Benefits of pre-treatments on MSWI FA before alkali-activation

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Municipal solid waste incineration

INCINERATION ADVANTAGES

In Europe 5.2 tons of waste per inhabitant was produced in 2018 and 6% was incinerated with energy recovery.

Incineration of waste means 90% of waste volume reduction and energy and heat recovery

INCINERATION DRAWBACKS

BOTTOM ASH
(25-30 wt% of input waste)

Unburned waste material collected at the end of the furnace

Not dangerous waste

FLY ASH
(2.5–3 wt% of input waste)

Fine particulate collected from air pollution control devices (electrofilters)

Heavy metals (Pb, Cd, Cr, Zn)
Soluble salts (Cl-, SO4 --)

MSWI FLY ASH

- **Hazardous waste**
- **European Waste Code 19 01 13***

PRE-TREATMENTS

Investigate the possible benefits on the environmental properties of a geopolymer that uses MSWI FA

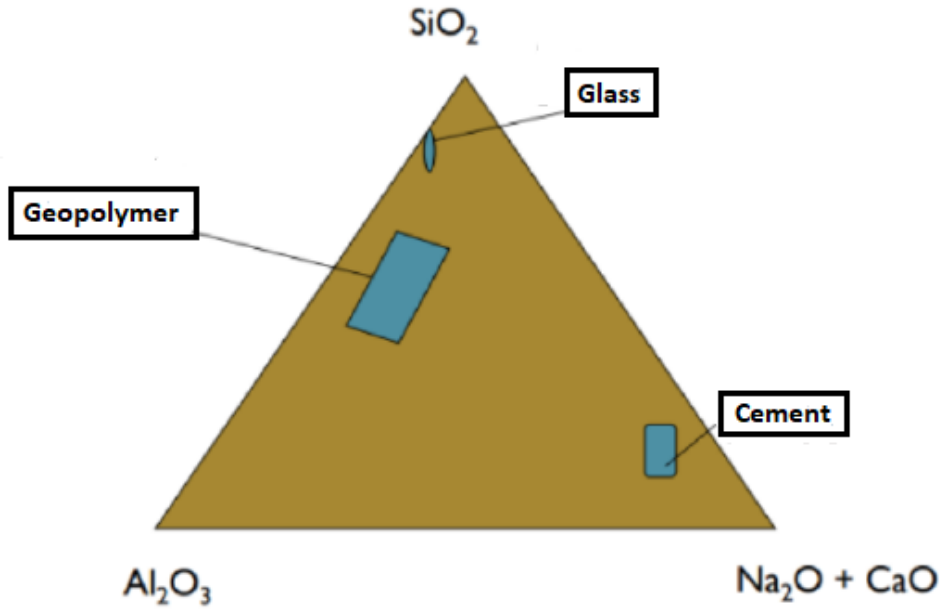
GEOPOLYMERIC MATRIX

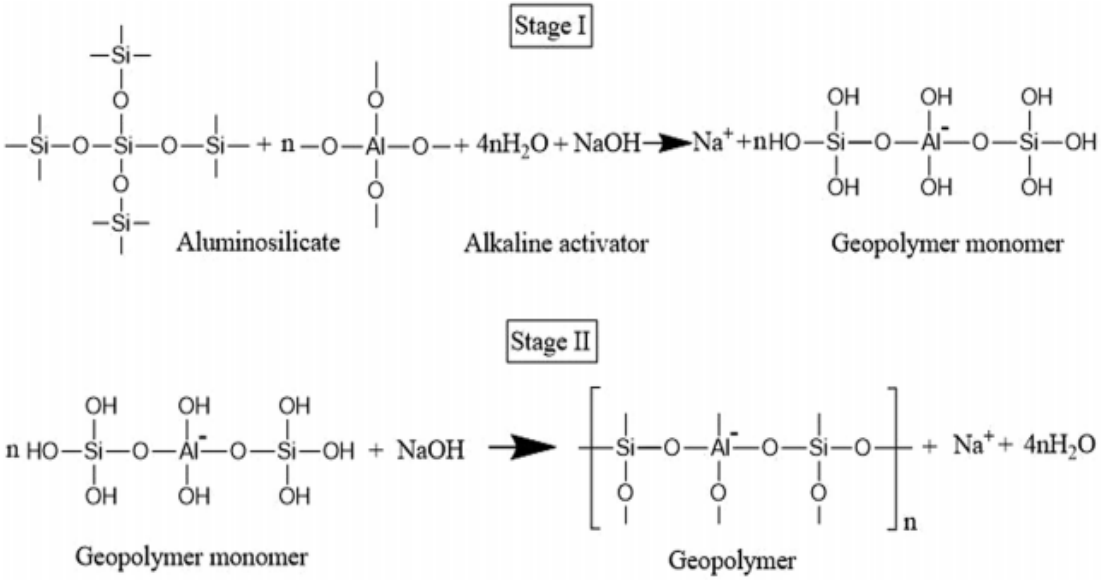
-Good mechanical properties
-Low production temperature
-Low CO2 emission
- Good waste encapsulation medium

