UNIVERSITÉ DE LYON

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

deep

Waste, Water, Environnement, Pollution

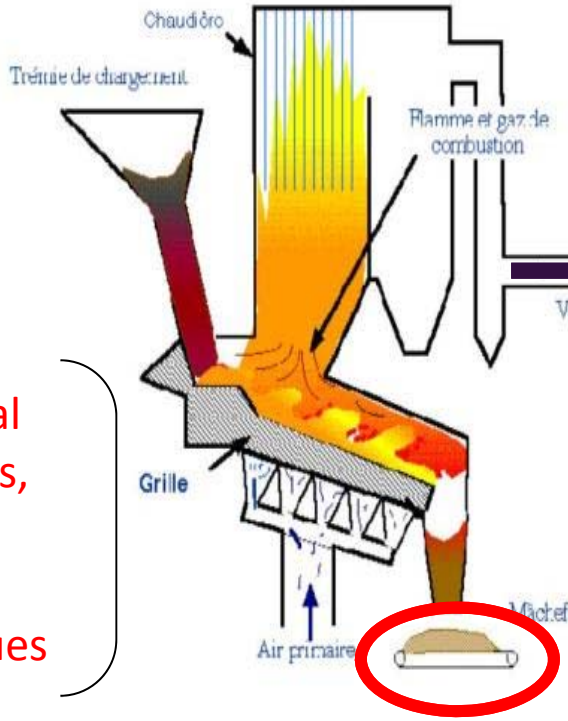
Influence of Chemical Pre-treatment on the Leaching Behaviour of Bottom Ash

Ola Hammoud, Denise Blanc, Maria Lupsea-Toader, Christine de Brauer

ola.hammoud@insa-lyon.fr

5th International Conference on Sustainable Solid Waste Management – Athens – 21 June 2017

Context

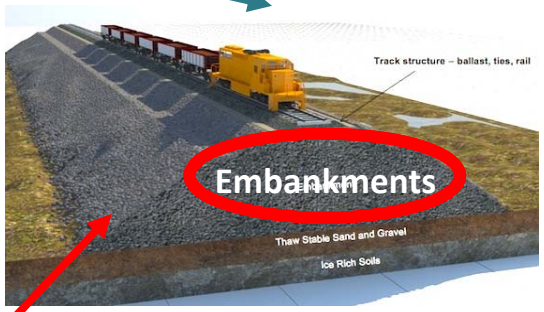


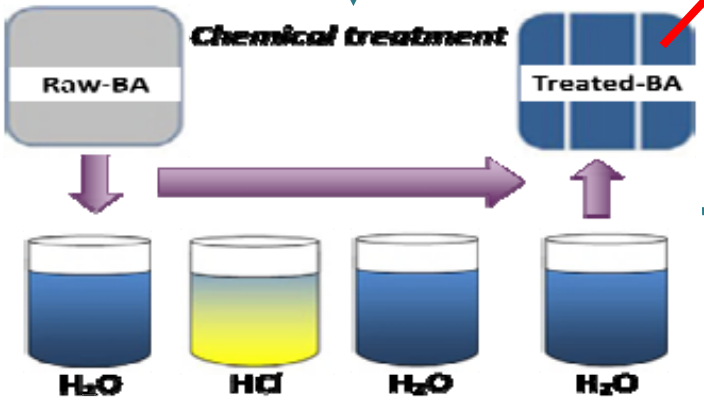
Fly Ash

- heterogeneous material
- inert residues (ceramics, bottle glass…)
- incineration products
- unburned MSWI residues

Context

French decree from 18/11/2011*

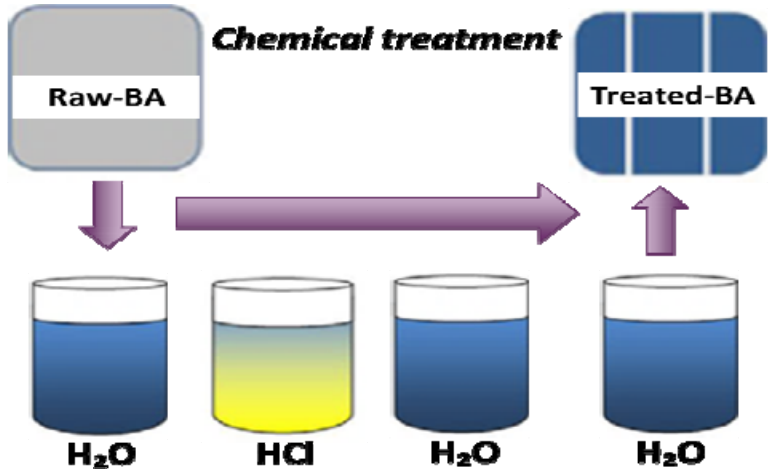




New decree of building construction

*French decree from 18/11/2011 on the recycling of MSWI-BA in road materials based on the released quantities of pollutants (European leaching test EN12457-2)

Chemical pre-treatment



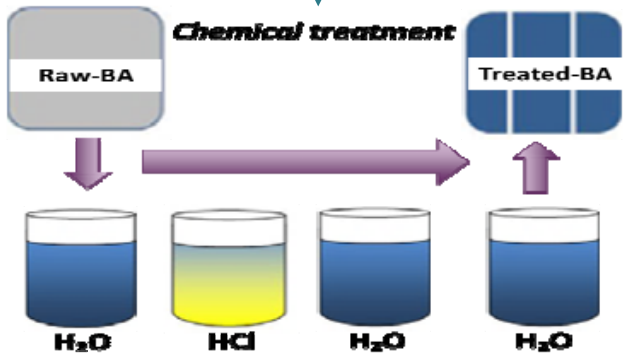
Objective

Reduce the released quantities of fines particles and inorganic contaminants

Removed by washing

Stabilised in the solid matrix

Materials and methods



H_2O
stirring
24 hours
10 L/kg

Treated-BA

Raw-BA

Optimisation of various washing parameters

Extractant	HCl concentration ($mol.L^{-1}$)	Washing time (hours)	L/S ratio ($L.kg^{-1}$)
HCl	0.18	1	2
HNO_3	0.5	3	5
EDTA	1	6	10
	1.50	24	

