Determination of the fate of metallic compounds during sewage sludge gasification: preliminary research results

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Gasification: introduction

- Problem of sewage sludge: increasing **disposal restrictions** because of risks due to release of pesticides, endocrinic disruptors, heavy metals, etc.
- (Co-)**Incineration** coupled with electricity production has **restricted energetic efficiency**: alternative treatment options needed
- **Gasification** transforms sludge at high temperature (800-1000 °C) into CH_4, H_2 and CO

Gasification: advantages

- Several advantages for gasification
  - Higher energetic **efficiency** than incineration
  - Smaller **exhaust gas volume** to treat
  - Simple end product composition → **little refining required** (<-> pyrolysis: oily phase)
  - Endproduct highly interesting for production of "**fuels of the future**"
    - H_2: hydrogen based economy
    - Fischer-Tropsch process: synthetic fuels

Gasification: unknown facts

- Biomass gasification = **relatively new process**, most experience on wood and coal with more simple and constant composition
- **Biomass composition may vary** substantially in time, depending on source, climatic conditions, etc.
- Very little known on **fate of inorganic and metallic compounds**, which may entail several problems:
  - Downstream catalyst poisoning
  - Leaching of ashes and slags (ecotoxicological risk)
  - Contamination to condensed phase

Gasification: unknown facts

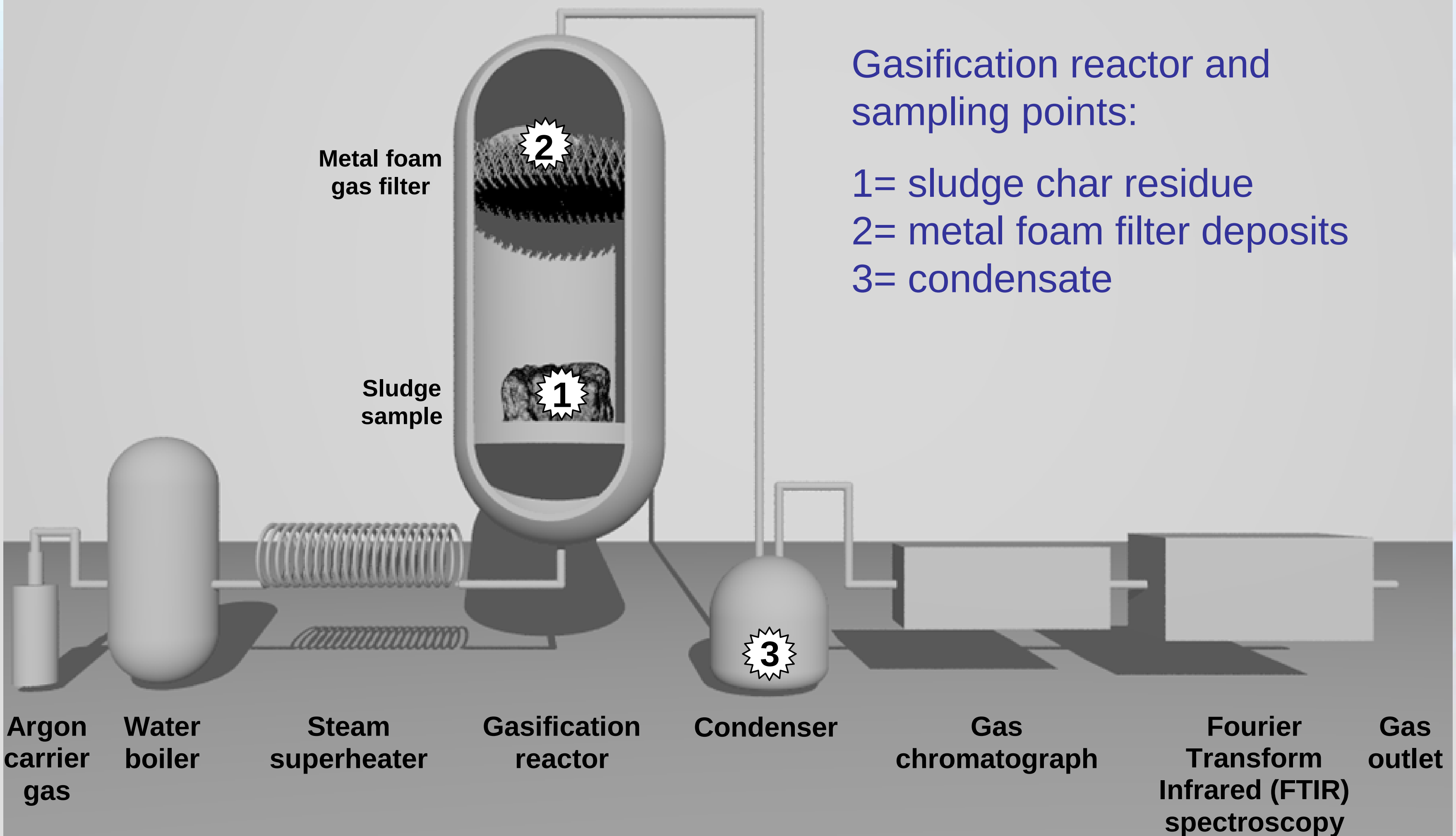
- Especially **sewage sludge** contains high levels of heavy metals (data: “La Pioline” WWTP 2008 average values)