Geopolymer

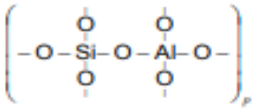
Alkali-activated material with amorphous or semicrystalline structure.

- Aluminium-silicate precursor: Metakaolin, fly ash, bottom ash etc.
- Alkali activator: Sodium hydroxide/ silicate

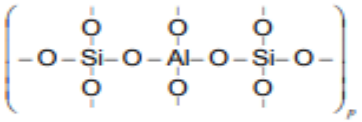




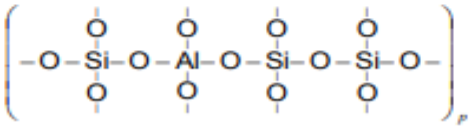
z = 1: Poly(sialate)



z = 2: Poly(sialate-siloxo)



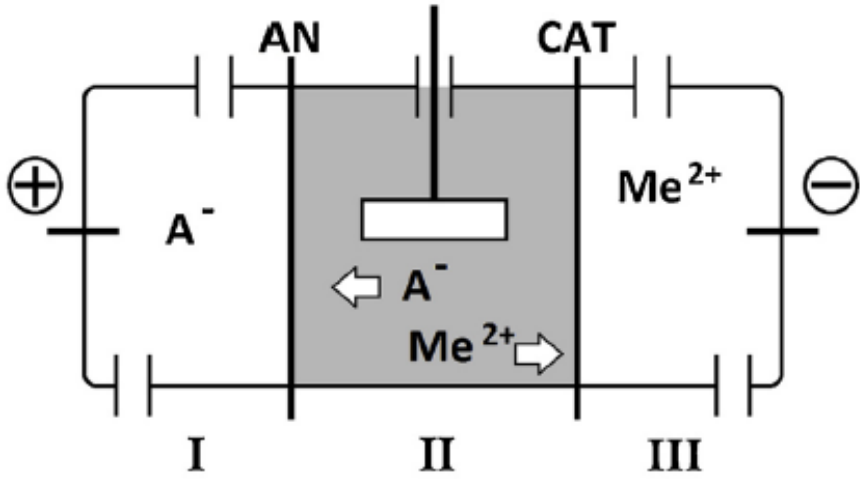
z = 3: Poly(sialate-disiloxo)