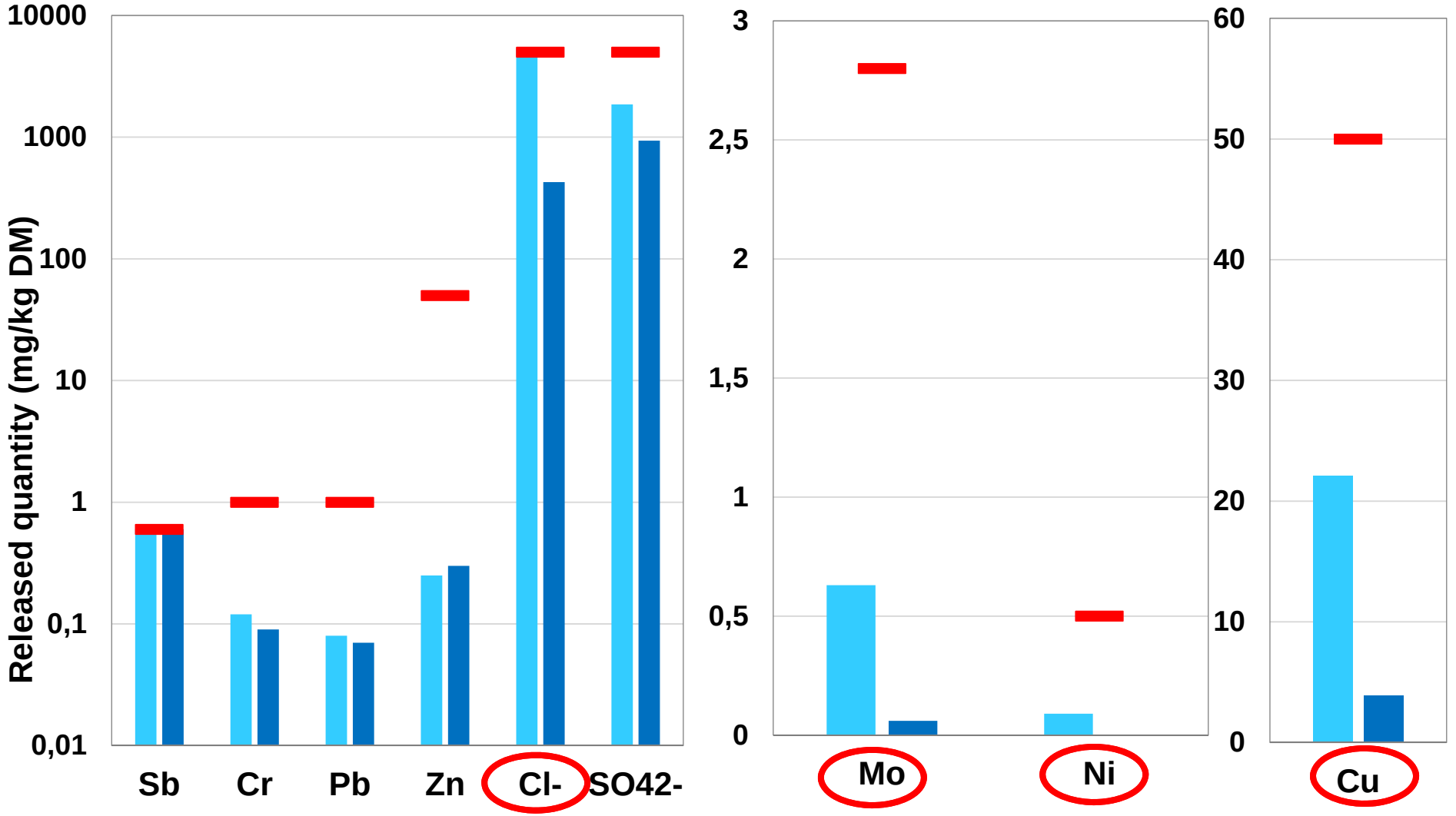
Chemical pre-treatment washing protocol

Prewash → Reduce the quantity of soluble elements

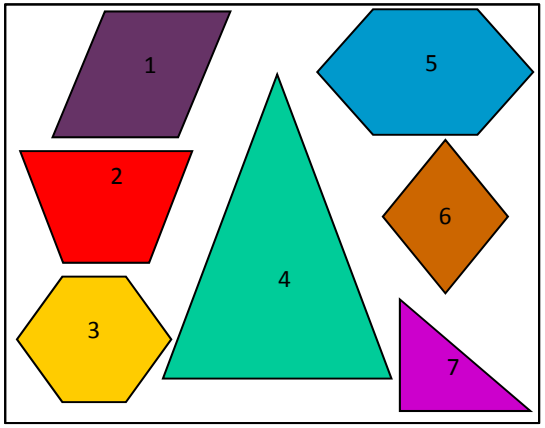
Acid extraction → Destabilize the mineralogical phases