Parameter	**Content**	**Parameter**	**Content**
Dry matter (% mass/mass)	17.9	Cu (mg/kg dry matter)	538
Organic matter (% of dry matter)	66.17	Zn (mg/kg dry matter)	462
Nitrogen (% m/m)	1.11	Pb (mg/kg dry matter)	53.9
Phosphor (% m/m, expressed as P_2O_5)	1.65	Cr (mg/kg dry matter)	31.3
Sulphur (% m/m, expressed as SO_3)	2.63	Ni (mg/kg dry matter)	20.8
Na (% m/m, expressed as Na_2O)	0.01	Hg (mg/kg dry matter)	1.6
K (% m/m, expressed as K_2O)	0.07	Cd (mg/kg dry matter)	1.0
Ca (% m/m, expressed as CaO)	1.29		
Mg (% m/m, expressed as MgO)	0.23		

Aim of the current study

This study aims at investigating the fate of metallic compounds during and following gasification of sewage sludge

Materials and Methods



Gasification reactor and sampling points:

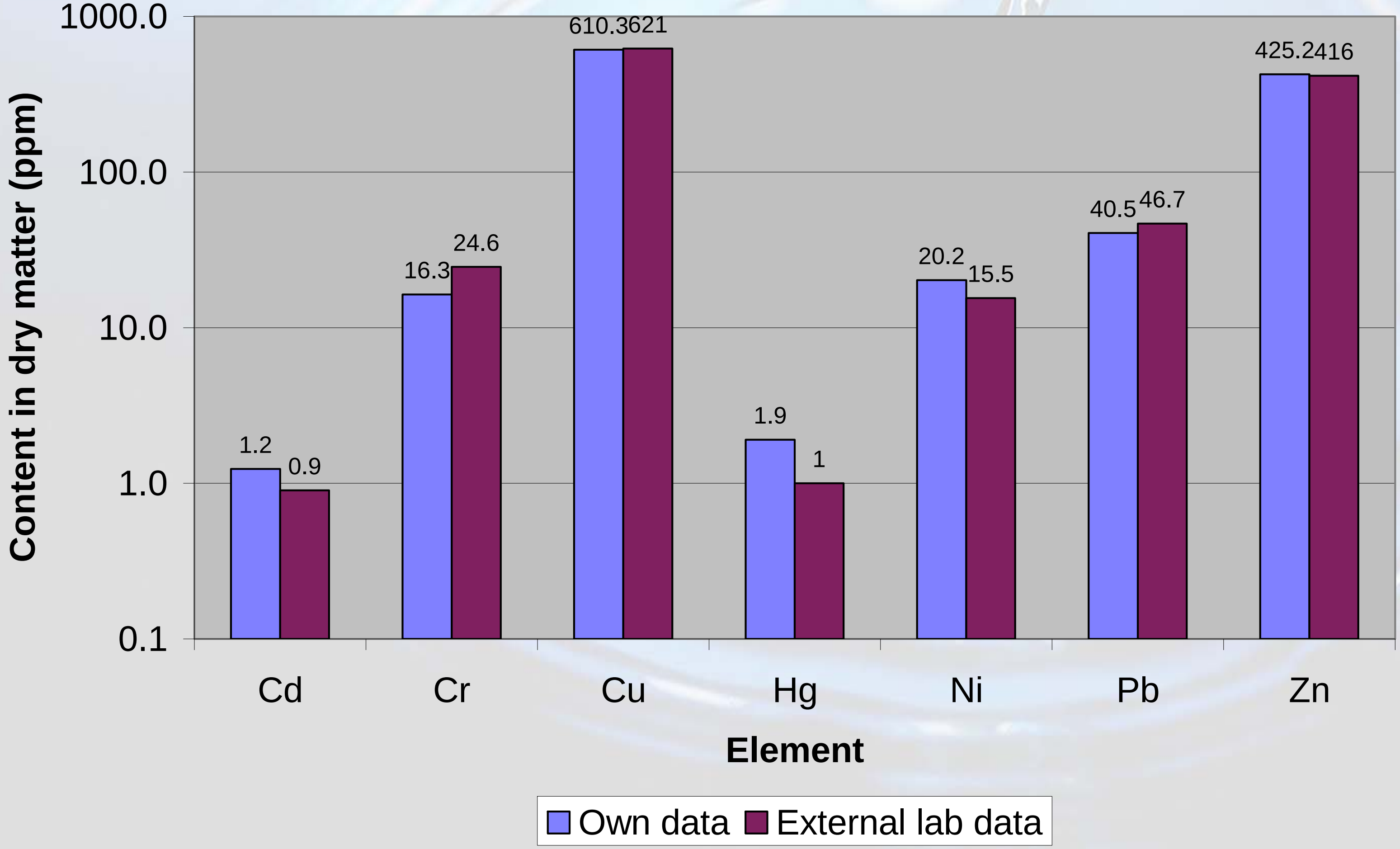
1= sludge char residue
2= metal foam filter deposits
3= condensate

Materials and Methods

- Dewatered sewage sludge (17% dry matter) from **STEP "La Pioline"** (Aix-en-Provence, France)
- Gasification experiments at **different temperatures** (105, 350, 650 & 850°C)
- Metal analyses performed by **inductively coupled plasma** atomic emission spectroscopy (ICP-AES, Horiba Ultima-C 2000)
- **Two sample preparation** methods applied
  - Microwave digestion: Cd, Cr, Cu, Hg, Ni, Pb, Zn
  - Alkaline fusion: Al, Ca, Fe, K, Mg, Mn, Na, P, Si, Ti

