



Win4Collective – RED4SOLS

Short-time electrodialectic remediation of Walloon polluted soils

Intersoil 2026 – 07/10/2026

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07/10/2026



Introduction

Context: high extents of Walloon polluted soils

Goal: Implementation of electrodialytic remediation inside industrial soil washing plant

→ Electrokinetic extraction with ion exchange membranes

→ ↘ remediation time < 5h (literature: min 48h batch mode)

→ Energy: < 100 kWh/t.d.m. (literature: min 340 kWh/t.d.m.)

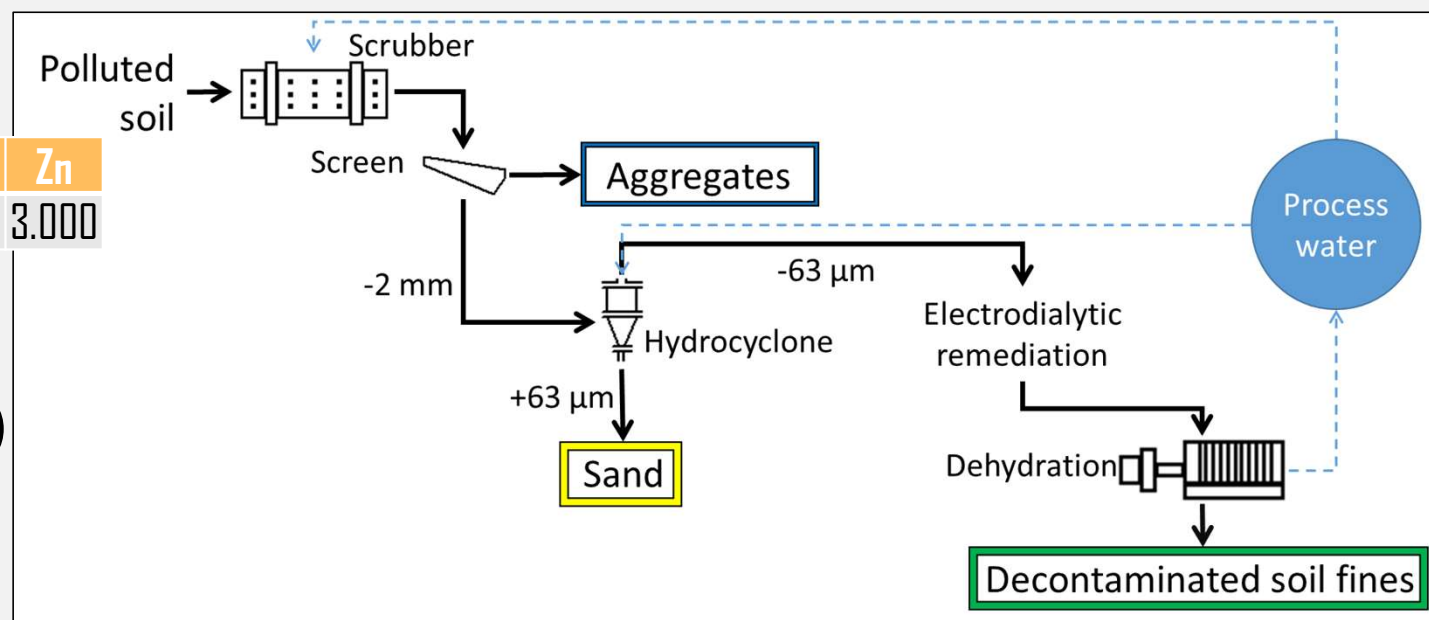
→ Limited reactants consumption

→ **Industrial soil (type V)**

	As	Cd	Cr	Cr ^{VI}	Cu	Hg	Ni	Pb	Zn
Type V (mg/kg)	65	20	288	13	600	5	350	1.840	3.000

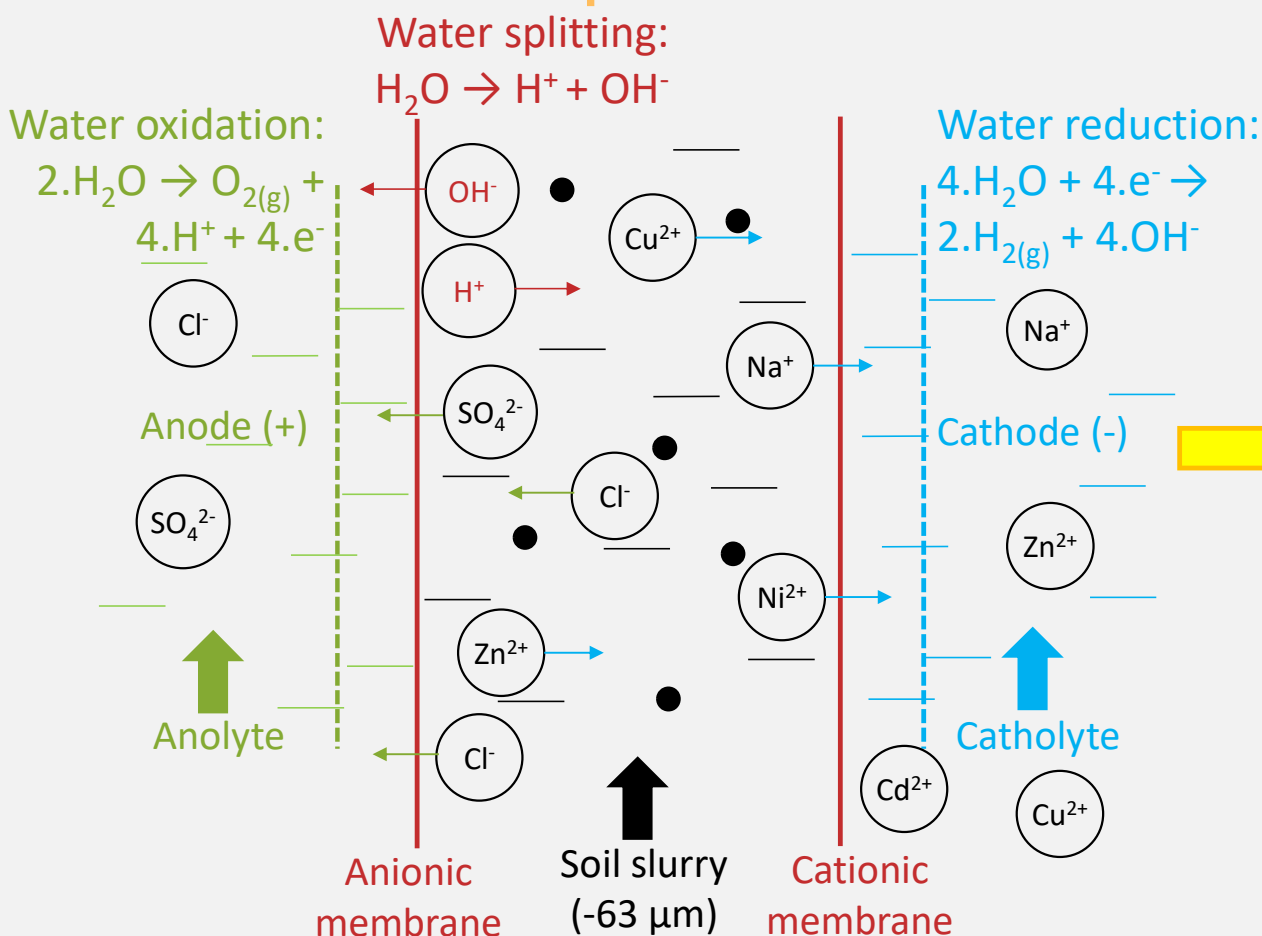
Win4Collective project:

- 2.5 years (01/01/2024 → 30/06/2026)
- CTP – U.Liège Gembloux Agro BioTech

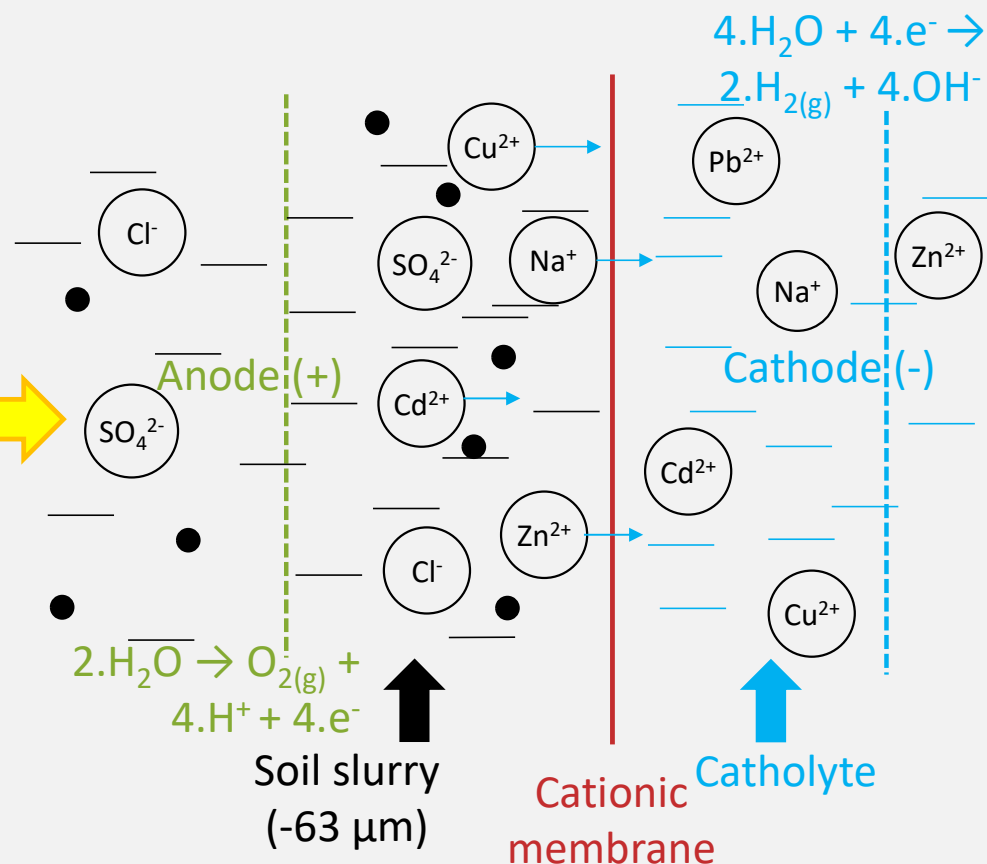


Electrodialytic remediation

3 compartments

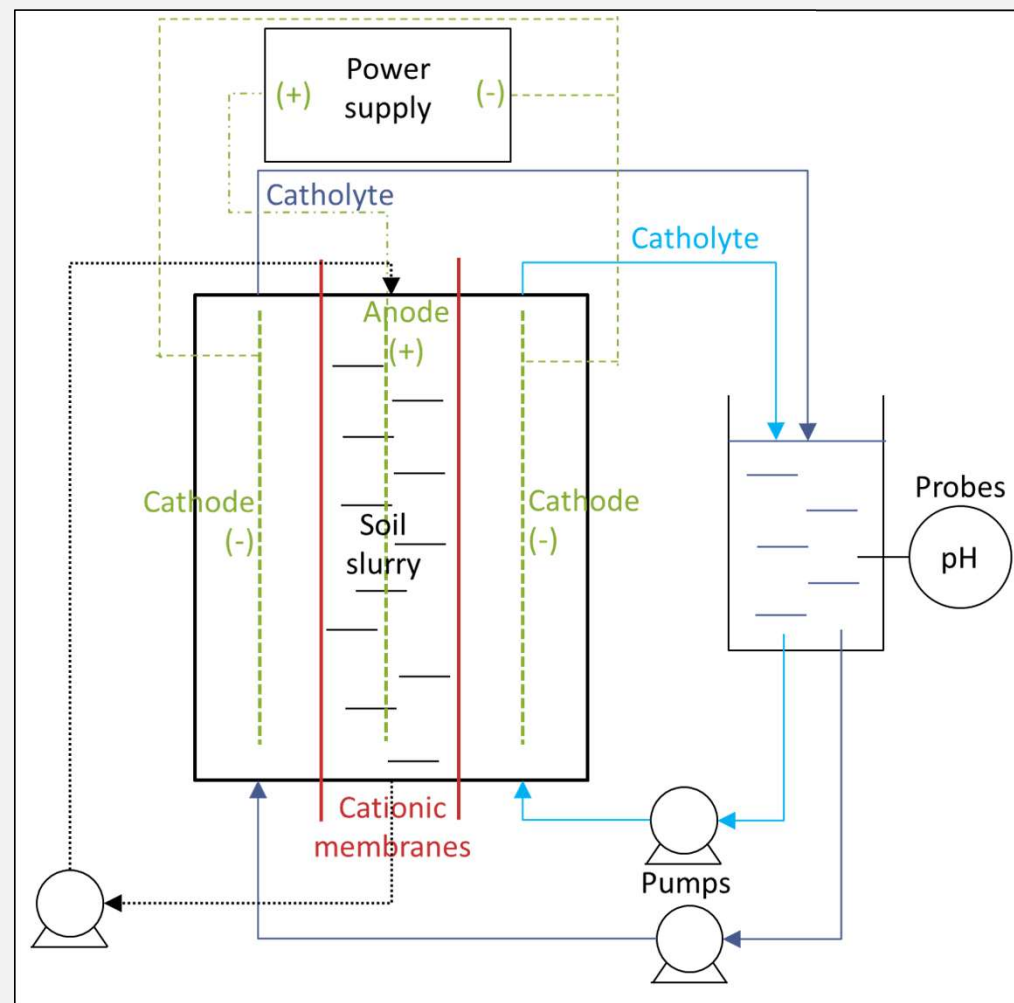
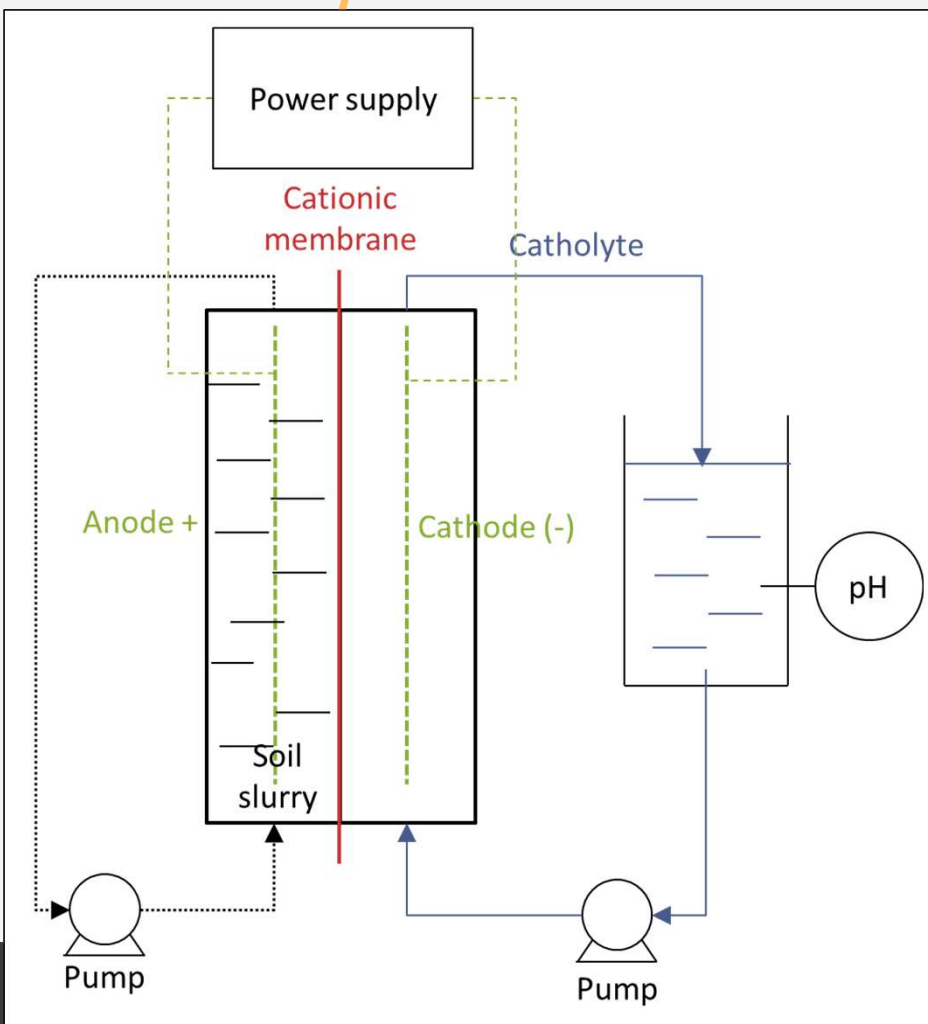