2 steps of rinsing → Remove the elements trapped on the solid matrix

Efficiency of the chemical pre-treatment



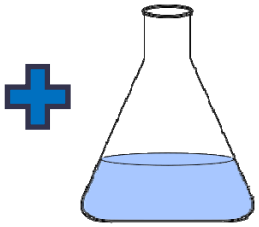
Modelling principles



Mineralogical assemblage

=

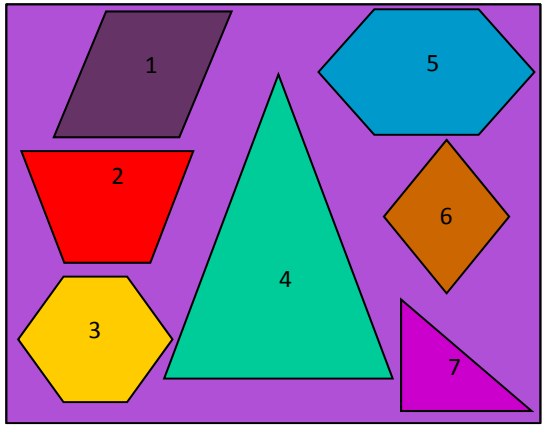
MSWI-BA



Solution

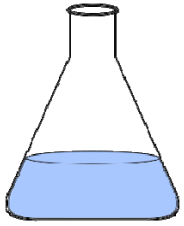
Phreeqc Interactive

Thermodynamic equilibrium



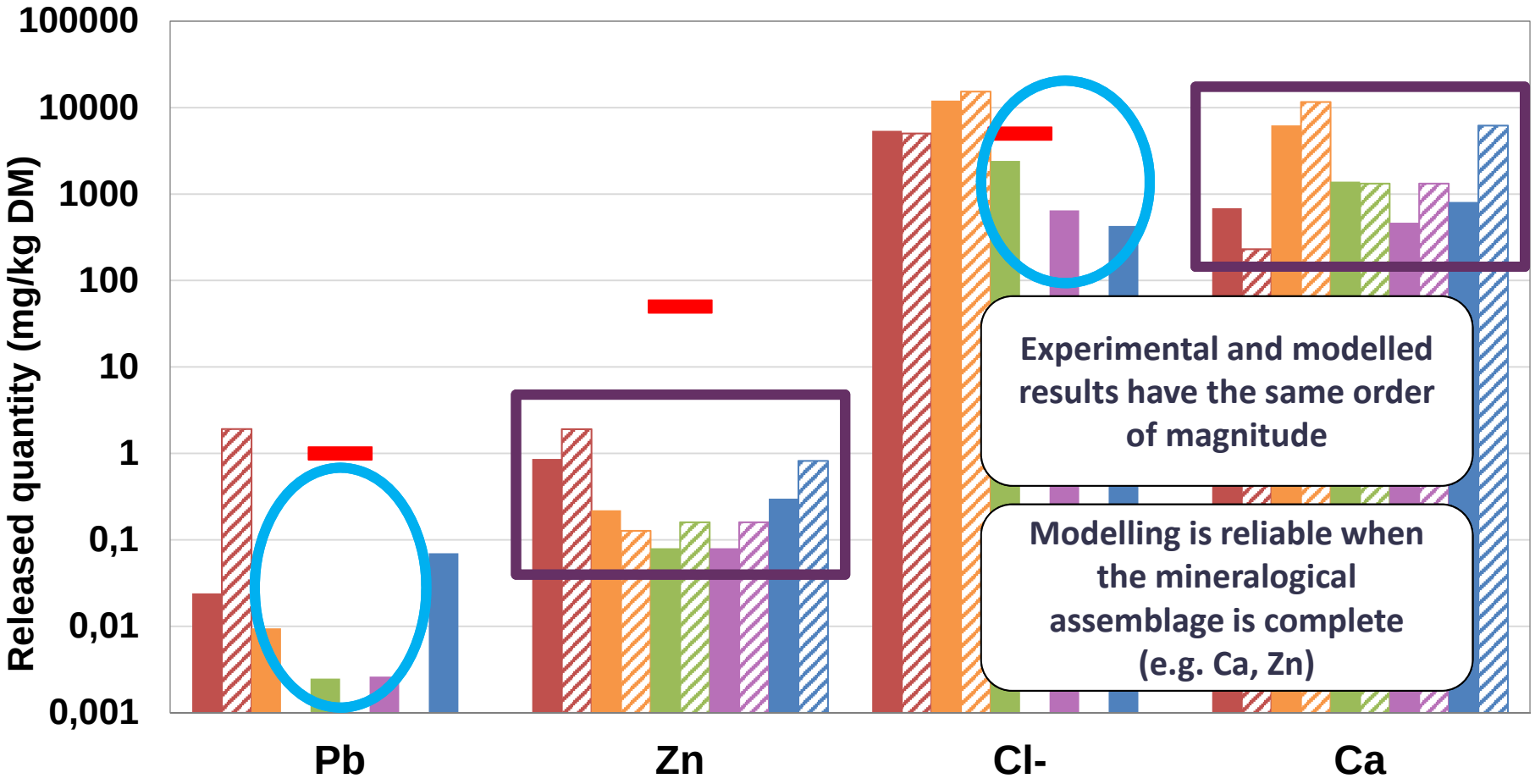
New mineralogical assemblage

Input data for the following step



[Elements] ; pH

Modelling vs. experimental



Prewash (H_2O, stirring 1 hour, 2 L/kg)
Extraction (HCl, stirring 1 hour, 2 L/kg)
First rinsing (H_2O, stirring 1 hour, 2 L/kg)
Second rinsing (H_2O, stirring 1 hour, 2 L/kg)
Leaching test (H_2O, stirring 24 hours, 10 L/kg)
Thresholds for road material (French decree)

Conclusions & perspectives

- Efficient chemical pre-treatment protocol:
  - HCl in small concentration (2M)
  - low L/S ratio
  - short contact time

- Dynamic rinsing is necessary to remove the traces of dissolved metals

- Improvement of the mineralogical assemblage: other characterisation methods (SEM-EDS, sequential extraction...)

UNIVERSITÉ DE LYON

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

deep

Waste, Water, Environnement, Pollution

Thank you for your attention!

Influence of Chemical Pre-treatment on the Leaching Behaviour of Bottom Ash

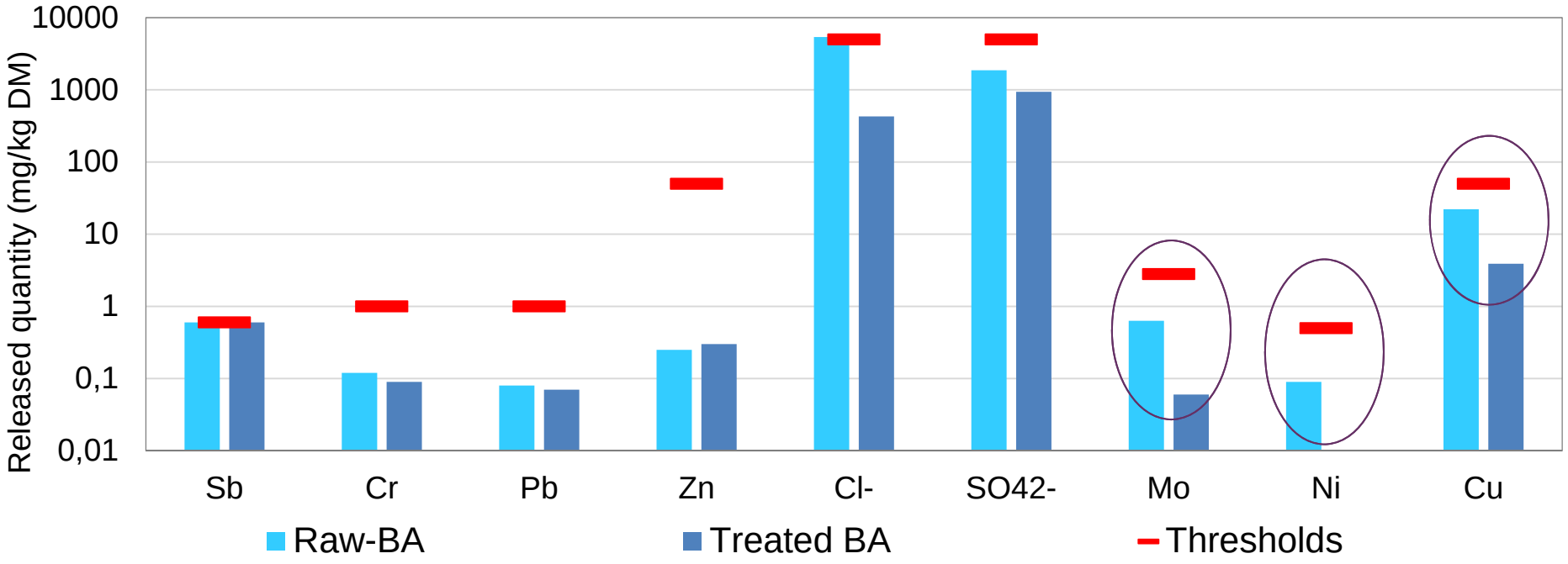
Ola Hammoud, Denise Blanc, Maria Lupsea-Toader, Christine de Brauer

