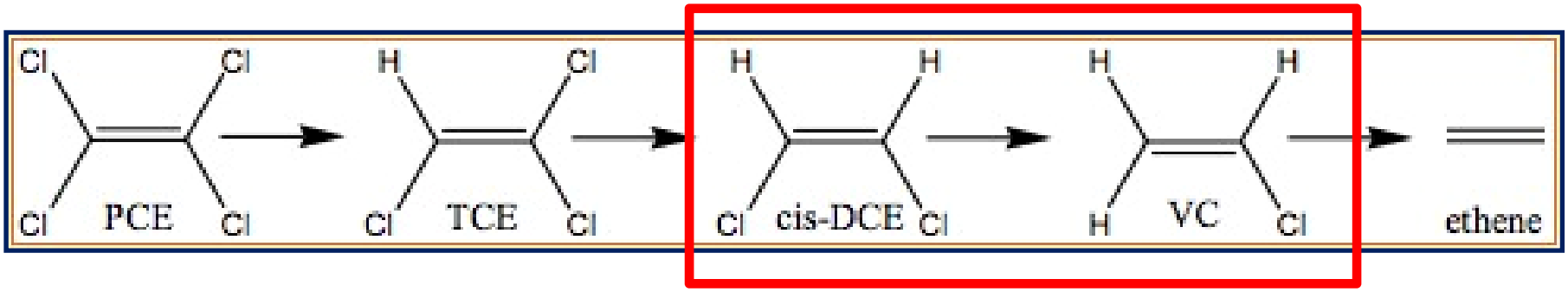
- *DESULFITOBACTERIUM DICHLOROELIMINANS* STRAIN DCA1 (De Wildeman et al., 2003)
- ISOLATED ON SITE
- **UNIQUE** BACTERIUM FOR THE DEGRADATION OF **1,2-DCA**
- NO ACCUMULATION OF TOXIC INTERMEDIATES



KEY PLAYERS IN THE MIXED CULTURE:

- *DEHALOCOCCOIDES* SPECIES: STEPWISE DEGRADATION OF **PCE AND TCE**

$$R\text{-}Cl + 2[H] \rightarrow R\text{-}H + H^{+} + Cl^{-}$$



HISTORY / RESEARCH

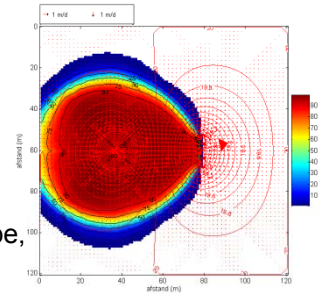
- DEVELOPMENT OF A 'MULTIDECHLORINATING' CULTURE

- **DEVELOPMENT OF THE 'HGB-CELL'**

DEVELOPMENT OF THE HGB-CELL

- LOW GROUNDWATER FLOW VELOCITY (1,7m/d)

→ HOW TO SPREAD BACTERIA/NUTRIENTS?



Prof. L. Lebbe, UGent

- INTENSIVE MODELLING (MOCDENS3D) RESULTED IN THE 'HYDROGEOBIOCELL' OR '**HGB-CELL'** (IN-SITU BIOREACTOR):
  - ❖ OPTIMISED CONFIGURATION OF PUMPING AND INJECTION WELLS + PUMPING SCHEME
  - ❖ OPTIMISED SPREADING AND CONTACT BETWEEN NUTRIENTS AND BACTERIA

LIFE PROJECT

« LVM-BIOCELLS »

PROJECT TITLE «LVM-BIOCELLS»

Financial Support:

- LIFE+ programme EC

Duration: Start: 01/01/2010 - End: 31/12/2014

Project's Implementors:

- Coordinating Beneficiary: LVM NV
- Associated Beneficiary(ies): RSK Benelux/ESA

