14th International HCH and Pesticides Forum

SÁEZ JIMÉNEZ, CRISTINA

Full Professor

Universidad de Castilla-La Mancha

UCLM Universidad de Castilla-La Mancha
CAMPUS DE EXCELENCIA INTERNACIONAL

DISMANTLING STRATEGIES FOR HIGHLY HCH-POLLUTED LANDFILL LEACHATE POND USING ELECTROCHEMICALLY ASSITED TECHNOLOGY

Isidro, J., Fernández-Cascán, J., Guadaño, J., <u>Sáez, C.</u>, Rodrigo, M.A

emgrisa

GOBIERNO DE ARAGON

Introduction


Old landfill
leachate pond
Sardas landfill


Old landfill
leachate pond
Sabiñánigo
reservoir

Old landfill leachate pond:

- **HPDE sheet and dimension of 50x25 m^2**
- **Thickness of more than 1 m of sludge (saturated and without compacting)**
- **Heterogeneous HCH contamination. From few mg/kg to dozen g/kg**
- **It is currently collecting runoff and leachate drained in the ditch and leachate pumped from boreholes, which includes contributions of DNAPL microdroplets**

CRITICAL dismantling

Risk of affecting groundwater and Sabiñánigo reservoir

CRITICAL dismantling

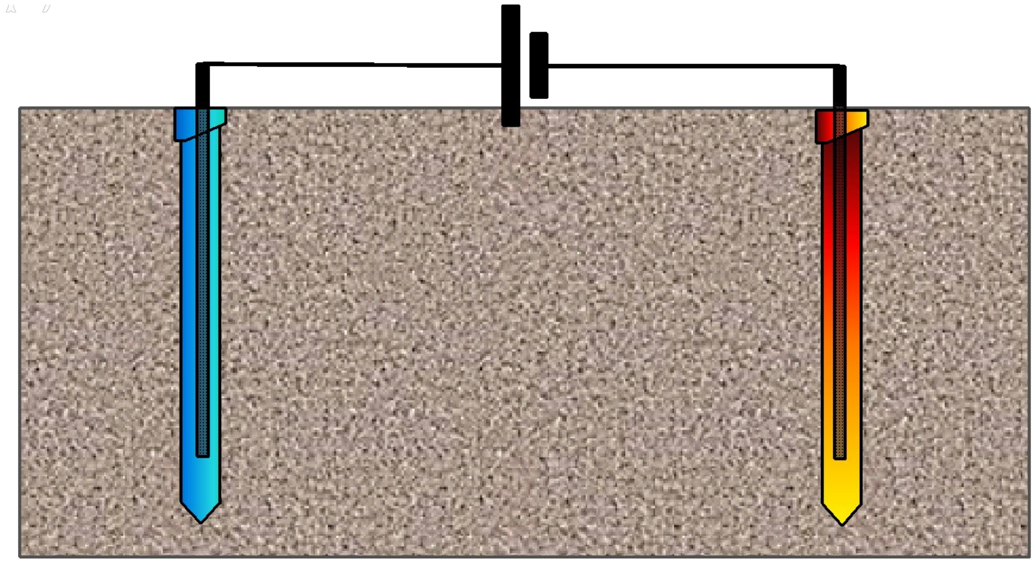
- ✔ to not damage the sheet of the pond
- ✔ To avoid leachate infiltration
- ✔ to not affect quality of surface water
- ✔ To guarantee the safety and health of the operators

Sample of solid-liquid matrix with mud texture characteristics (obtained in the pond of the landfill of Sardas)

Sludge characteristics:

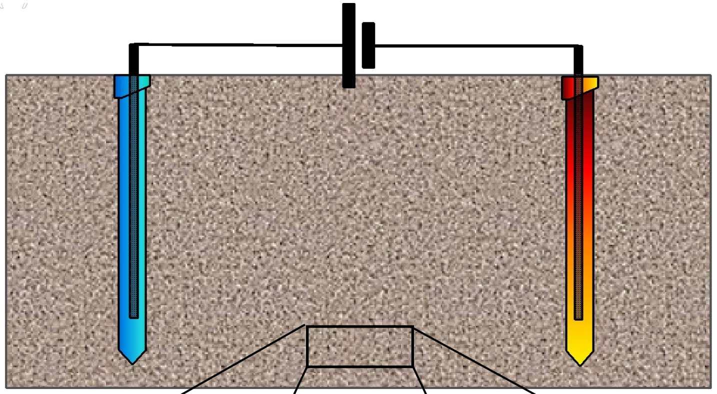
- ✔ **black color, with gray tones on the surface by oxidation**
- ✔ **very plastic, adherent and difficult to handle.**

What happens when we apply an electric field to electrodes placed in the sludge?



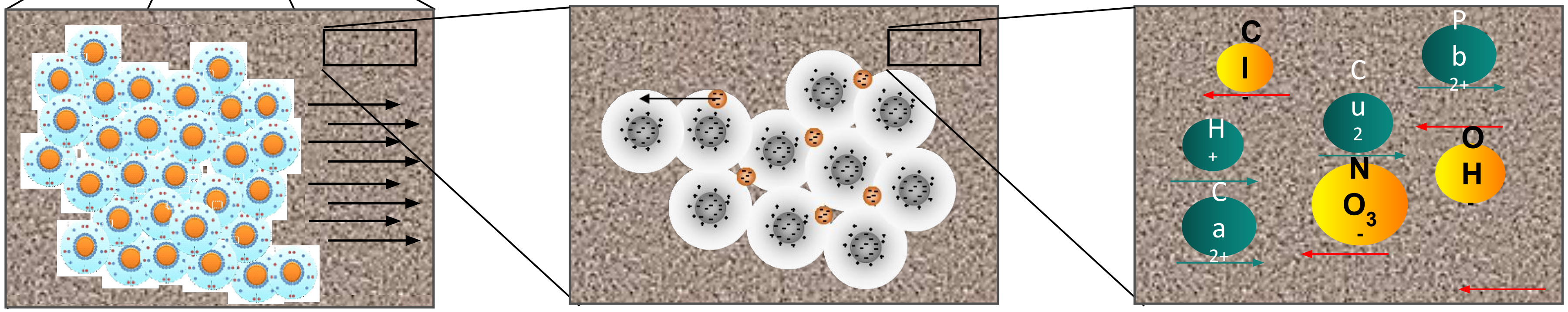
Includes ***different processes*** that take part in a soil:

- ❑ Physical processes (heating)
- ❑ Chemical processes (ionic exchange, precipitations, etc.)
- ❑ Electrochemical processes (water oxidation and reduction)
- ❑ Electrokinetic processes (electrosmosis, electrophoresis and electromigration)



Electrokinetic processes

Includes ***different processes*** that take part in a soil as a result of the application of an electric field.



MACROSCOPIC LEVEL

Electro-osmosis
movement of the water into the soil through the application of electric field.

MICROSCOPIC LEVEL

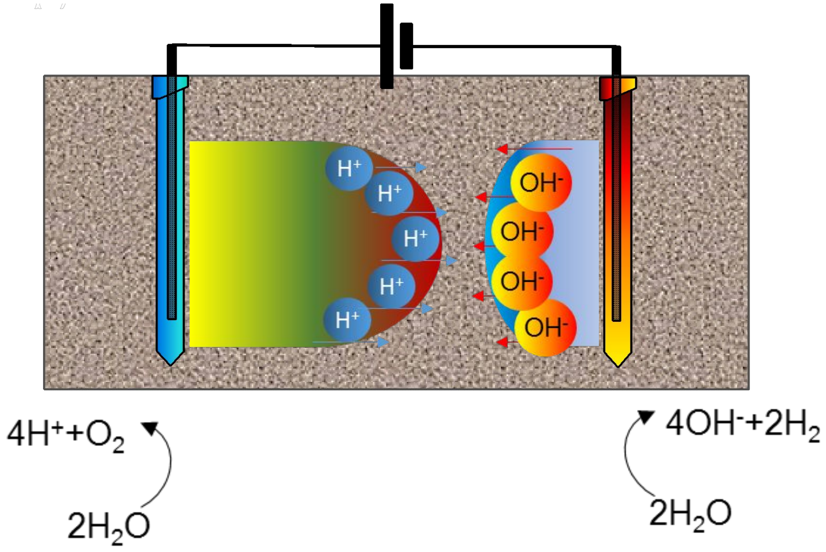
Electrophoresis
movement of the charged particles into the soil through the application of electric field.

MOLECULAR LEVEL

Electromigration
movement of the ions into the soil through the application of electric field.

Electrolysis

Water oxidation on the anodic surface
Water reduction on the cathodic surface

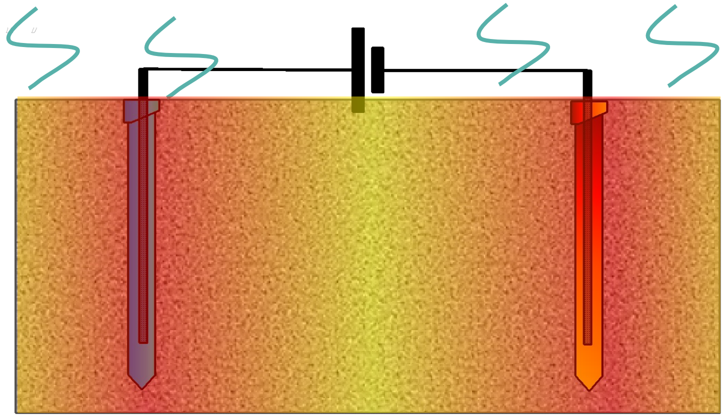


Influences on:

- ❑ Different species precipitation / redisolution
- ❑ Fixation or liberation of species by ionic exchange
- ❑ Microbial viability

Soil electrical heating

Temperature increase that occurs in the soil due to the ohmic drop generated by the **high electrical resistance** of the soil.



Influences on:

- ❑ Viscosity changes in liquids contained in the soil
- ❑ Pollutants volatilization
- ❑ Water evaporation

Objectives

TO DISMANTLE HIGHLY HCH-POLLUTED LANDFILL LEACHATE POND USING ELECTROCHEMICALLY ASSITED TECHNOLOGY

The ideal conditions for dismantling the pond would be:

- **To reach a level of dryness in the sludge that would allow its mechanical handling without risk.**
- **To minimize the atmospheric emissions.**
- **To minimize the need for necessary infrastructure and equipment, as well as subsequent treatments for conditioning, transfer, or decontamination**

Partial technical objectives

1. To determine the **mobility of pollutants** in the sludge under the action of **electric field**.
2. To evaluate the **dewatering** of the sludge by the action of the **electric field**.
3. To study the **treatment of water** mobilized and recovered from the treatment by **electrochemical** technologies.
4. To evaluate the implementation of **GAC column to retain organics transfer to the atmosphere**
5. **To implement the technology in real scale**

Results

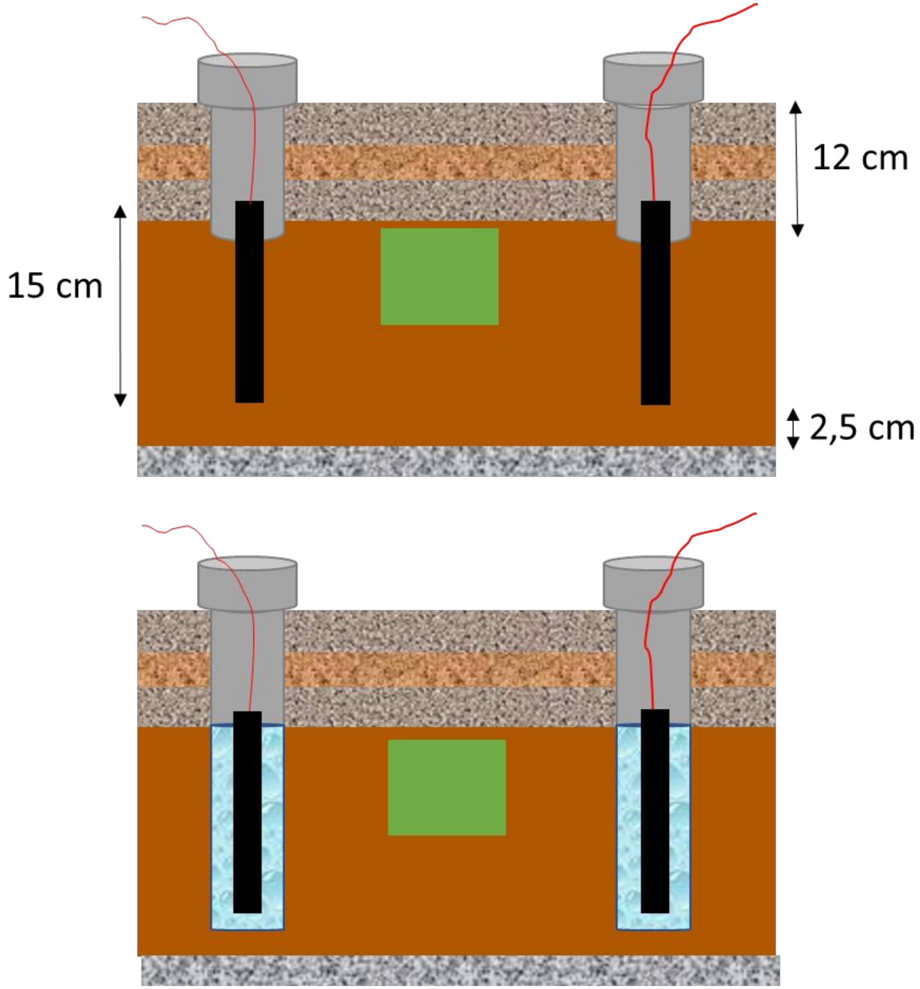
1 Study of mobilization

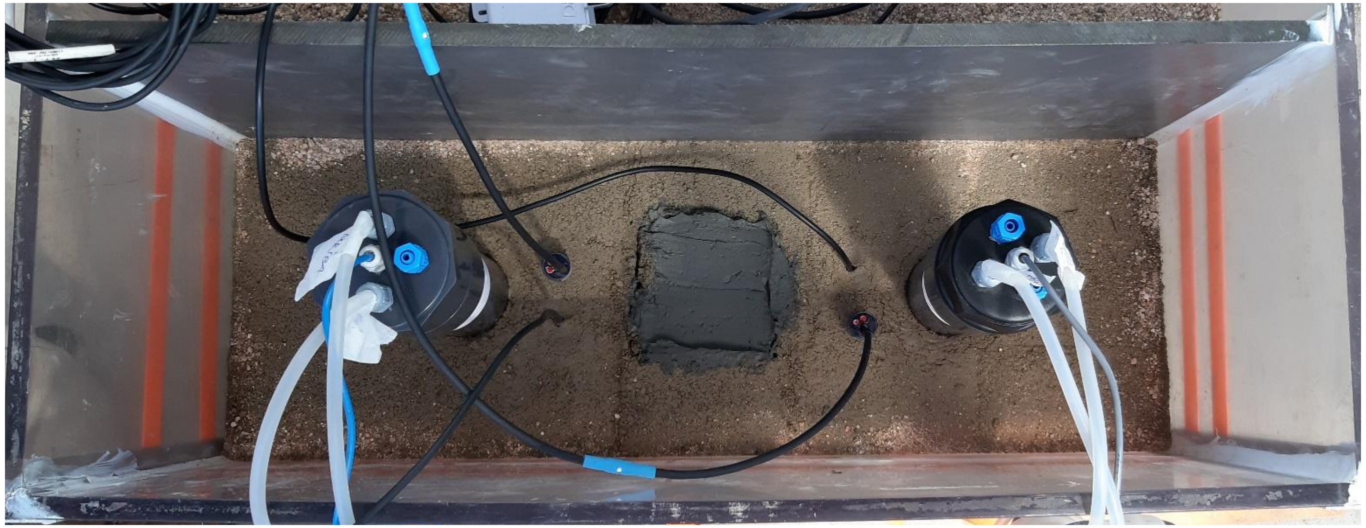
2 EK treatment and dewatering of the sludge at bench scale

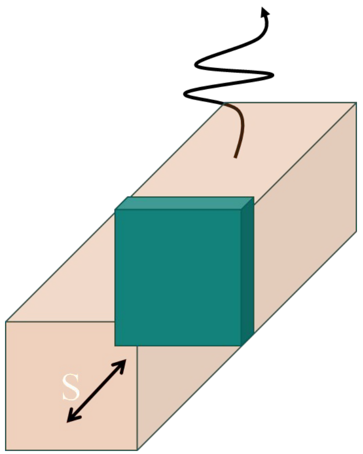
3 Electrochemical treatment of liquid streams

4 Field application

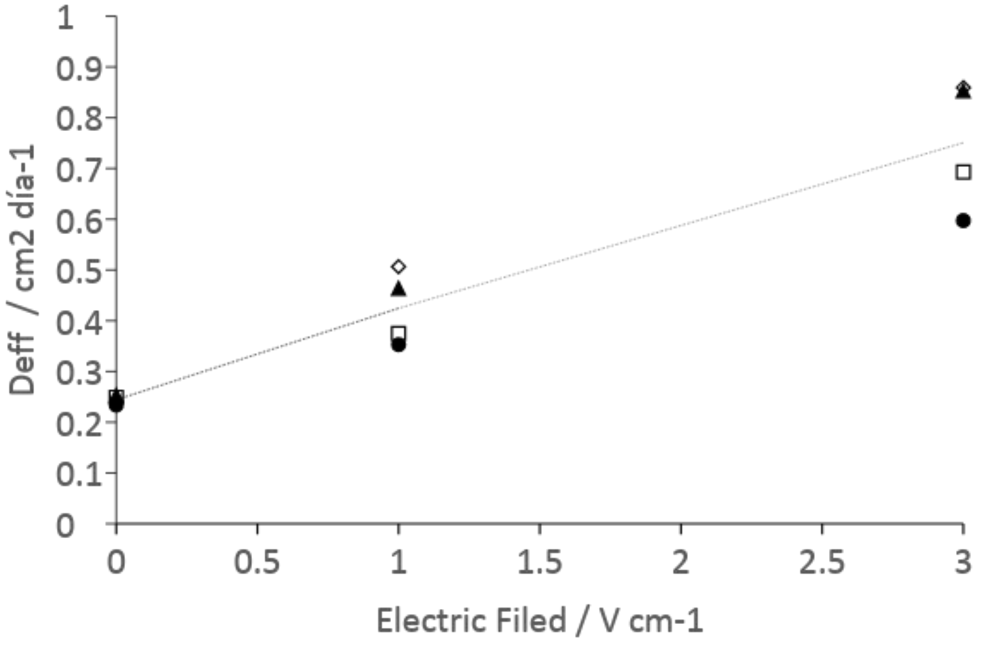
Characterization of sludge water and contaminant mobility under the action of the electric field during the first electrochemically assisted stage. Stage1.