ola.hammoud@insa-lyon.fr

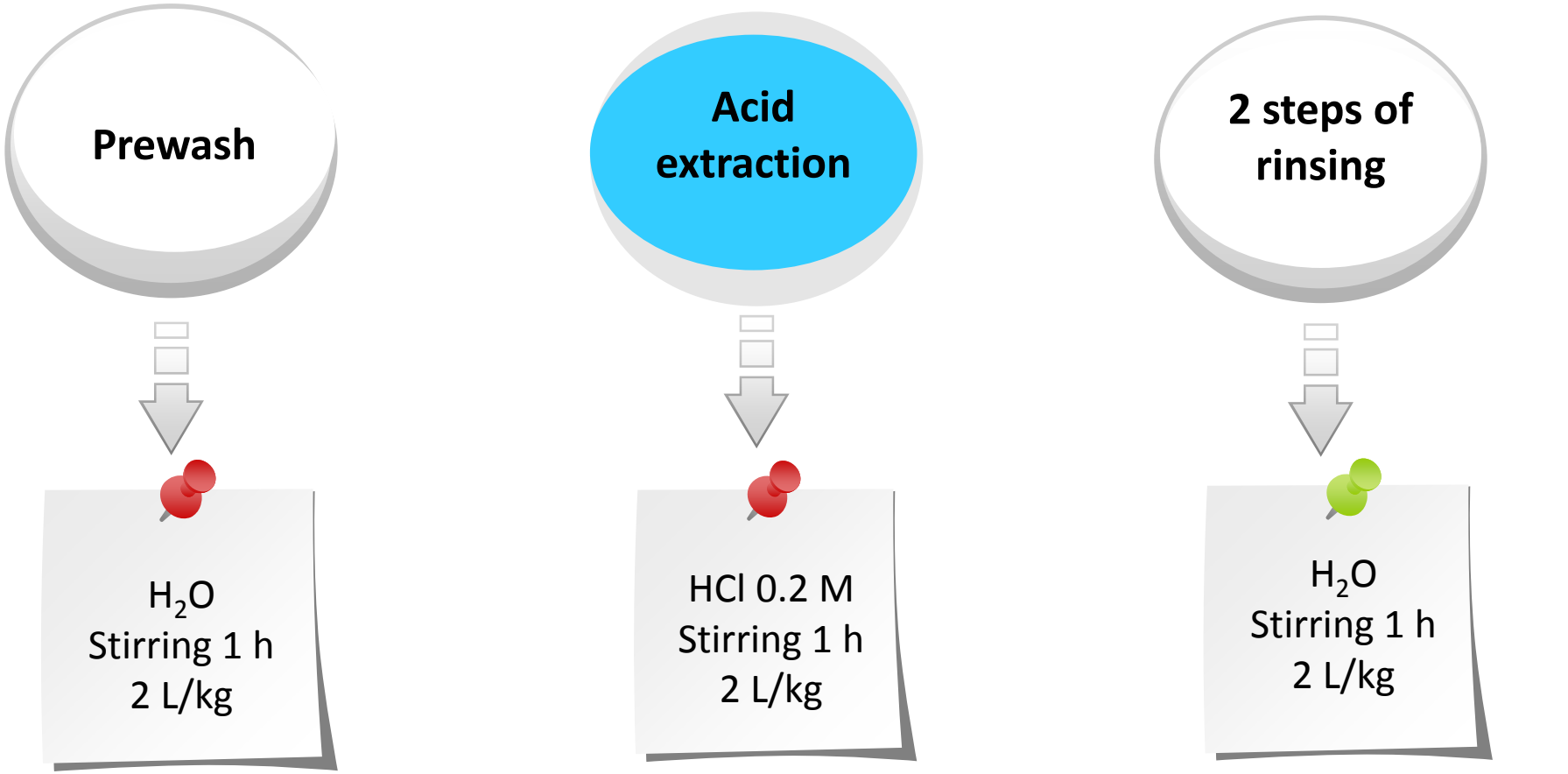
ANNEXE

Optimisation of different washing parameters

Extractant (concentration)	Washing time (h)	HCl concentration ($mol.L^{-1}$)	L/S ratio ($L.kg^{-1}$)
HCl (0.18 M)	1	0.18	2
HNO_3 (0.5 M)	3	0.50	5
EDTA (0.05 M)	6	1.00	10
	24	1.50	



Optimisation of a chemical pre-treatment protocol



To reduce the quantity of soluble elements

To destabilize the mineralogical phases

To remove the elements which have been trapped on the solid matrix

Context

MSWI-BA

New decree of building construction

French decree from 18/11/2011

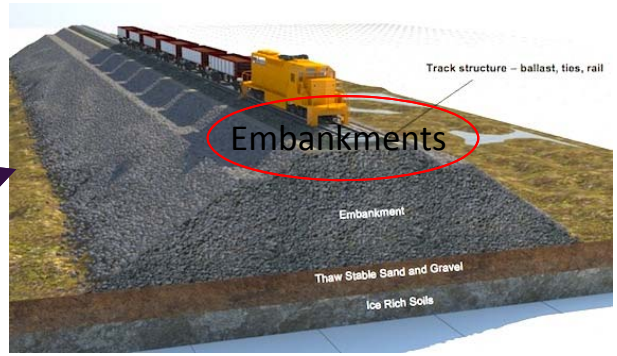
1. To have an other alternatives ways of valorization
2. To reduce the use of natural aggregates and also the price of construction materials

1. Competition with other natural materials
2. The environmental restrictions
3. The image of the materials as a waste and not as a product

French decree from 18/11/2011 on the Recycling of MSWI-BA in road materials based on the release quantities of pollutants from leaching test –EN12457-2

Context

French decree from 18/11/2011

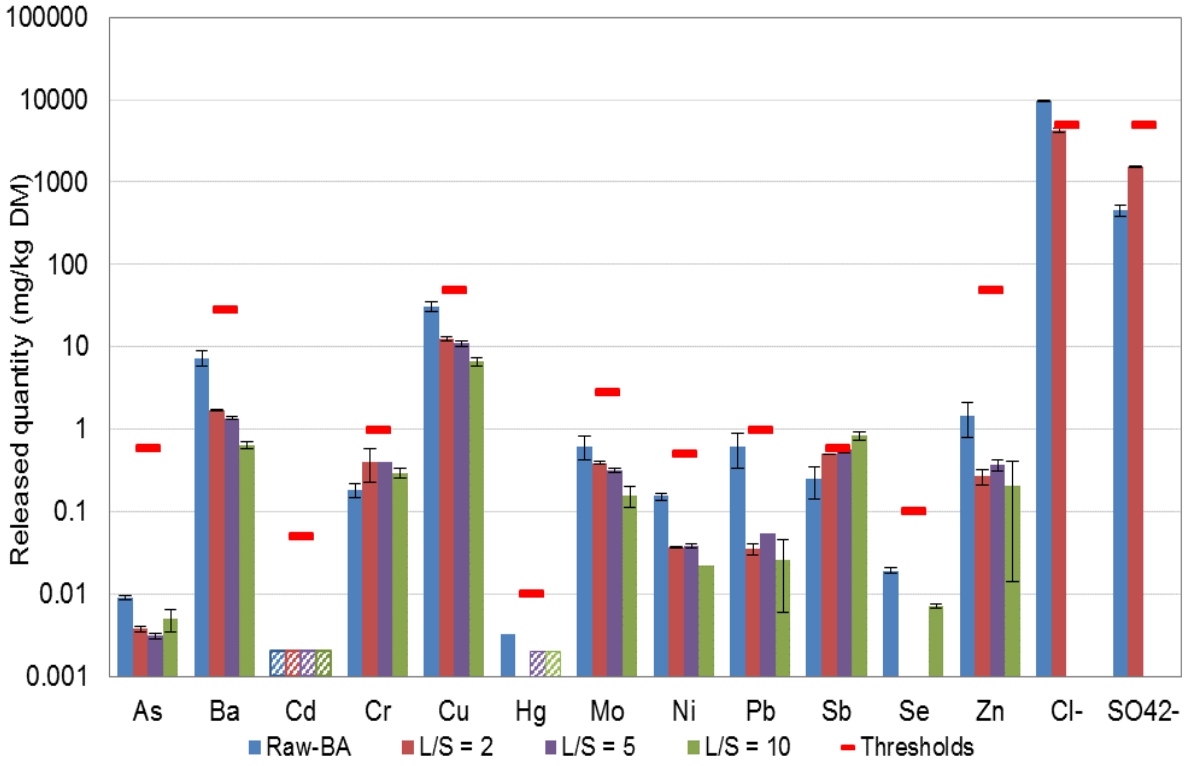


New decree of building construction

French decree from 18/11/2011 on the Recycling of MSWI-BA in road materials based on the release quantities of pollutants from leaching test –EN12457-2

Optimisation of the L/S ratio

3 L/S ratio were tested: 2, 5 and 10 L/kg {HCl 0,18 M; contact time 6 h; V<2 fraction }



The leachability of most MTE increases with the decrease of pH

L/S = 2 L/kg has been selected for global chemical treatment for economical and environmental reasons

Optimisation of different washing parameters

L/S ratio, size particle fraction and contact time

L/S

- The leachability of most MTE increases with the decrease of pH
- L/S = 2 L/kg has been selected for global chemical treatment for economical and environmental reasons

Size particle fraction

- The release of most MTE decreases after treatment with HCl for all particle size fractions (expt Sb, Cr and As)