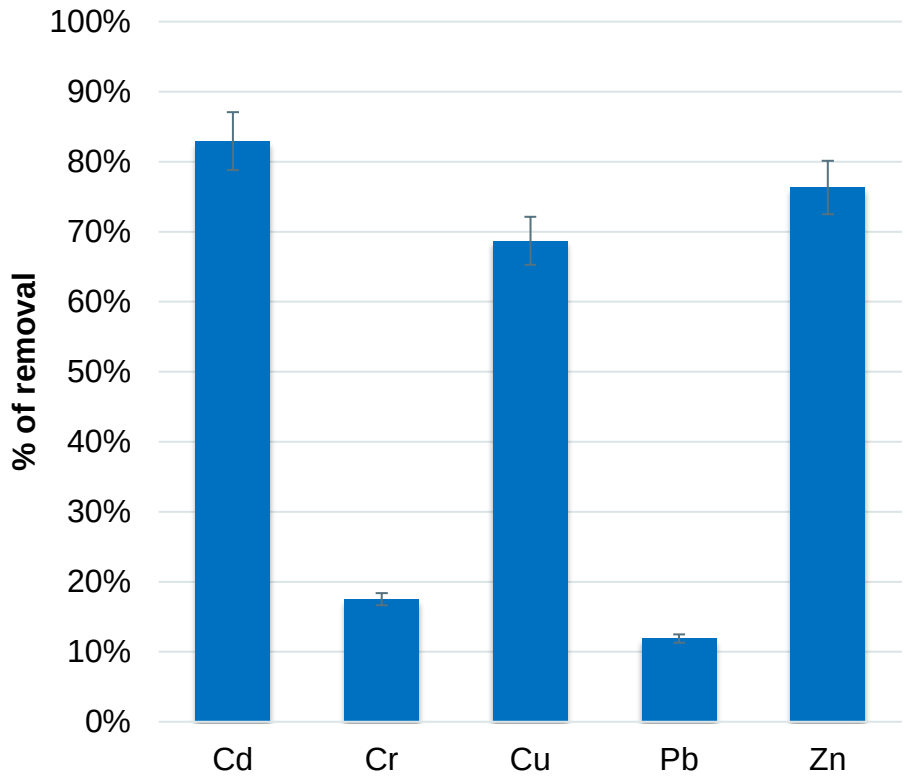


Pre-treatment I:

ELECTRODIALYTIC TREATMENT (EDR)

- Duration: 28 days
- Electrolytic solution: 0,01 M NaNO3 pH 2
- L/S 3.5
- Constant DC Current: 50 mA