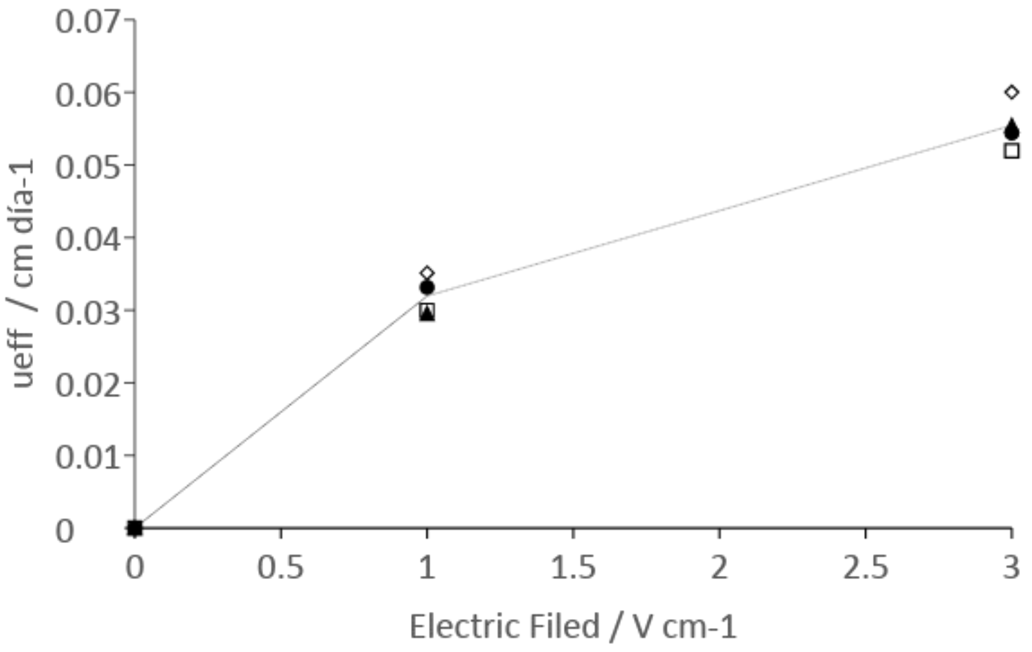




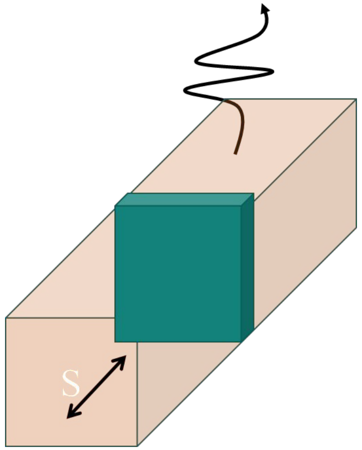


$$\frac{\partial C_i(x,t)}{\partial t} = D_{eff}\frac{\partial^2 C_i(x,t)}{\partial x^2} - u_{eff}\frac{\partial C_i(x,t)}{\partial x} - \lambda A C_i(x,t)$$

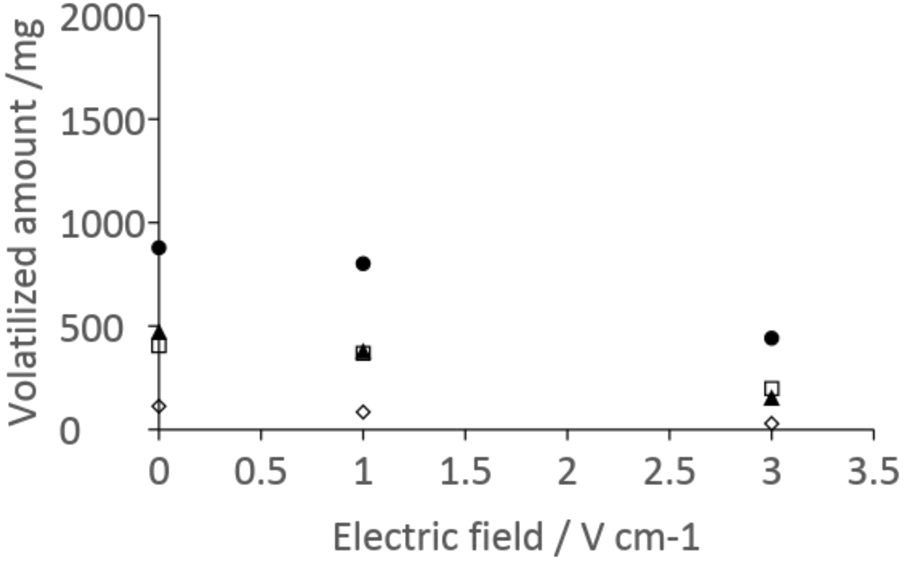


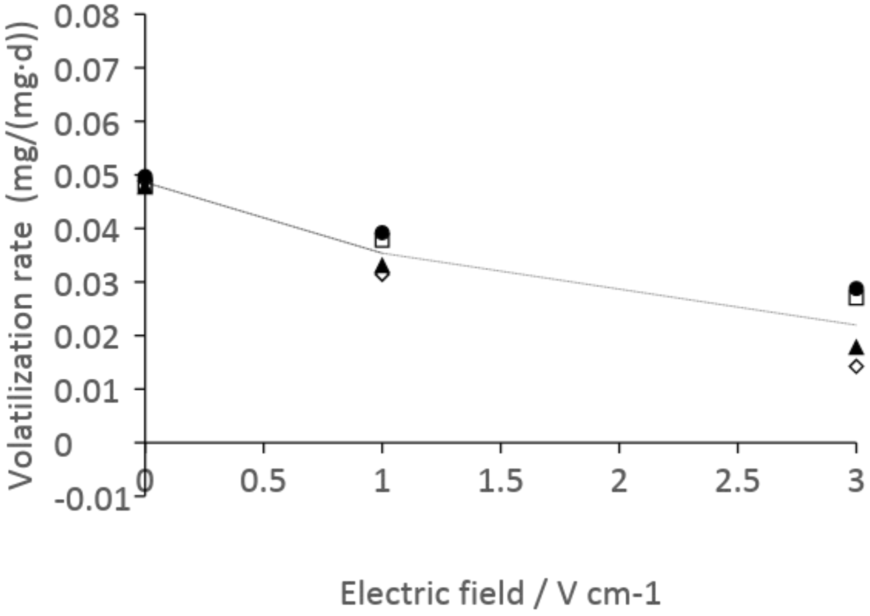


□ α-HCH ◇ ε-HCH ▲ δ-HCH ● γ-HCH.



$$\frac{\partial C_i(x,t)}{\partial t} = D_{eff}\frac{\partial^2 C_i(x,t)}{\partial x^2} - u_{eff}\frac{\partial C_i(x,t)}{\partial x} - \lambda A C_i(x,t)$$

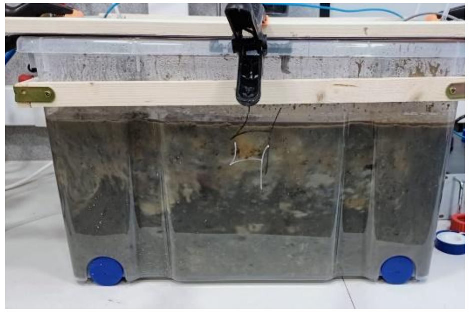




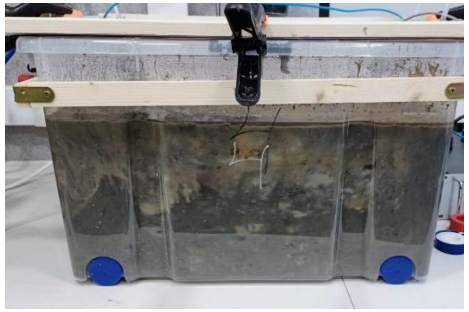
□ α-HCH ◇ ε-HCH ▲ δ-HCH ● γ-HCH.

Characterization of sludge water and contaminant mobility under the action of the electric field during the first electrochemically assisted stage. Stage 2.

2 V/cm

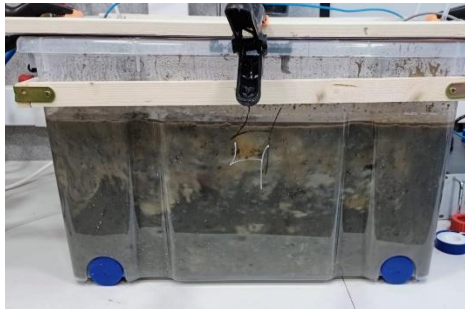


0.5 V/cm

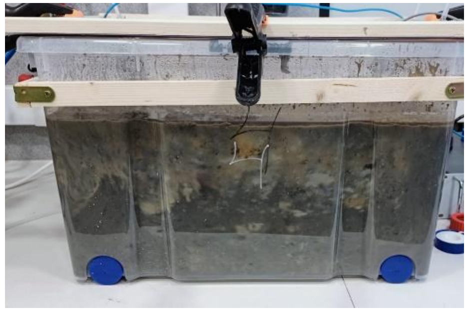


50 kg sludge / test

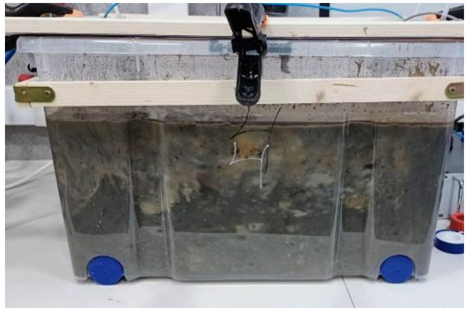
1 V/cm



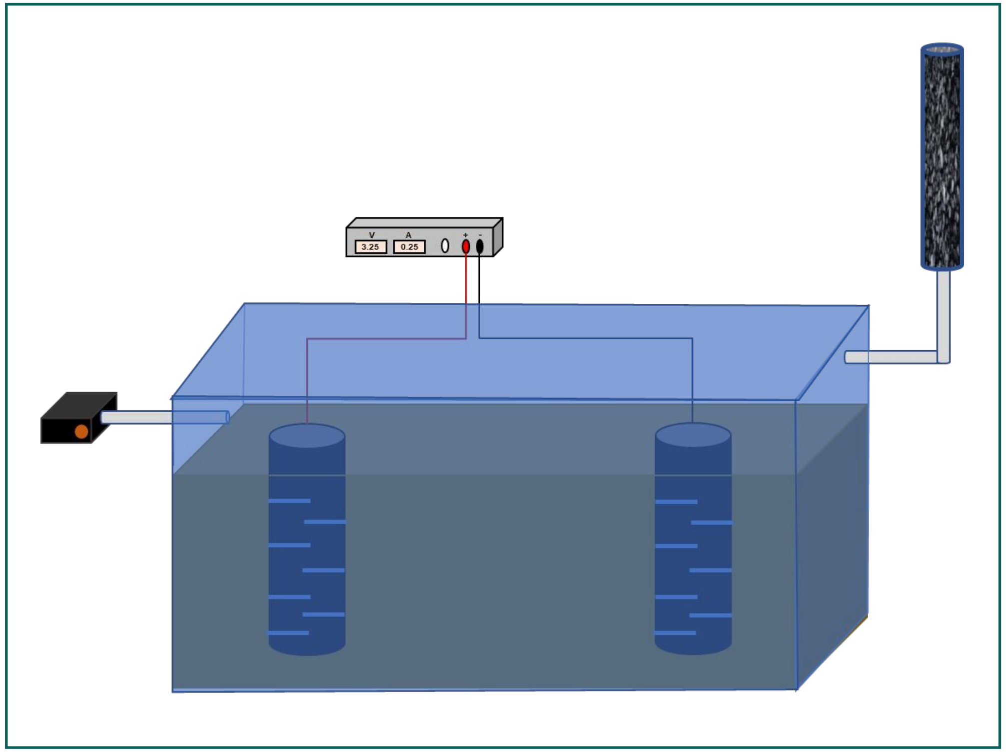
1 V/cm + SDS



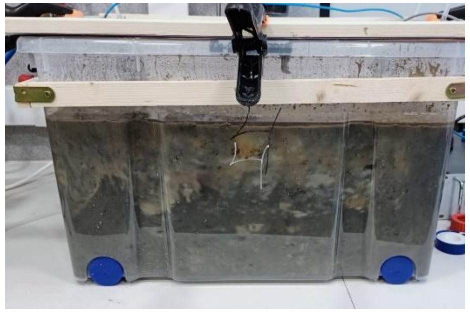
1 V/cm + iron electrodes



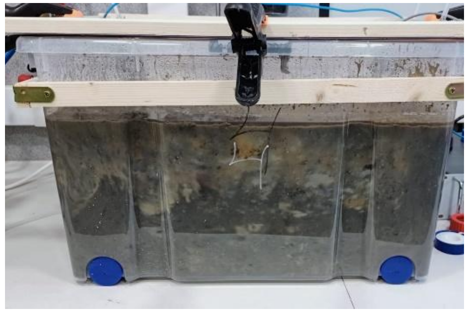
Characterization of sludge water and contaminant mobility under the action of the electric field during the first electrochemically assisted stage. Stage 2.



