Session E : treatment

DéPLAssMétaux
ExPELMetals project: using a polluted soil to produce essential oils

PLAN OF PRESENTATION

- Origin of the project
- The research project
  - Presentation of the site
  - The soil
  - Pollutants
- Research works
  - Lab's
  - Greenhouse
  - On field
- Results
- Conclusion

PRELUDE

- The concept of remediation by phytoextraction comes from 2 facts
  - The existence of hyperaccumulative plants
  - Phytomining possibilities
- There, we can see 2 limitations:
  - Very accumulative plants produce a poor biomass
  - After mining the terrain isn't clean
- Thus, we have to explore a 3rd path

The plant: odorant pelargonium sp.

- A rustic plant able to grow upon heavy metals contaminated soil
- Producing enough biomass
- Non-edible for humans and animals
- Enhances bioavailability of metals through acidification by root system

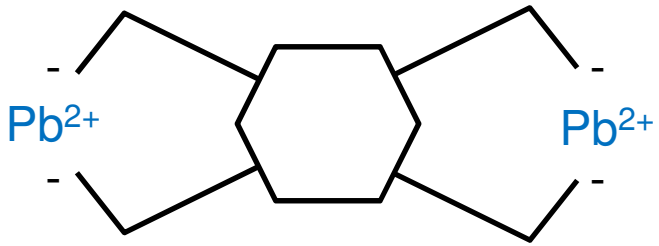
Pelargonium attar of rose

Pelargonium Atomic Snowflake

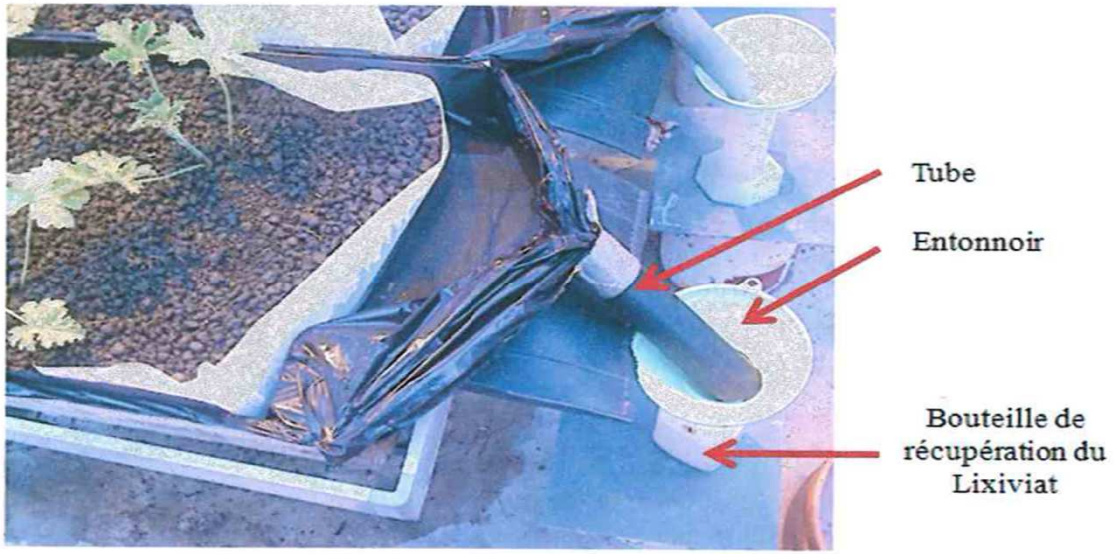
Pelargonium Lady Plymouth

PRELIMINARY WORKS

- With ENSAT's students, upon soils from METALEUROP
- Hypothesis : phytoextraction is limited by the low availability of metals
- → addition of a chelating agent
- But, to prevent chelatant' and metals' spreading in the environment, it's necessary to collect the leachates at the bottom, upon a watertight complex



PRELIMINARY WORKS



- Extracted metals were measured in plants and collected water
- analyses showed that most of the metals were found in leachates
- Example: extrapolation of the leaching rate of lead shows that we'll meet aims after 6 years of cultivation

Projet DéPLAssMétaux
ExPELmetals PROJECT

Démonstrateur de PhytoLixiviation Assistée des métaux

Experimental PhytoEnhanced Lixiviation of Metals

- A raw budget of:
  - 570 221 € for the 5 partners during 4 years+ 1 prolongation

- granting:
  - Through the project call EcoIndustries,
  - 400 000 € are granted by ADEME

PROJECT PARTNERS

Site Remediation company

Public entity
Provide an urban site

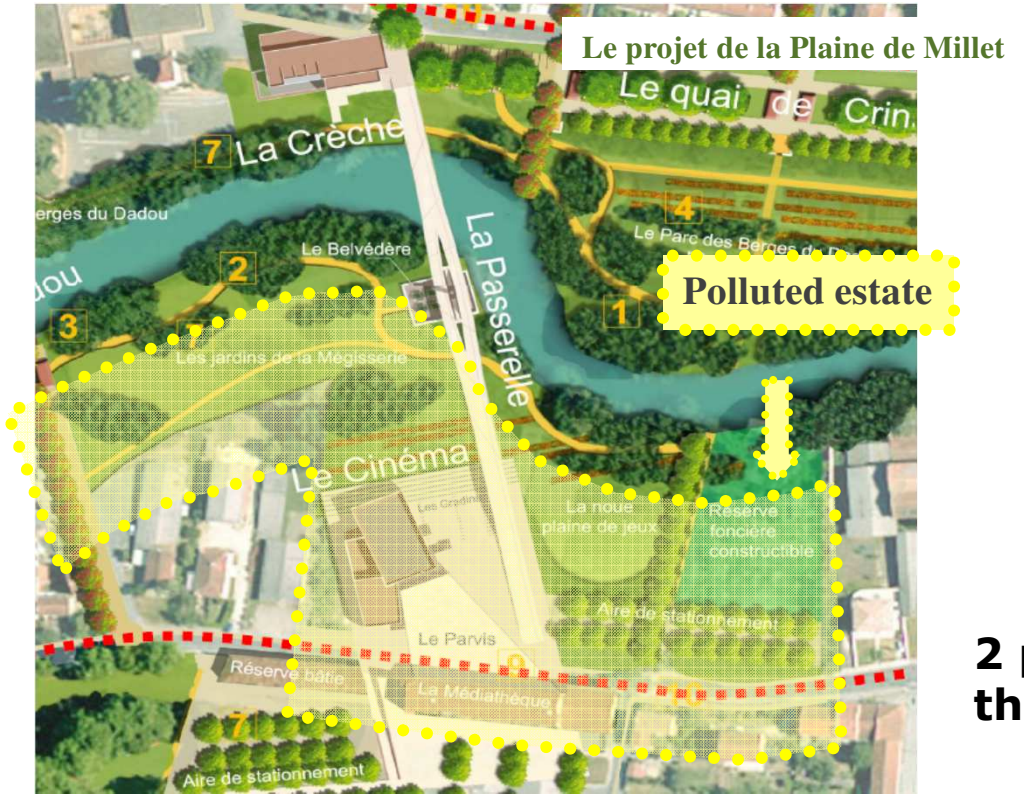
Public Lab studying
soils/plants/microbes
relationship

Studies Office
At pilot & industrial scales

Chemistry lab
- EO Extraction
- LCA

SITE IN GRAULHET

Due to an heavy industrial past, the City of Graulhet started in 2008 an active remediation approach of industrial sites.
167 brownfields are identified; 2 are used in the Plaine de Millet rehabilitation project:



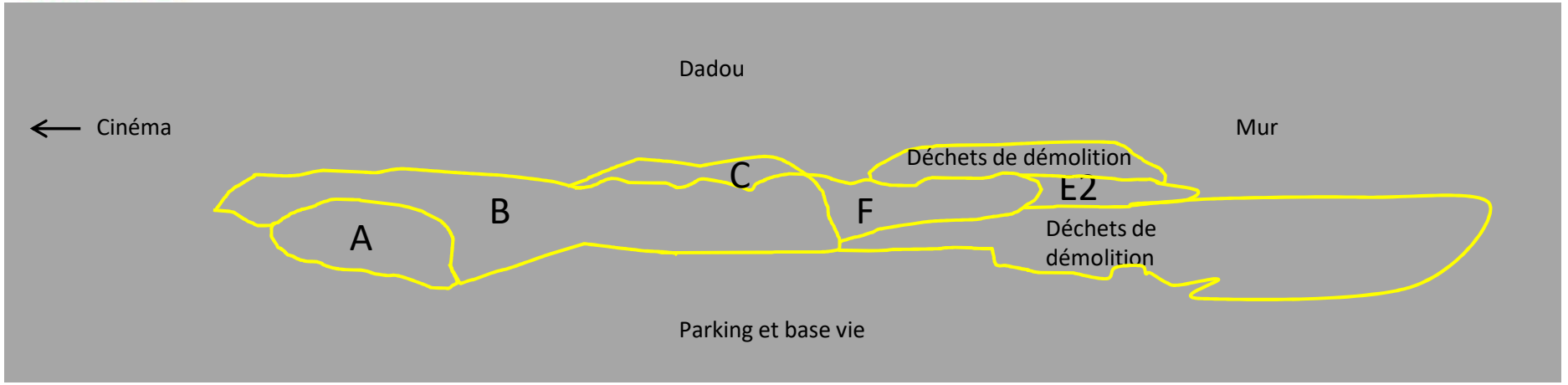
2 persons involved in the project

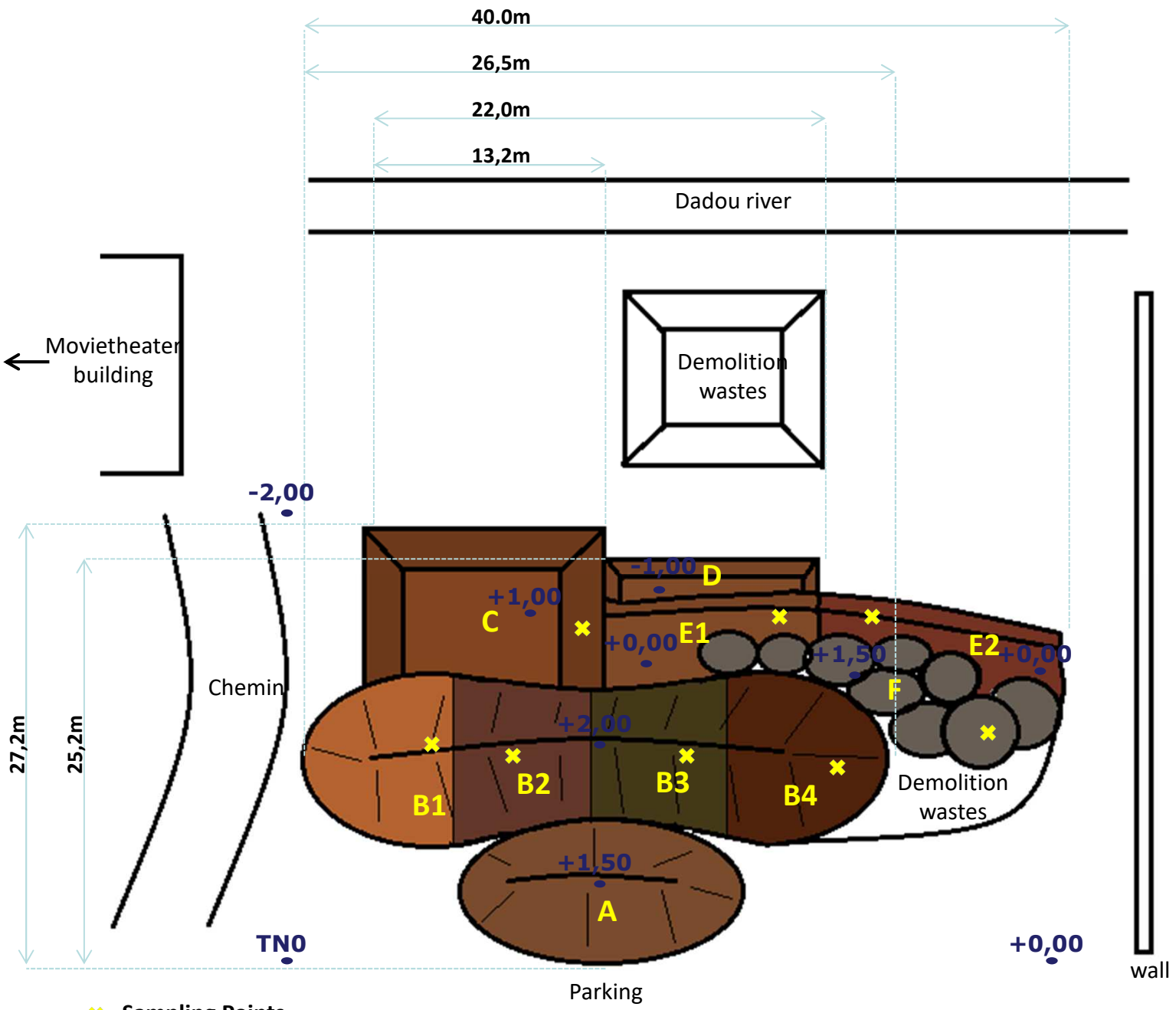
THE PROJECT IN THE HEART OF WORKS

POLLUTED SOILS

EcoLab
Laboratoire écologie fonctionnelle

GRAULHET




40.0m
26,5m
22,0m
13,2m
Dadou river
Movietheater building
Demolition wastes
-2,00
27,2m
25,2m
Chemin
+1,00
C
-1,00
D
+0,00
E1
+1,50
E2
+0,00
F
+2,00
B1
B2
B3
B4
Demolition wastes
+1,50
A
TN0
+0,00
wall
Parking
Sampling Points

POLLUTED SOILS

METAUX		A	B1	B2	B3	B4	C	E1	E2	F	Bruit de fond ordinaire
arsenic	mg/kg MS	49	11	22	41	20	23	38	41	16	25
cadmium	mg/kg MS	0,27	0,2	1,2	0,4	0,39	2,4	0,42	0,29	0,34	0,45
chrome	mg/kg MS	14	22	28	36	64	31	64	140	48	90
cuivre	mg/kg MS	17	16	19	28	32	18	37	28	30	20
mercure	mg/kg MS	0,12	0,04	0,09	0,12	0,13	0,09	0,09	0,06	0,08	0,2
plomb	mg/kg MS	190	19	120	84	93	180	420	240	78	50
nickel	mg/kg MS	13	12	9,3	13	14	11	13	18	13	60
zinc	mg/kg MS	61	61	530	120	110	160	120	88	97	100

Légende :
- < bruit de fond
- > bruit de fond
- > 2×bruit de fond

POLLUTED SOILS

Mixing C+E2 : silty soil, low permeability, water retention = 31,7%

Eléments trace métalliques	Concentration (mg/kg de MS)	Bruit de fond géochimique (mg/kg de MS)
Arsenic	21	25
Cadmium	0.47	0.45
Chrome	38	90
Cuivre	31	20
Plomb	98	50
Zinc	140	100

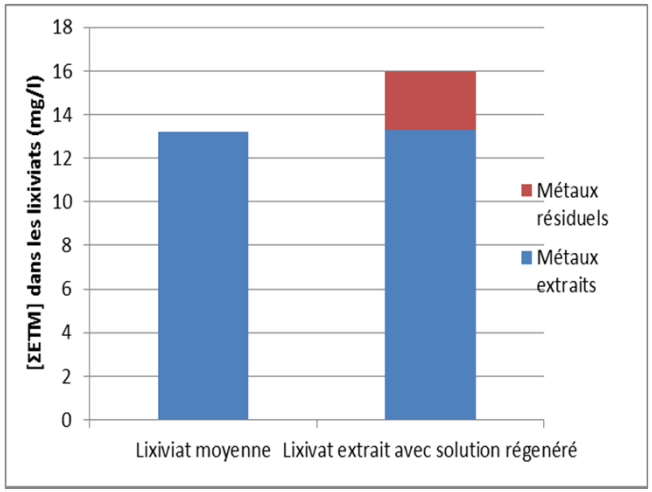
Légende

< bruit de fond
> bruit de fond
> 2×bruit de fond

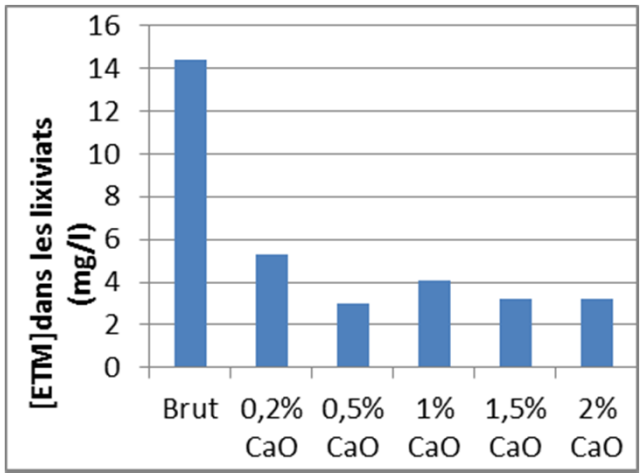
PREPARATION TESTS

1- IN THE LAB

- Chelatant
  - selection
  - Dose
  - Mode of addition
  - Secondary effects
  - Regeneration