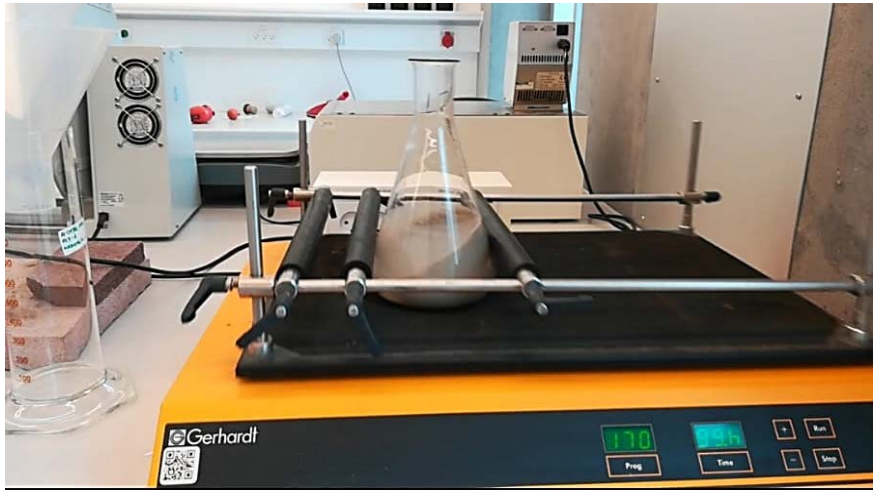


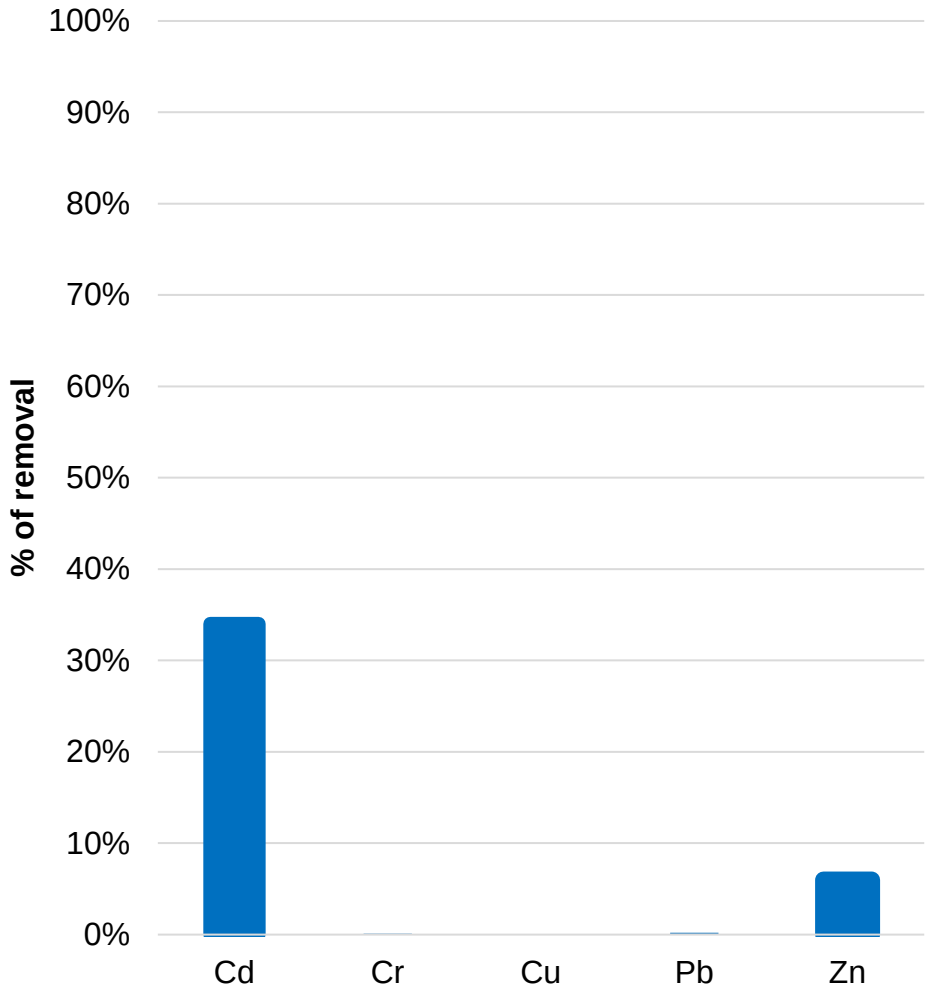


Pre-treatment II:

WATER-WASHING

- Duration: 5 minutes
- L/S 3
- Mixing with shaking-table
- Filtration with passive method

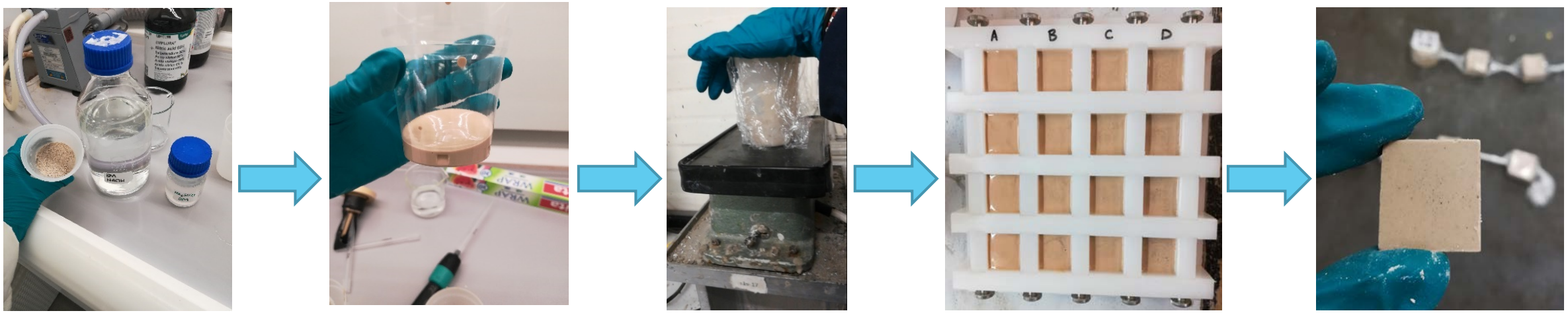




ALKALI-ACTIVATION

MK (g)	FA (%)	3M Na2SiO3 (g)	8M NaOH (g)	Si/Al	Na/Al
25	0-5-10-20	25	4	2	1

GEO_METAKAOLIN GEO_RAW GEO_EDR GEO_WASH



Leaching test on untreated and treated fly ash

RESULTS

European norm EN 12457 "Compliance test for leaching of granular waste materials and sludges"

- Granulometry of the material <4mm
- Distilled water
- L/S 10
- Mixing at room T for 24h
- Filtration for separation of the liquid

- Heavy metals analysis: Inductively Coupled Plasma-Mass Spectrometry (ICP-MAS)
- Soluble salts analysis: Ion Chromatography (IC analysis)