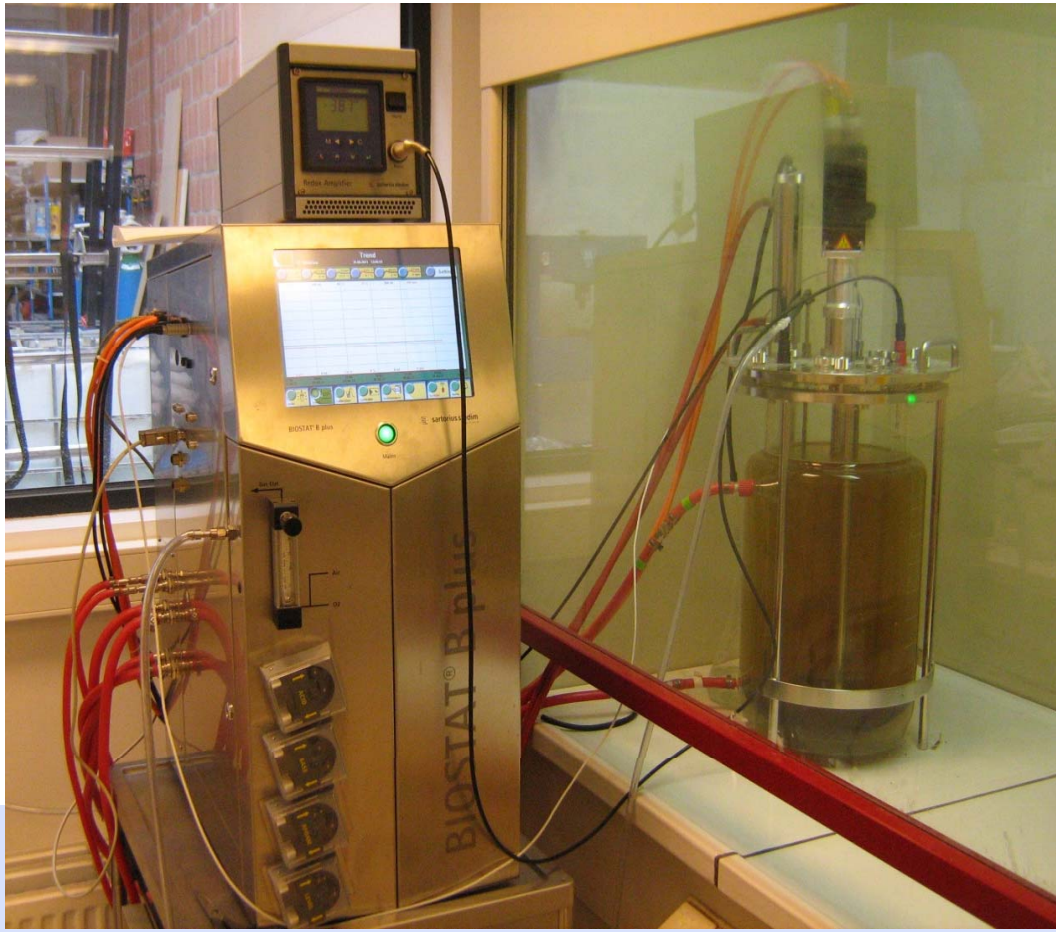
  Avecom NV

2 TECHNOLOGICAL INNOVATIONS:

- BIOREMEDIATION BY A UNIQUE BACTERIAL CULTURE ON FULL SCALE
- GROUNDWATERCIRCULATION BY ‘HYDROGEOBIOCELLS’ (HGB-CELLS) FOR IN-SITU REMEDIATION BY BIOSTIMULATION & BIO-AUGMENTATION

MULTIDECHLOROBAC PART 1

- UPSCALING OF THE GROWTH OF THE DECHLORINATING MICROBIAL CULTURE
- 10L → 100L → 1000L
- STARTED IN JAN 2011



MULTIDECHLOROBAC PART 2

- INVESTIGATING FEASIBILITY OF **ON SITE** BIOMASS GROWTH ON CAH FROM GROUNDWATER:

ADVANTAGES:

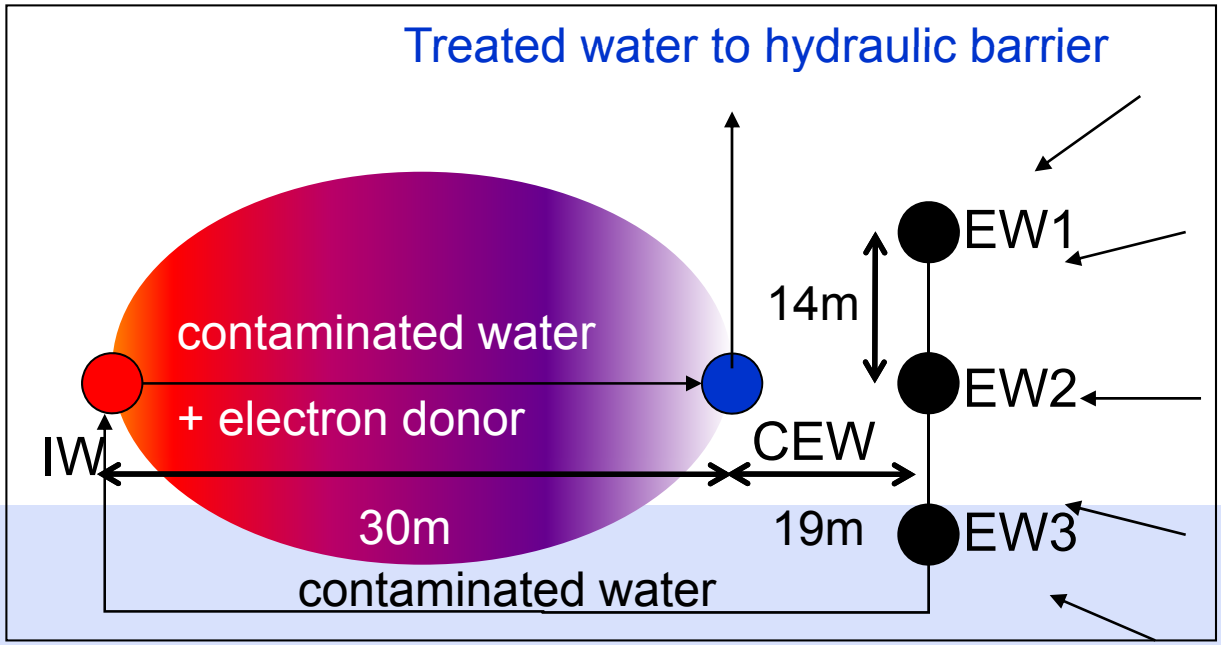
- NO COMMERCIALLY PRODUCED CAH NEEDED
- NO TRANSPORT OF THE CULTURE FROM PRODUCTION PLACE TO THE SITE