2 V/cm

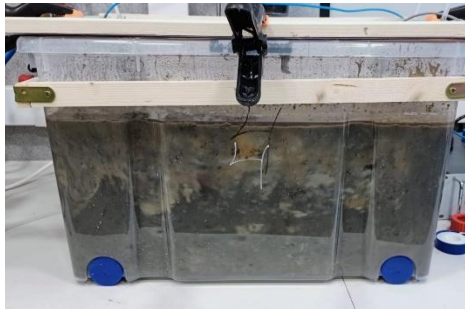


0.5 V/cm

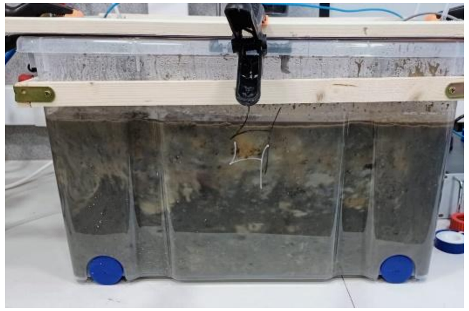


50 kg sludge / test

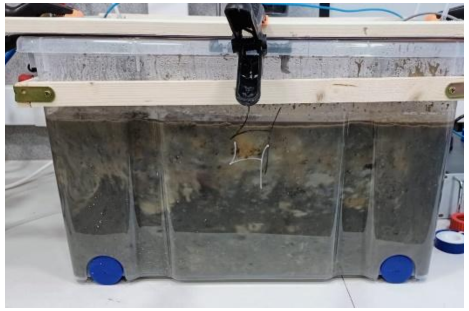
1 V/cm



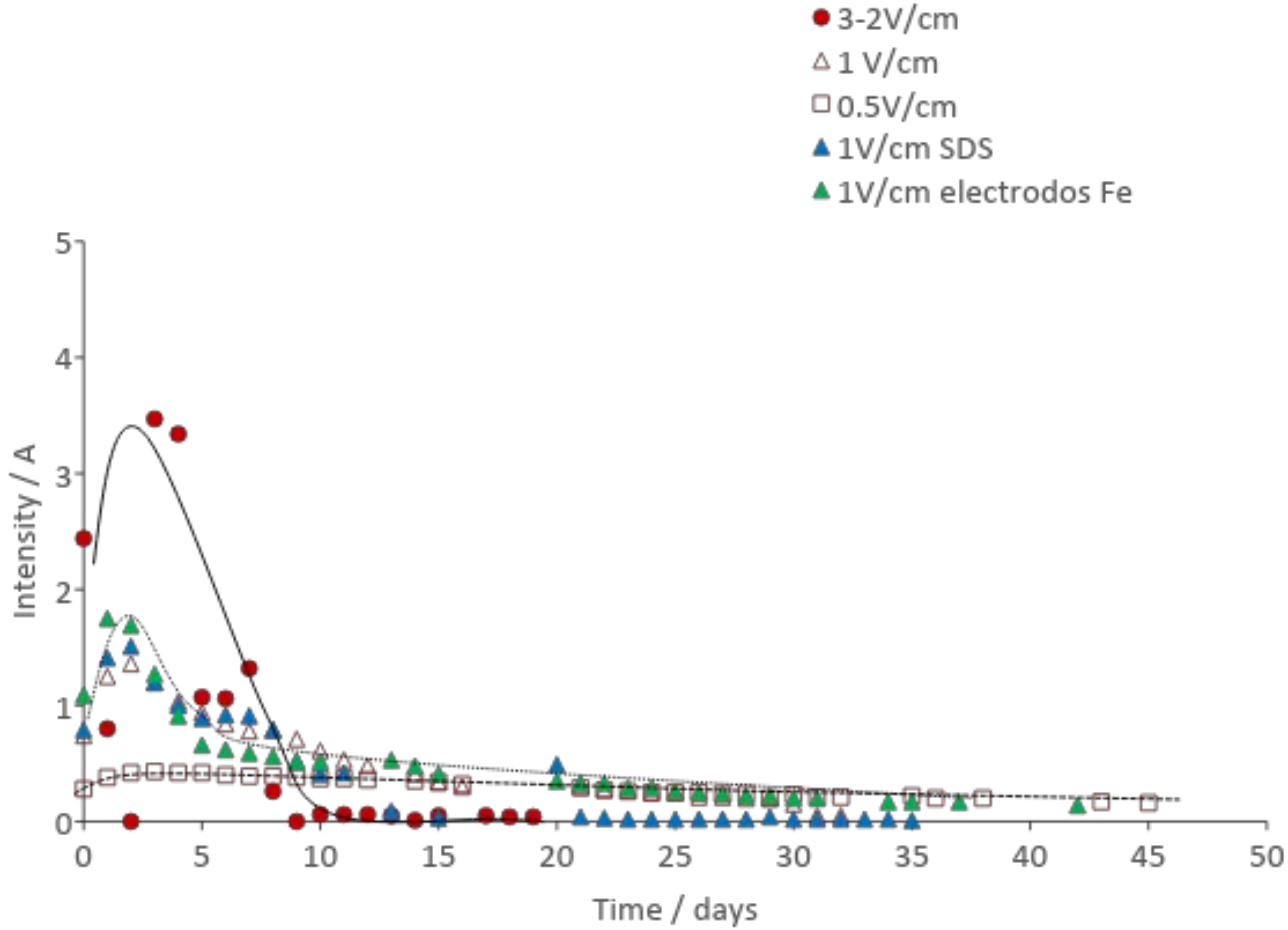
1 V/cm + SDS



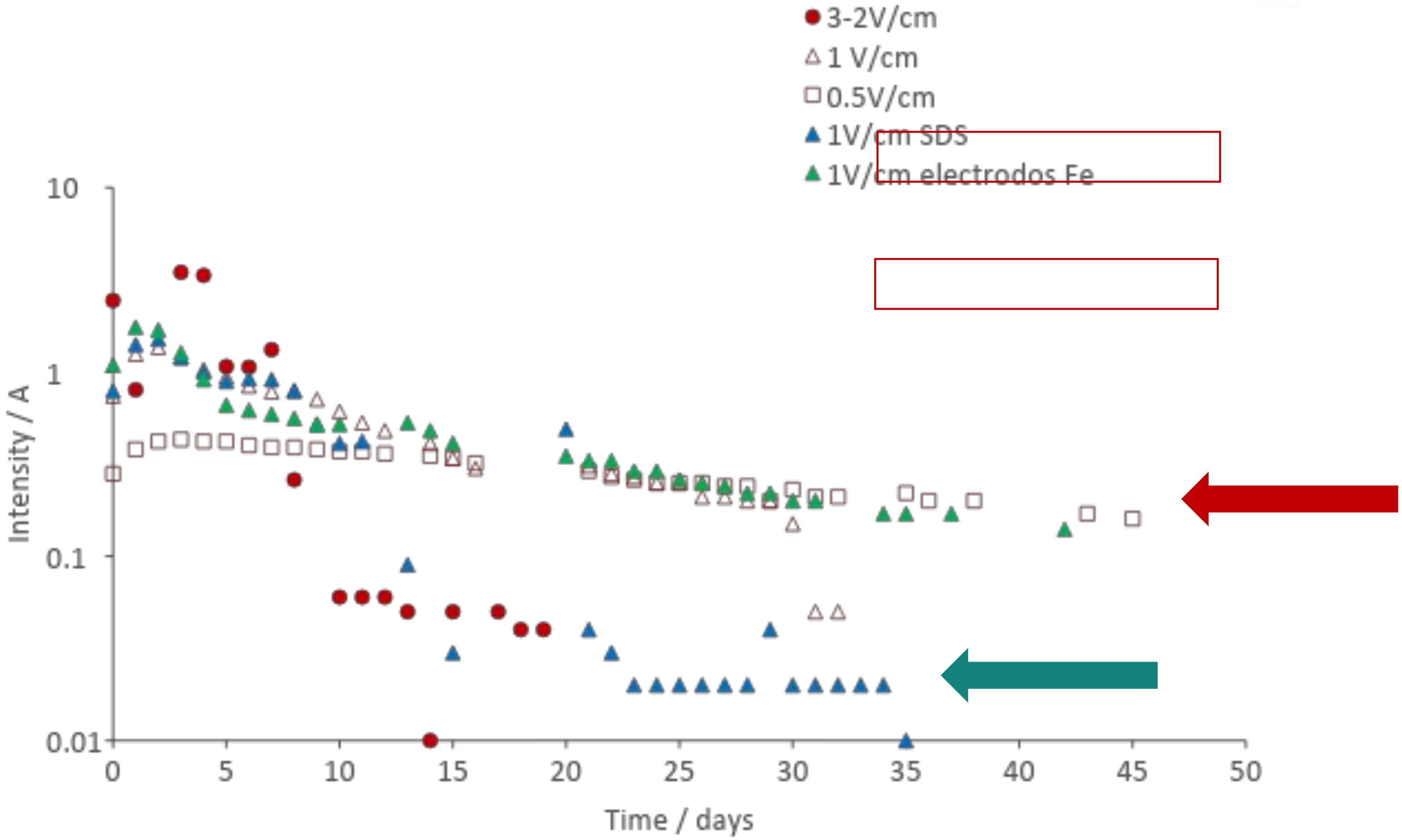
1 V/cm + iron electrodes



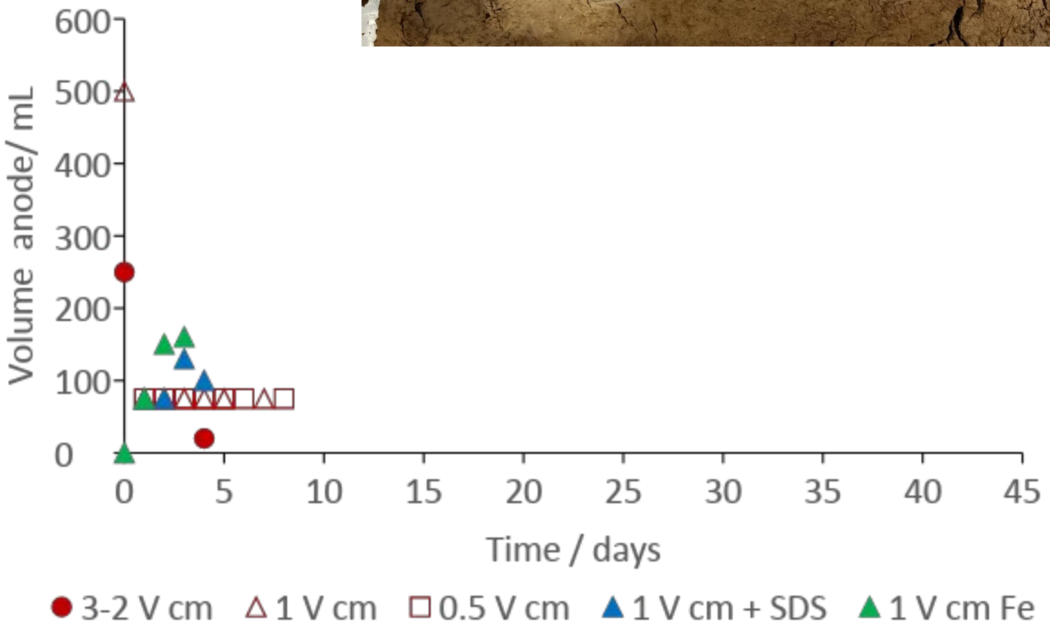
General behaviour. Current intensity.

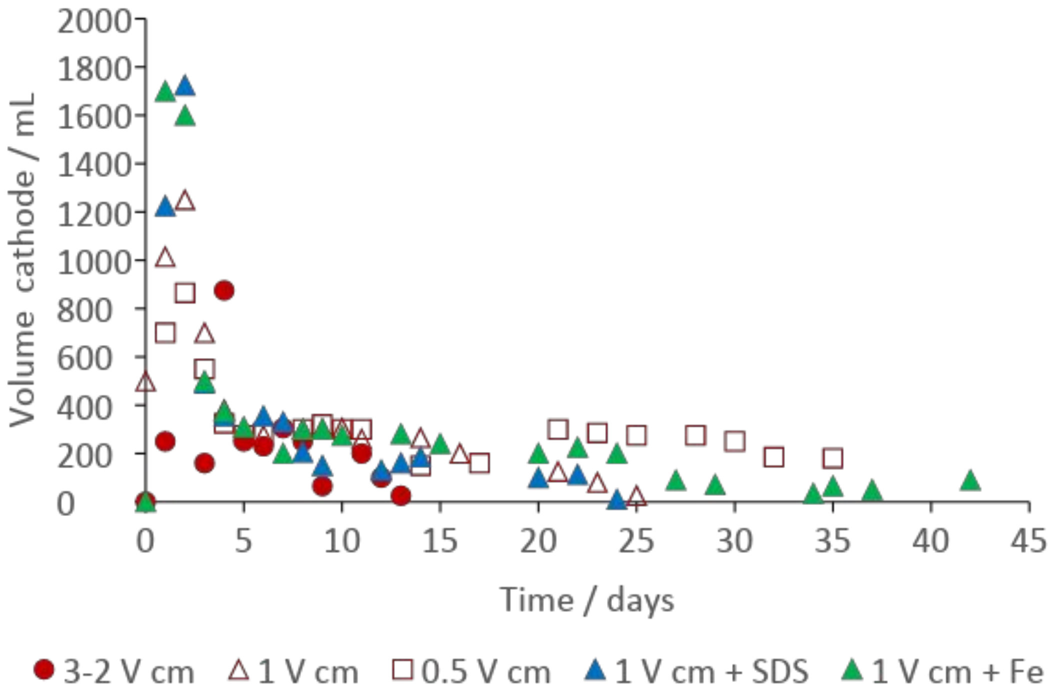


General behaviour. Current intensity.

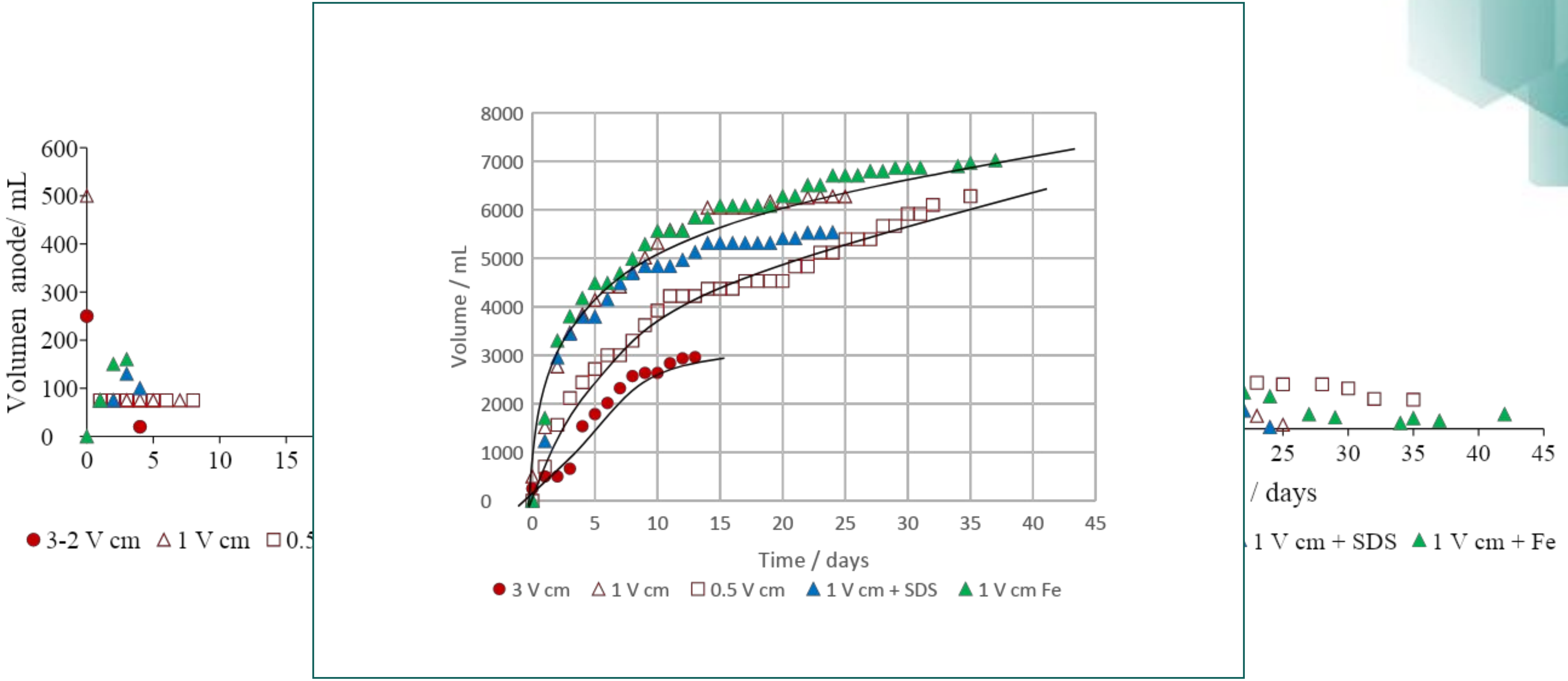


General behaviour. Transport of water.