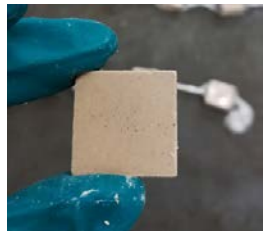
Values compared with law limits for disposal of non-reactive hazardous wastes in disposal sites for non-hazardous wastes (2003/33/EC)

	Raw ash	EDR ash	Washed ash	Law limits
Cd (mg/l)	*	0.80±0.09	*	0.1
Cr (mg/l)	0.80±0.04	0.020±0.002	0.70±0.02	1
Cu (mg/l)	*	1.0±0.3	*	5
Pb (mg/l)	0.7±0.1	0.5±0.3	0.40±0.01	1
Zn (mg/l)	1.0±0.1	78±6	0.40±0.01	5
Chlorides (mg/l)	8086±150	126±9	1316±15	1500
Sulphates (mg/l)	19316±793	1871±8	5551±66	2000

* Values <0.02mg/l (Detection Limit)

GEOPOLYMERIZATION PROCESS FOR THE INERTIZATION OF THE FLY ASH IS **NECESSARY**

ENVIRONMENTAL GEOPOLYMERS CHARACTERIZATION



Detection limit:
0.02 mg/l

Leaching test – granular samples (EN12457) - 7 days of curing

GEO_RAW

	Cd	Cr	Cu	Pb	Zn
5%	0.001	0.044	0.016	0.01	0
10%	0,002	0,05	0,01	0,008	0,03
20%	0,004	0,06	0,01	0,04	0,11

GEO_EDR

	Cd	Cr	Cu	Pb	Zn
5%	0.002	0.05	0.002	0.013	0
10%	0.002	0.03	0	0.009	0
20%	0.005	0.04	0.005	0.016	0

GEO_WASH

	Cd	Cr	Cu	Pb	Zn
5%	0.002	0.08	0.03	0.009	0.09
10%	0	0.1	0.05	0.015	0.13
20%	0	0.15	0.02	0.021	0.14

Leaching test – monolithic samples (EN12457) – 7 days of curing

GEO_RAW

	Cd	Cr	Cu	Pb	Zn
5%	0.002	0.04	0	0.013	0
10%	0.001	0.03	0.001	0.017	0.04
20%	0.002	0.05	0	0.02	0.03

GEO_EDR

	Cd	Cr	Cu	Pb	Zn
5%	0.002	0.04	0	0	0
10%	0.003	0.03	0	0.02	0
20%	0.004	0.02	0	0.013	0

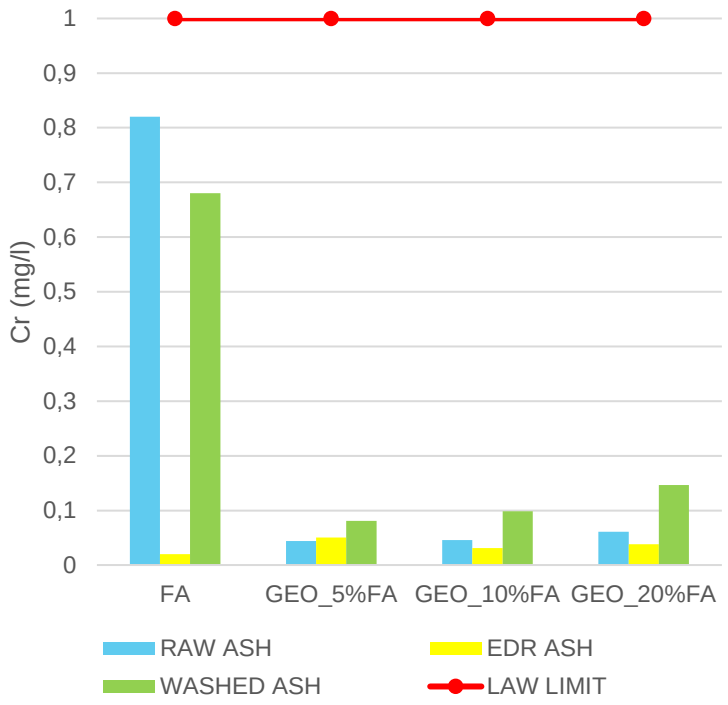
GEO_WASH

	Cd	Cr	Cu	Pb	Zn
5%	0.001	0.06	0.006	0.01	0.12
10%	0.001	0.07	0.02	0	0.14
20%	0.001	0.17	0.02	0,01	0.18