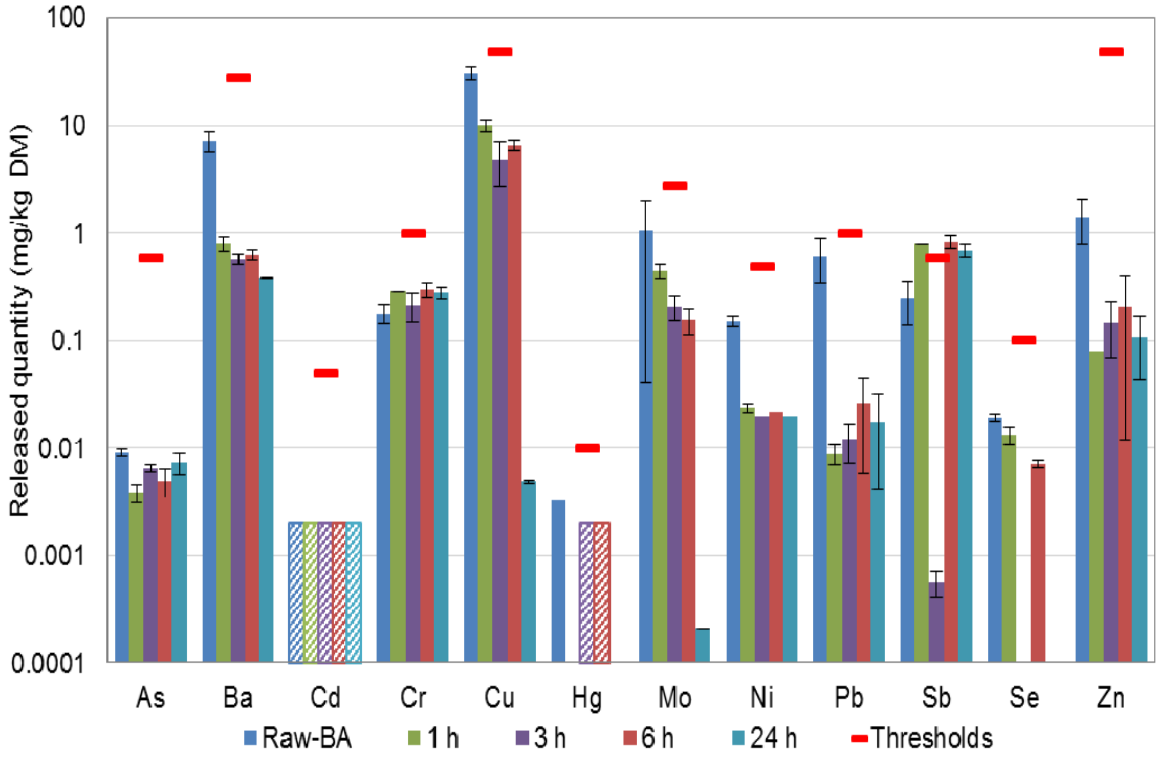
Contact time

- Whatever the contact time, a reduction in the overall metal concentration was observed.
- More than 60% of MTE were released for short contact time with HCl
- The contact time of 1 h has been chosen for the global chemical washing

- L/S = 2 L/Kg ; V < 2 mm and t = 1 h

Optimisation of contact time

4 washing time were tested: 1, 3, 6 and 24 h {HCl 0.18 M; L/S = 10 L/kg; V<2 fraction}



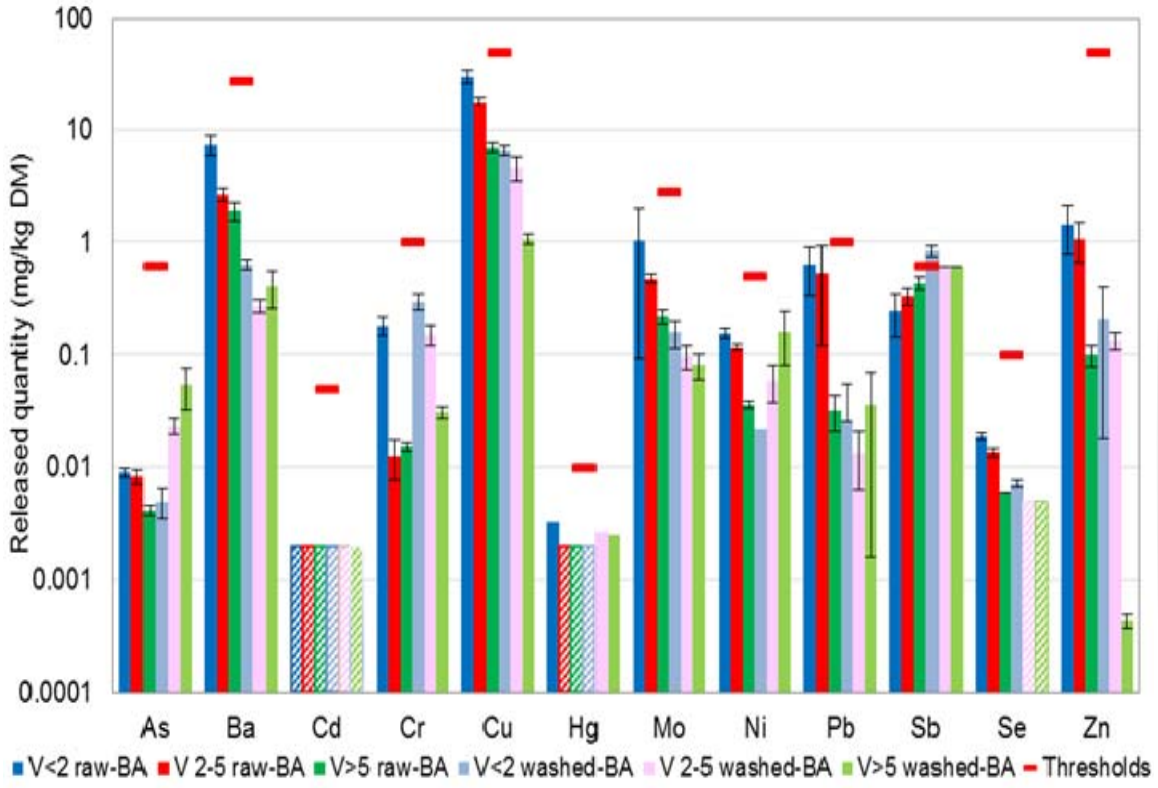
Whatever the contact time, a reduction in the overall metal concentration was observed.

More than 60% of MTE were released for short contact time with HCl

The contact time of 1 h has been chosen for the global chemical washing

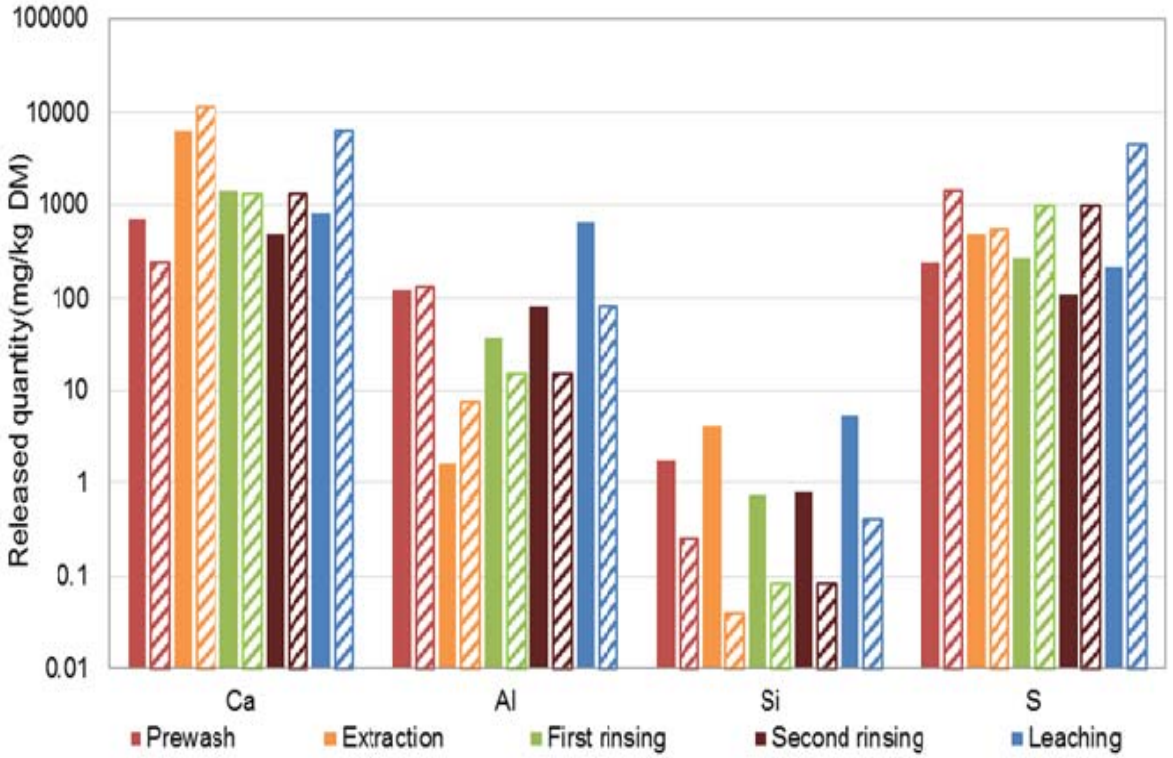
Influence of the washing on the particle size fraction