2 compartments



2 compartments cells for electrochemical remediation

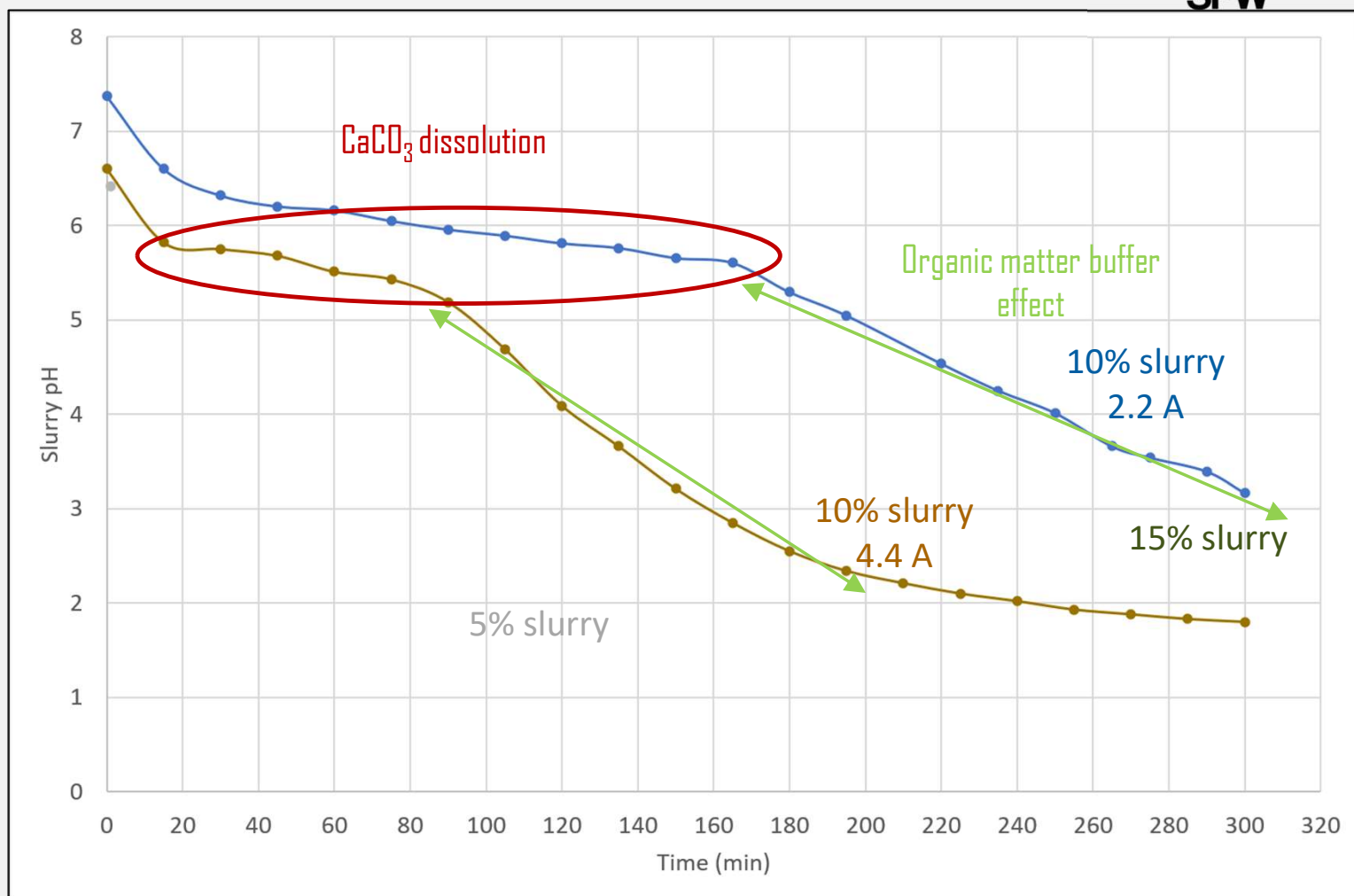
Anode in slurry: direct acidification / 2 tested setup



Electrodialytic remediation in batch mode

Direct acidification:

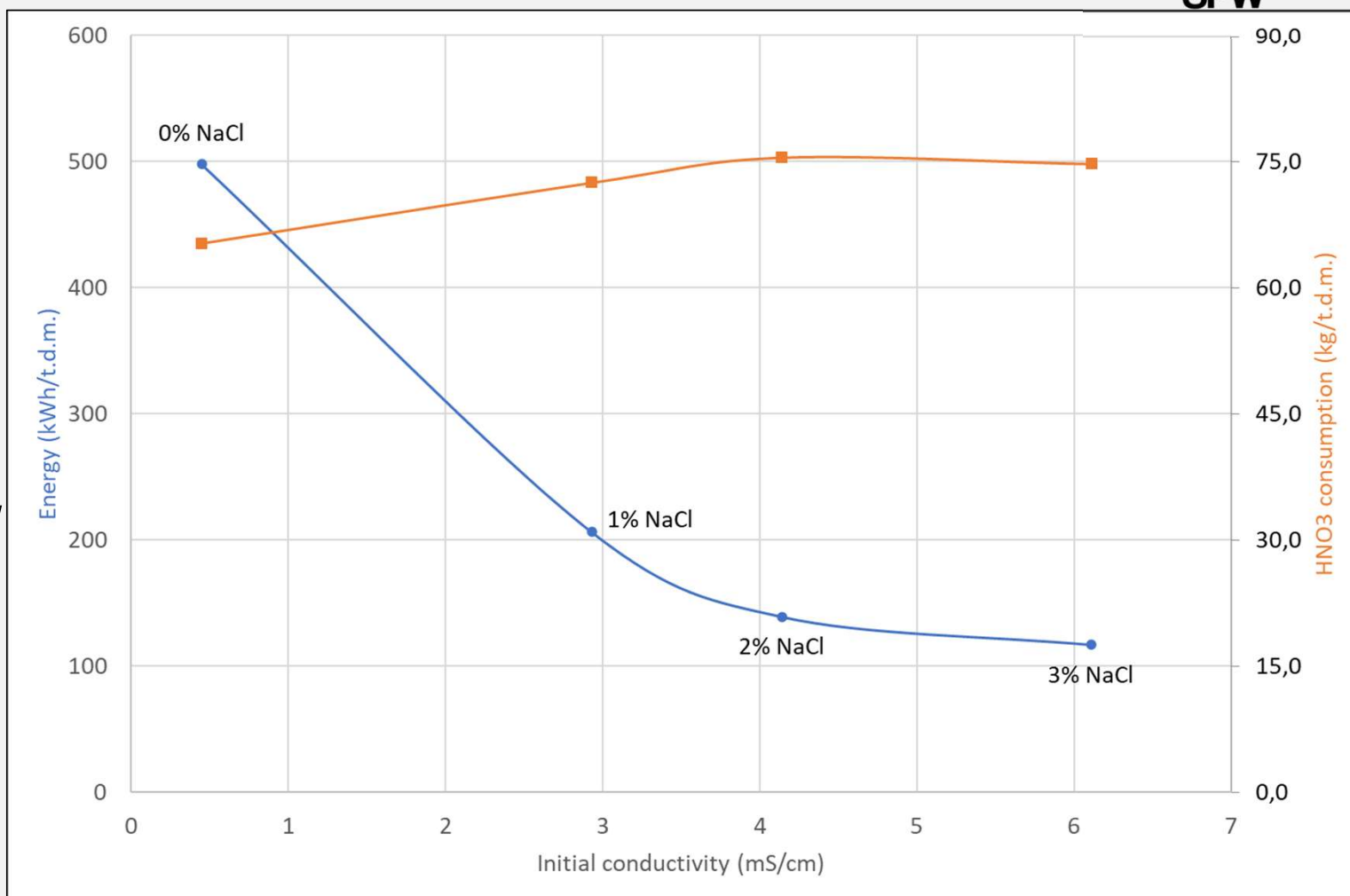
- Current intensity
→ constant current density
- Soil constituents:
 - $[\text{CaCO}_3]$
 - $[\text{OM}]$
- Slurry dry matter
- ↘ remediation time to 2-3h