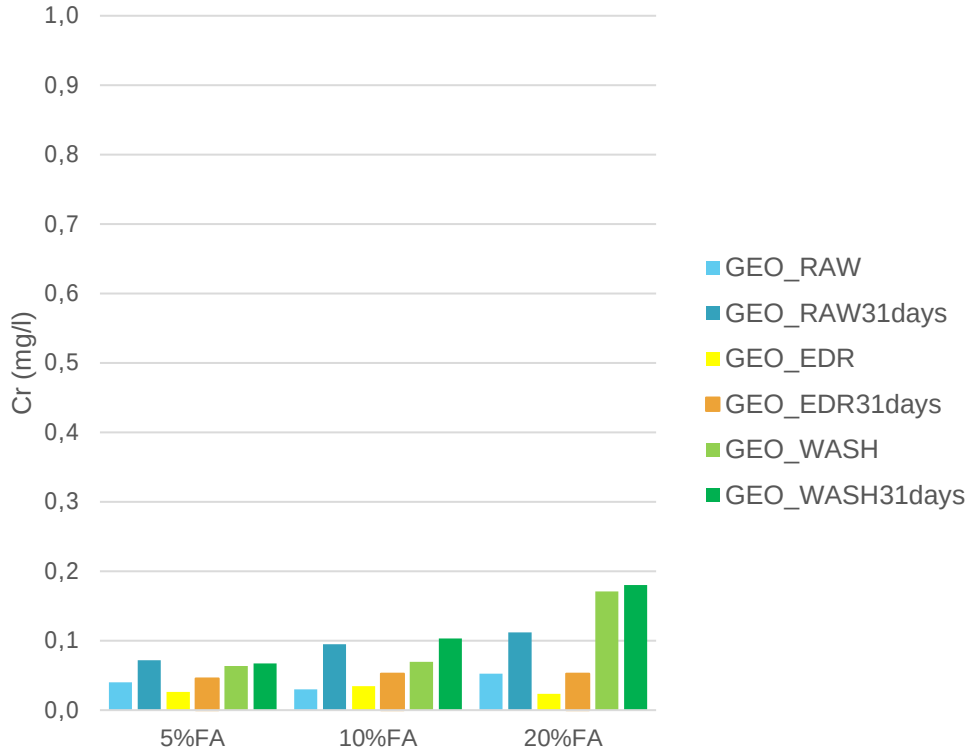
- Release of Cr as function of fly ash content

	pH GEO_RAW	pH GEO_EDR	pH GEO_WASH
5%	12.4	12.3	12.4
10%	12.3	12.3	12.3
20%	12.2	12.1	12.2

Cr leaching before and after the inertization compared with law limit (granular samples - EN12457 leaching test) - 7 days of curing



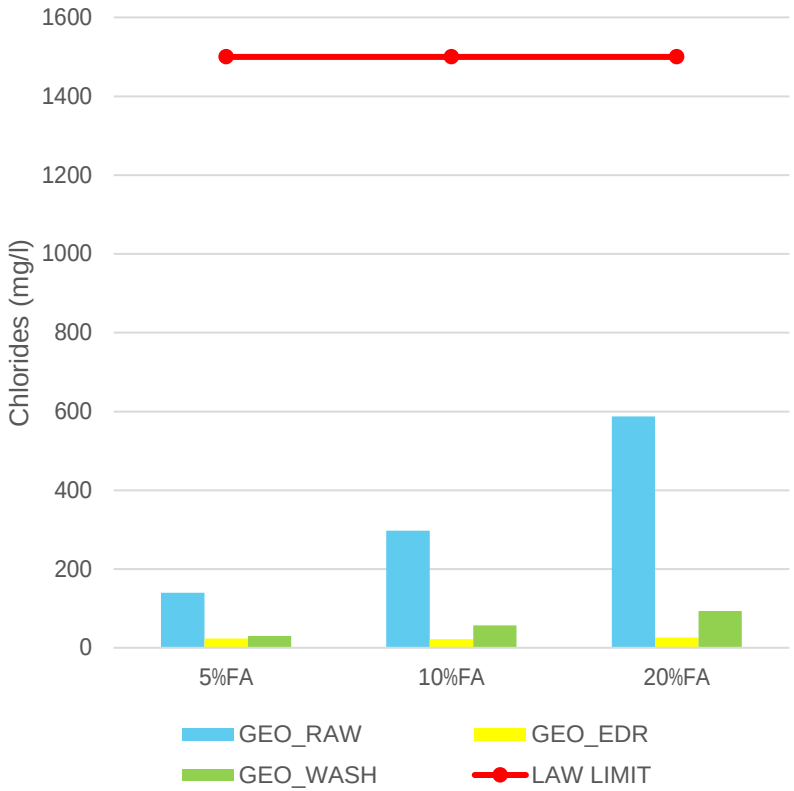
Cr leaching after 7 and 31 days of curing (Monolithic samples – EN12457 leaching test)