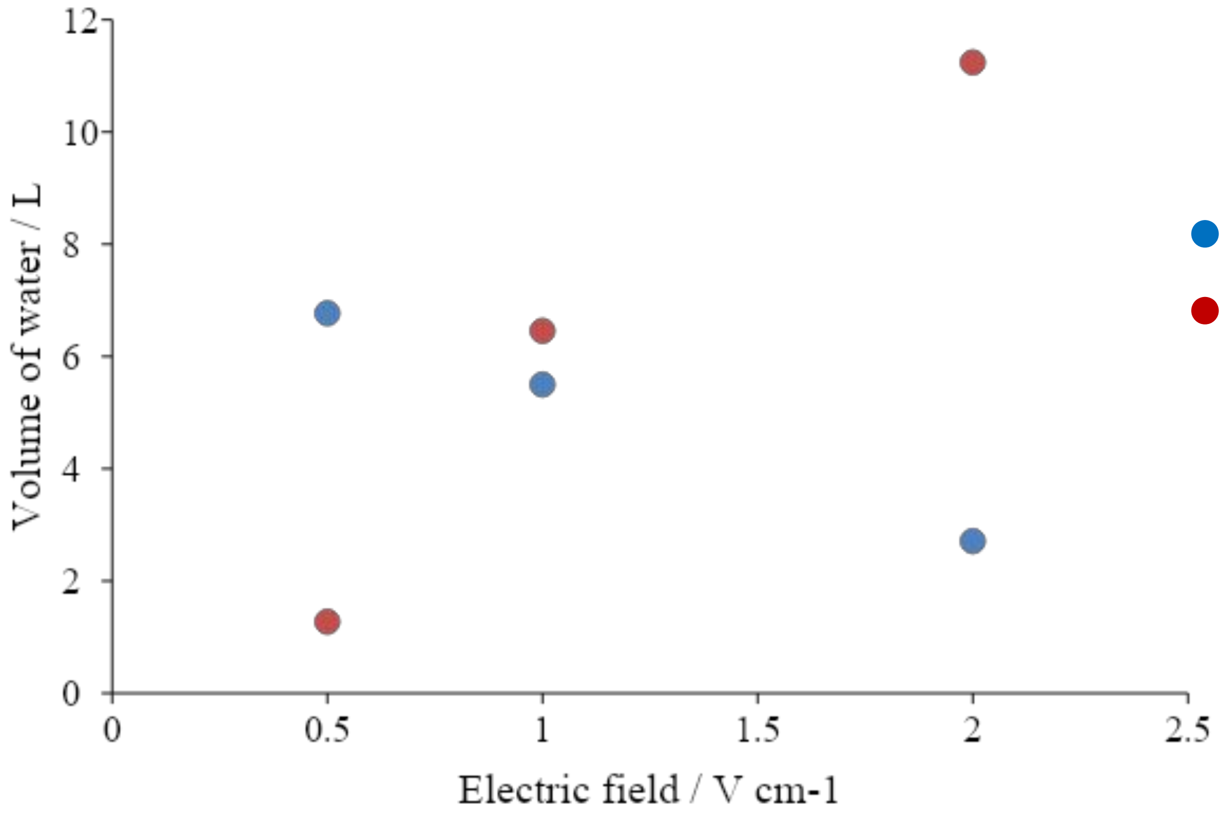




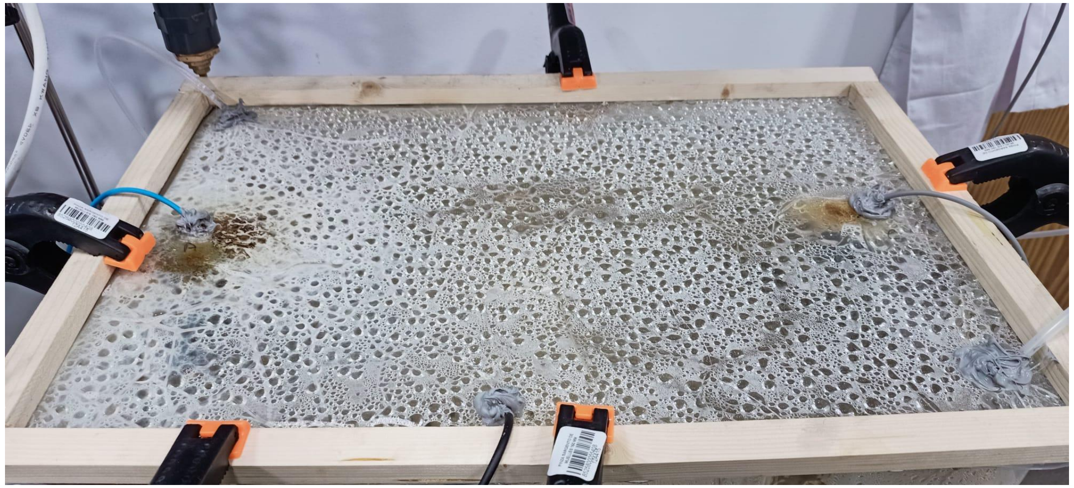
General behaviour. Transport of water.



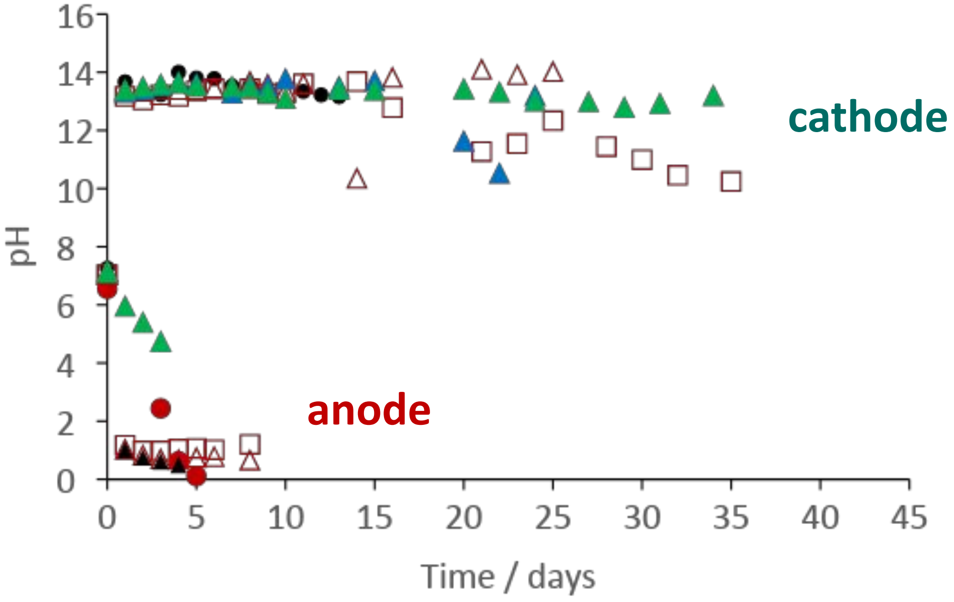
General behaviour. Transport of water.

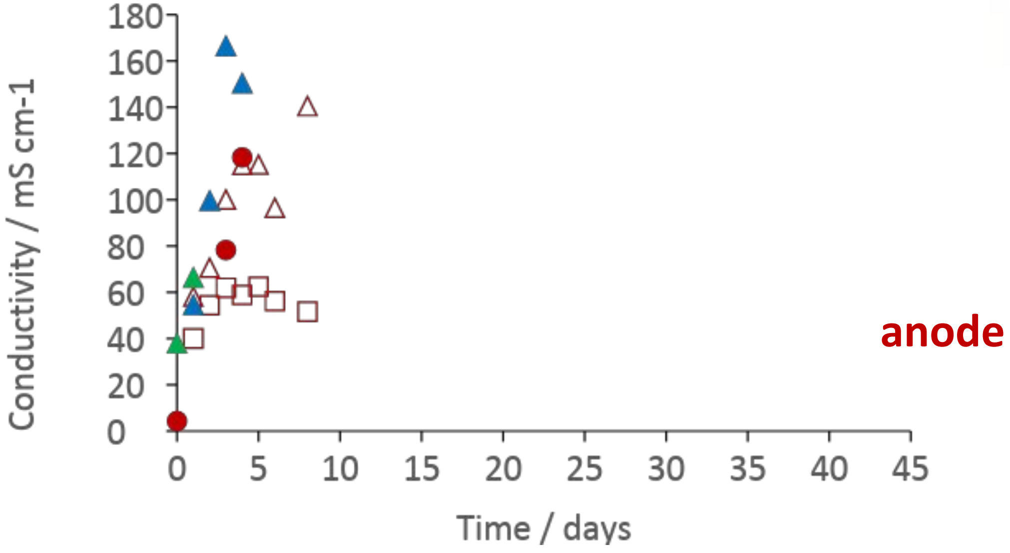


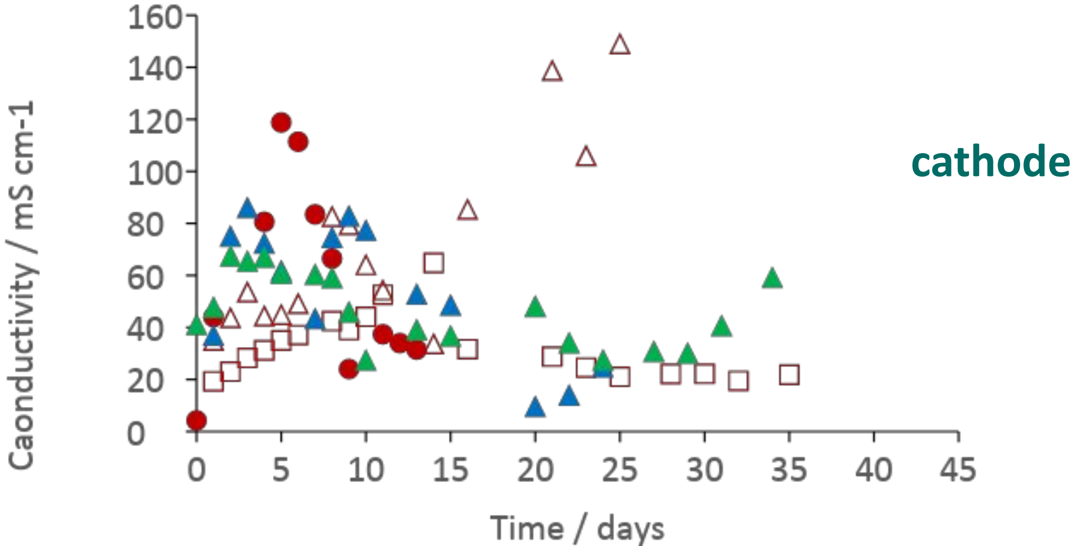
● mobilized by EK
● evaporated



General behaviour. pH and conductivity of mobilized water.

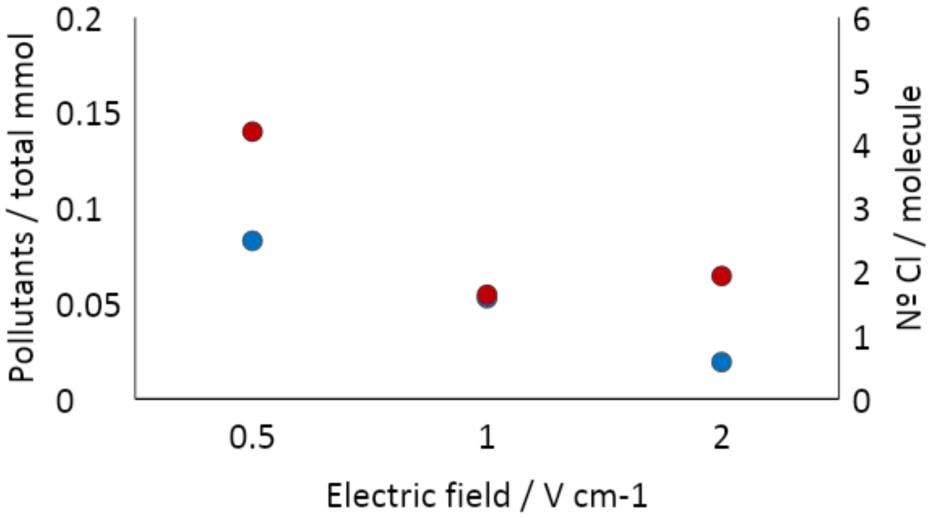


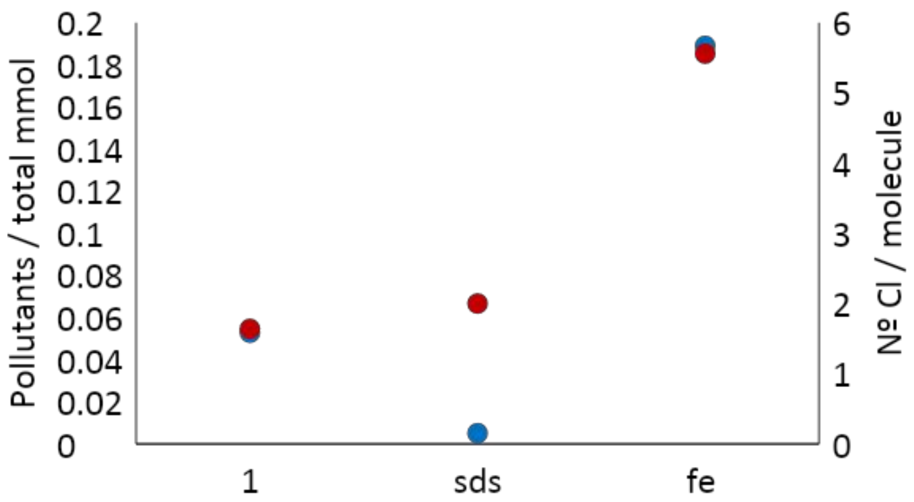




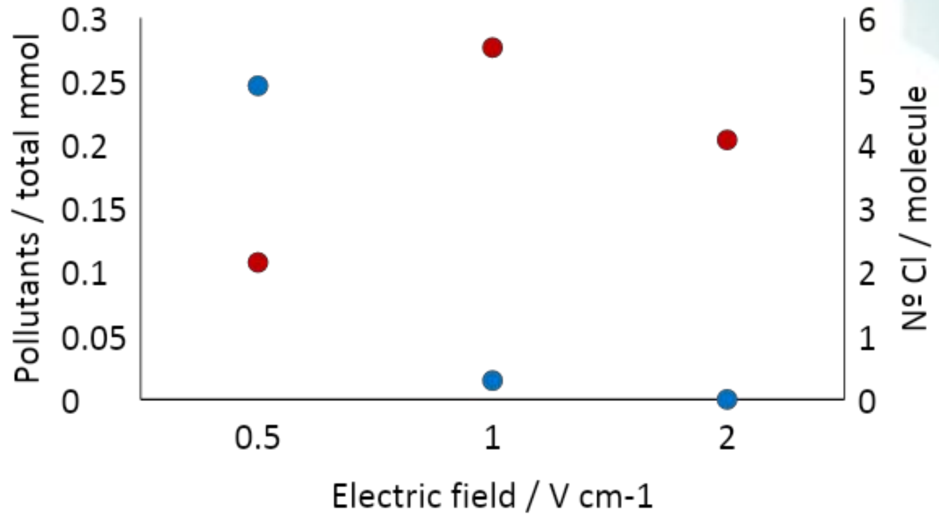
General behaviour. Organics mobilized with water.

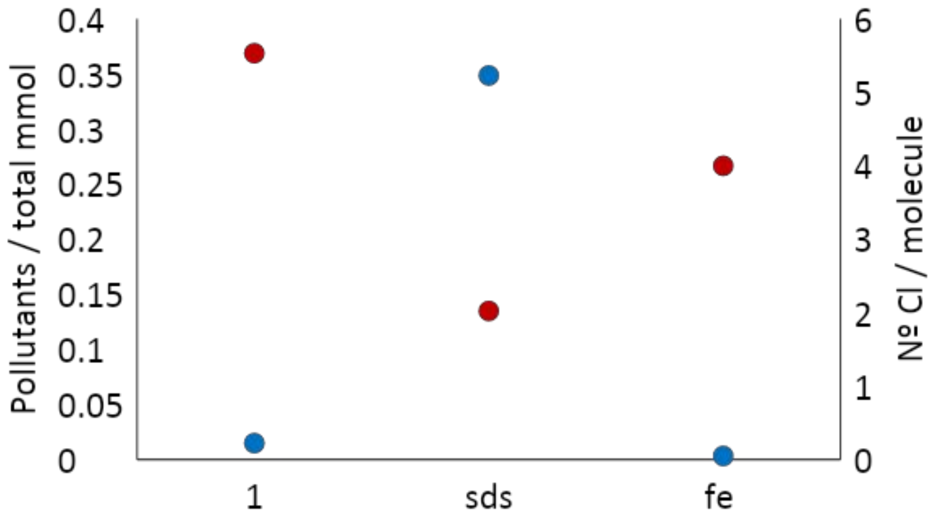
cathode





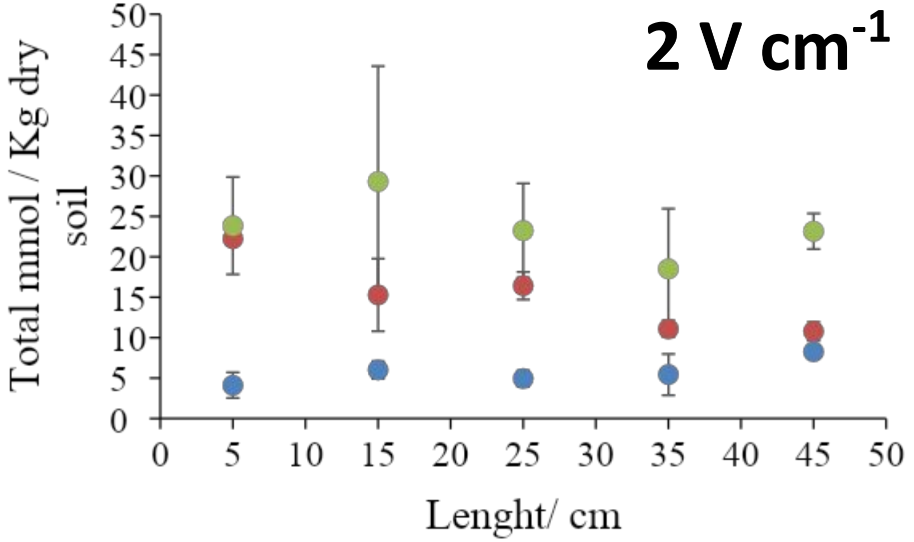
anode





General behaviour. Organics in treated sludge.