Electrodialytic remediation in batch mode

Importance of conductivity

- Conductivity $\uparrow \rightarrow \searrow$ Energy
- Adding NaCl (2.3 mA/cm^2)
 - $\rightarrow \uparrow$ conductivity
 - $\rightarrow \searrow$ energy
 - $\rightarrow$ Acid consumption $\approx$
- Long-term stability of conductivity
 - $\rightarrow$ liquid pulp recycling



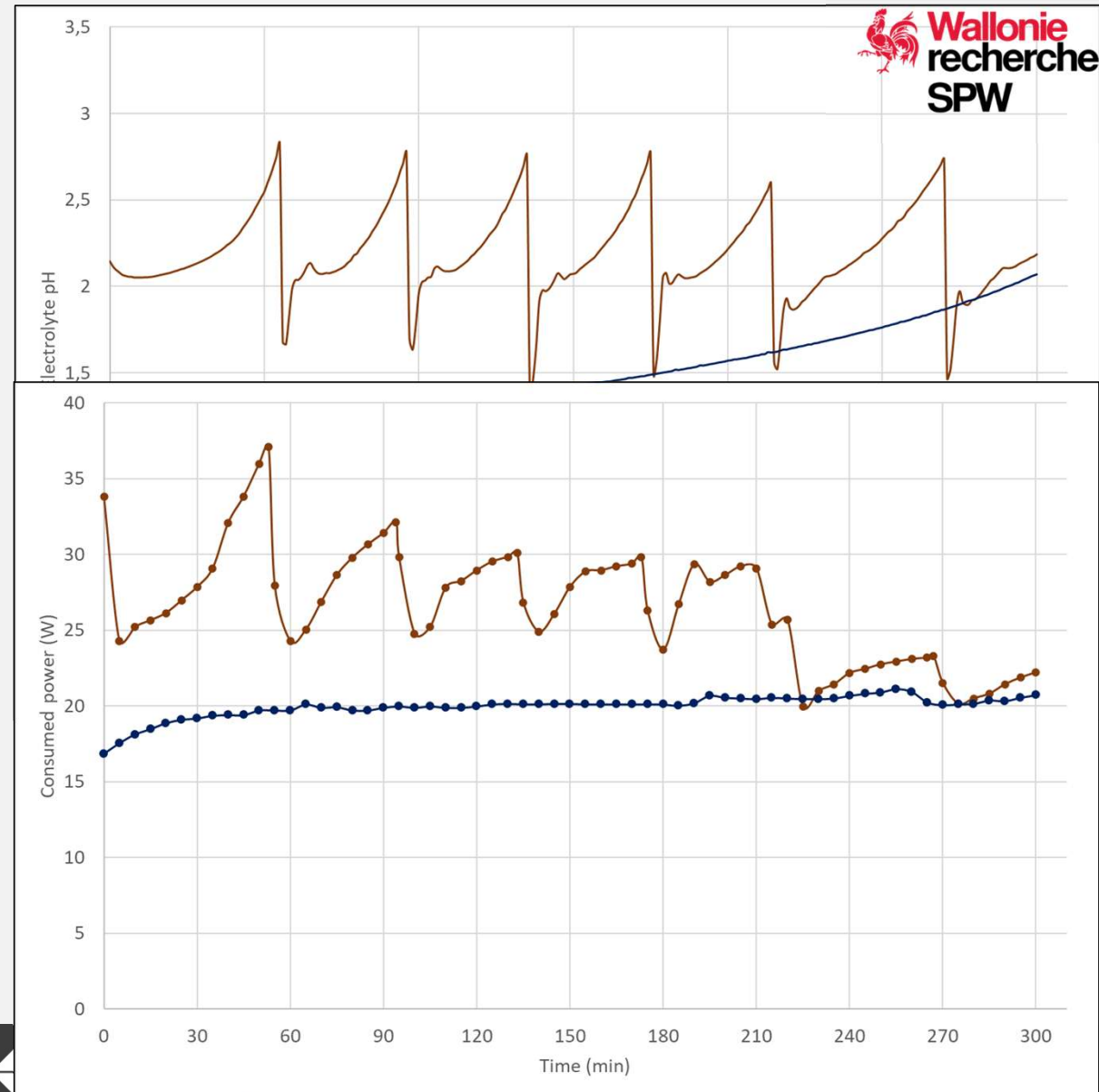
Electrodialytic remediation in batch mode

Electrolyte: importance of conditioning

- Partial: overtension $\rightarrow$ Energy $\uparrow$
- Total: stable consumed power $\rightarrow$ Energy $\downarrow$

Conditioning	Consumed energy (kWh/t.d.m.)	Consumed HNO_3 (kg/t.d.m.)
Partial	220.9	138.5
Total	166.5	145.3