- Release of chlorides as function of FA content

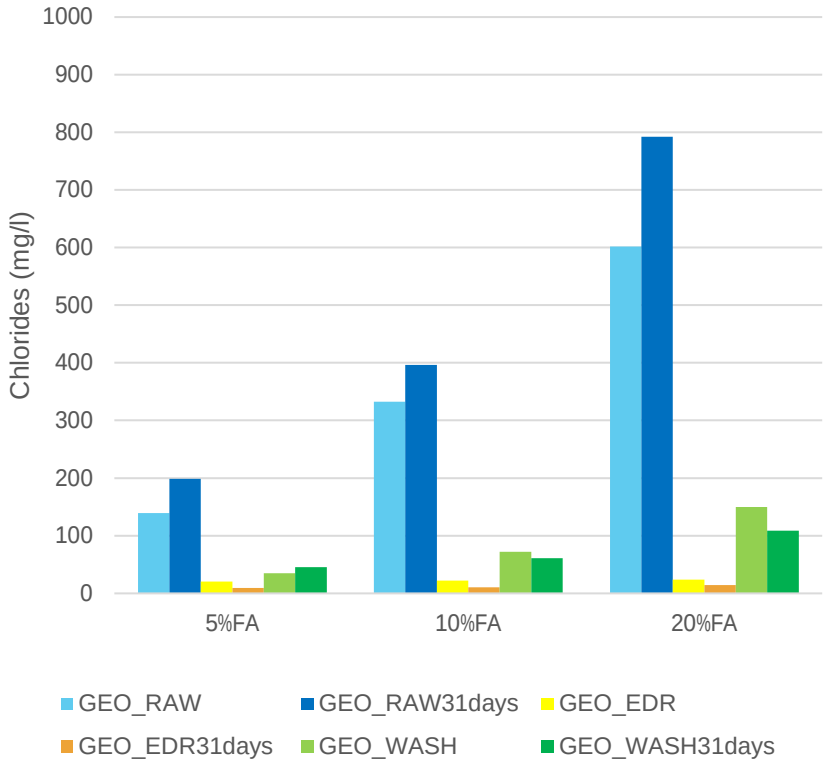
	pH GEO_RAW	pH GEO_EDR	pH GEO_WASH
5%	12.4	12.3	12.4
10%	12.3	12.3	12.3
20%	12.2	12.1	12.2

Chlorides leaching compared with law limit (granular samples - EN12457 leaching test) - 7 days of curing