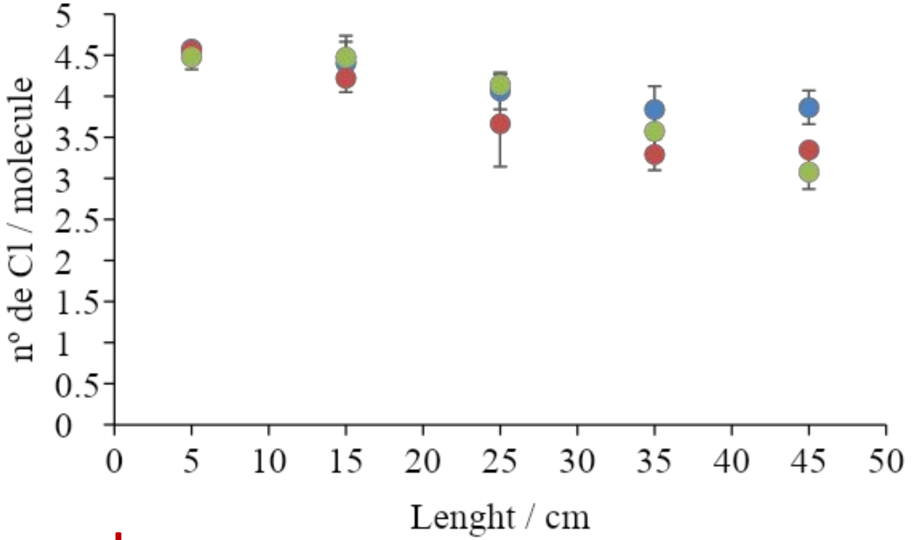
2 V cm^{-1}



Average zone 1= 5.75 mmol / Kg SS

Average zone 2= 15.16 mmol / Kg SS

Average zone 3= 23.61 mmol / Kg SS



anode

cathode

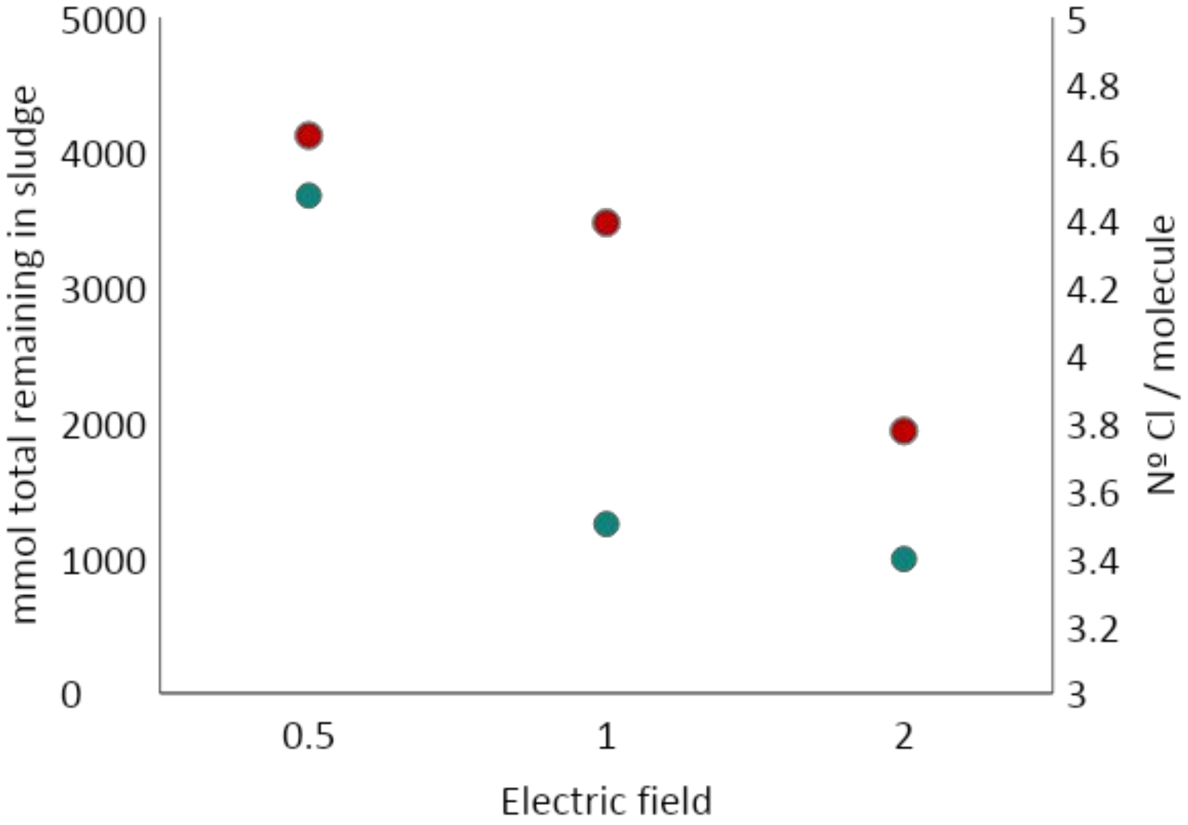
Initial average value = 4.68

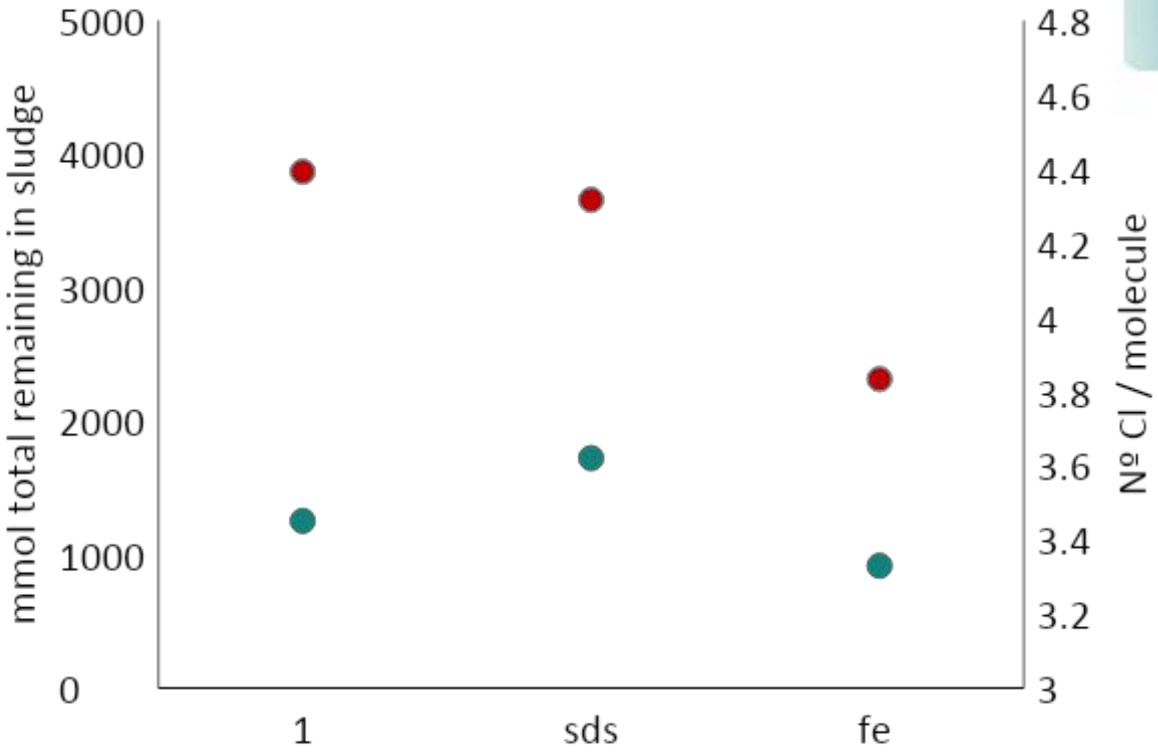
Final average value=3.78

Postmortem analysis of sludge

General behaviour. Organics in treated sludge.

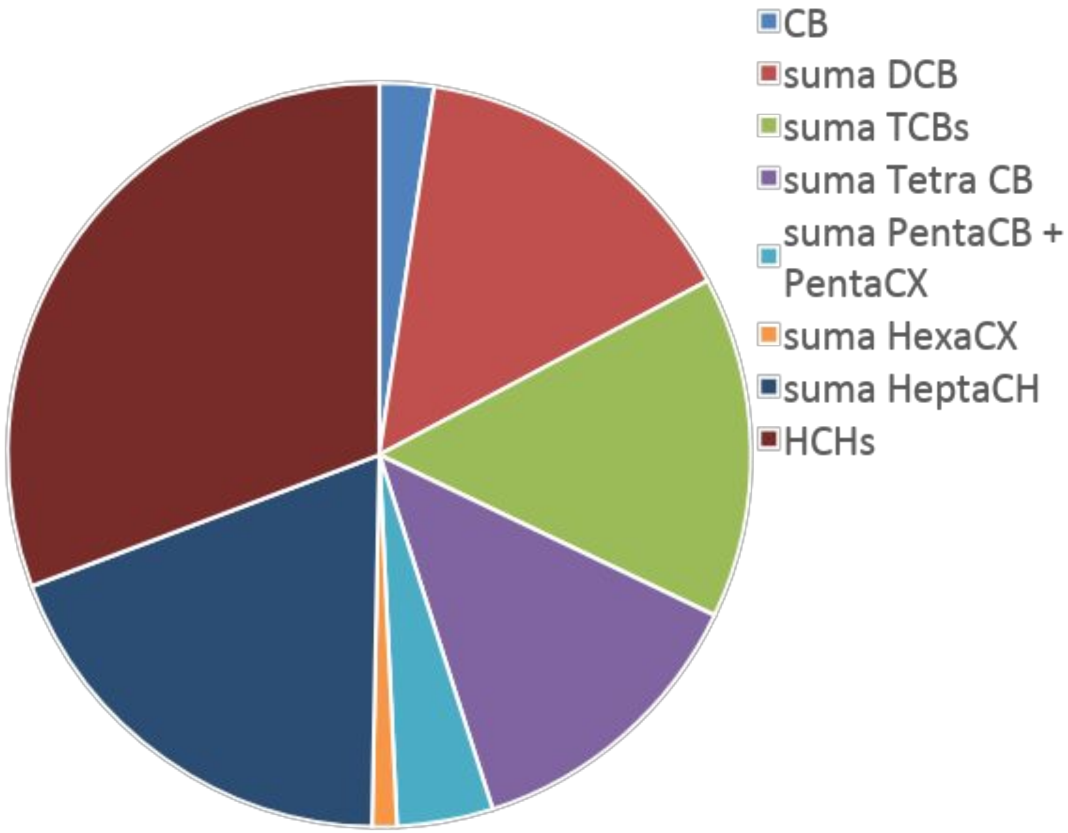
Postmortem analysis of sludge



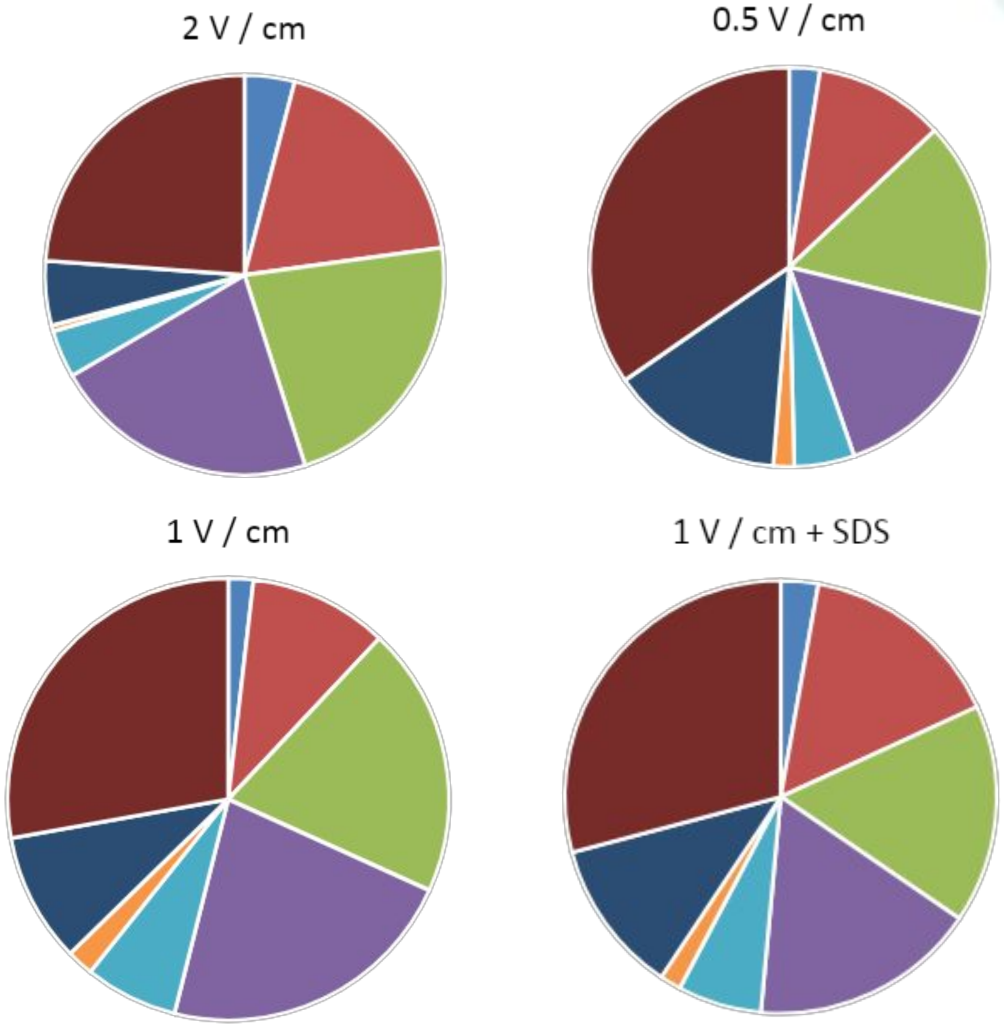


General behaviour. Organics in treated sludge.