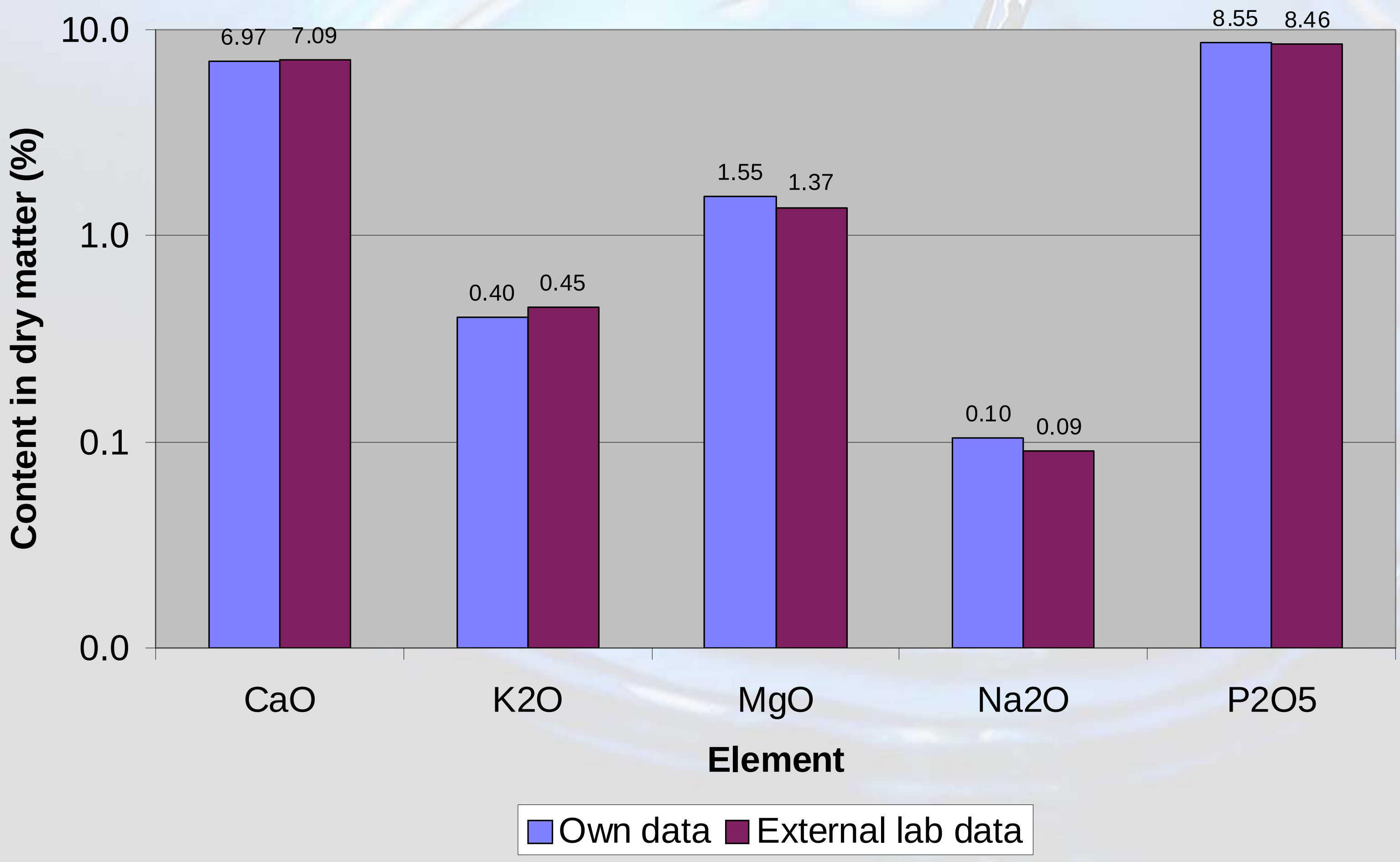
Results and Discussion

- Verification of experimental results against reference lab (Laboratoire LCA): metals



Results and Discussion

- Verification of experimental results against reference lab (Laboratoire LCA): others