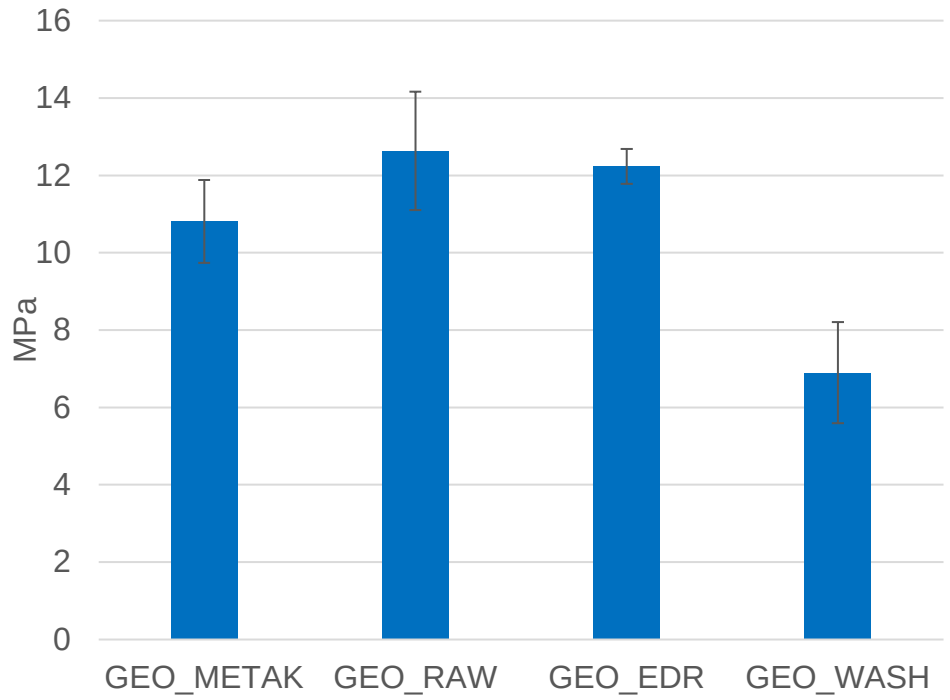
Chlorides leaching values before inertization between **126 and 8000 mg/l**

Chlorides leaching after 7 and 31 days of curing (Monolithic samples – EN12457 leaching test)

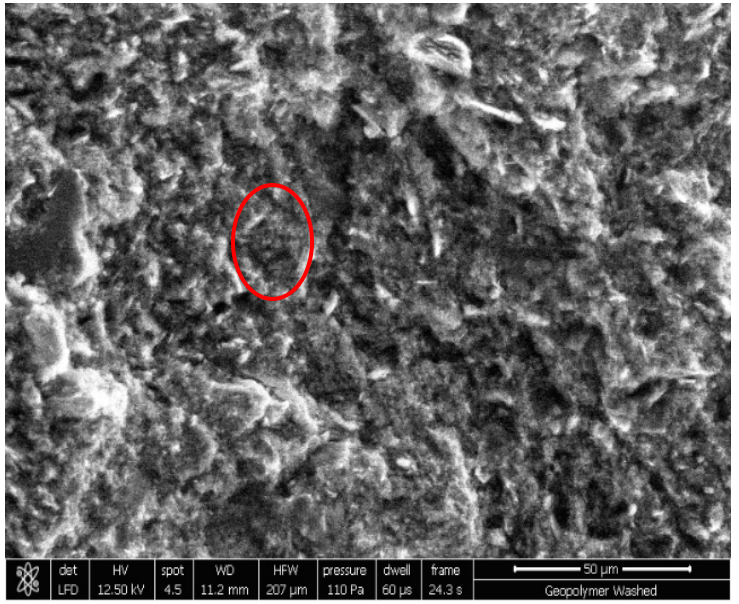


MECHANICAL AND STRUCTURAL GEOPOLYMERS CHARACTERIZATION

Compressive strength
28 days of curing – 20 wt% FA



Microstructural analysis
28 days of curing – 20 wt% EDR FA



Geopolymer gel

Conclusions:

- ✓ High removal of Cd, Cu and Zn from MSWI FA with EDR treatment
- ✓ Decrease of leaching of heavy metals from MSWI FA with water-washing treatment

Benefits of pre-treatments before inertization

- ✓ Geopolymer is a good encapsulation medium for MSWI FA
- ✓ **EDR treatment: low leaching of Cr and chlorides also increasing curing time and content of MSWI FA in geopolymers**
- ✓ High compressive strength of GEO_EDR and GEO_RAW

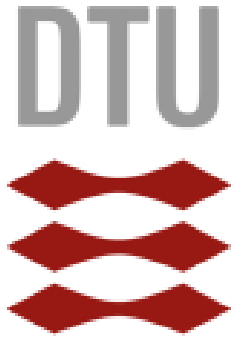
Benefits of pre-treatments in geopolymers

- X High energy consume and long duration of EDR treatment
- X Polluted water to dispose of after washing treatment

Drawbacks of pre-treatments before inertization

- X Not significant environmental benefits with washed ash in geopolymers
- X Low compressive strength of GEO_WASH

Drawbacks of pre-treatments in geopolymers



Thank you for your attention

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