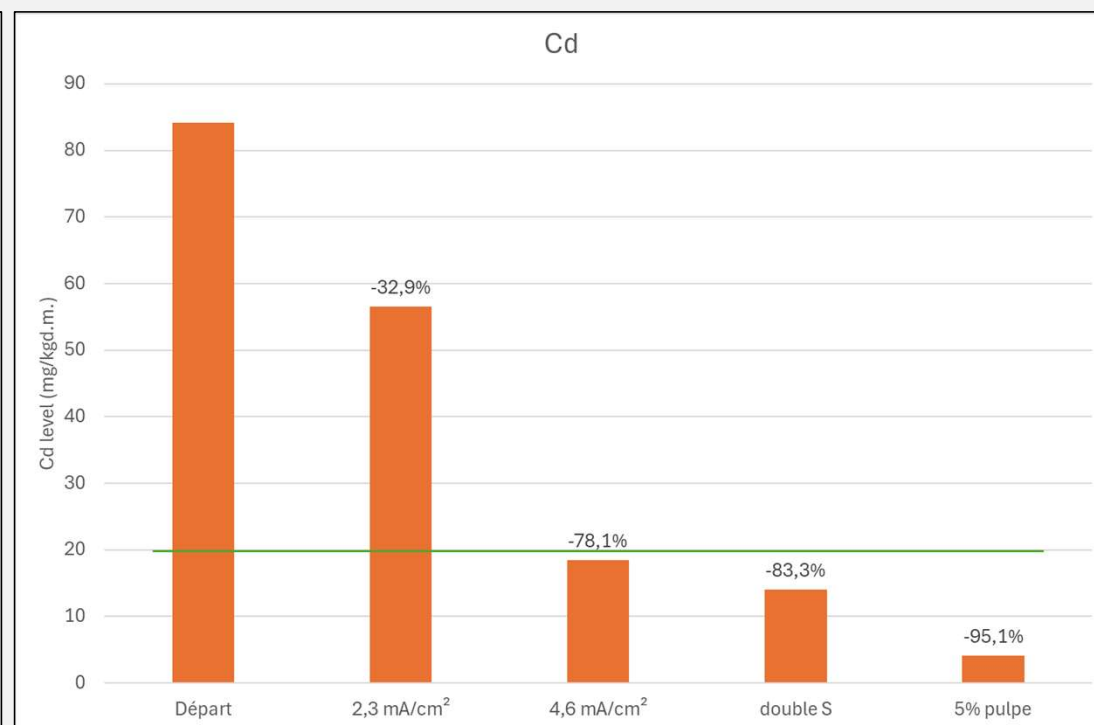
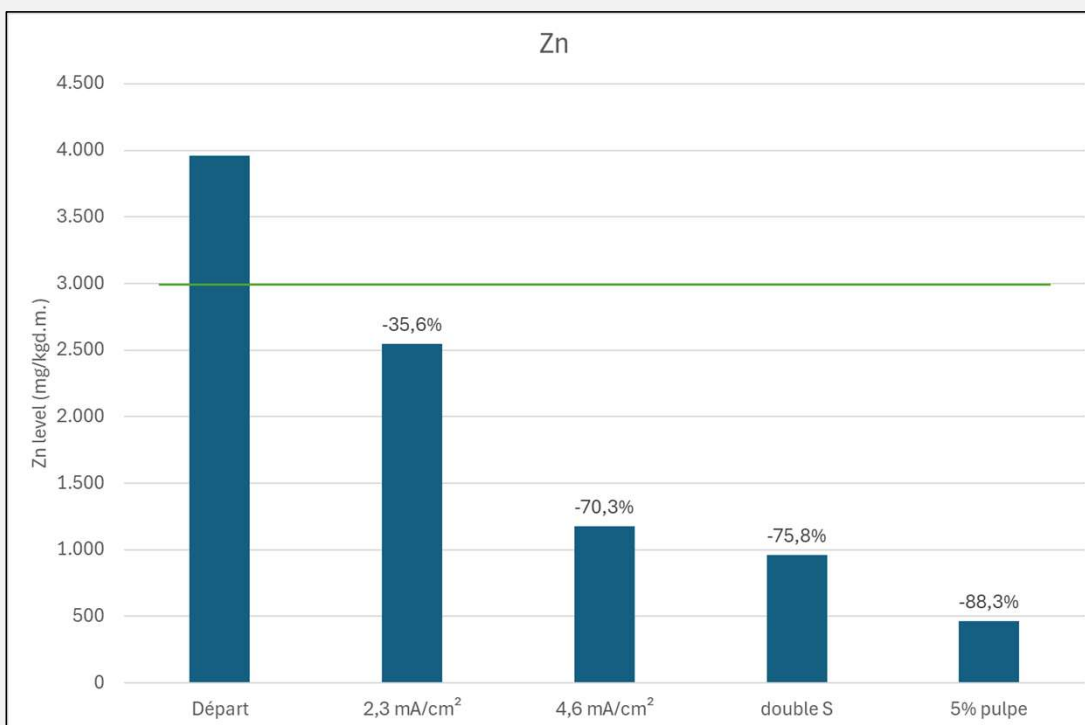
- HNO_3 (1 mol H^+) $\rightarrow$ H_2SO_4 (2 mol H^+)



Electrodialytic remediation in batch mode

Heavy metals levels (after 5h)

Trial	Cell	Current	Slurry	Electrolyte
	-	mA/cm ²	Dry matter / NaCl	-
2.3 mA/cm ²	2 comp	2.3	10% / 3 g/L	Partial
4.6 mA/cm ²	2 comp	4.6	10% / 5 g/L	Partial
double S	2 comp/double S	2.3	10% / 5 g/L	Partial
5% DM	2 comp/double S	2.3	5% / 5 g/L	Total

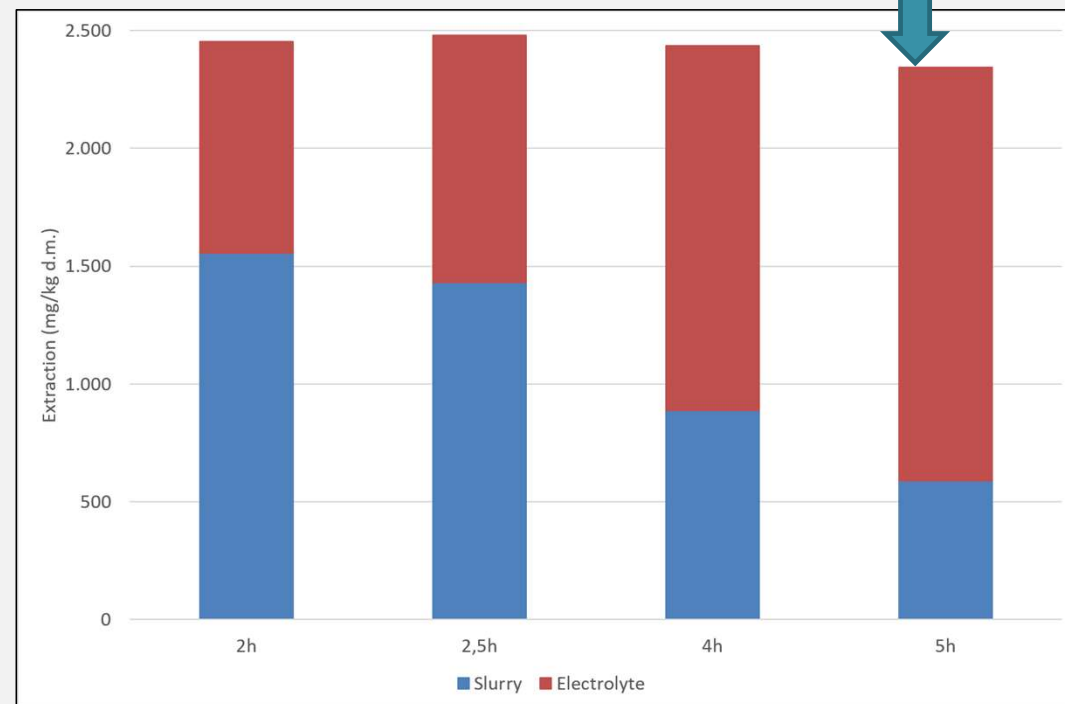
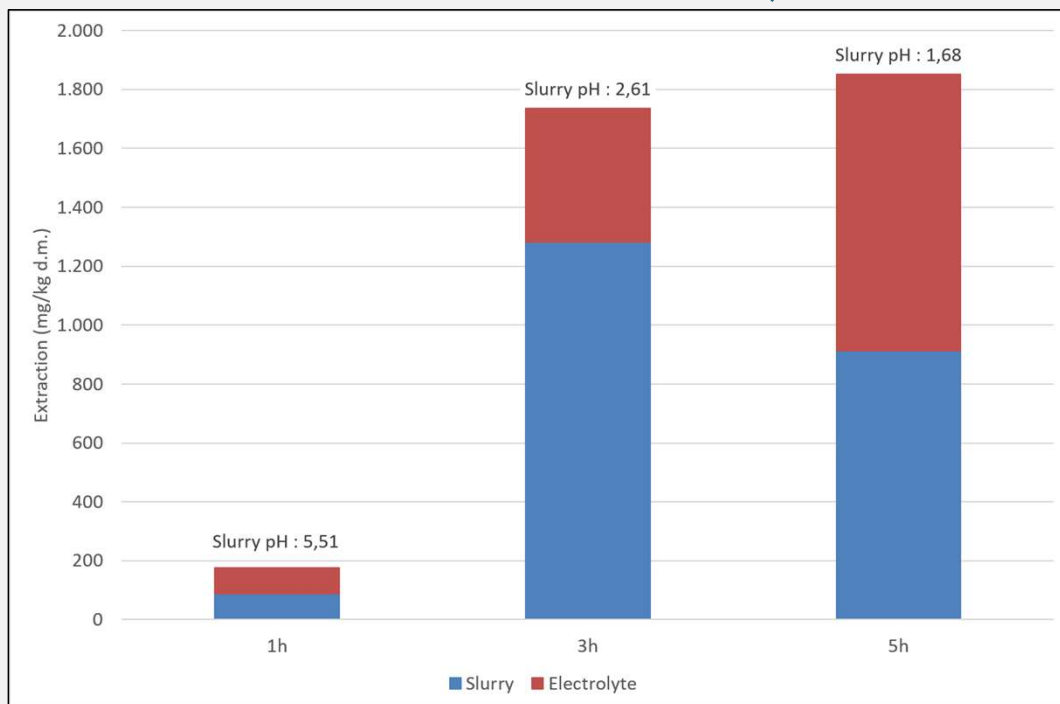