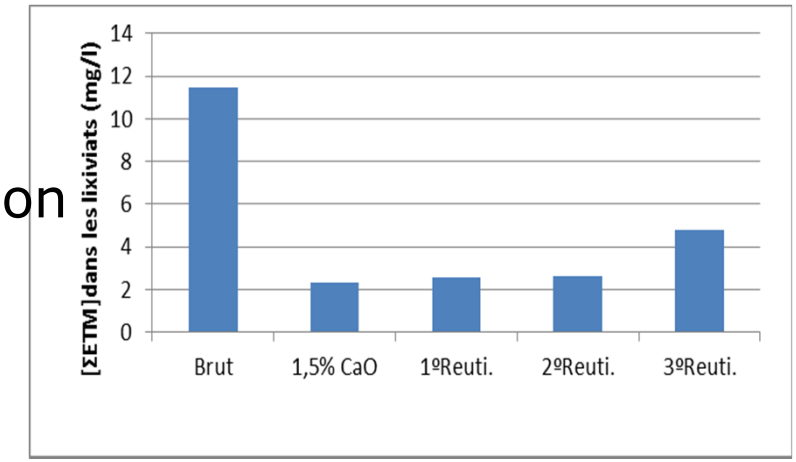
- Metals
  - Extraction rate
  - “harvesting” method
  - Sampling rate



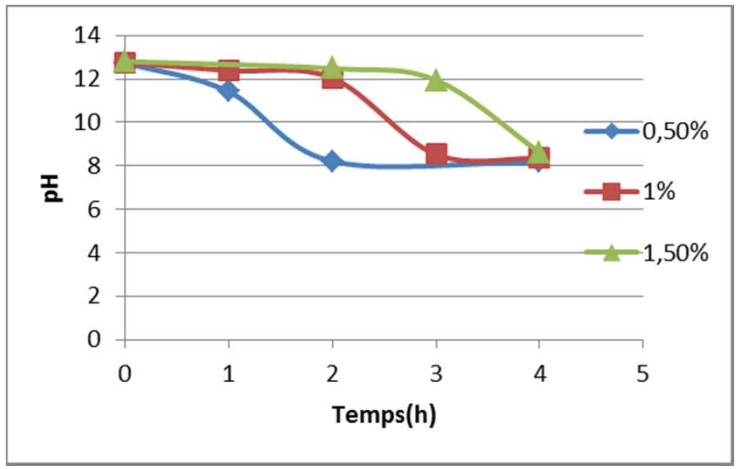
PREPARATION TESTS

1- in the lab

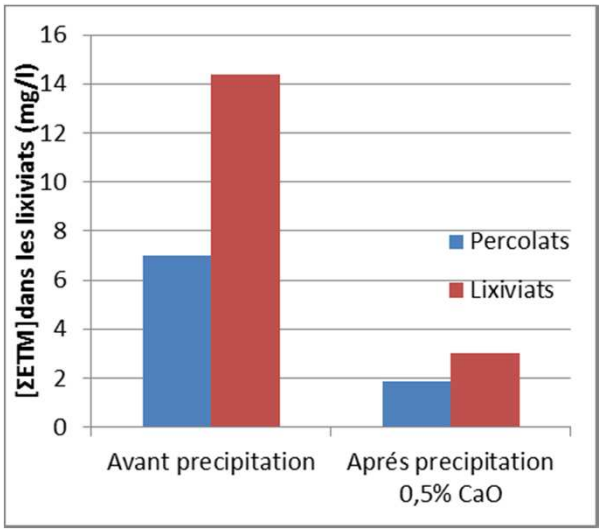
- Precipitation with lime
  - Selection – mode of action
  - Dose, kinetics
  - implementation
  - Volume of sludges

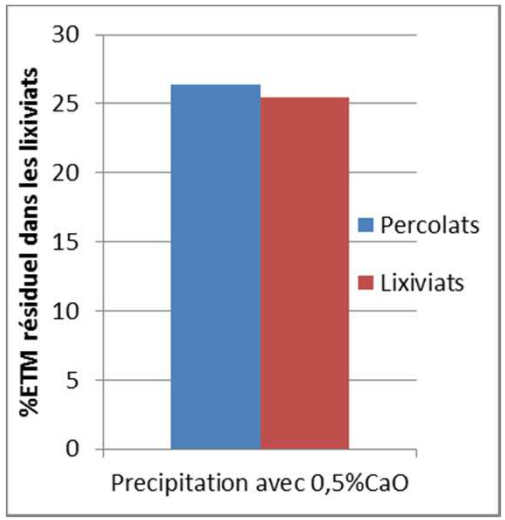


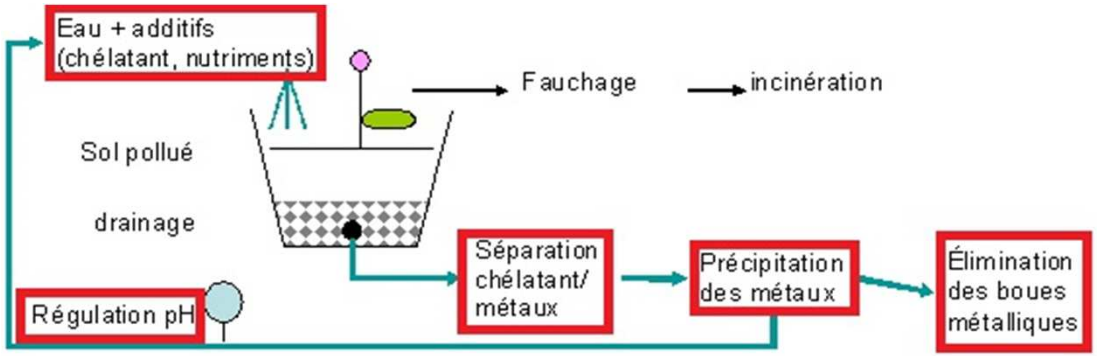
- Neutralisation
  - HCl
  - carbonatation
  - duration
  - Buffer role of the soil