Different size particle fractions were tested: V<2; V 2-5; V>5 {HCl 0.18 M, L/S = 10 L/kg; 6 h}



The release of most MTE decreases after treatment with HCl for all particle size fractions (expt Sb, Cr and As)

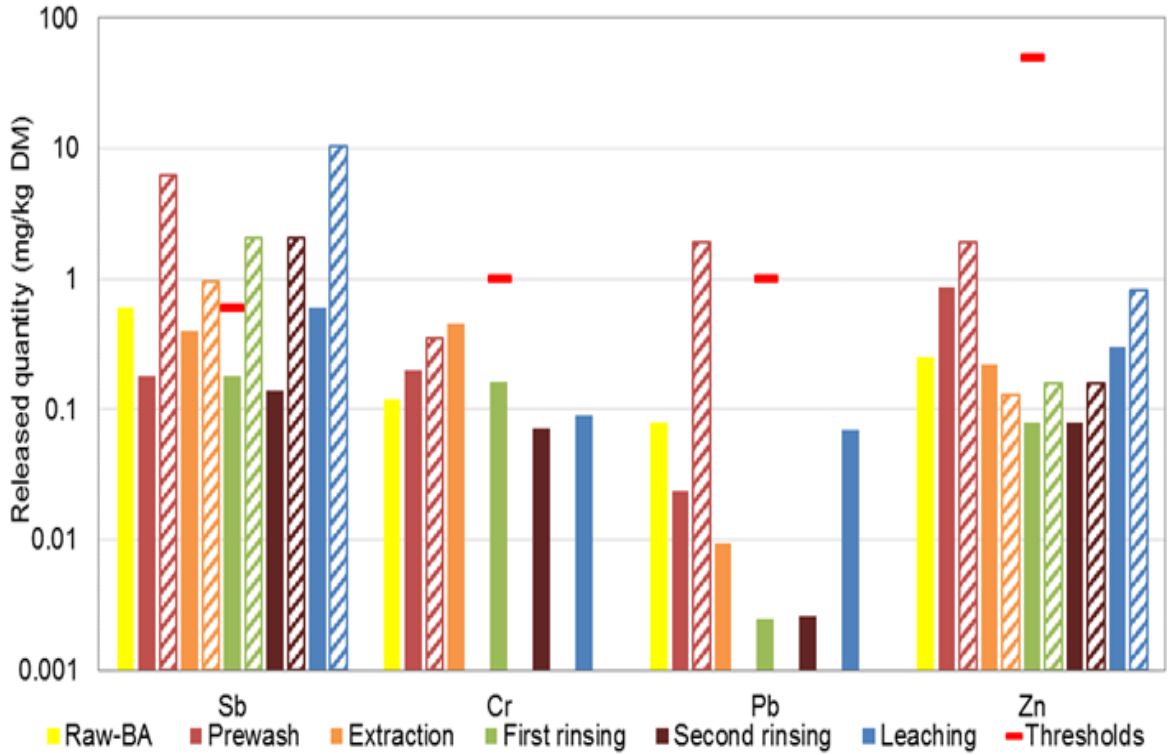
Study of the leaching behaviour of major elements



Both experimental and modelled results have the same order of magnitude

The modeling is more reliable when the assembly mineralogical is complete ex: Ca

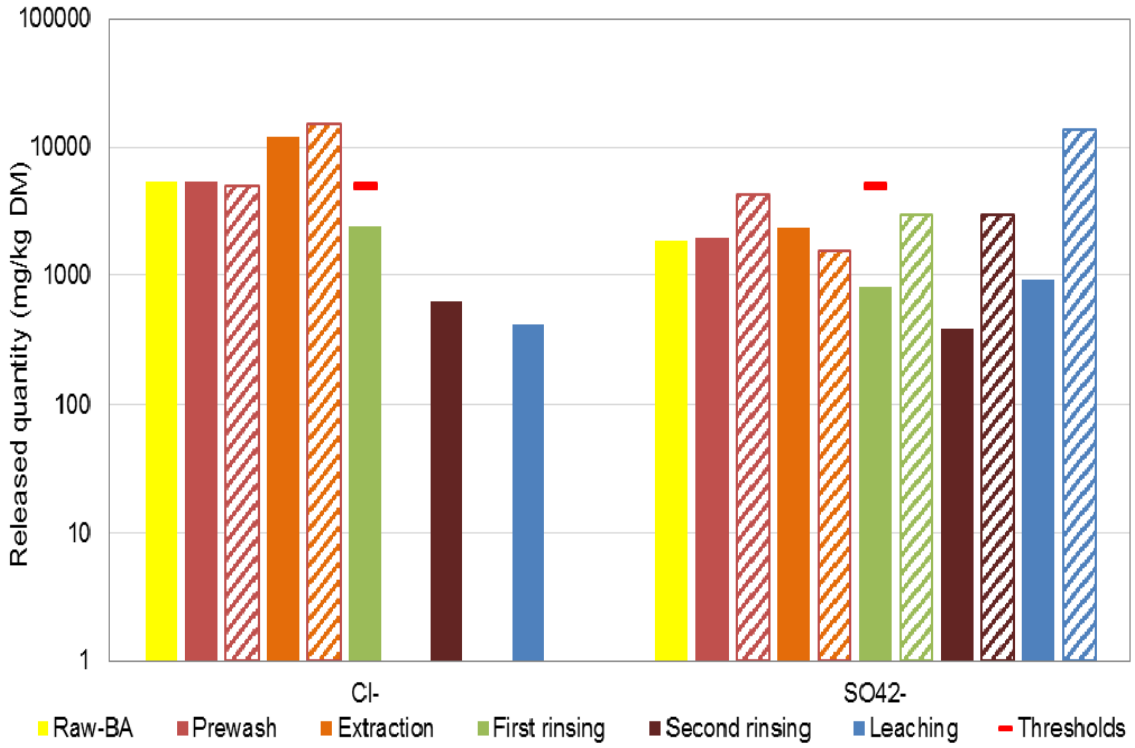
Study of the leaching behaviour of major MTE



Chemical treatment applied in this study has been proven to be efficient for all MTE

Zinc shows a good coherence between experimental and simulated leaching behaviour (its assemblage is well defined)

Study of the leaching behaviour of chlorides and sulphates



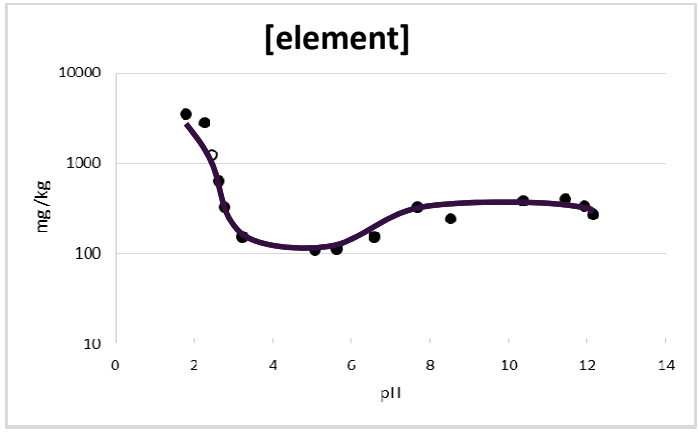
An important quantity of chlorides and sulphates is solubilised during the pre-wash step ; most of NaCl and KCl can be removed by simple washing and rinsing

Perspectives

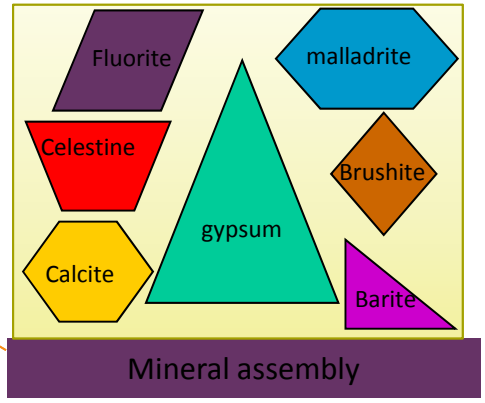
- Development of construction materials incorporating treated materials (concrete, cement mortar…)
- Environmental and mechanical evaluation of materials (MLT, compressive strength, slump test…)
- Modelling of scenario

How modelling BA?