Electrodialytic remediation in batch mode

Heavy metals: electromigration

- Cd + Cu + Pb + Zn

Trial	Cell	Current	Slurry	Electrolyte
	-	mA/cm ²	Dry matter / NaCl	-
Double S	2 comp/double S	2,3	10% / 5 g/L	Partial
5% DM	2 comp/double S	2,3	5% / 5 g/L	Total



Electrodialytic remediation in batch mode

Preliminary conclusion for batch mode:

- 2 compartments cell
- Working with **constant** current density
- Acidification:
 - Able to reduce **below pH 2 in 2h !**
 - Key parameters: **current density/intensity**, **soil nature** and slurry **dry matter** content
- Electricity consumption: importance of **slurry conductivity** and **electrolyte conditioning**
 - higher but close to 100 kWh/t.d.m.
- **High heavy metals removal:**
 - Mobilisation linked to acidification
 - Slower electromigration



Close-continue mini-pilot

Observations:

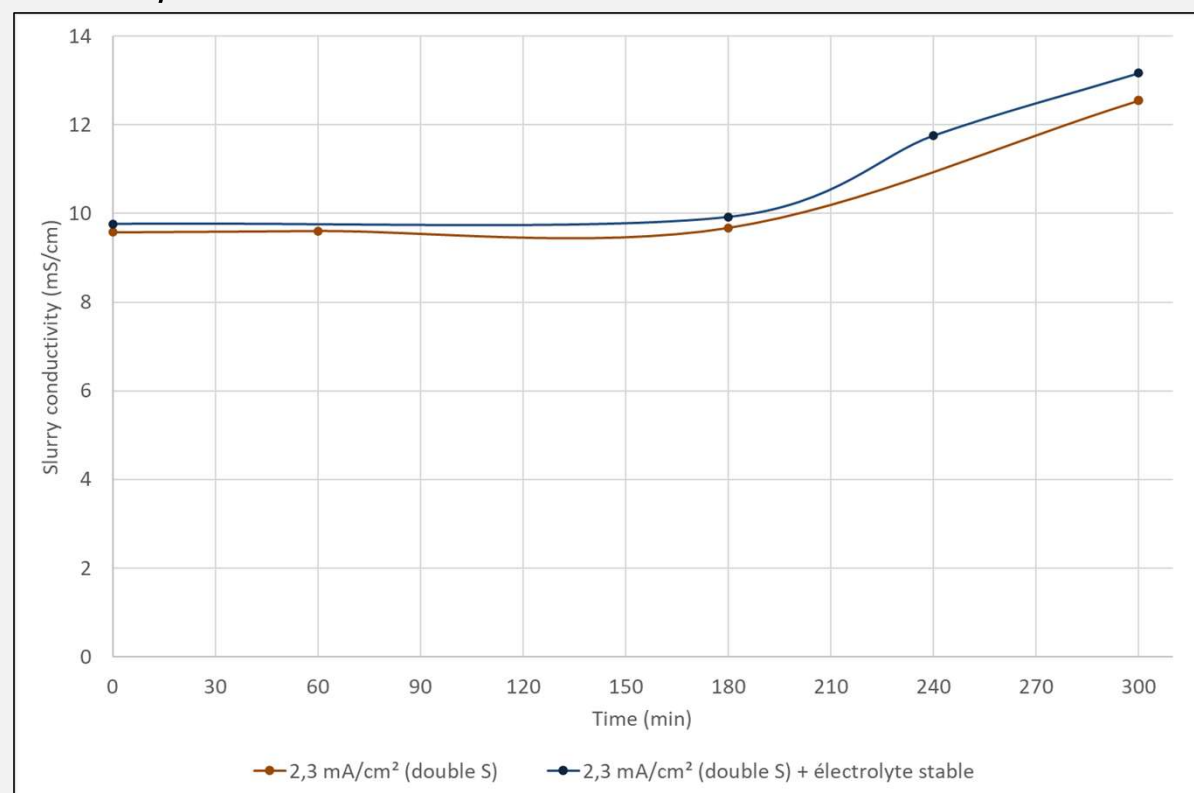
- Stability of slurry conductivity with time
- Final liquids already meet specifications (pH or conductivity)

→ Reuse in close loop of several liquids

→ Namely, working in a mode "close to continue"

Industrialization → test EDR in continue mode

} NaCl et H_2SO_4

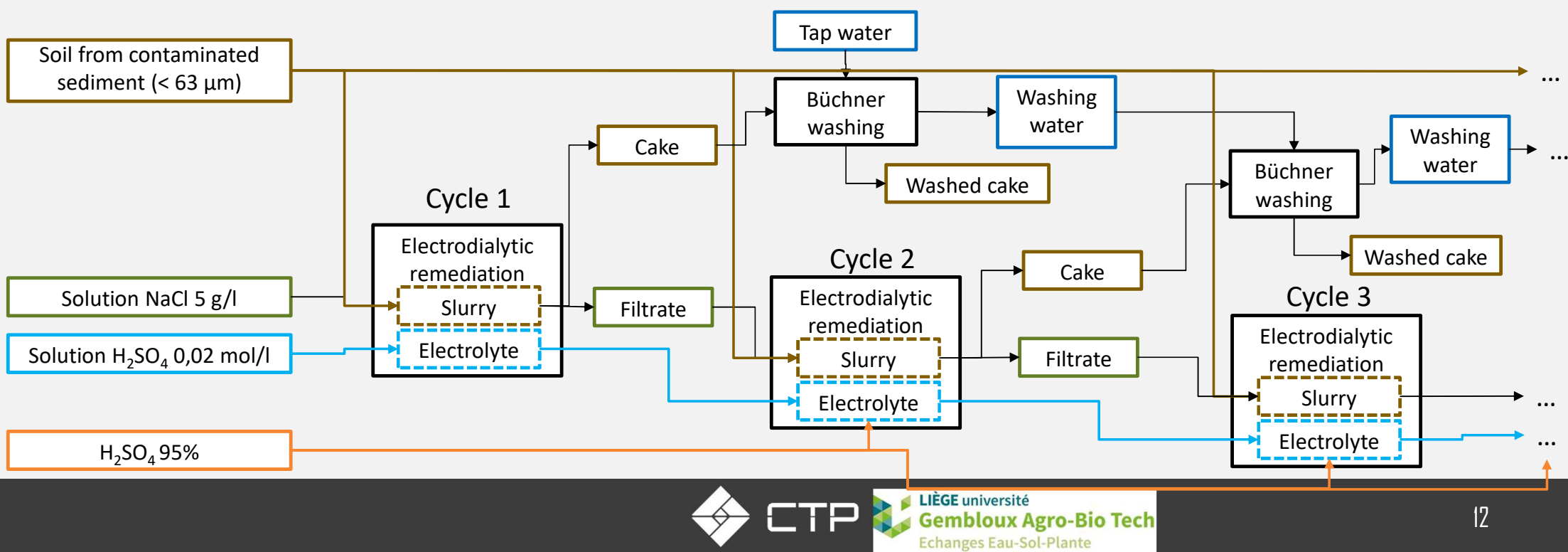


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LIÈGE université
Gembloux Agro-Bio Tech
Echanges Eau-Sol-Plante