PREPARATION TESTS





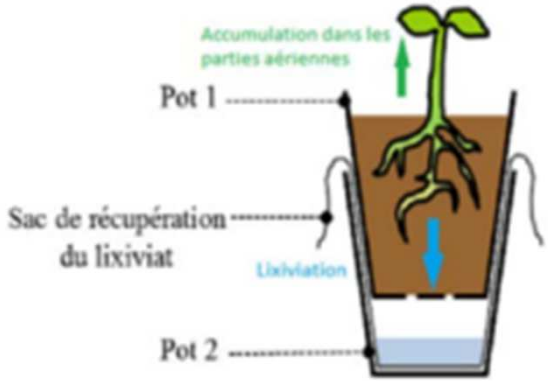


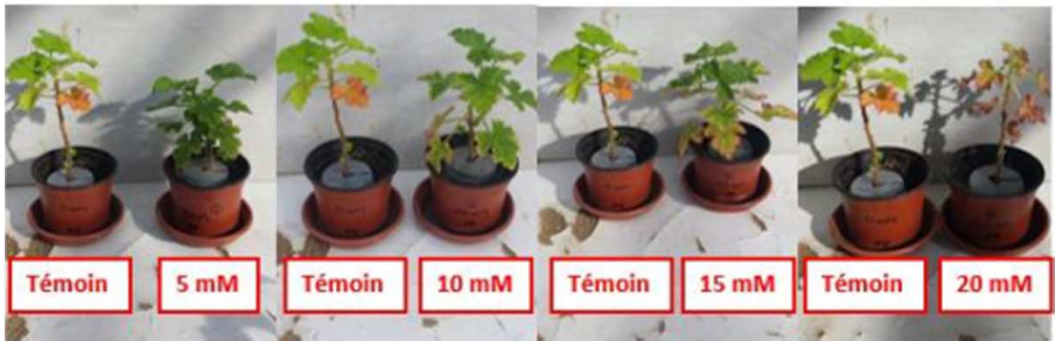
PREPARATION TESTS

- 2- in greenhouse

PREPARATION TESTS

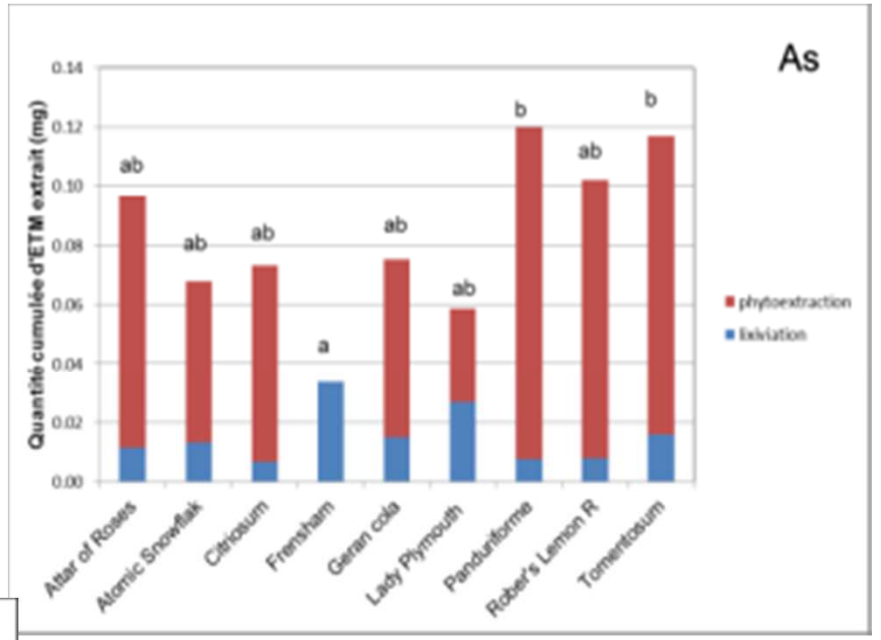
- 2 –in greenhouse

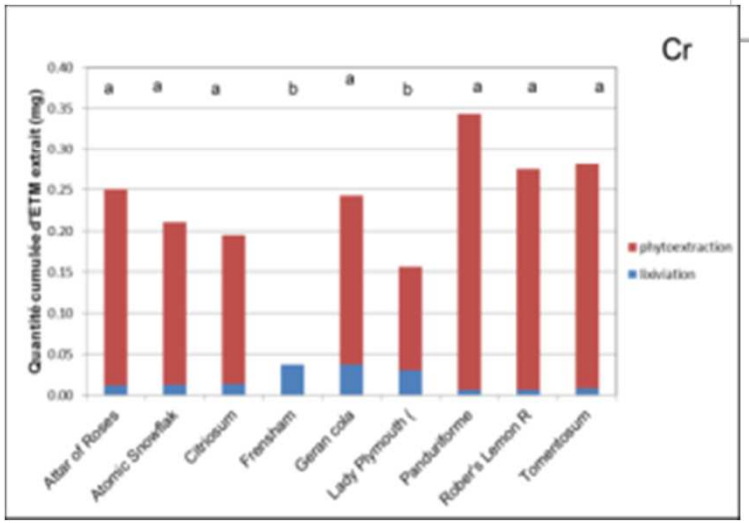




PREPARATION TESTS

- 2 –in greenhouse
  - Phytoextraction / lixiviation





PREPARATION TESTS

- 2 –in greenhouse
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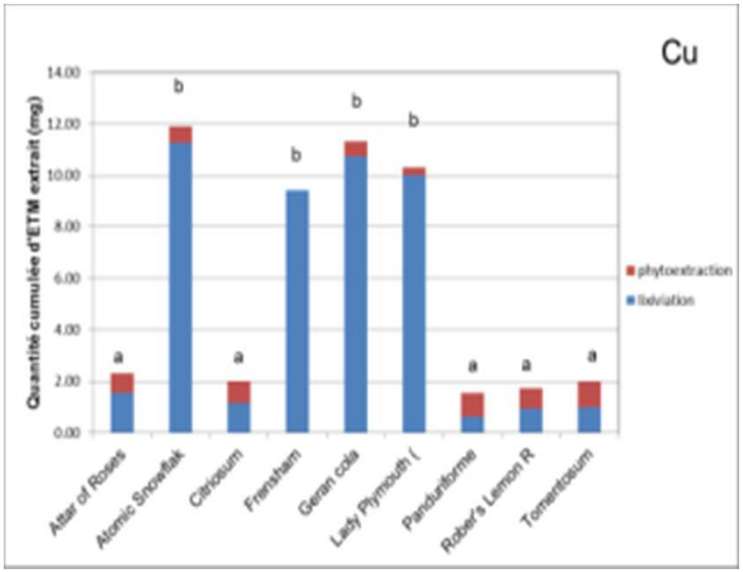
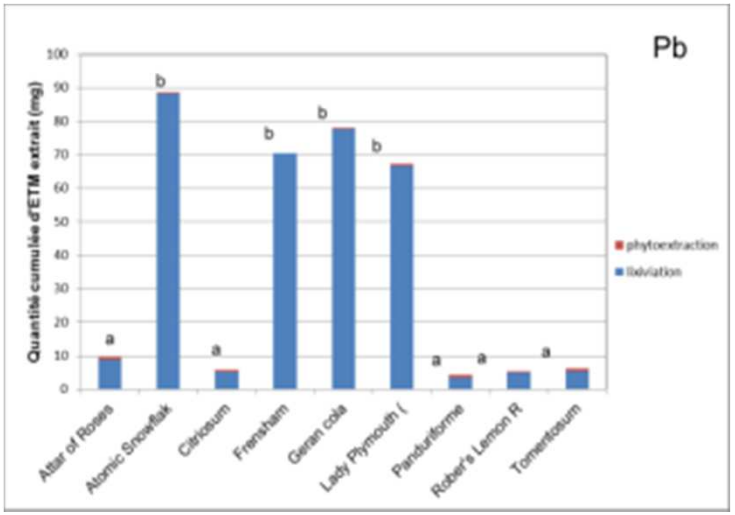
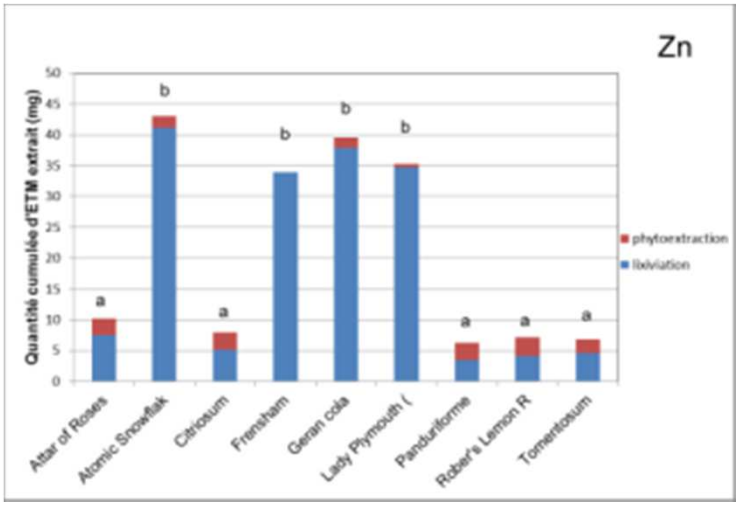
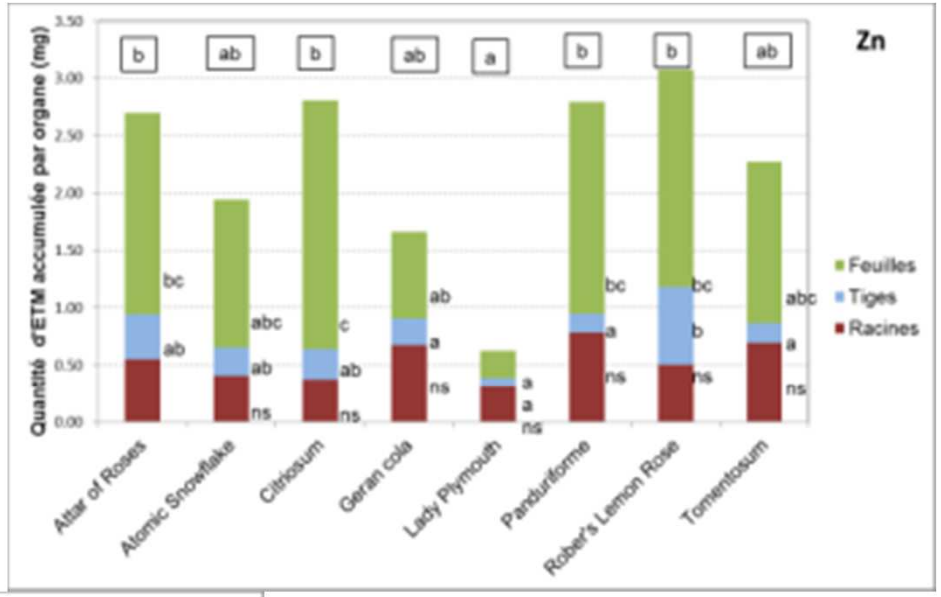