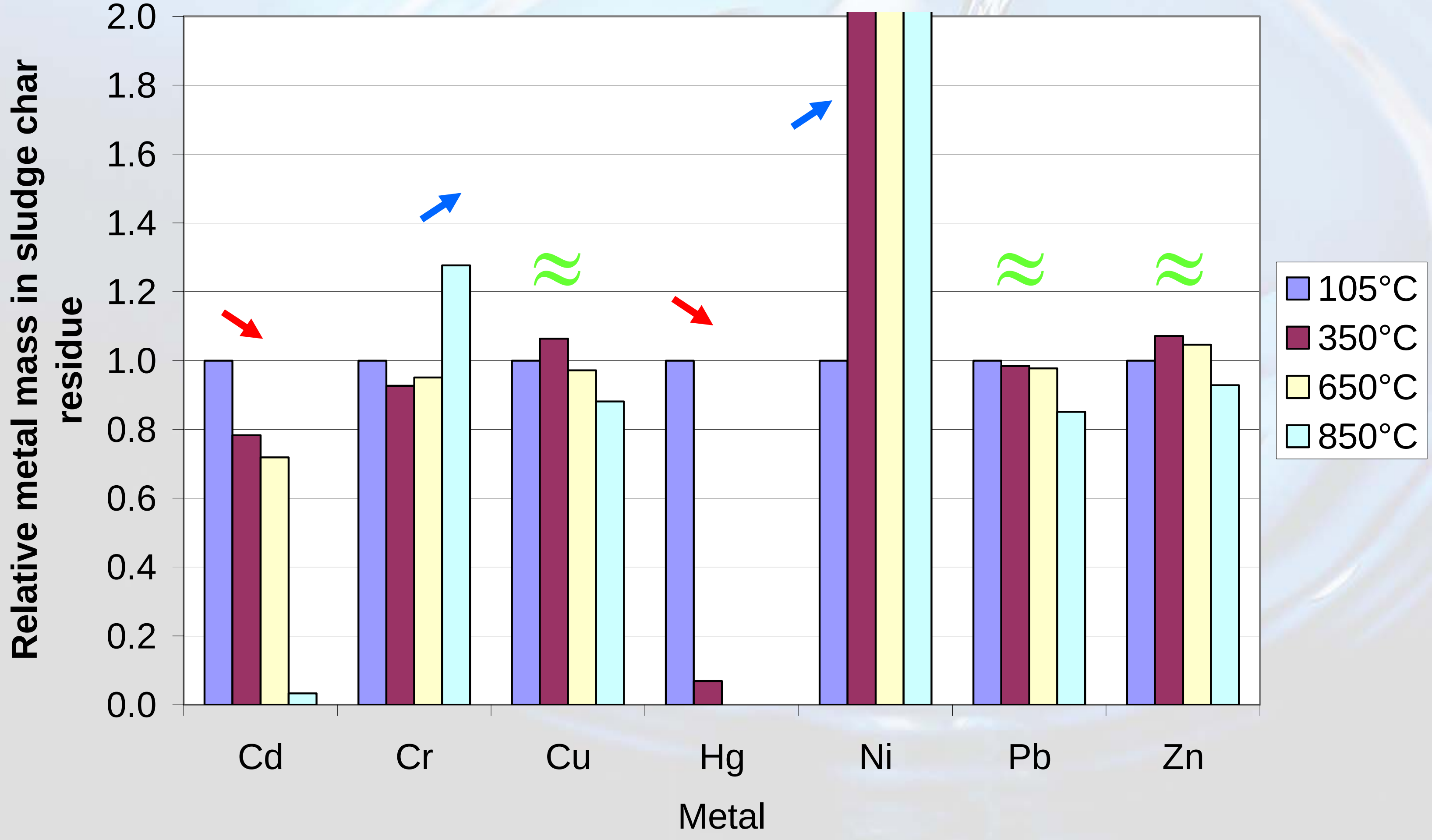


Results and Discussion

- **Alkaline fusion** also delivered results for Cr, Cu, Ni and Zn: similar but less reliable than microwave digestion results
- Generally **very good agreement** between own data and data from external lab
- Both series of data show **high levels of heavy metals in sewage sludge** (especially Cu and Zn), as well as **other inorganic species** (especially Ca and P)