Close-continue mini-pilot

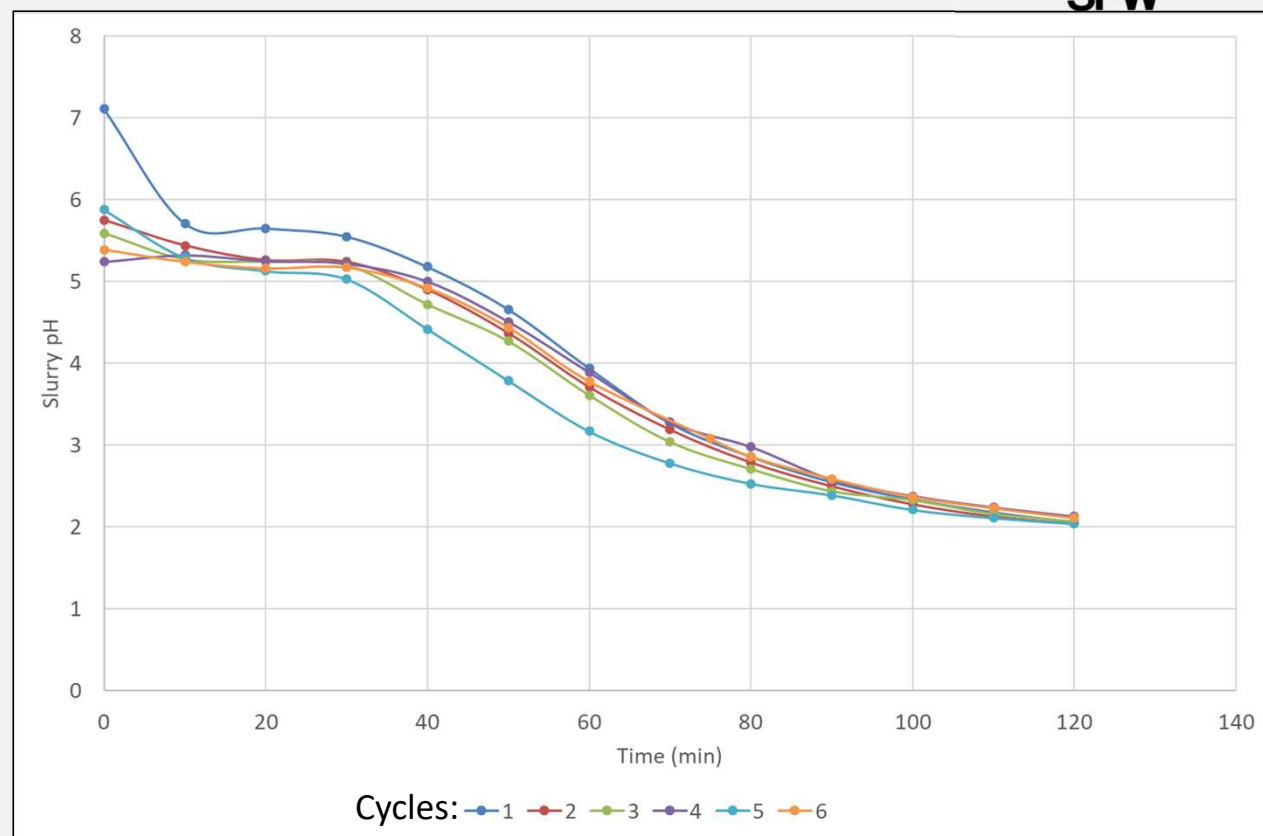
- Goal: reuse of liquids, with specifications close to goals
- Conditions: 2 compartments cell with double membrane / 2.3 mA/cm^2 / **2h** / slurry: 5% DM + 5 g/L NaCl / Electrolyte: H_2SO_4
- Reiterated 6 times, reuse of liquids



Close-continue mini-pilot

General parameters and results

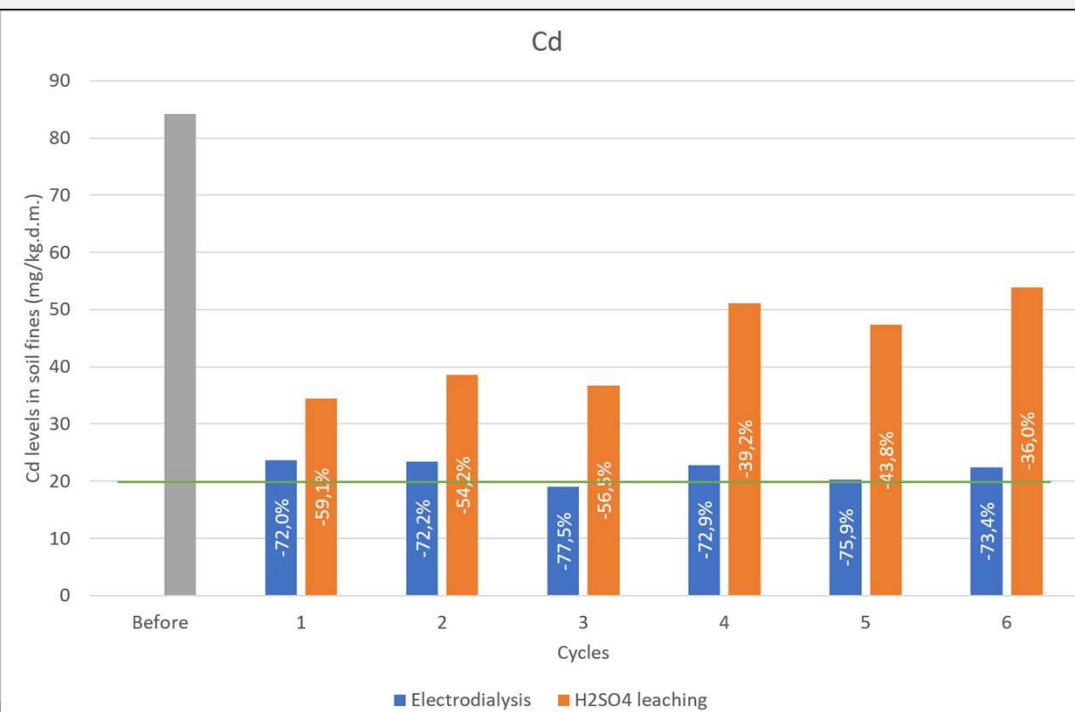
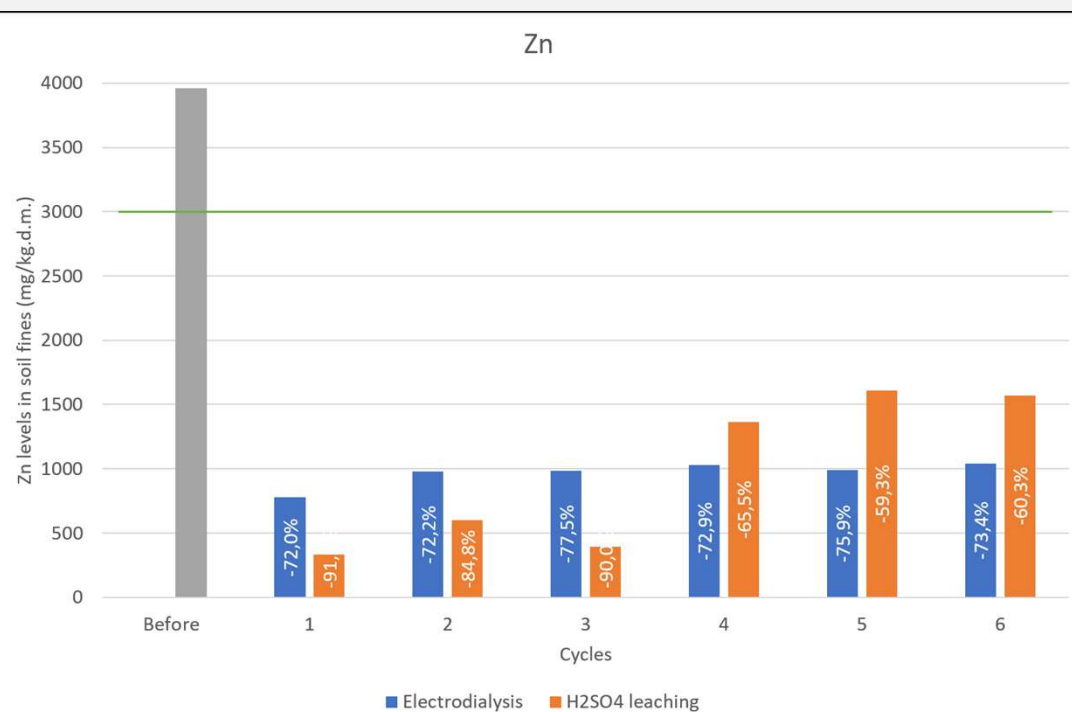
Cycles	Final pH	Energy (kWh/t.d.m.)	H ₂ SO ₄ (kg/t.d.m.)	NaCl (kg/t.d.m.)
1	2.06	146.7	91.7	100
2	2.04	150.0	69.4	0
3	2.07	146.6	67.5	0
4	2.13	152.2	67.3	0
5	2.04	150.0	53.1	10
6	2.11	272.3	53.3	10