→ COSTS ↓

CARBON FOOTPRINT ↓

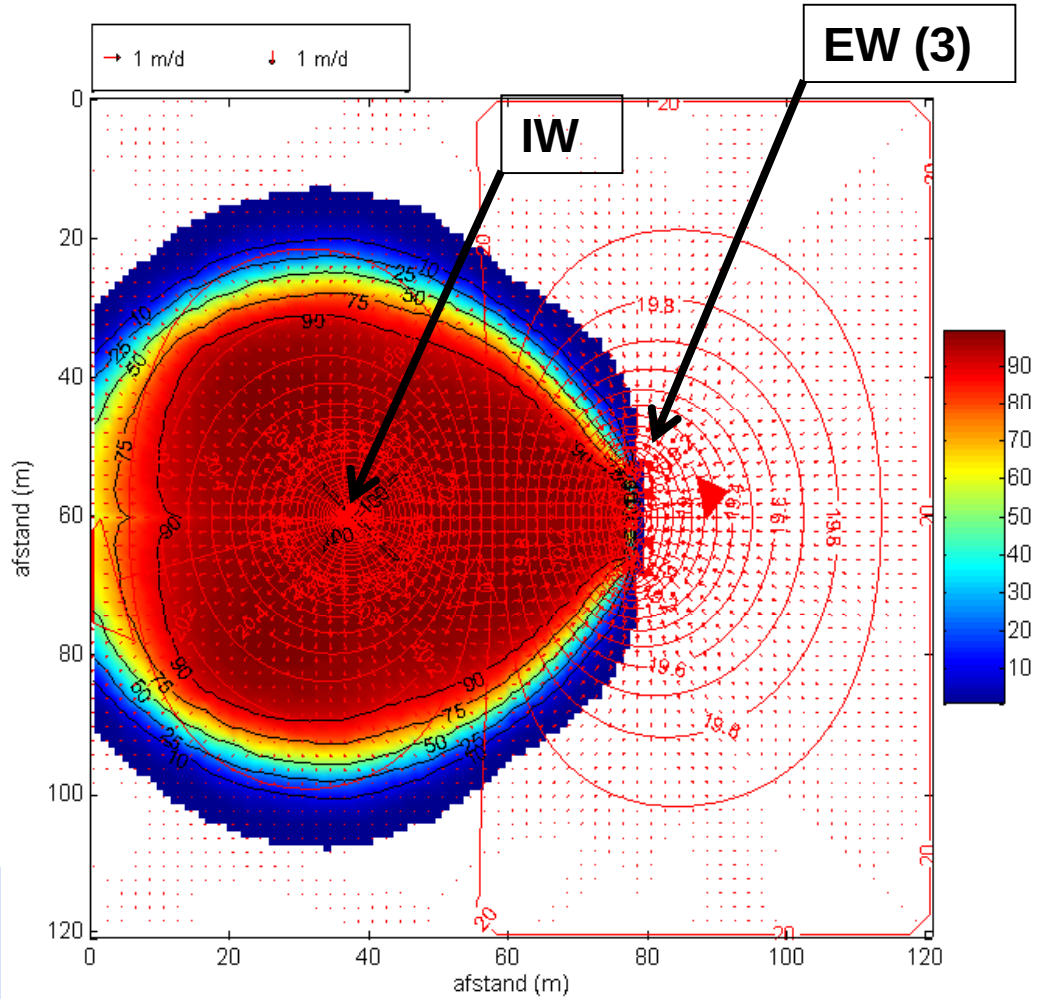
HGBcell - CONCEPT

- 3 extraction wells (EW) to pump the contaminated water
- 1 injection well (IW) at 'large' distance
- 1 central extraction well (CEW) to pump the treated water: QCEW = QIW = 3*QEW= 13,4 m³/h



