



**HAL**  
open science

## Fine fraction of municipal solid waste incinerator: Zinc and copper urban mine

Mathilde Perrin, Jonathan Deseure, Lenka Svecova

### ► To cite this version:

Mathilde Perrin, Jonathan Deseure, Lenka Svecova. Fine fraction of municipal solid waste incinerator: Zinc and copper urban mine. WasteEng 2022 - 9th International Conference on Engineering for Waste and Biomass Valorization, Jun 2022, Copenhagen, Denmark. . hal-03836121

**HAL Id: hal-03836121**

**<https://hal.science/hal-03836121>**

Submitted on 1 Nov 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

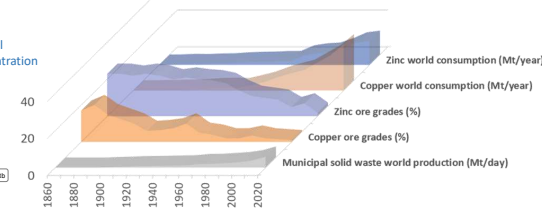
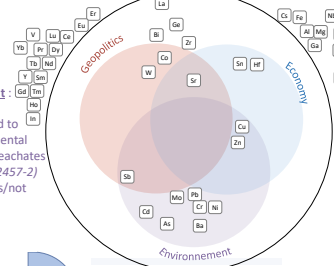
## Introduction

Fine fraction (< 2 mm) of bottom ashes from municipal solid waste incineration (MSWI) represent 30% wt. of the total produced bottom ashes amount. The objective of the Refina project is to recover the most valuable metals based on the environmental, economic and geopolitical criteria. The zinc and the copper have been identified as the priority elements (Fig. 2). Their mean concentrations are close to actual mining grades (Fig 1); 3000-3500 mg/kg, corresponding to around 18 000 Mt of each metal landfilled each year in Europe. With the decrease of mining grades and increase of metal demand (Fig 1), MSWI could become a new secondary resource of copper and zinc (Fig.2).

**Geopolitics :**  
- Criteria : critical element according to EU or not  
- Limit : yes/not

**Environment :**  
- Element submitted to environmental limits in leachates (NF EN 12457-2)  
- Limit : yes/not

**Economy :**  
- Economic potential (product of concentration by market value)  
- Limit : 5\$/t BA



The objective of the current work is to develop a low-cost process to recover Cu and Zn. Heap leaching technology is envisaged here to recover metals from MSWI via laboratory column leaching experiments.

Fig. 1 : Evolution of world municipal solid waste production, compared with zinc and copper ore grades evolution and copper and zinc world consumption since 1860

## Materials

**Origin of samples:** Indaver incineration plant - Belgium  
**Pretreatments:** quenching – wet screening  
**Particle size fraction used:** 0.063-2 mm  
**Homogenizing and sampling:** by wet quartering on large plastic tarpaulin

**Characterizations:** Elementary analysis - SARM Nancy, XRD, SEM-EDS

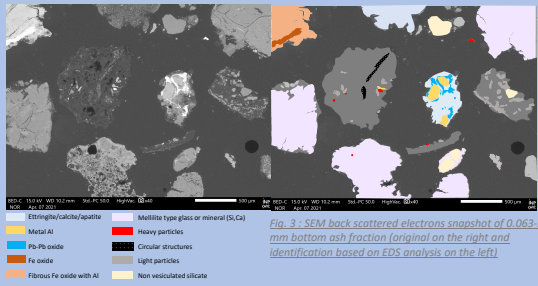


Fig. 3 - SEM back-scattered electrons snapshot of 0.063-2 mm bottom ash fraction (original on the right and identification based on EDS analysis on the left)

## Zn Recovery

### Objectives

- Recover the maximum of Zn
- Recirculate the leaching solution (no changes in pH and reactants concentrations)

Precipitation has been chosen to satisfy these objectives

### Zn precipitation

Maximum precipitation achieved at :

- Temperature of approx. 40°C
- Precisely 2 moles of  $AlNO_3 \cdot 9H_2O$  / 1 mole of Zn
- Best at 1.5 M total ammonia

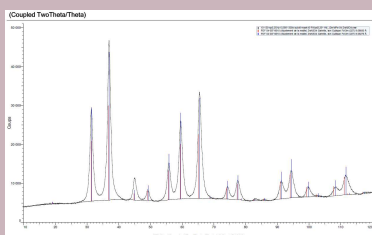
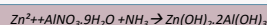


Fig. 4 : XRD spectrum of calcinated zinc precipitate corresponding to a pure  $ZnAl_2O_4$  phase.