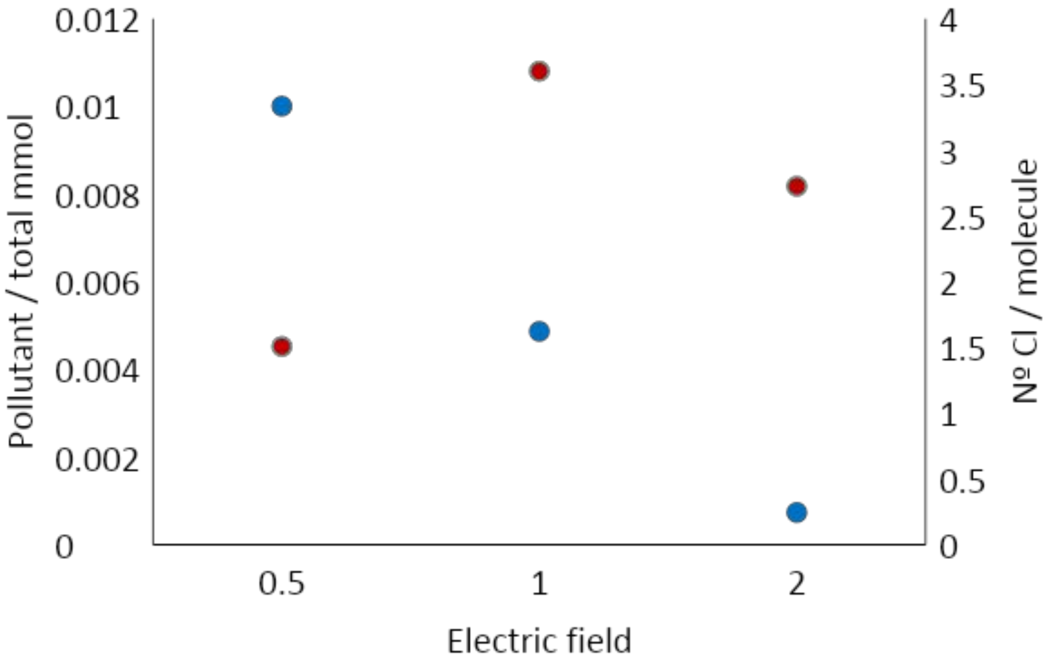
Initial pollutant distribution

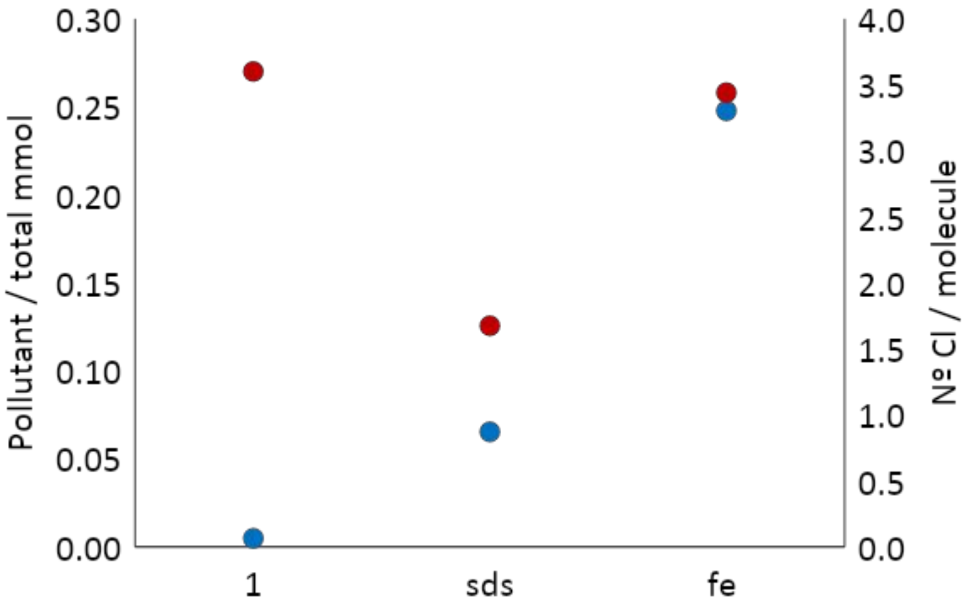


Final pollutant distribution



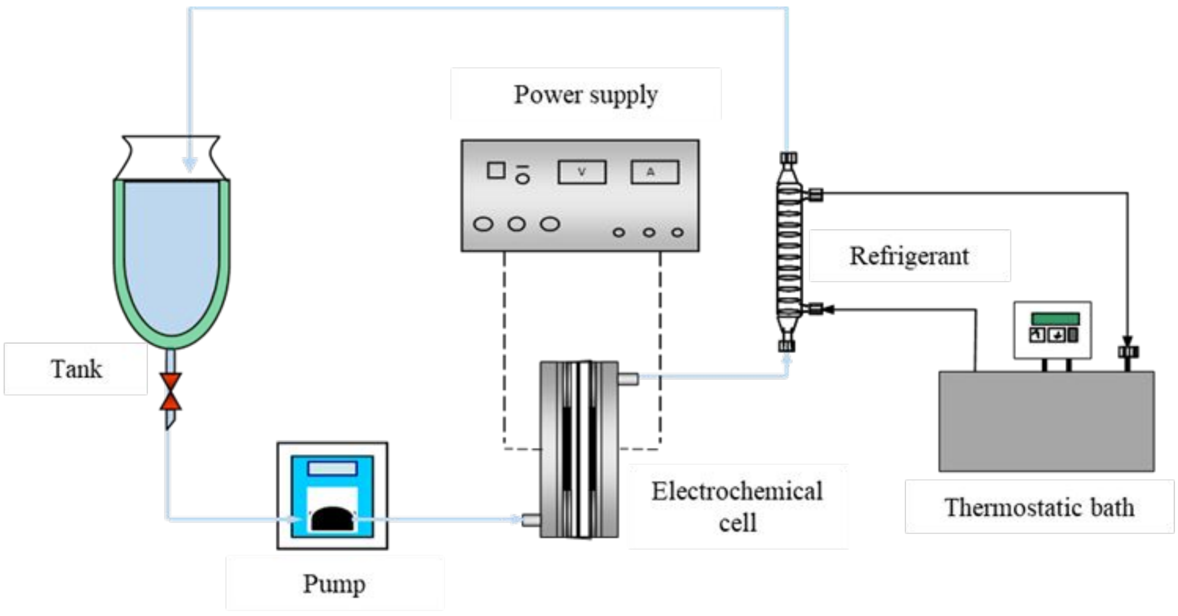
General behaviour. Organics retained in activated carbon.

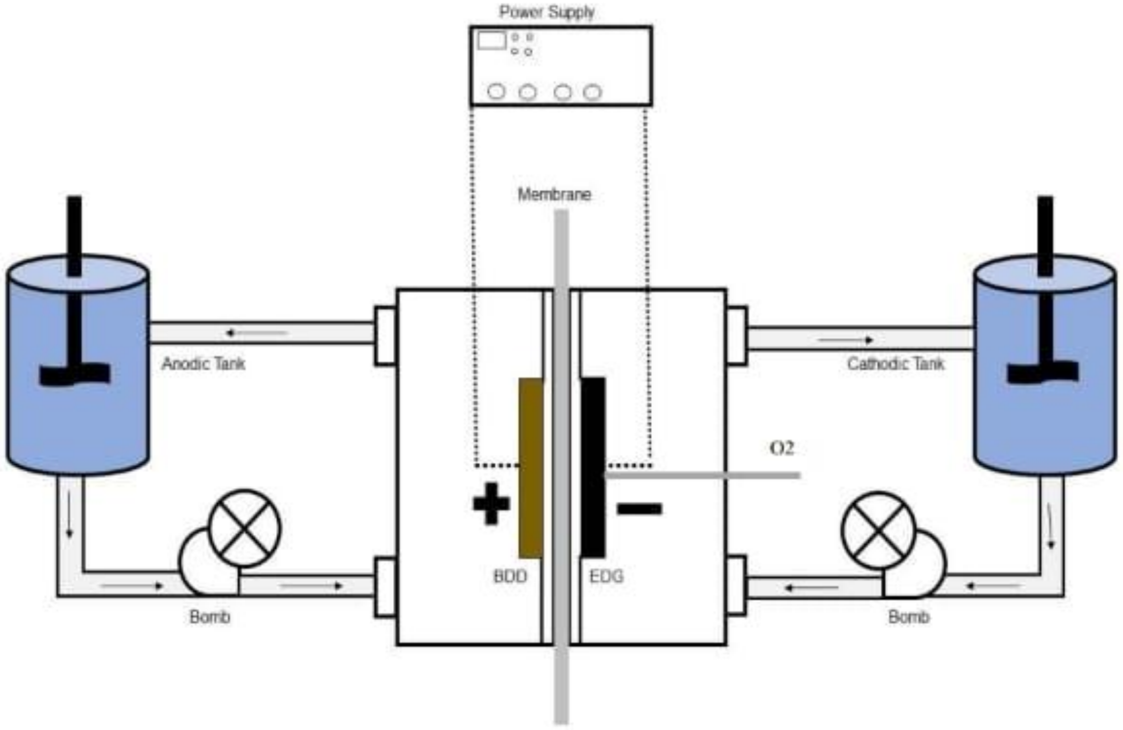




Expected results	Conclusions
Draging of pollutants with electroosmotic flux	Pollutants are strongly retained in sludge. Low mobilization
Mobilization of water by EK	Mobilization of water by EK, but high cell voltaje leads to lower EO fluxes
Evaporation of water favoured at high cell voltage	Evaporation of water is favoured at high cell voltaje
SDS helps to drag HCH	Negative effect of SDS
Iron electrodes has positive effect	Iron electrodes contirbute to minizime acid front and dehalogenation
COVs can be transfered to gas phase	COVs are stripped and they can be retained in GAC, but water trap should be implemented

Electrochemical treatment of extracted water.



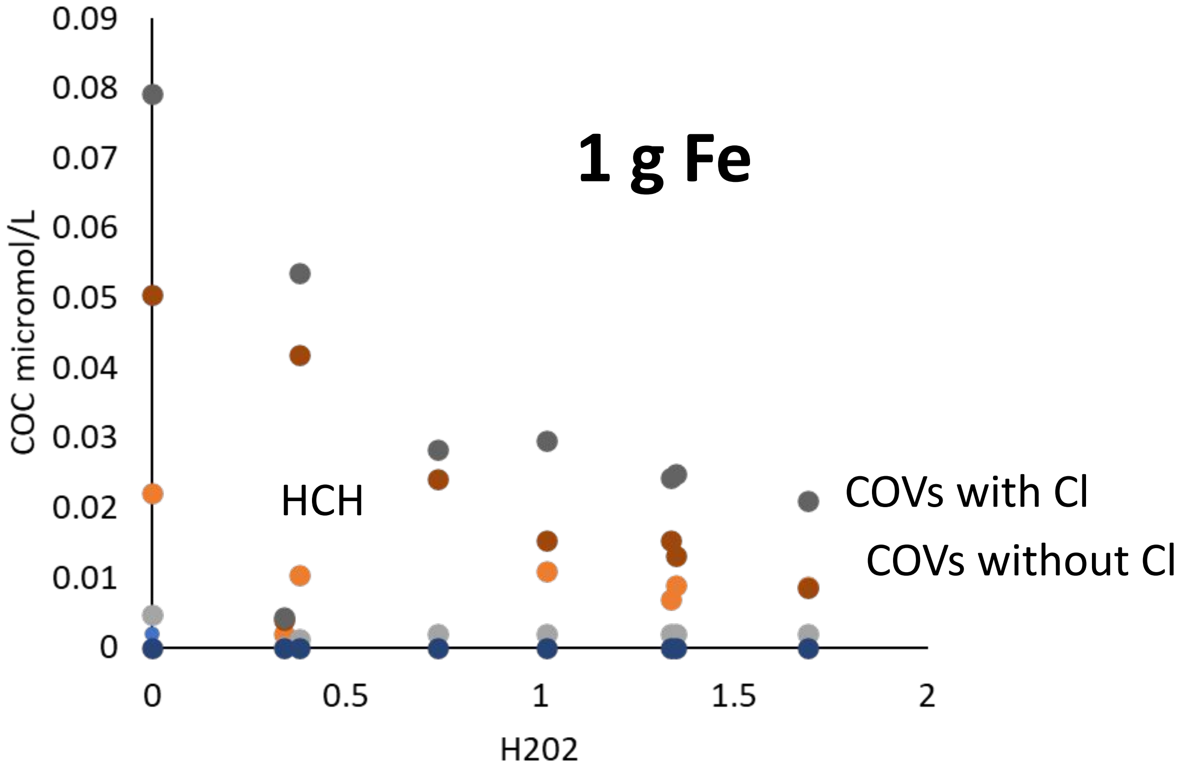


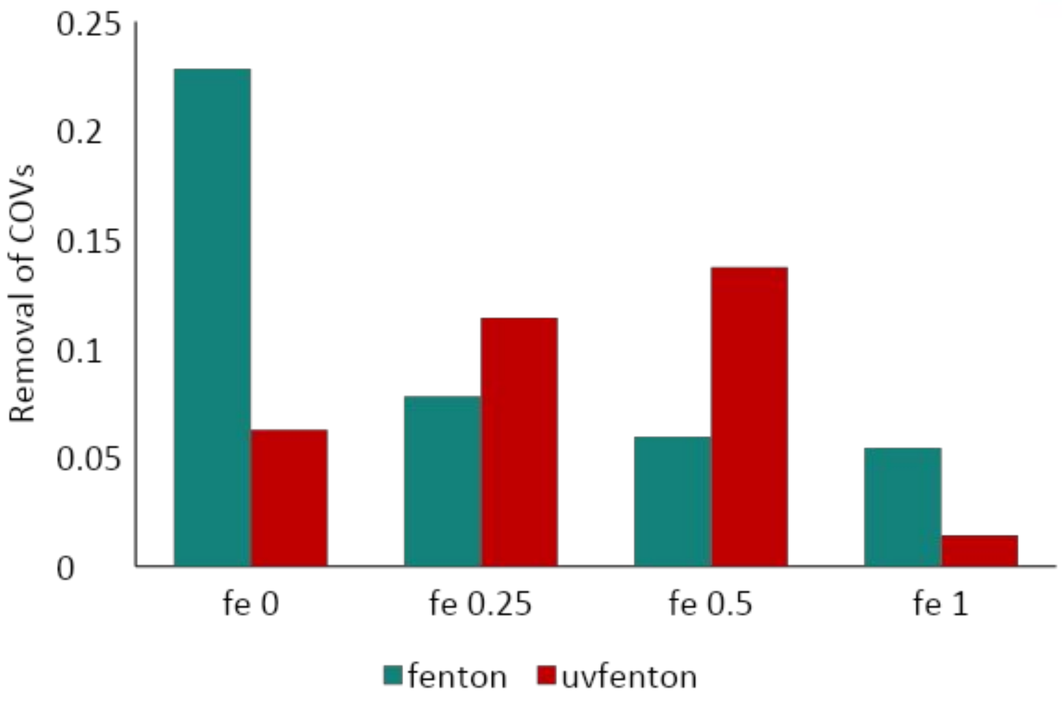
Electrolysis
PhotoElectrolysis
Electrodes: BDD and MMO

Electrofenton
Photoelectrofenton
H2O2/Fe ratio

Electrochemical treatment of extracted water.

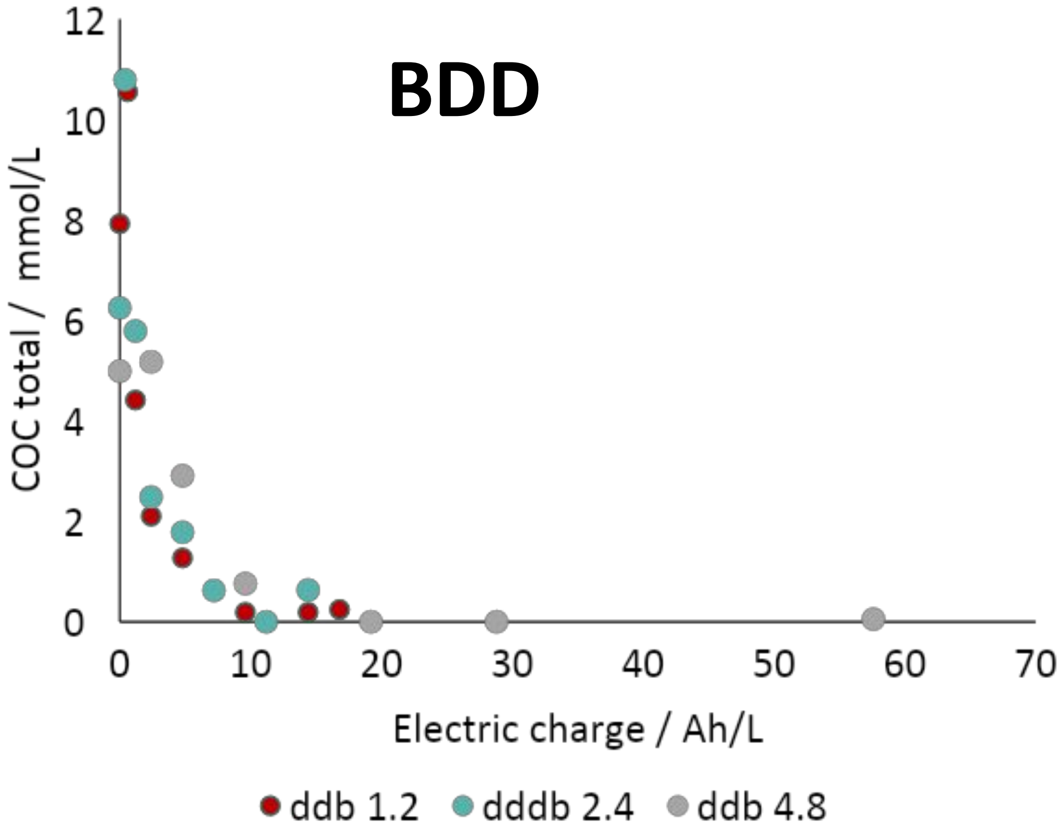
Electrofenton
Photoelectrofenton
H_2O_2/Fe ratio