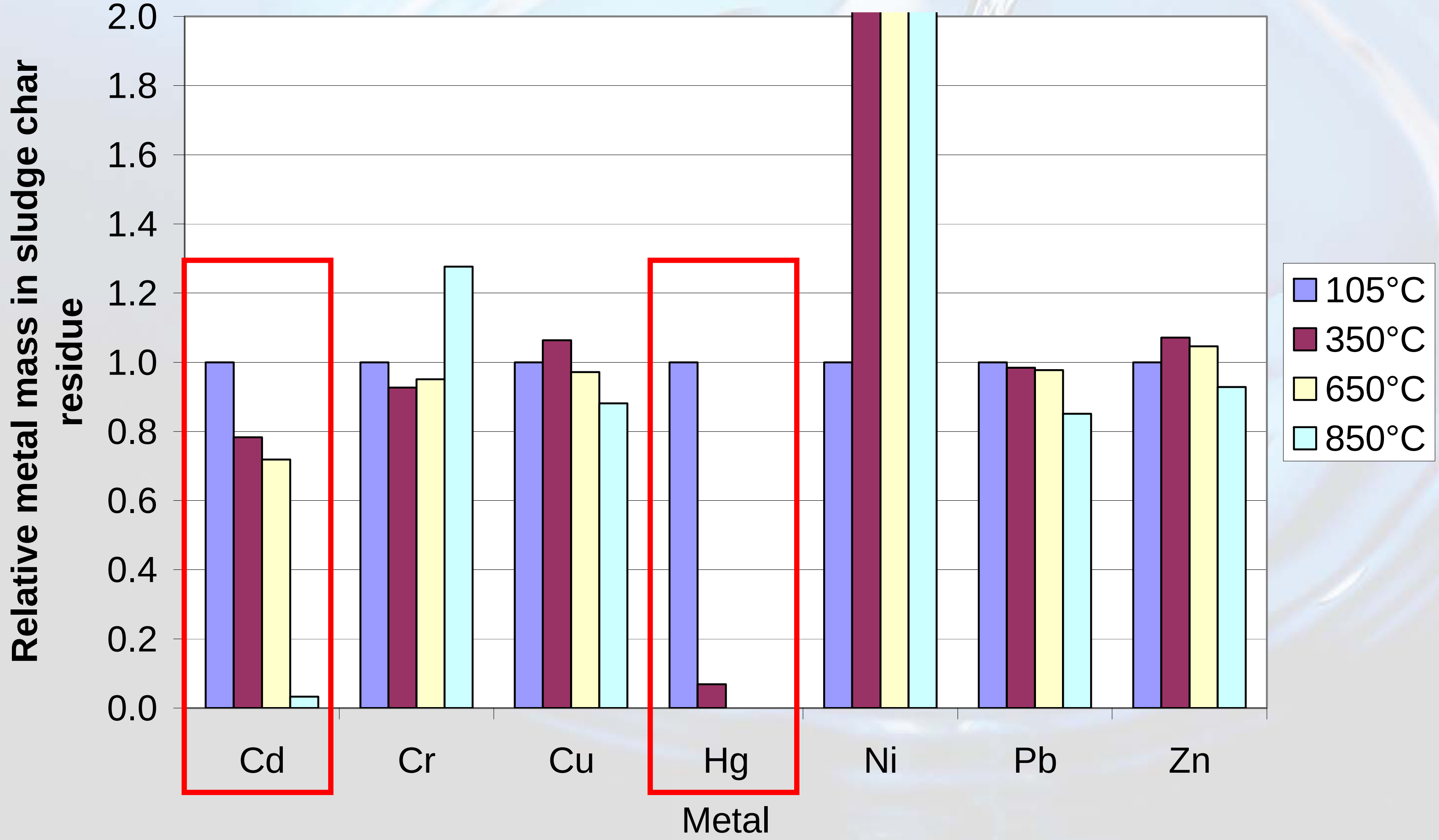
Results and Discussion

- Results from series of gasifications at different temperatures: remaining metal mass in char residue