Use a previous work ⟺ **Definition of a mineral assemblage representative of BA**



➡ **Geochemical modeling (Phreeqc)**



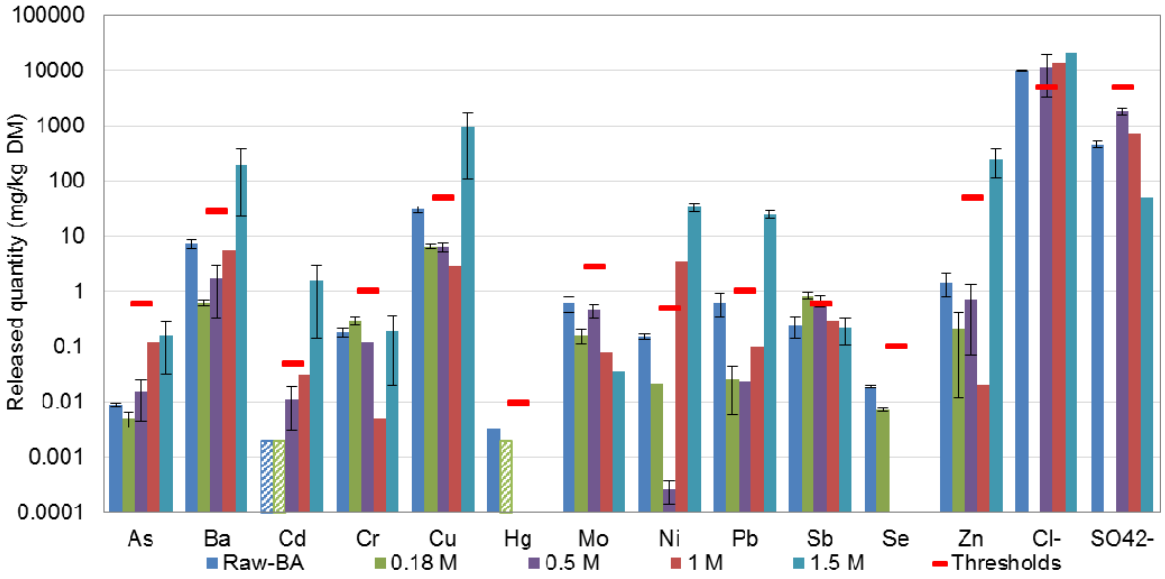
Dissolution - précipitation

$K_s = f(T, pH)$

Adaptation of the assembly ⟺ **From total content**

Optimisation of different washing parameters

Concentration of hydrochloric acid: 0.18 M, 0.5 M, 1 M, 1.5 M
L/S = 10 L/kg, 6 hours contact time, V<2 fraction



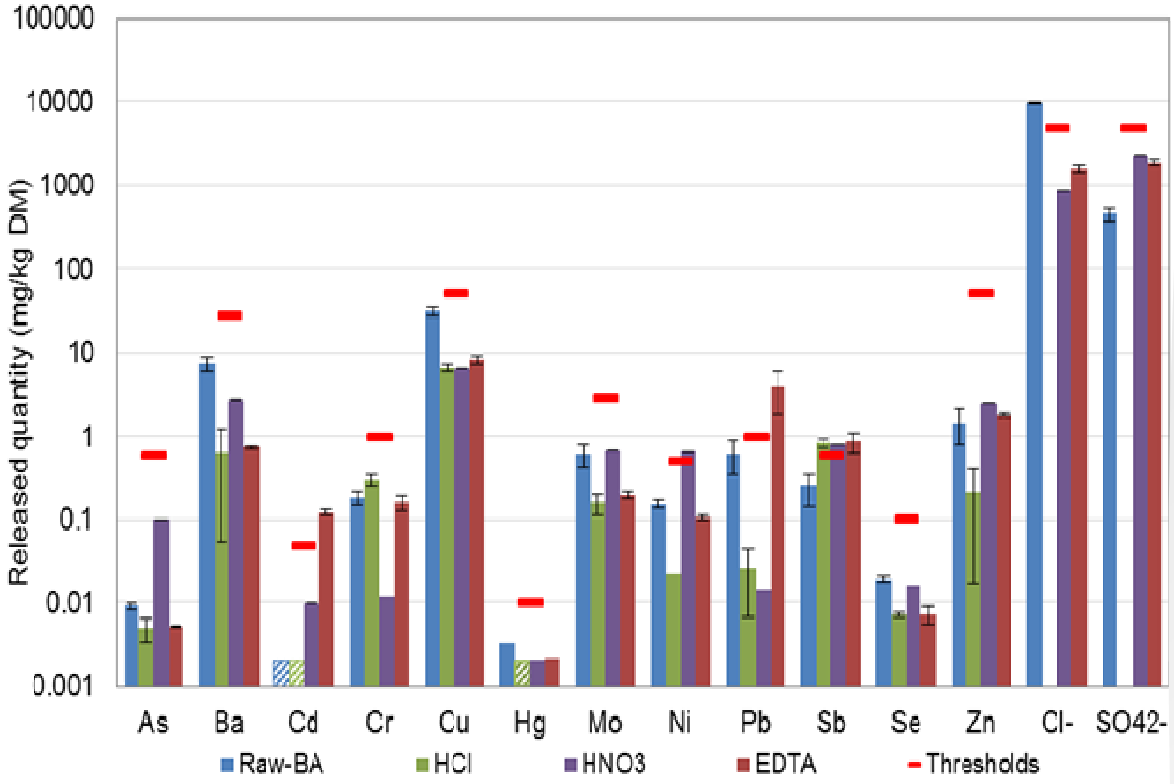
The efficiency of the washing process ↘ With the ↗ of the [HCl] for most element (expt Sb and Mo)

At low alKaline pH, Sb and Cr are more stable

Optimisation of different washing parameters

Washing solution: HCl, HNO_3, EDTA

L/S = 10 L/kg, 6 hours contact time, V<2 fraction



The behaviour of elements varies depending on the washing solution

HNO_3 is a strong oxidizing agent
EDTA is a complexing agent

MTE have been trapped on the solid matrix so a rinsing step is necessary

Optimisation of different washing parameters

L/S ratio, size particle fraction and contact time

L/S

- The leachability of most MTE increases with the decrease of pH
- L/S = 2 L/kg has been selected for global chemical treatment for economical and environmental reasons

Size particle fraction

- The release of most MTE decreases after treatment with HCl for all particle size fractions (expt Sb, Cr and As)