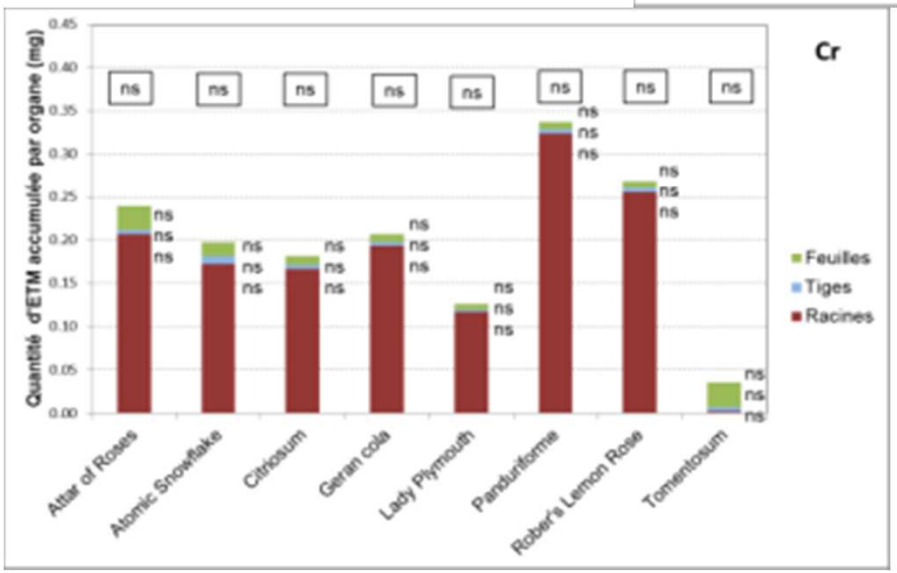




PREPARATION TESTS

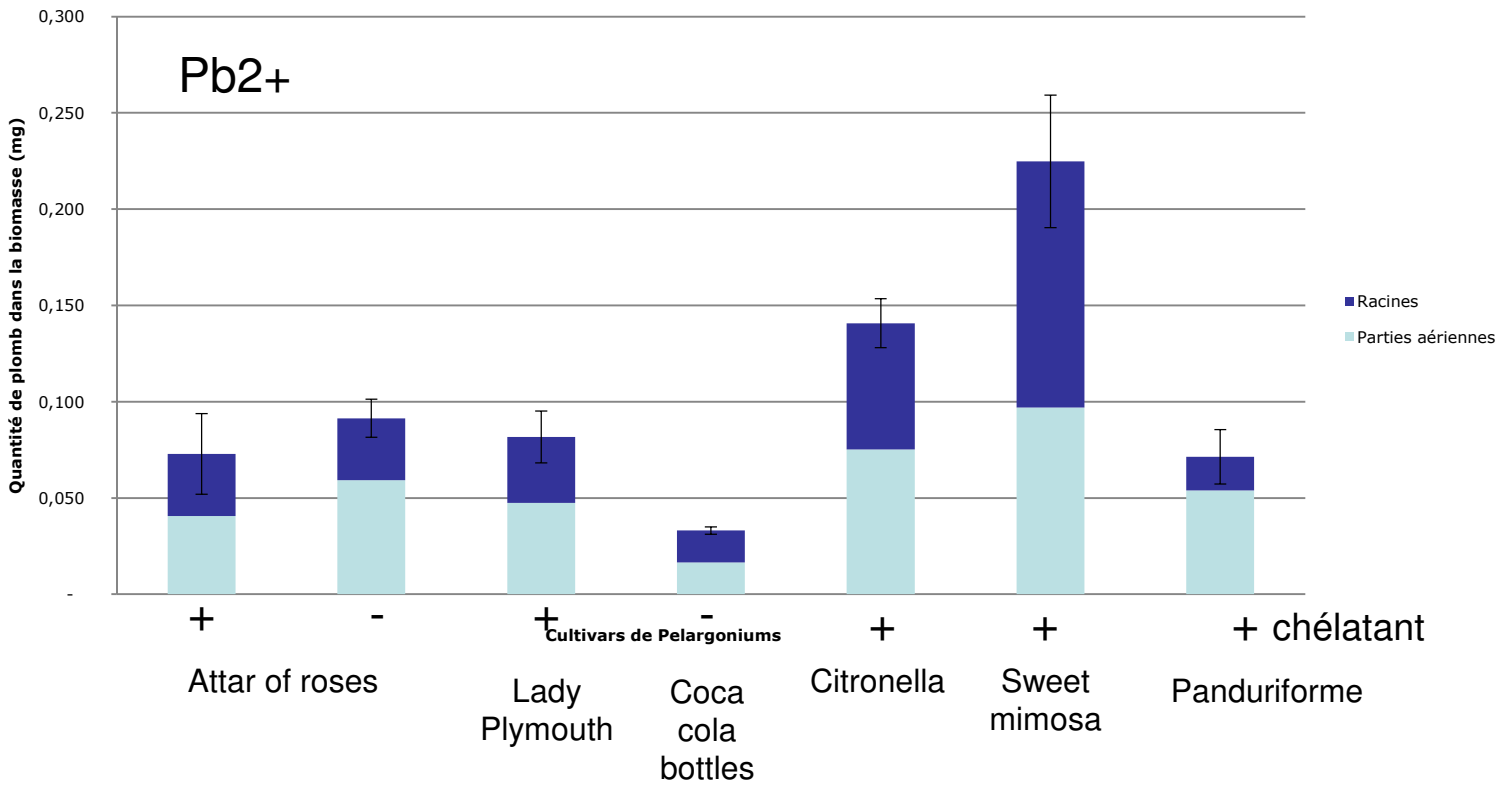
- 2 –in greenhouse
  - Sorting inside the plants





PREPARATION TESTS

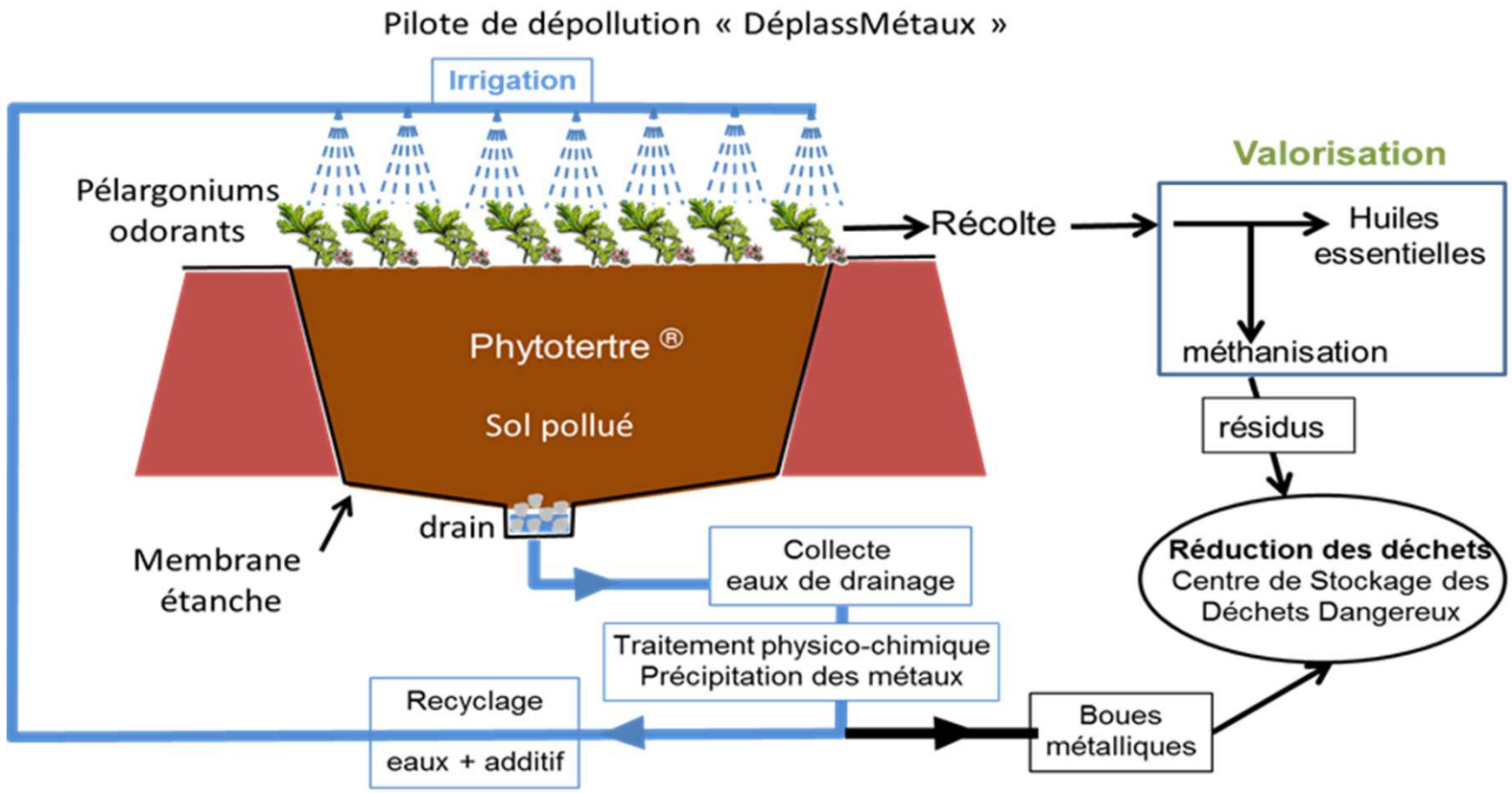
- 2 –in greenhouse
  - Accumulation in plants