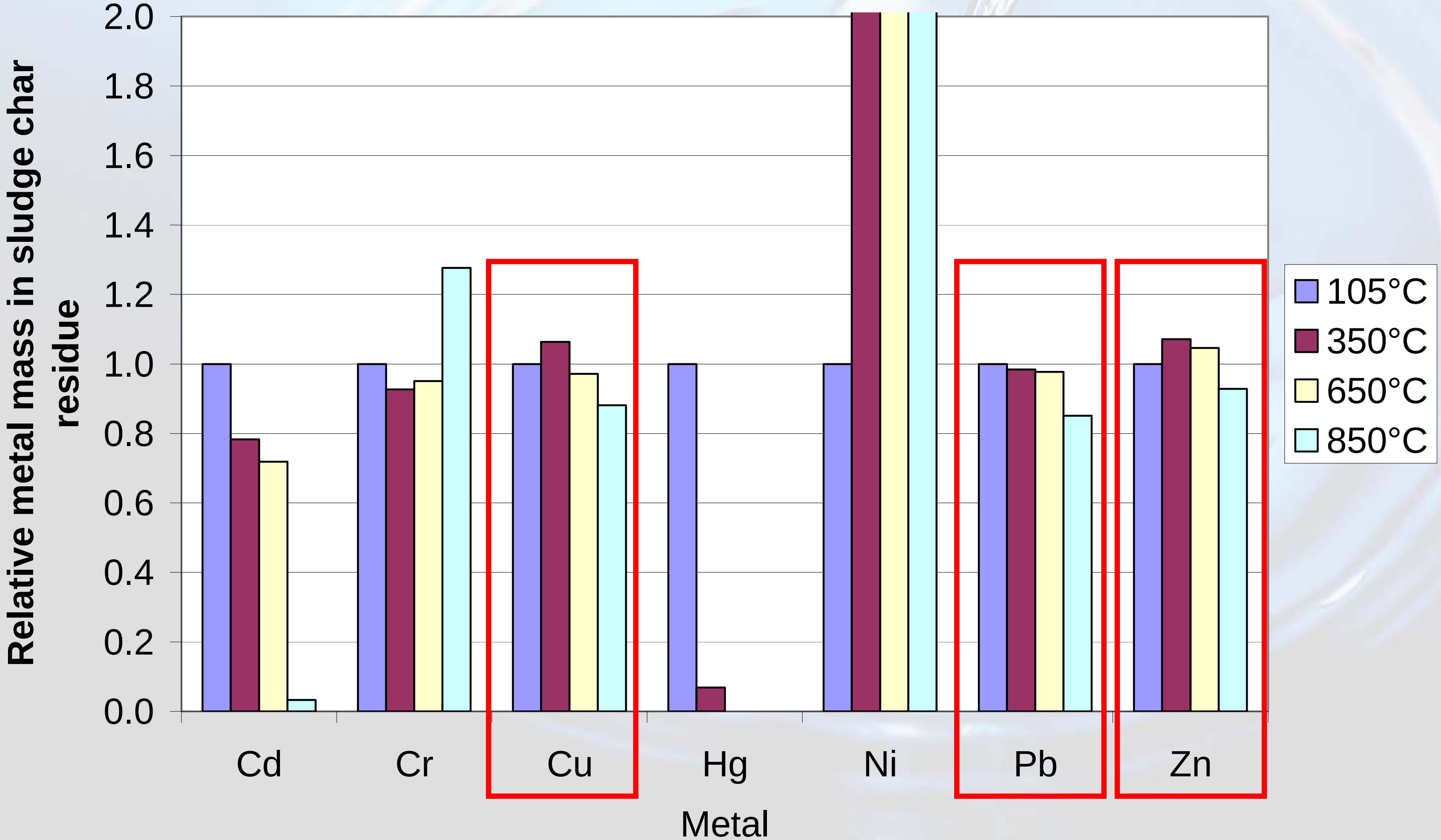
Results and Discussion

- Two elements **disappear**: directly linked to **boiling point** of metal: 357°C for Hg and 765°C for Cd