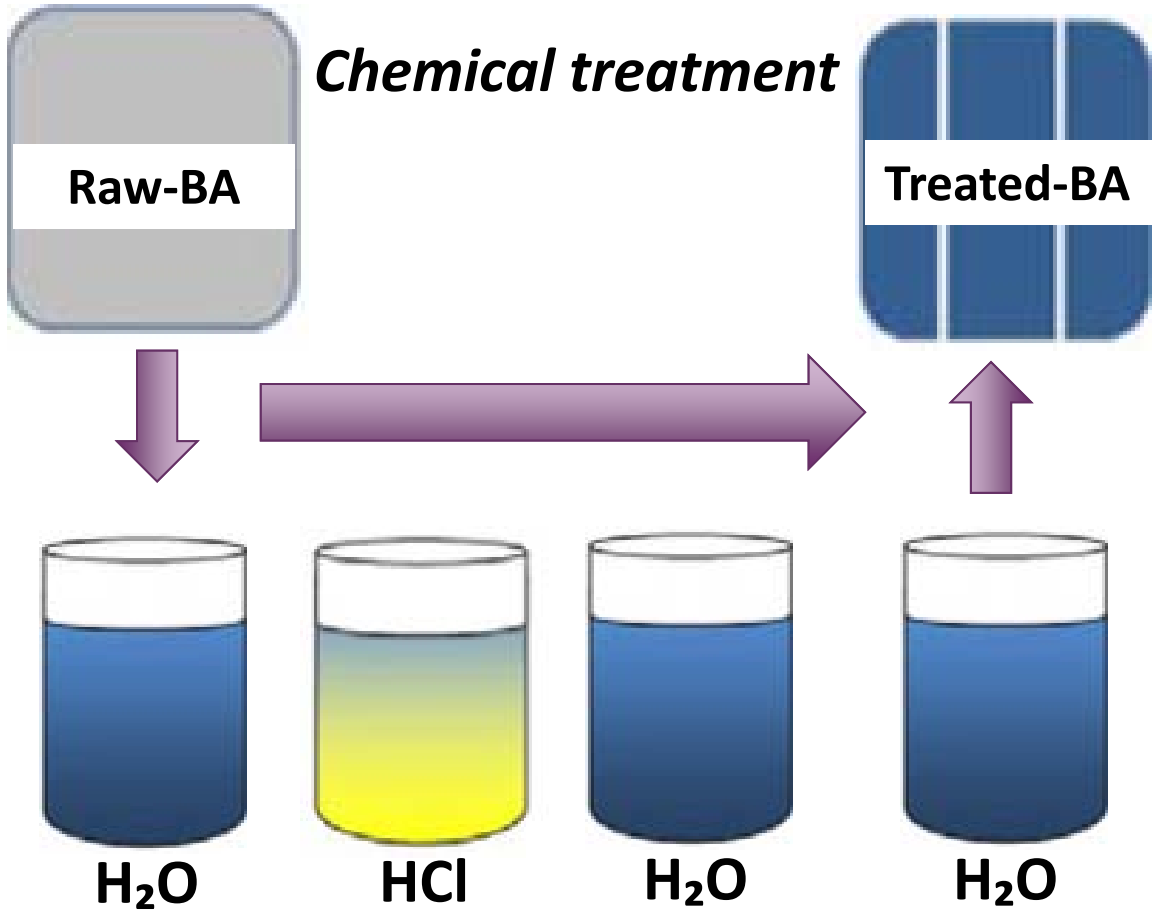
Contact time

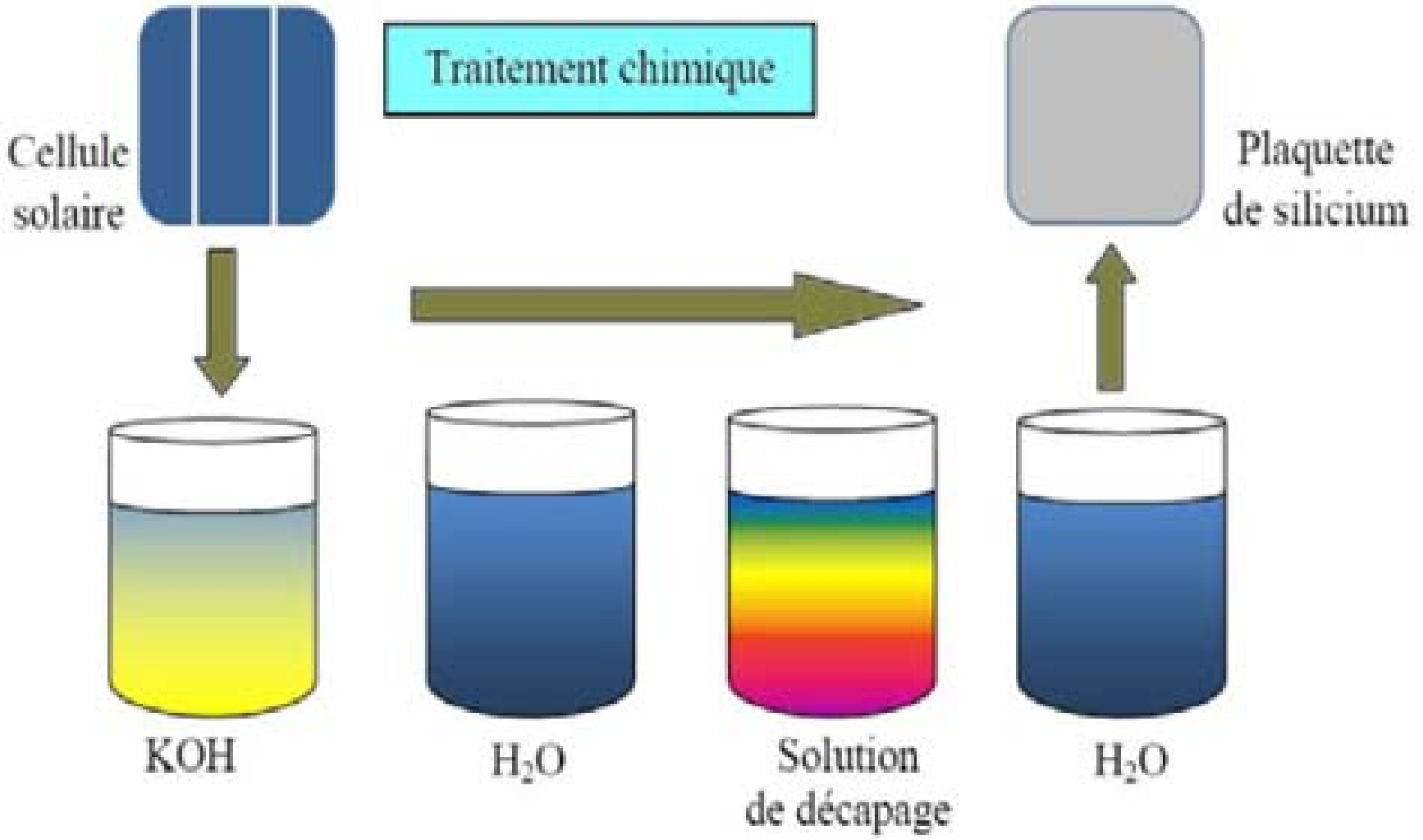
- Whatever the contact time, a reduction in the overall metal concentration was observed.
- More than 60% of MTE were released for short contact time with HCl
- The contact time of 1 h has been chosen for the global chemical washing

- L/S = 2 L/Kg ; V < 2 mm and t = 1 h

Conclusions & perspectives

- Fine particle size is more charged in MTE
- HCl with small concentrations, Low L/S ratio and a short contact time are efficient to increase the efficiency of pre-treatment process
- A dynamic rinsing is necessary to remove the traces of metals
- Different characterisation (XRD, SEM...), are necessary to improve the mineralogical assemblage
- Incorporation of the treated materials in different formulations to know if we can recover them in building construction
- Perform different environmental and mechanical tests of this material (compressive strength, slump test…)


Chemical treatment
Raw-BA
Treated-BA
H2O
HCl
H2O
H2O


Cellule solaire
Traitement chimique
Plaquette de silicium
KOH
H_2O
Solution de décapage
H_2O