Close-continue mini-pilot

Remediated soil fines

Levels (mg/kg _{d.m.})	As	Cd	Cr	Cu	Ni	Pb	Zn
Before	46.1	84.2	229.1	219.9	116.3	876.1	3,957.8
After electro dialysis (mean)	43.2	21.9	235.4	165.2	69.8	738.9	966.4
	-6.3%	-74.0%	+2.8%	-24.9%	-39.9%	-15.7%	-75.6%
Type V	65	20	288	600	350	1,840	3,000



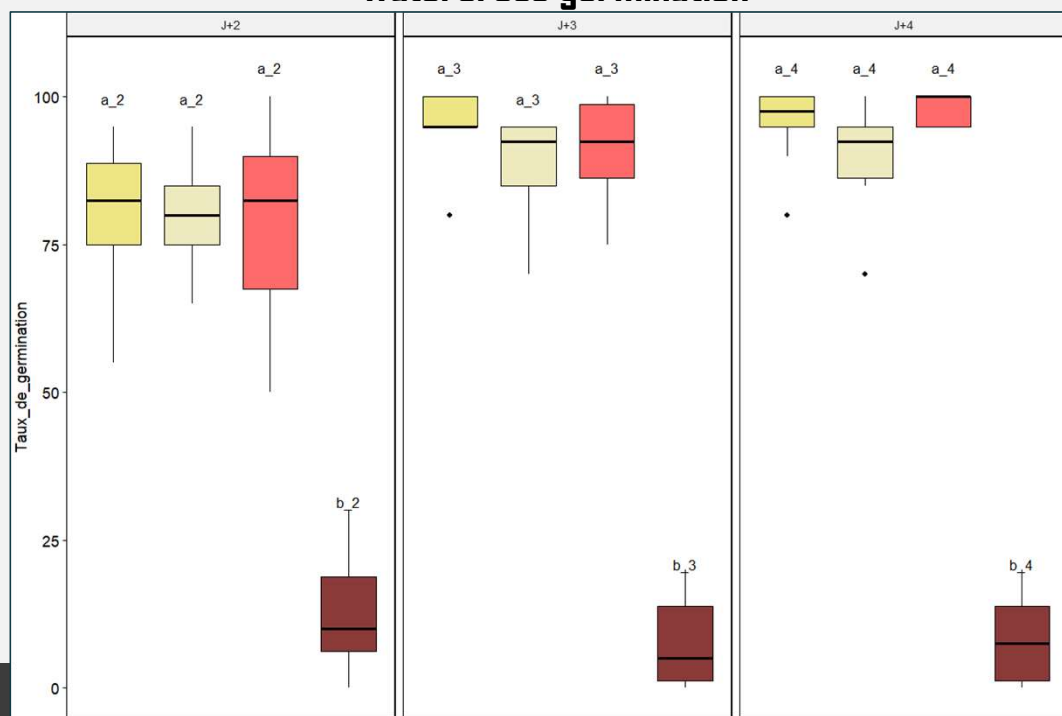
Remediated soil fines

Environmental assessment

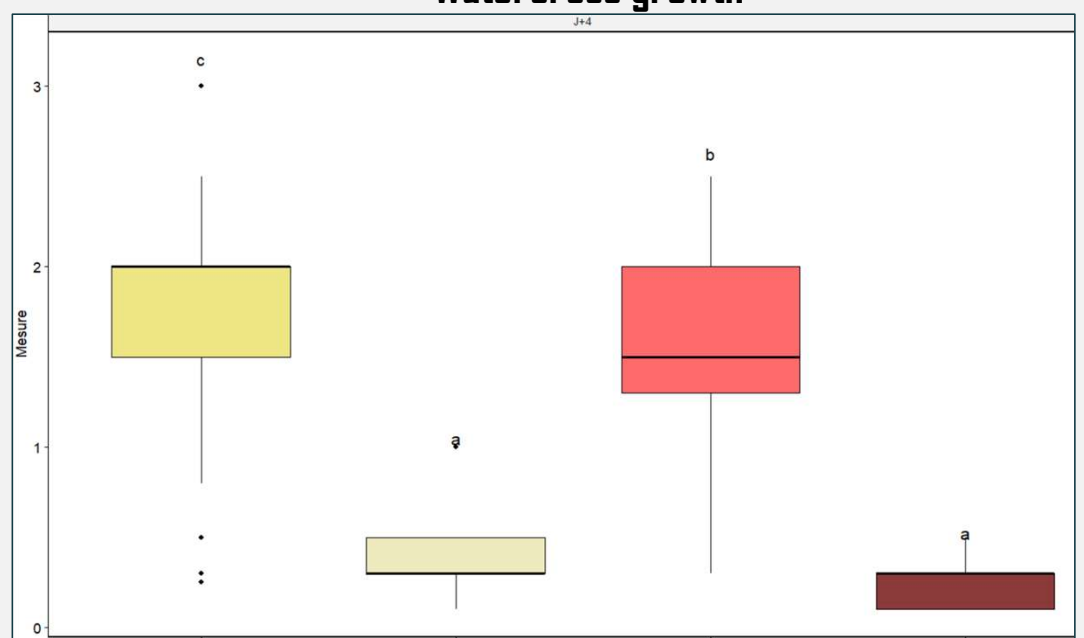
- Low pH, high HM mobility, $[Cl^-]$ and C/N
- Delay in germination → Reduce by ↘ residence time
- Slower plant growth

→ Need amendments: coarse materials / lime / basic by-products

Watercress germination



Watercress growth





Soil washing + electrodialysis

Economic assessment: 107,43 €/t.d.m., with landfilling of gypsum and metal sulfurs (without valorisation)

Operating parameters		Results
Electric consumption (kWh/t.d.m.)		150
Duration (h)		2
H ₂ SO ₄ consumption (kg/t.m.s.)		55
-63 μm (%)		63.11
NaCl consumption (% DM)		1
Slurry dry matter (%)		5
Produced gypsum (kg/t.d.m.)		13
Consumption Na ₂ S•3.H ₂ O (kg/t.d.m.)		28.61
Metal sulfurs (kg/t.d.m.)	ZnS	2.53
	FeS	5.71
Lime consumption (%)		1
Electrodes		Ti/Pt

Posts	Distribution	
	€/t.d.m.	%
Return on investment	44.90	41.8
Electric consumption (cell)	18.07	16.8
Electrolyte treatment	16.45	15.3
Mineral processing	7.33	6.8
Supervision, engineering and management	7.19	6.7
Reactants	5.38	5.0
Landfilling	4.99	4.6
Laboratory/analysis costs	2.40	2.2
Fines neutralisation	0.71	0.7
TOTAL	107.43	100
Investment costs (M€)	44,9	

→Need improvements in :

- Electrode materials: better cost/efficiency to ↘ investments and electric consumption
- Electrolyte treatment



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Conclusion

- **Electrodialytic remediation can be implemented in an industrial soil washing plant**
 - Optimal operating conditions determined
 - Possibility to recover valuable cations
 - Better performances than acid leaching
 - Impact on soil fertility
 - Economics: 107.43 €/t.d.m. for 44.9 M€ of investment

Perspectives:

- Obtaining a more economic process: cheaper electrodes, electrolyte treatment
→ Already made on stainless steel 316, but not efficient
- **Looking for partners to further projects:** B2B with industrial or collaborative projects, aiming to reach pilot scale

Questions?



Mathieu HENRY

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Acknowledgments:

RED4SOLS steering committee:

DC Environment

SPAQUE

IIS Wastes2Bio

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Duferco

ATRASOL

Belgarena

ARCEA

All Clean

Embridge