PREPARATION TESTS

- 2 –in greenhouse, conclusion
  - Kinetic studies showed an elimination of lead in 18 months of cultivation
  - On field, due to season's cultivation periods, it makes 3 years

BUILDING THE RESEARCH TOOL - principle



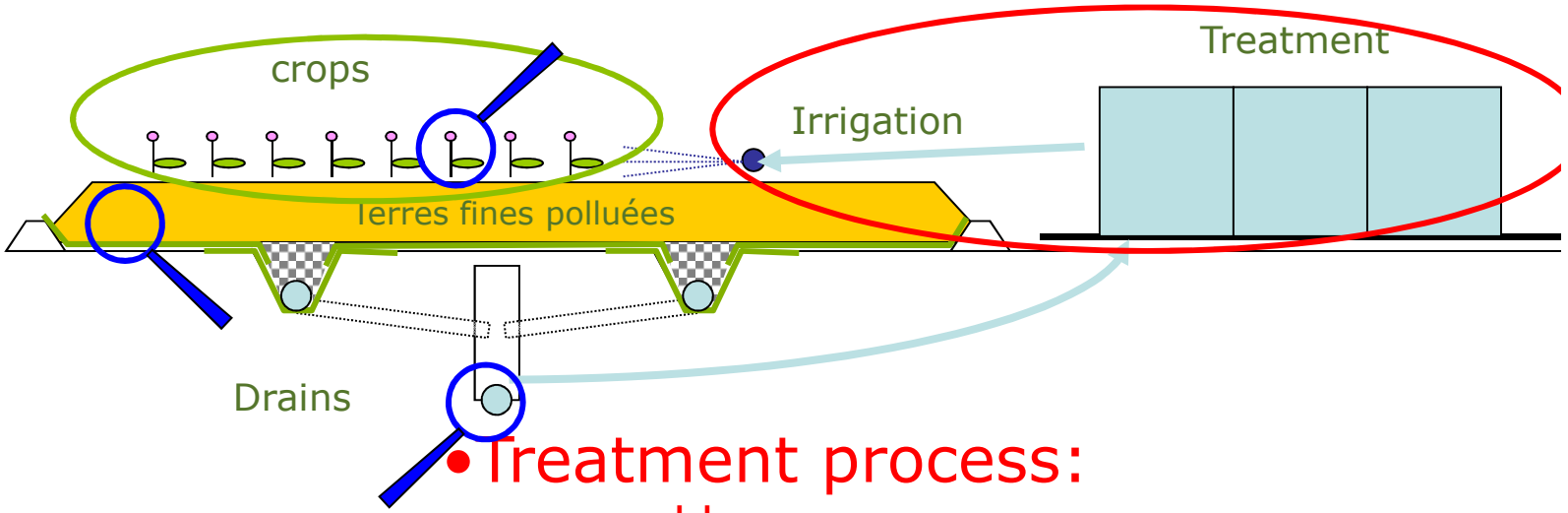
BUILDING THE RESEARCH TOOL - culture

BUILDING THE RESEARCH TOOL - culture

BUILDING THE RESEARCH TOOL - culture

SURVEY & MAINTENANCE

- Several levels of intervention:

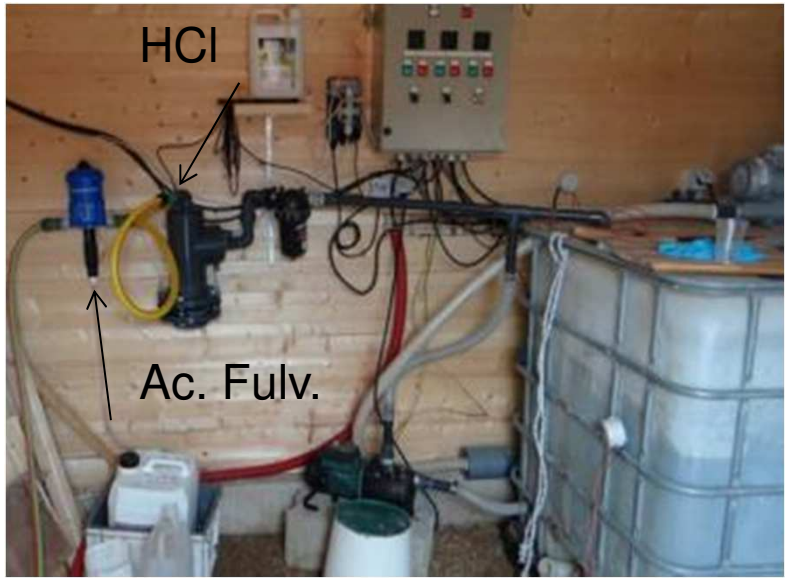


- Treatment process:
  - weekly survey
  - monthly maintenance
  - managing wastes (metallic sludges)
- Cultures :
  - Survey of vegetation phases
  - annual harvest; valorization assays
  - managing plant wastes
- Analysis of soils and water

SURVEY & MAINTENANCE

CHANGES DURING THE PROJECT

- Treatment loop
- Add a greenhouse



SUIVI – ANALYSES - EAUX

µg/L	pit		tank	Irrigation	
year	2015	16	2015	15	16
Arsenic	-	16	-	-	8,1
Cadmium	19	88	19	6,7	46
Cupper	480	2400	430	230	210
lead	1500	10000	2200	130	590
iron	890		17000		
Zinc	1700	12000	1900	260	1100

The iron comes from the tank; no effect upon other metals

SUIVI - ANALYSES

mg/kg	carbonat ation	Limed sludges 15	16	Initial soil
Arsenic	-	-	5,9	32
Cadmium	0,34	2,4	4,4	1,34
cupper	11	61	250	23
lead	53	320	850	210
iron	15000	15000		
Zinc	64	480	730	124