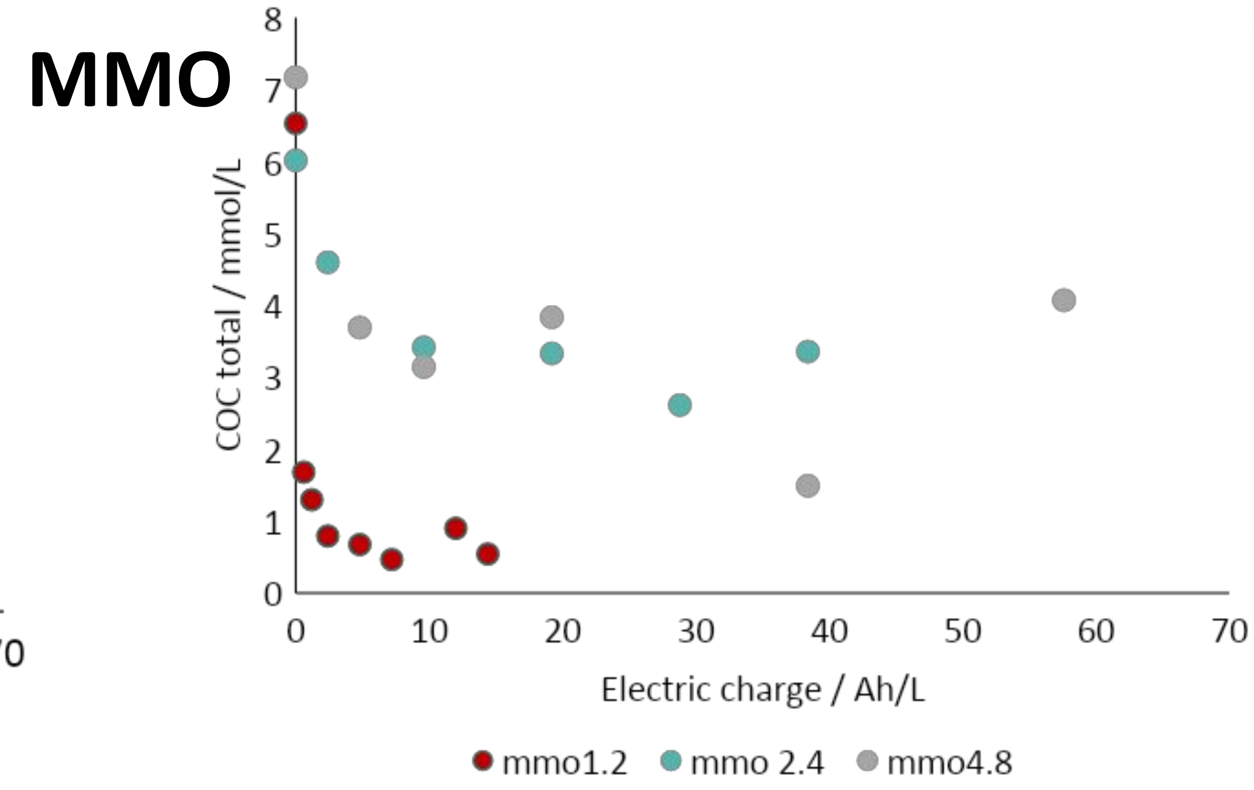


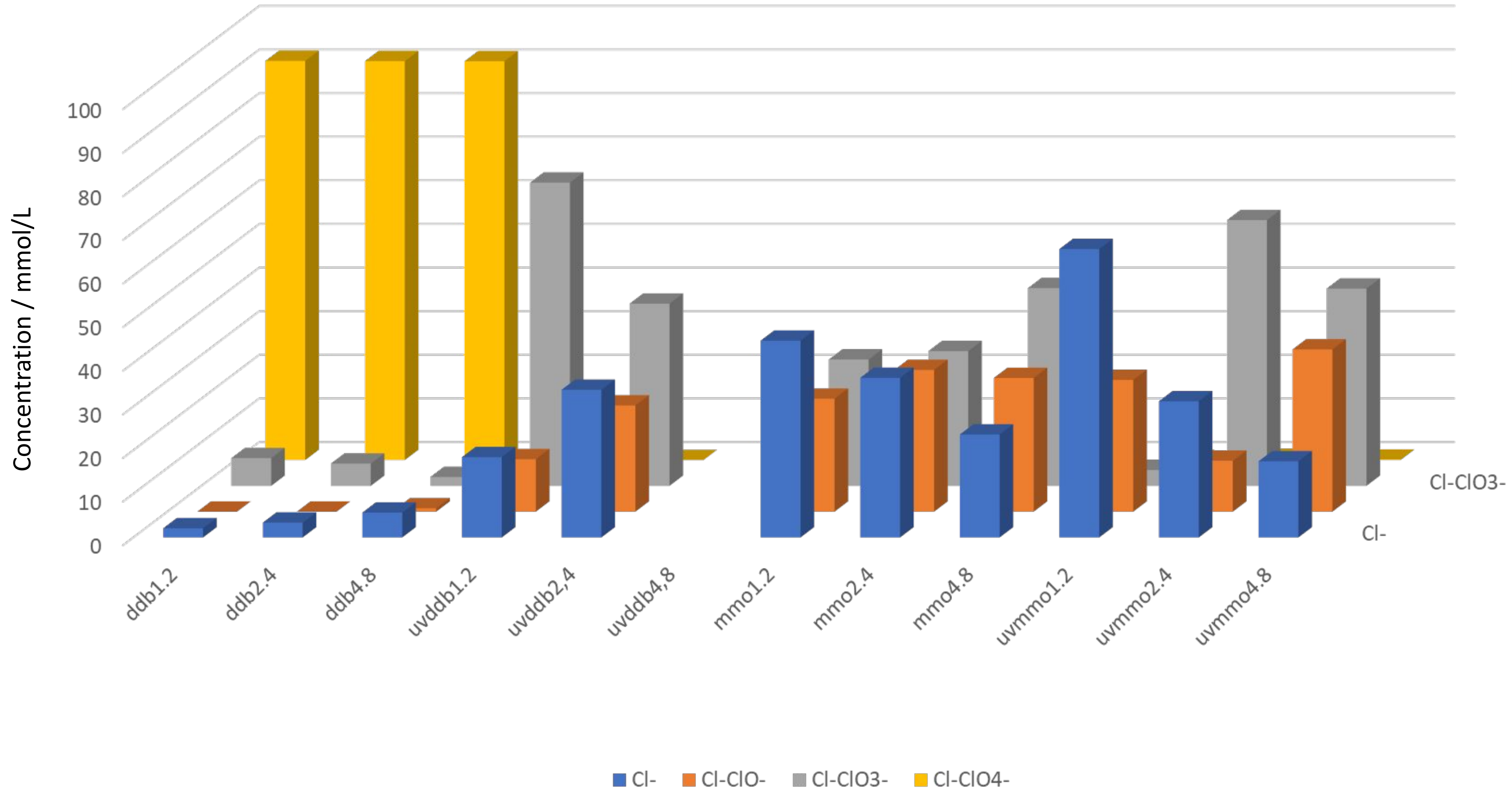


Electrochemical treatment of extracted water.

Electrolysis
PhotoElectrolysis
Electrodes: BDD and MMO






Concentration / mmol/L
100
90
80
70
60
50
40
30
20
10
0
ddb1.2
ddb2.4
ddb4.8
uvddb1.2
uvddb2,4
uvddb4,8
mmo1.2
mmo2.4
mmo4.8
uvmmo1.2
uvmmo2.4
uvmmo4.8
Cl-ClO3-
Cl-
Cl-
Cl-ClO-
Cl-ClO3-
Cl-ClO4-

Conclusions

Low efficiency of E-fenton Process.

H_2O_2 can partially degrade HCH

Electrooxidation with BDD is able to attain complete removal of HCH and derivates, but perchlorate is also generated

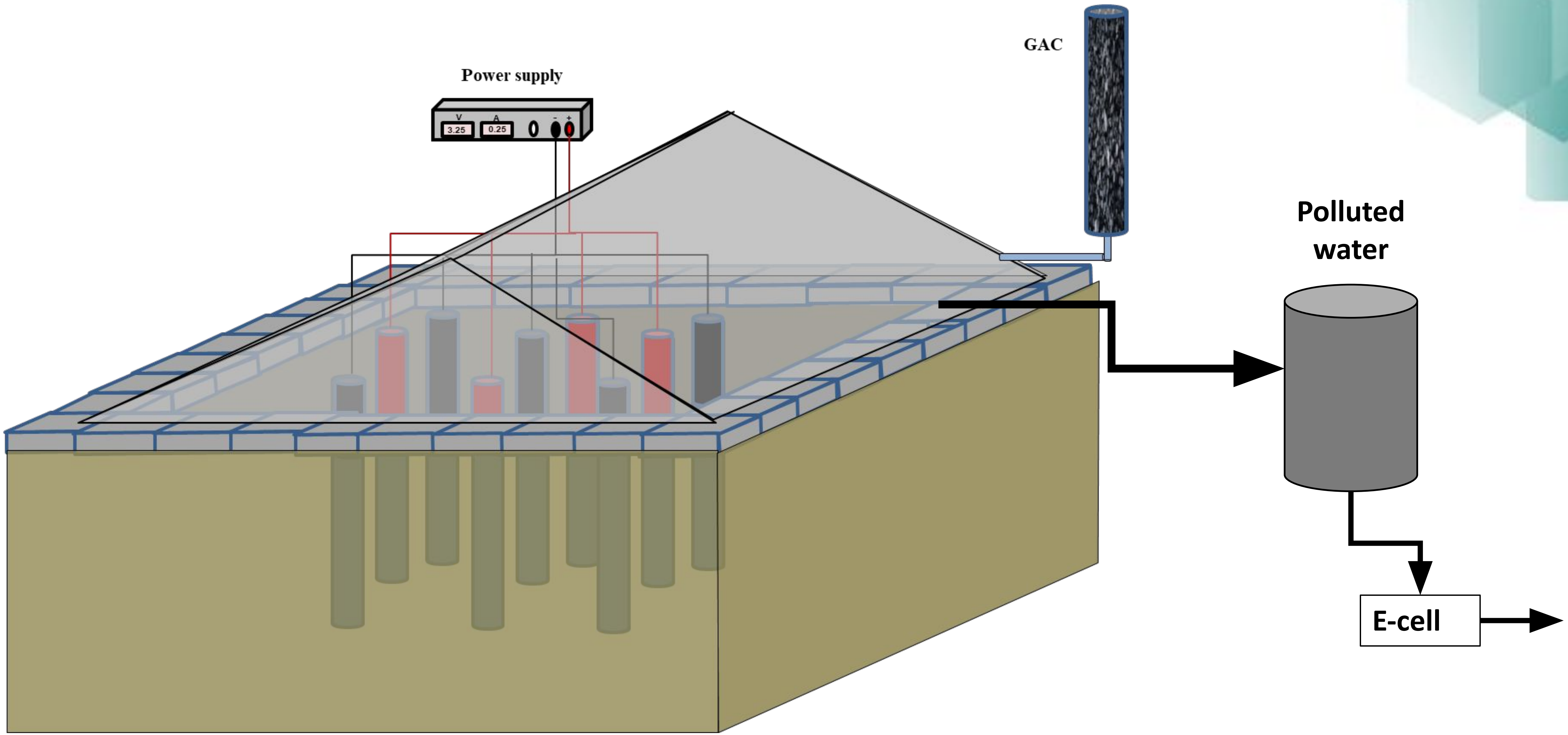
Low efficiency of MMO electrodes

UV irradiation negatively affects COVs degradation

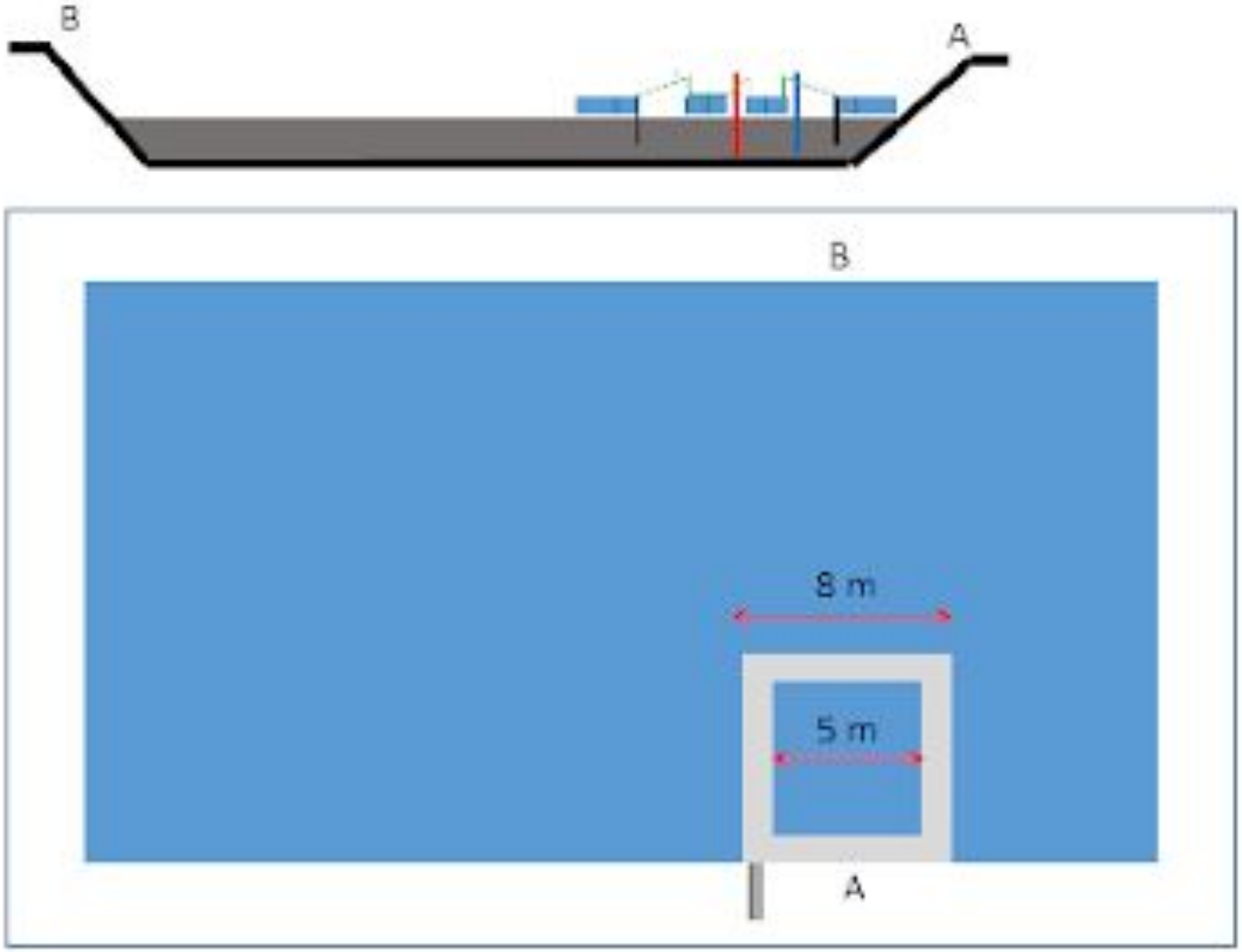
Direct process instead of radicalary process

Dismantling sludge dump

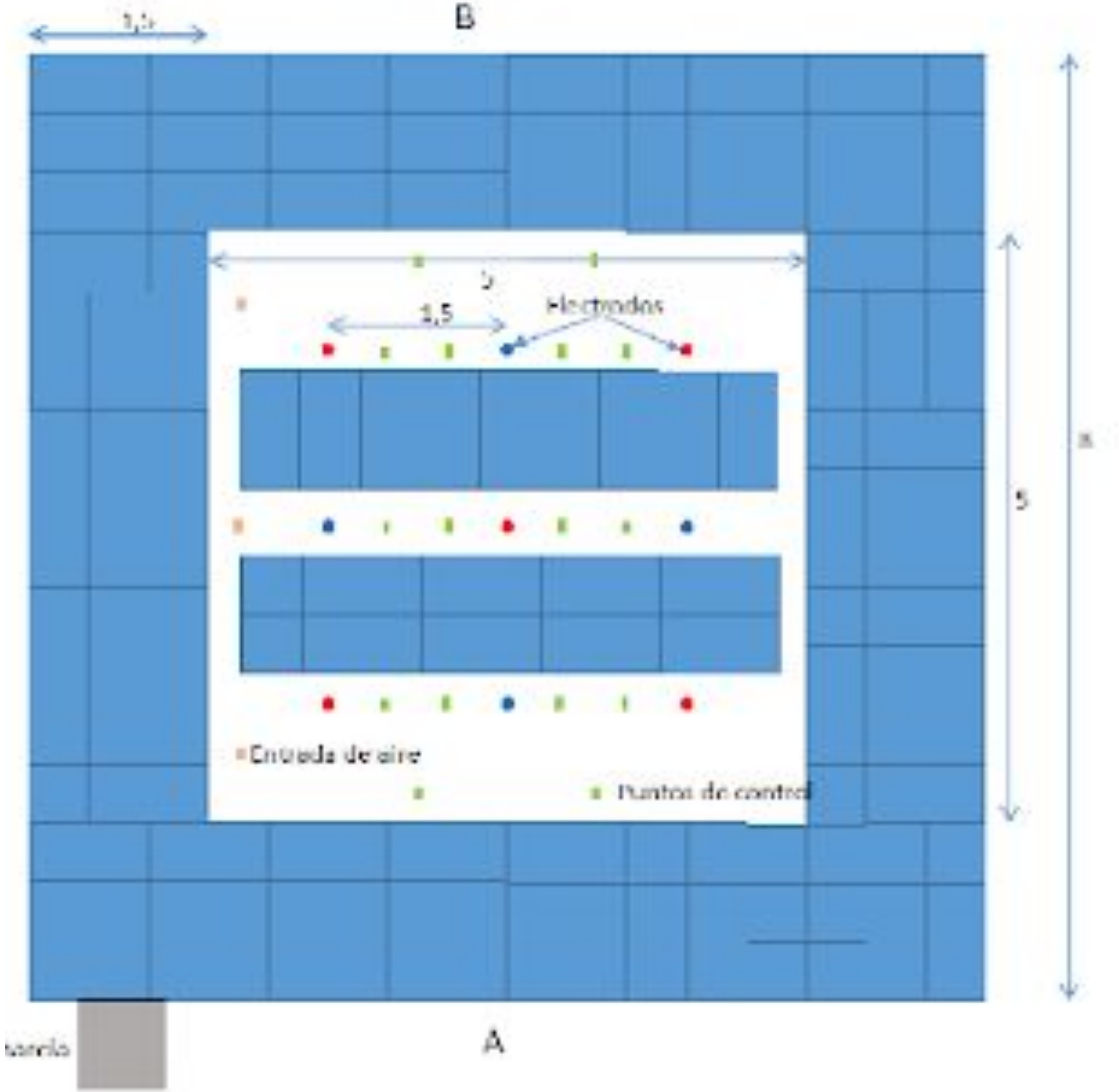
Sludge dump dismantling.