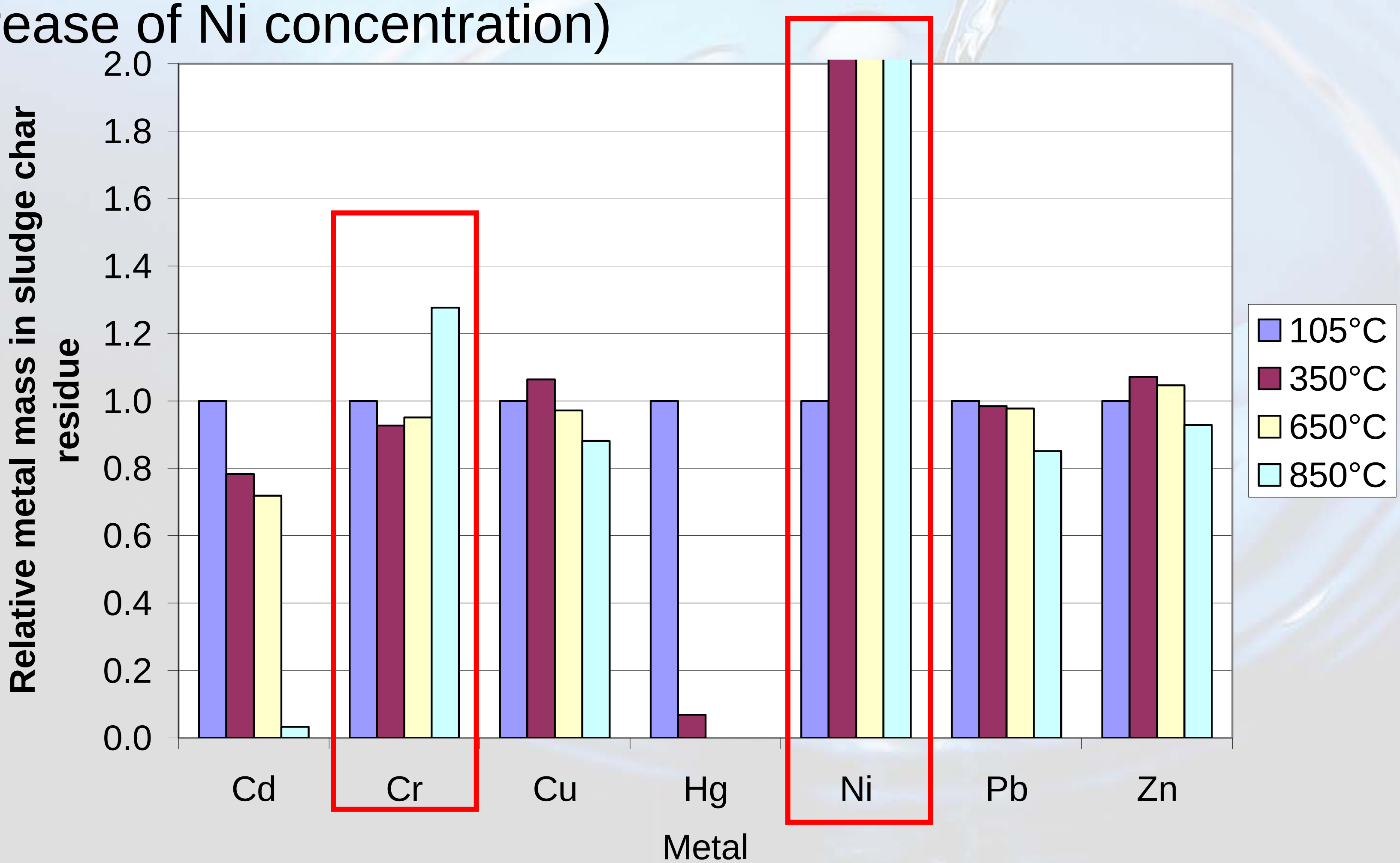
Results and Discussion

- Three elements remain **± constant**: **higher boiling points**: 2267°C (Cu), 1740°C (Pb), 907°C (Zn)



Results and Discussion

- Two elements **increase** in concentration: Cr, Ni **probably due to contamination** from metal foam support or reactor (12 fold increase of Ni concentration)



Conclusions

- Sewage sludge metal analysis was **validated** against external lab data
- **High levels** of heavy metals were demonstrated
- Initial results showed **clear shifts in metal distribution** after gasification, hence importance of heavy metal monitoring during gasification

Future research

- **Elucidate pathways** of metal loss or enrichment by analysis of condensate and metal foams (X-ray microfluorescence, ICP)
- Establish methods of **producing clean reaction gas**, e.g. by working at gradually increasing temperature levels

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