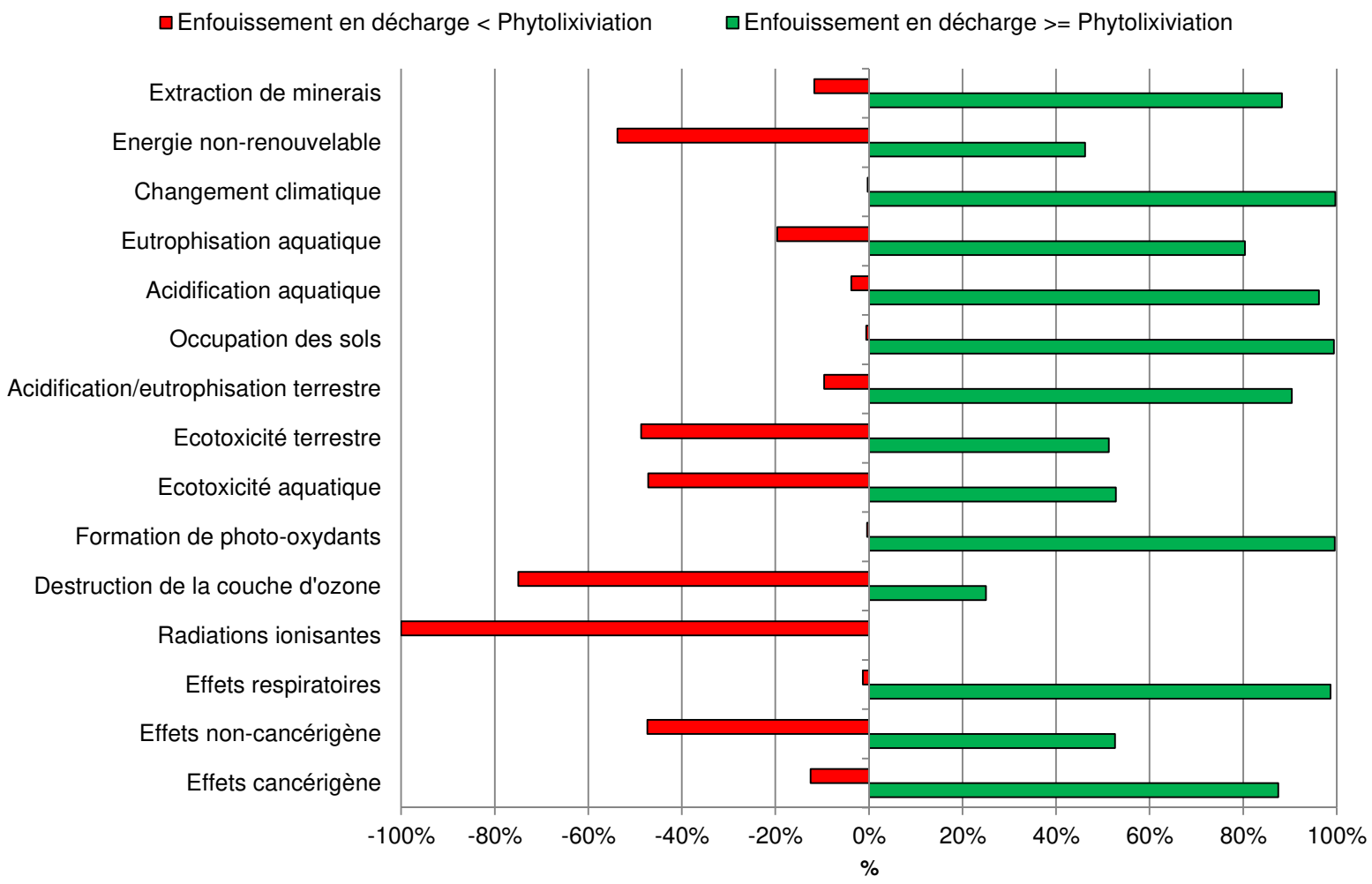
CONCENTRATION RATE: 1,5 to 4 in 2015

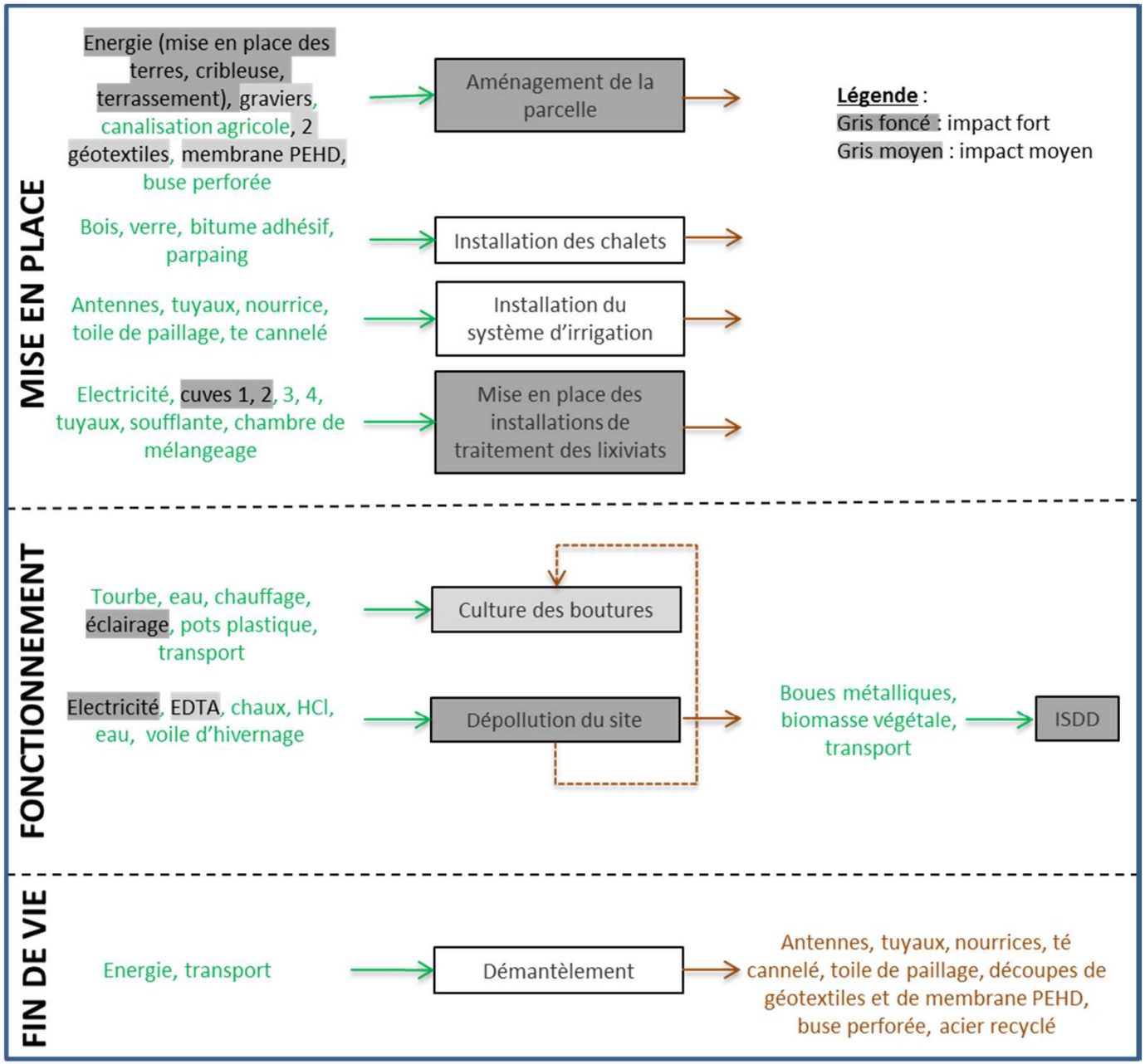
3 to 11 in 2016

QUESTION

- **Why a such difference concerning kinetics between greenhouse and on-site?**
- Main factor for metal removal= leaching, thus directly related to the irrigation with chelating solution
- In 1 L flowerpots, weekly watering was 0,5 L
- Upon the Phytotertre® (50 m^3) weekly watering is about 1 m^3, during the whole growing period
- Reason : packing down, loss of permeability