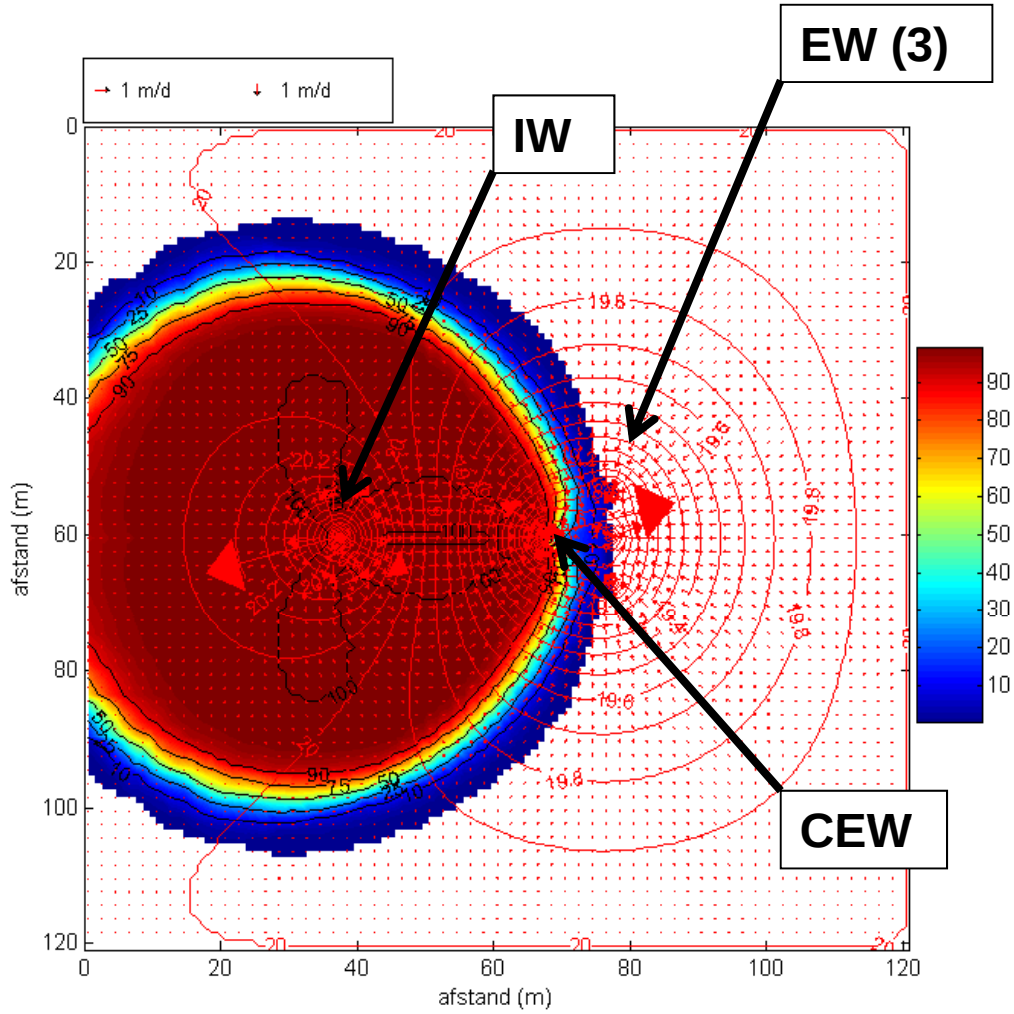
HGBcell - CONCEPT

- 1st phase:
  - injection + pumping on three wells
- Aim:
  - to provide the zone around the stagnation point with electron donor (=nutrolase)
- Legend:
  - Head and electron donor percentage
  - Horizontal cross section T = 120 d, Q = 26.4 m³/h



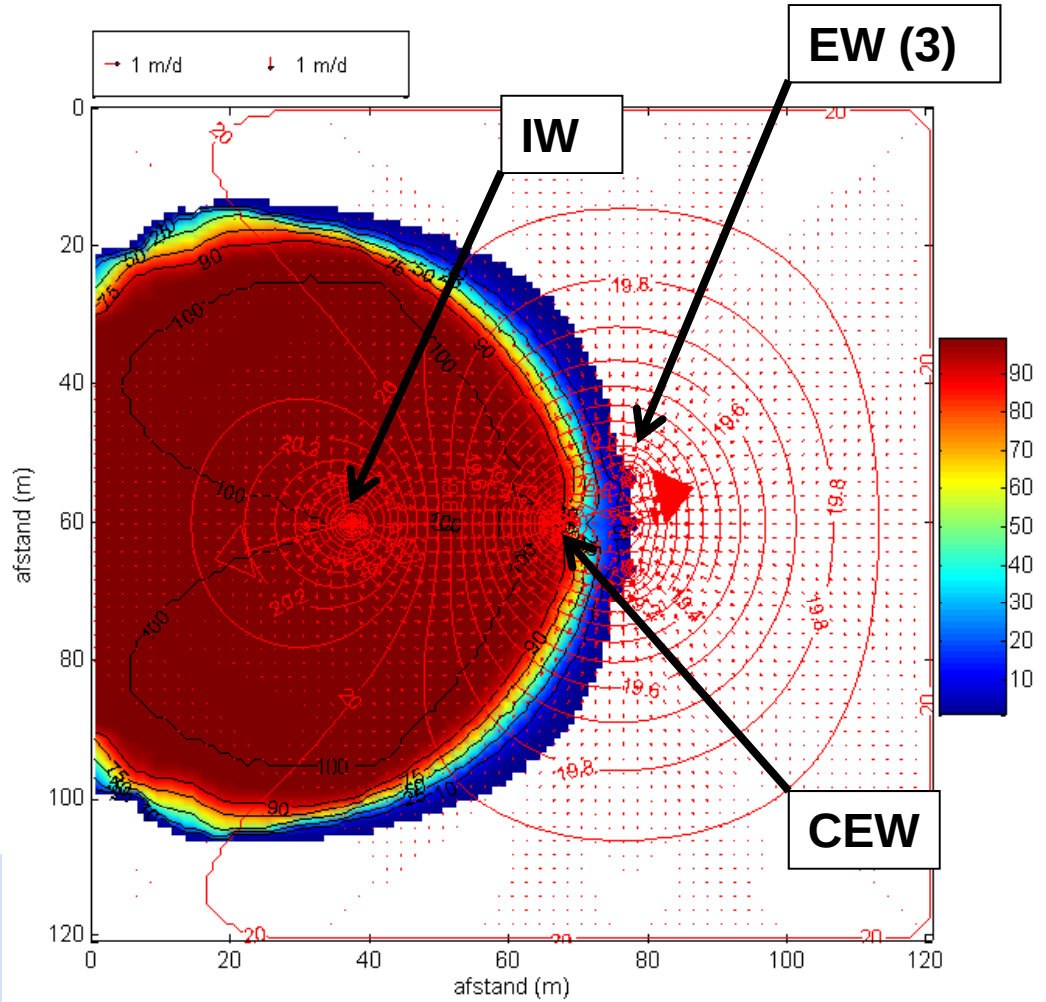
HGBcell - CONCEPT

- 2nd phase:
  - Start of withdrawal on the central extraction well (CEW) to the hydraulic barrier
- Aim:
  - Active clean up
- Legend:
  - Head and electron donor percentage
  - Horizontal cross section T = 180 d, Q = 13.2 m³/h