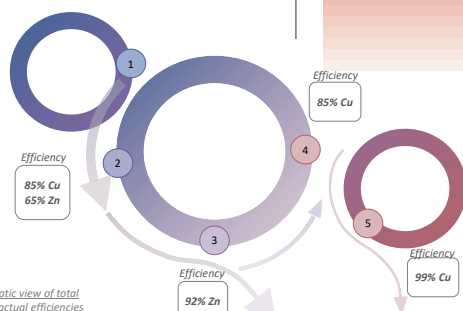
Precipitation by aluminum nitrate allows to reach a **zinc recovery of 92%** and it's a **selective operation** because the copper concentration remains constant during the precipitation step. No pH change is necessary or observed.

## Conclusions

Up to **70% of copper** and **60% of zinc** are now recovered via the **four steps process** based on column leaching with less than 0.1% of iron co-solubilized.

The leaching step is a key step to improve efficiencies. By identifying leaching limiting and improving factors it's possible to drastically improve total recovery for both metals.

Fig. 7: Schematic view of total process with actual efficiencies



## Washing

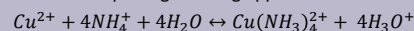
**Objective :** Reduction of leachable sulfates content prior to the leaching step.

**Experimental setup :** down-flow percolating column filled with 50 g to 2 kg of MSWI.

**Reactants :** saline solutions to enhance sulfate solubilization (increasing ionic strength and cationic exchange capacity) – NaCl 1M

## Leaching

**Objectives :** Copper and zinc selective leaching  
Ammonia based complexing leaching applied



**Experimental setup :** down-flow percolating column filled with 50 g to 2 kg of previously washed MSWI.

**Reactants :** Ammonia chemical grade and ammonium chloride salt

### Factors improving leaching efficiency

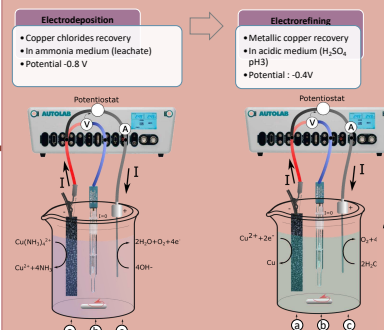
- o Optimized concentration and ratio of reactants
- o Oxygen access
- o Time
- o Promoted galvanic corrosion of zinc

### Factors limiting leaching efficiency

- o Copper cementation
- o Occurrence of galvanic protection of copper
- o Presence of others complexing agents forming less soluble complexes
- o Limited accessibility and liberation of metallic particles in column

## Cu Recovery

Electrodeposition in two steps (Fig. 5).



After copper electrodeposition, leachate is **recirculated** to leach again the column. Also, the cathodic deposit is redissolved in acidic media to perform to the electrowinning step.

- (A) Graphite foam cathode
- (B) Reference electrode Ag/AgCl (E=0.176 V/ESH)
- (C) Dimensional stable anode (DSA)

Fig. 5: schematic representation of electrodeposition and electrorefining steps

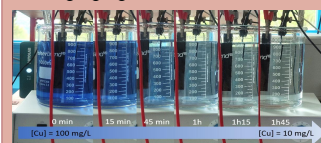


Fig. 6: Leachate color evolution during electrodeposition step

Copper removal efficiency : up to **85 %**

## References

- Farhadi, S., Panahandehjoo, S., 2010. Spinell-type zinc aluminate ( $ZnAl_2O_4$ ) nanoparticles prepared by the coprecipitation method: A novel, green and recyclable heterogeneous catalyst for the acetylation of amines, alcohols and phenols under solvent-free conditions. Appl. Catal. Gen. 382, 293-302. <https://doi.org/10.1016/j.apcata.2010.05.005>
- Sverdrup, H.U., Olafsdottir, A.H., Ragnarsdottir, K.V., 2019. On the long-term sustainability of copper, zinc and lead supply, using a system dynamics model. Resour. Conserv. Recycl. X 4, 100007. <https://doi.org/10.1016/j.resx.2019.100007>
- Thengvall, T., Chilkala, R., Habte, L., Tuan, L.Q., Kim, C.S., 2019. A Brief Note on the Heap Leaching Technologies for the Recovery of Valuable Metals. Sustainability 11, 3347. <https://doi.org/10.3390/su11123347>
- Woode, M.Y., Acheampong, M.A., Azanu, D., 2014. Optimal Conditions for Ammonia Leaching of Copper/Chalcoite-Rimmed Pyrite: Part 2. Int. J. Eng. Res. 3, 5.