LIFE Cycle ANALYSIS



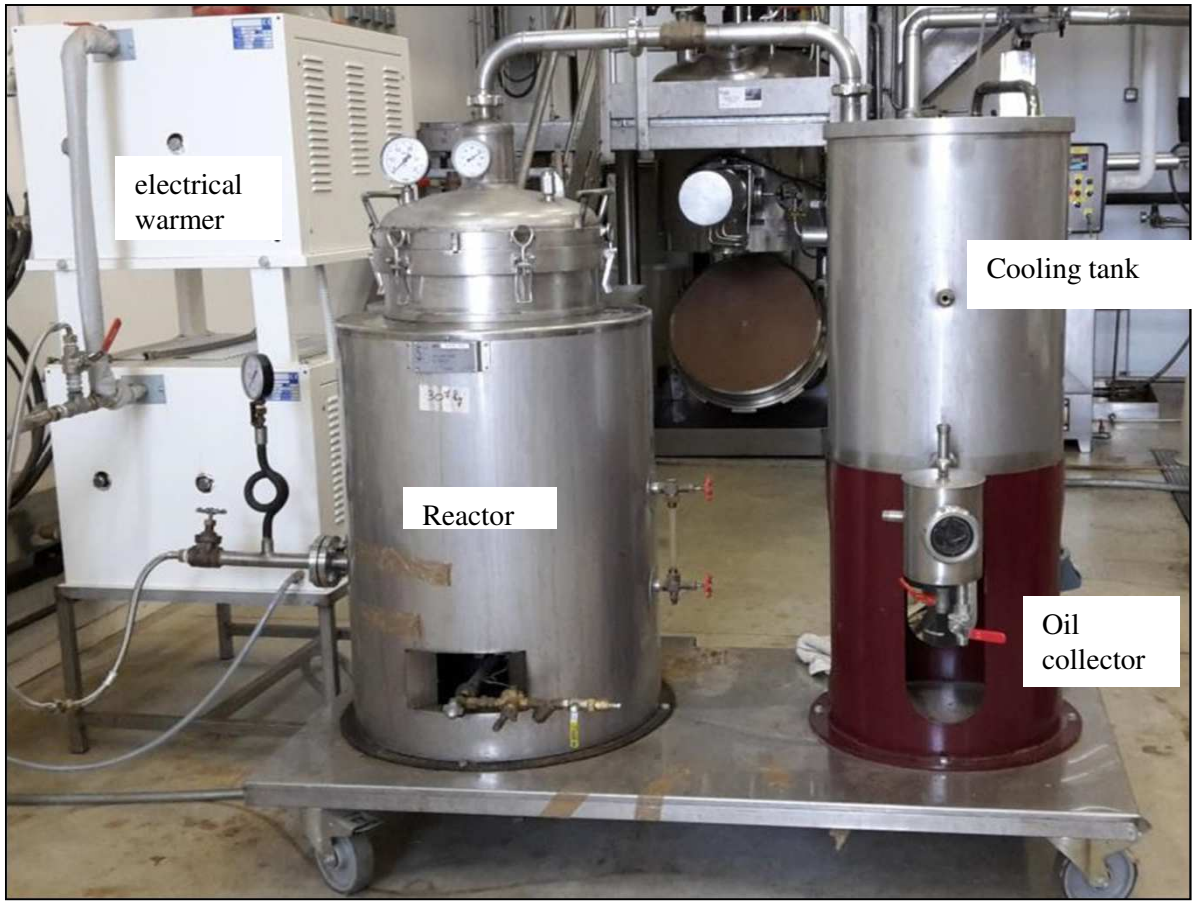

MISE EN PLACE
Energie (mise en place des terres, cribleuse, terrassement), graviers, canalisation agricole, 2 géotextiles, membrane PEHD, buse perforée
Aménagement de la parcelle
Légende :
Gris foncé : impact fort
Gris moyen : impact moyen
Bois, verre, bitume adhésif, parpaing
Installation des chalets
Antennes, tuyaux, nourrice, toile de paillage, te cannelé
Installation du système d'irrigation
Electricité, cuves 1, 2, 3, 4, tuyaux, soufflante, chambre de mélangeage
Mise en place des installations de traitement des lixiviats
FONCTIONNEMENT
Tourbe, eau, chauffage, éclairage, pots plastique, transport
Culture des boutures
Electricité, EDTA, chaux, HCl, eau, voile d'hivernage
Dépollution du site
Boues métalliques, biomasse végétale, transport
ISDD
FIN DE VIE
Energie, transport
Démantèlement
Antennes, tuyaux, nourrices, té cannelé, toile de paillage, découpes de géotextiles et de membrane PEHD, buse perforée, acier recyclé

HARVESTING

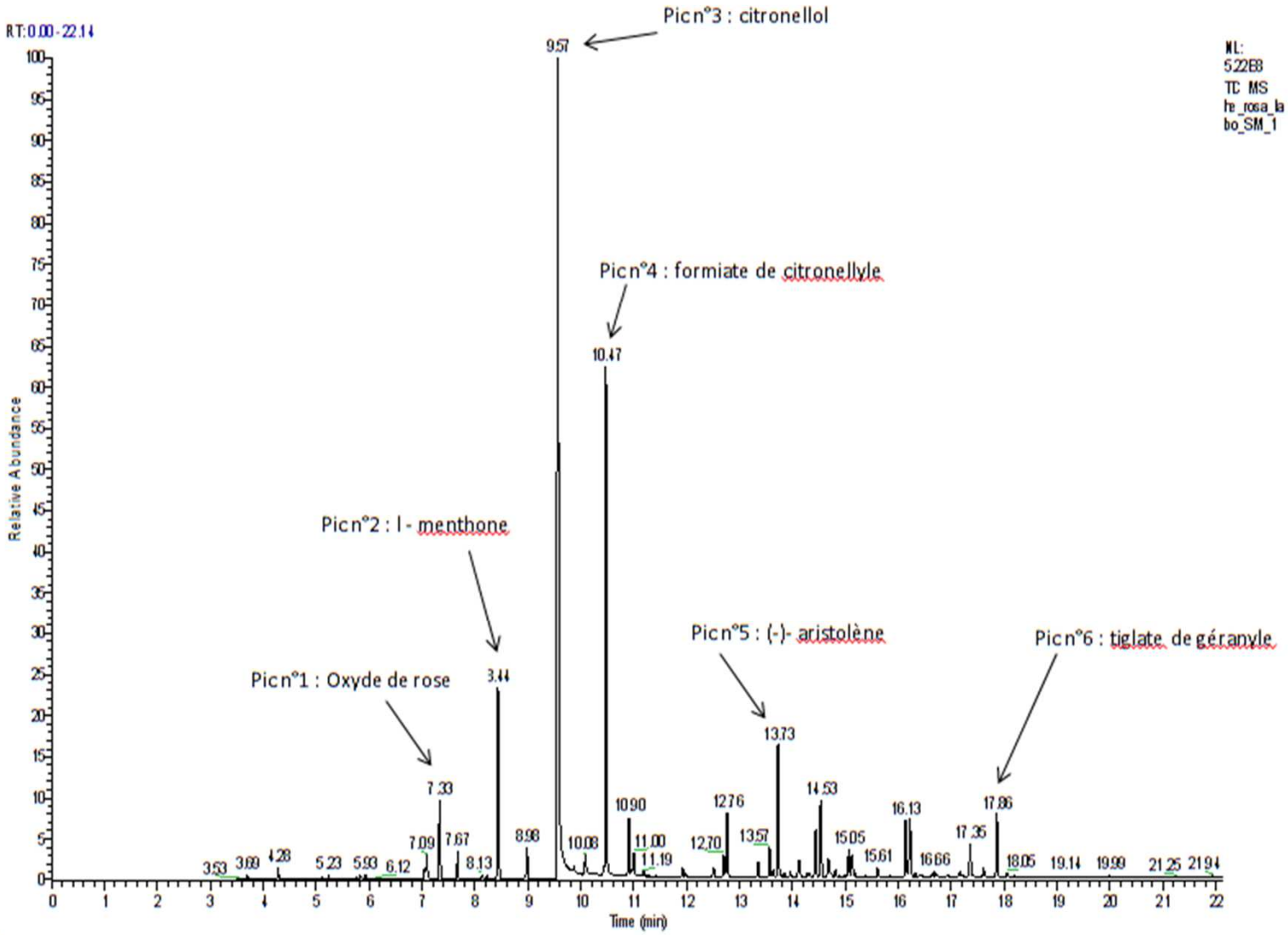
2014 : 350 kg fw
2015 : 730 kg
2016 : 453 kg

Rendement des extractions d'huiles essentielles du *Pelargonium* « attar of roses »						
	Masse pélargonium (en kg)	Masse sèche (en kg)	Masse huile essentielle (en g)	Rendement (en %/MS)	Moyenne	Ecart-type
Hydrodistillation 1	12,7	1,73	0,74	0,04	0,05	0,01
Hydrodistillation 2	12,7	1,73	0,78	0,05		
Hydrodistillation 3	12,7	1,73	0,99	0,06		
Hydrodistillation 4	12,7	1,73	0,94	0,05		
Hydrodistillation 5	12,7	1,73	0,88	0,05		

PRODUCTION of E.O.



PRODUCTION of E.O.



TEACHINGS FROM THE PROJECT

- **INNOVATIVE POINTS**
- phytoextraction is said to be slow.
- Our process combines chemistry and biology in synergy to enhance availability of metals and reduce the duration of recovery
- The Phytotertre® process is **safe**, because all risks are assessed: watertight complex, geotextile or greenhouse to prevent dust
- The Phytotertre® process allows to free rapidly the **space** for building, because soils are treated beside the works
- The planted pile is well integrated in urban landcraft, like other flowerbeds.

CONCLUSIONS and FURTHER…

- Under on-site conditions, the treatment remains too slow, even if ameliorations are expected to approach the optimums obtained in greenhouse
- A technico-economical study is to date in progress, to validate financial balance of E.O. production
- Doing this, we are creating a new usage for the soil, compatible with high amounts of heavy metals

- It’s a change of paradigm which is interesting to be studied a little ahead

MERCI DE VOTRE ATTENTION

VALGO - R&D
2, av Gutenberg
31120 PORTET sur Garonne

Laboratoire
72, bd A. Briand
76650 PETIT-COURONNE

www.deplassmetaux.com

Contact : laurent.thannberger@valgo.com