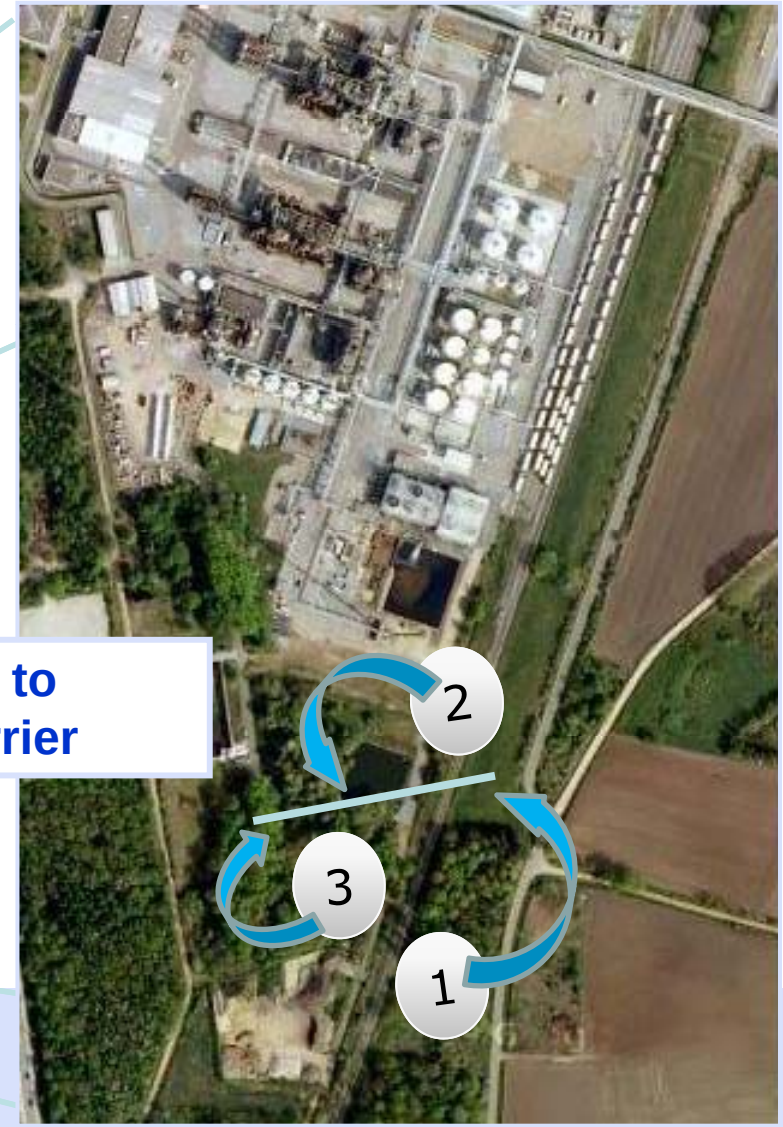


HGBcell - CONCEPT

- Active HGBcell
- Legend:
  - Head and electron donor percentage
  - Horizontal cross section
    T = 730 d, Q = 13.2 m³/h



HGBcells Geographically



HGBcell - STATUS

- 1st HGBcell is operational
  - Testruns of the system successfull
  - Nutrolase injection in coming weeks
- Phase 1 : biostimulation (low CAH conc)
- Phase 2 : bioaugmentation Multidechlorobac (high CAH conc)

EXPECTED RESULTS: TO DEMONSTRATE

1. **HGB-CELLS**:
    1) SOLUTION FOR THE USE OF IN SITU REMEDIATION TECHNIQUES IN AREAS WITH LOW NATURAL GROUNDWATER FLOW VELOCITIES
    2) DECREASE IN REMEDIATION COST AND ENERGY COST
    3) RESULT IN A BETTER WATER BALANCE AND LESS WATER EMISSIONS
2. THE OFF-SITE LARGE SCALE **PRODUCTION OF AN EMPOWERED DECHLORINATING MICROBIAL CULTURE** AND **BIOREMEDIATON ON THE FIELD** WILL BE ESTABLISHED
3. FEASIBILITY OF AN **ANAEROBIC ON-SITE BIOREACTOR** AS A BIOMASS PRODUCTION UNIT FOR A HGB-CELL

THANKS FOR YOUR ATTENTION QUESTIONS?

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