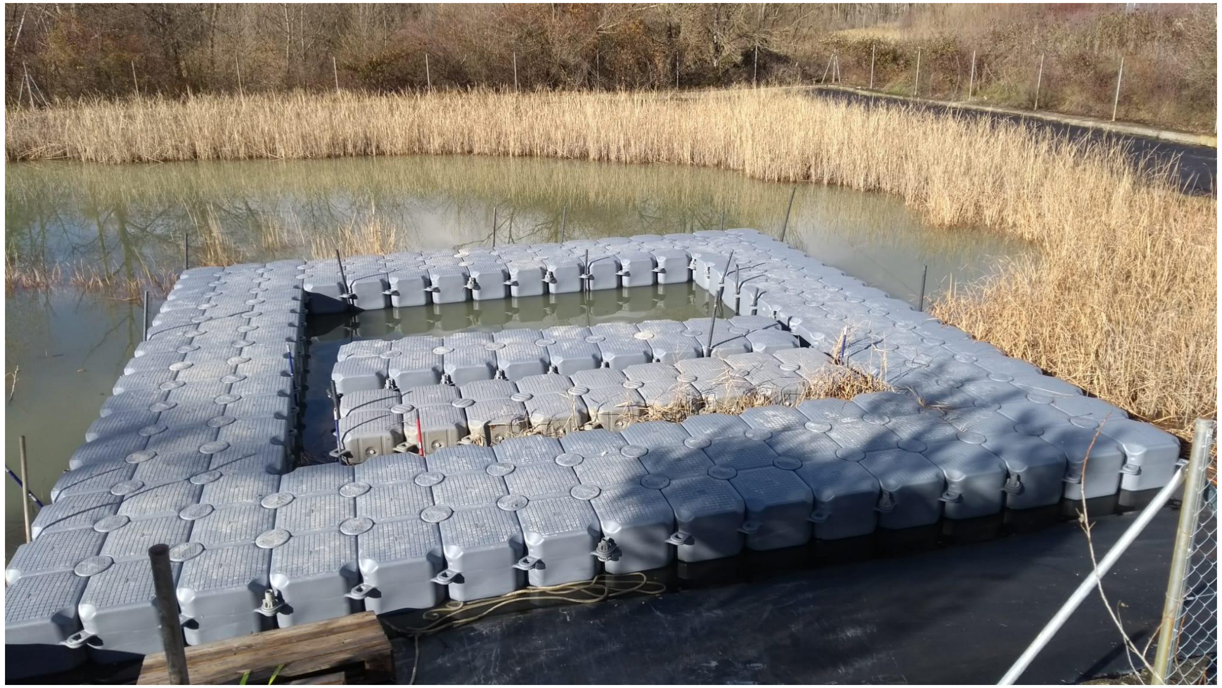


Sludge dump dismantling.



Sludge dump dismantling.

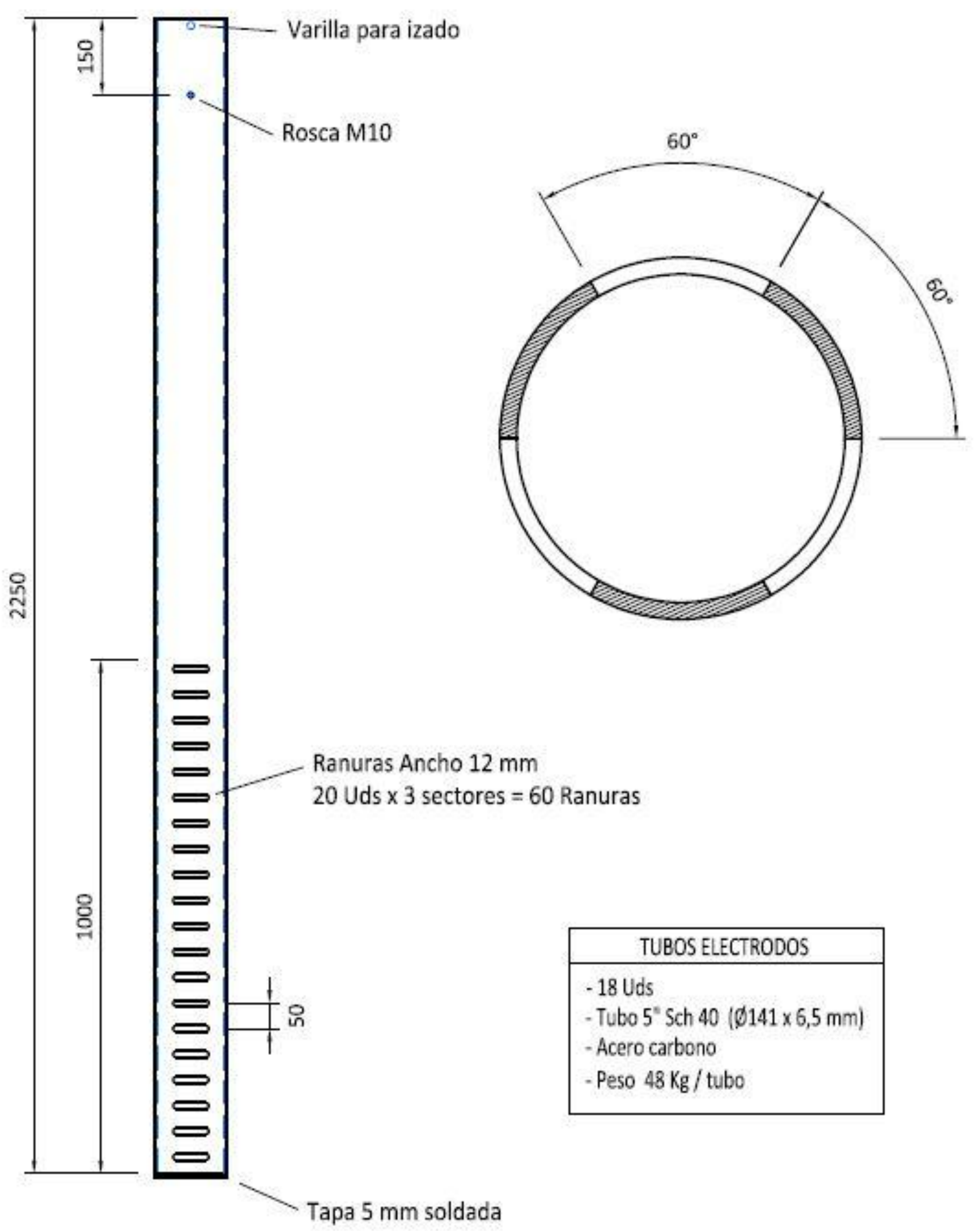




Sludge dump dismantling.

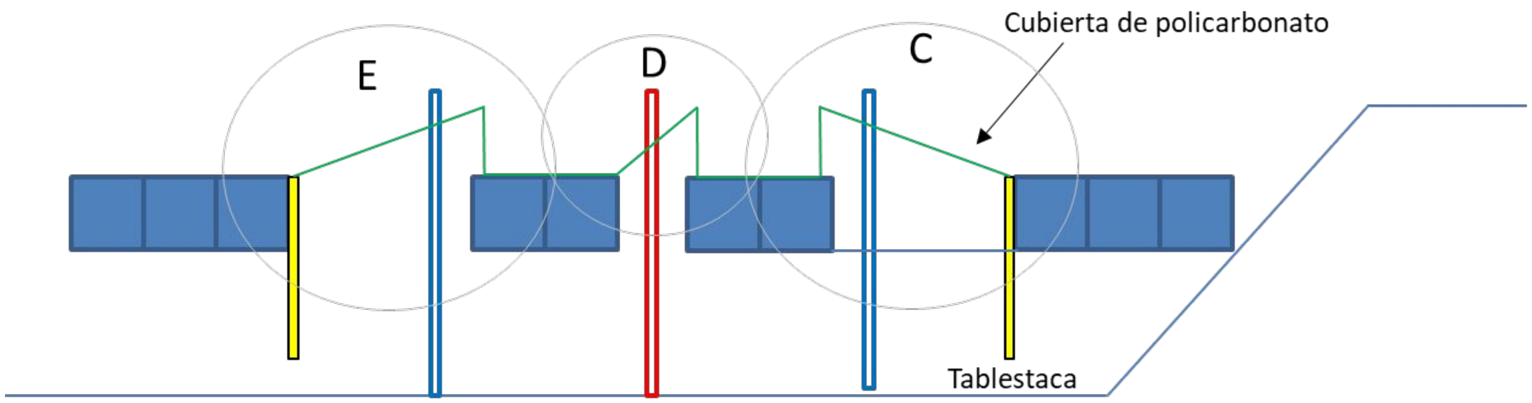
Electrodes:

Iron
hollow and perforated tube



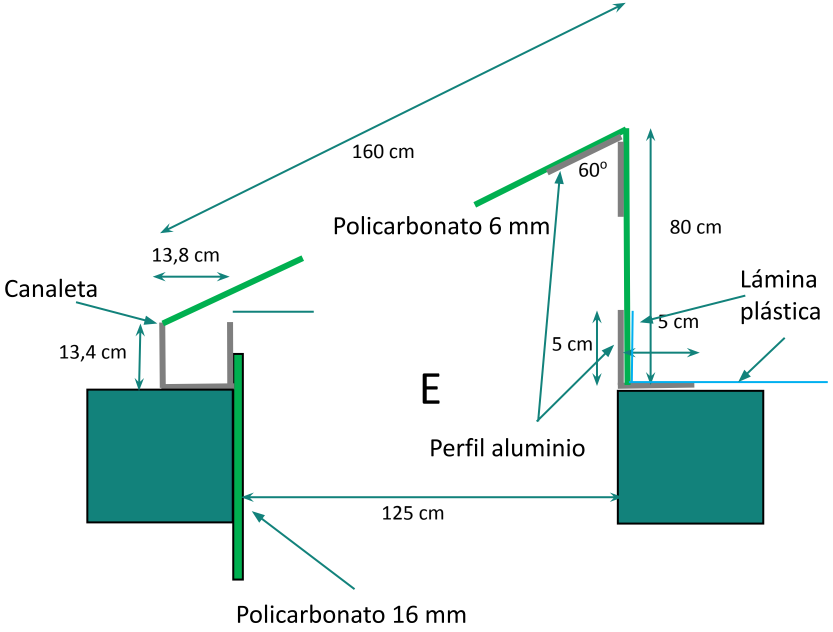
Sludge dump dismantling.

Cover:

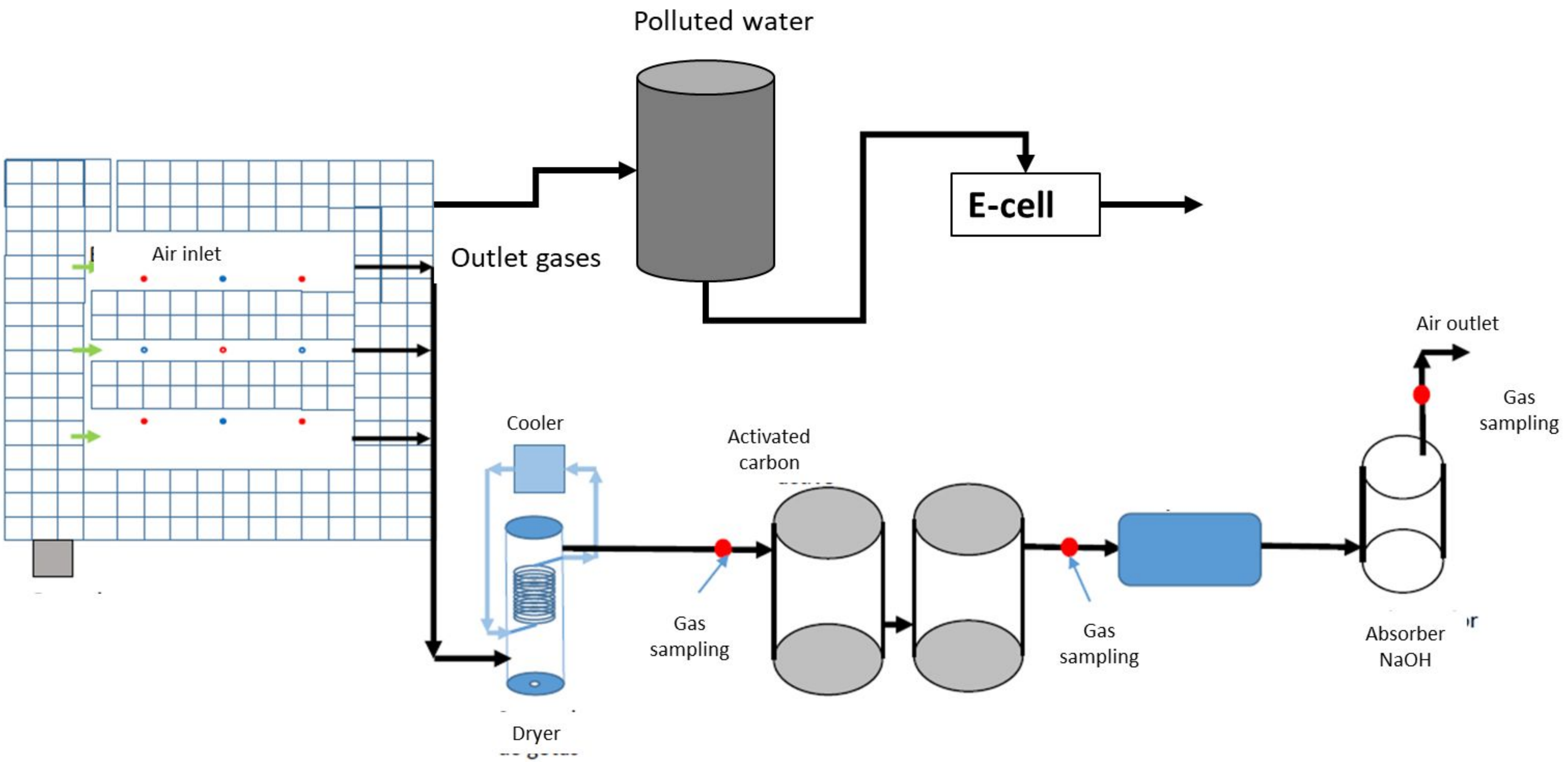


Polycarbonate plate (to cover)

Water collection channel



Sludge dump dismantling.



To be continued ….

14th International HCH and Pesticides Forum

THANK YOU FOR YOUR ATTENTION

Cristina.saez@uclm.es

emgrisa

GOBIERNO DE ARAGON

UCLM Universidad de Castilla-La Mancha

CAMPUS DE EXCELENCIA INTERNACIONAL

14th International HCH and Pesticides Forum