NaOH Replacement by High Salinity Water to Prepare Geopolymers

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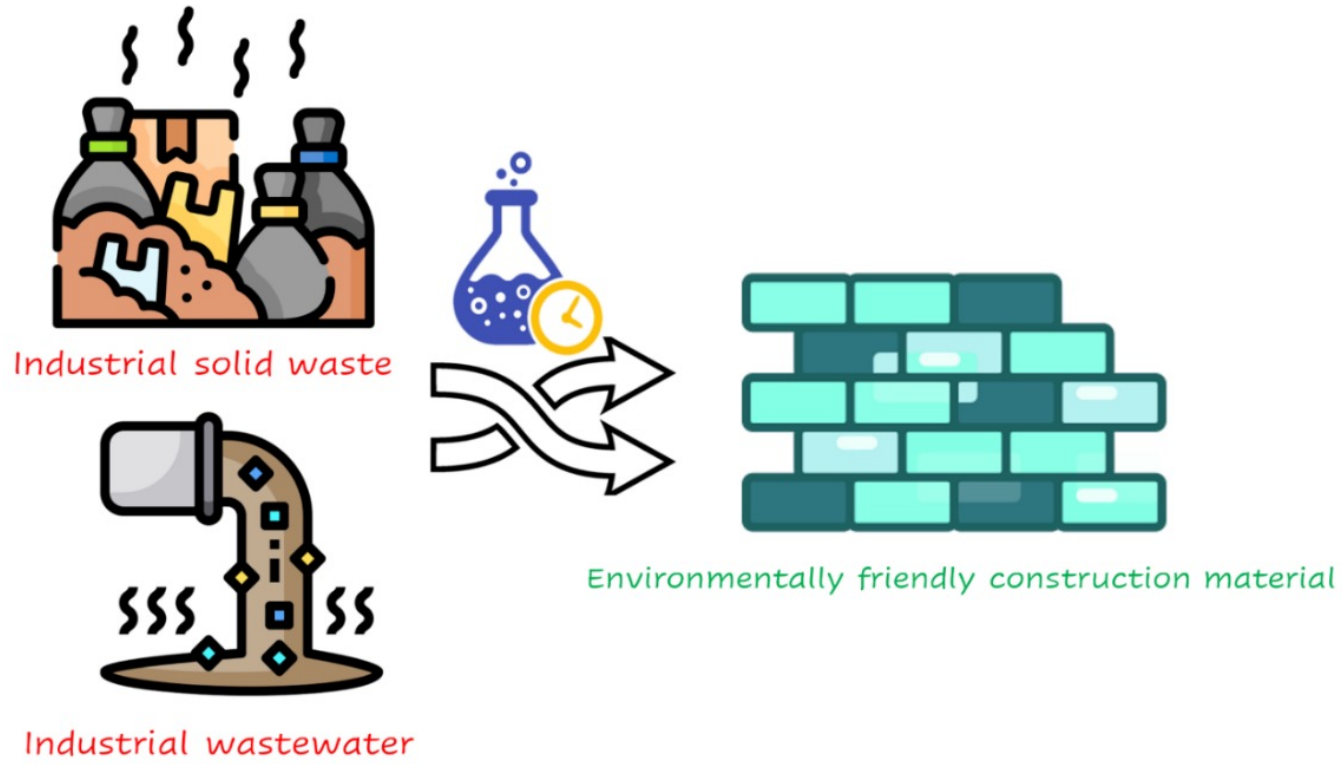
Fibre and Particle Engineering research unit focuses on sustainable inorganic and bio-based materials of circular and bio economies.

Our group under the supervision of Tero Luukkonen does research over three major themes:

- development of improved material preparation methods
- modifying the surface functionalities
- testing the materials in applications of water and wastewater treatment

Objective of PhD thesis



Selected raw materials and waters

Precursors:

Blast furnace slag

Metakaolin

Alkalin solution:

Sodium hydroxide pellet

Three types of water

1. 

Deionized water

2. 

Simulated seawater according to ASTM D1141–98 (with 1×, 2×, or 3× concentration of salts)

3. 

RO reject waters from pulp & paper and mining industries

Experimental Process

1. Optimization of mix design using deionized water

- Metakaolin, metakaolin/slag, or slag + NaOH solution
- Analyses:
  - 7 d compressive strength
  - Setting time

2. Effects of high salinity waters

- NaOH solution prepared using 1X, 2X, 3X seawater and RO reject waters
- Analyses:
  - 1 d, 7 d, 28 d compressive strength
  - Setting time
  - Calorimetry
  - Leaching test (crushed and uncrushed samples)
  - Efflorescence
  - Pore solution analysis
  - XRD
  - EPMA
  - SEM-EDS

3. Partial replacement of NaOH by the high-salinity water

- Blast furnace slag+ NaOH solution prepared using simulated brine
- Analyses:
  - 7 d, 28 d compressive strength
  - Isothermal microcalorimetry
  - Dissolution test
  - Thermodynamic modelling

Main results

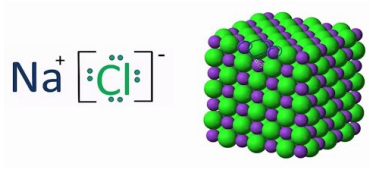
1

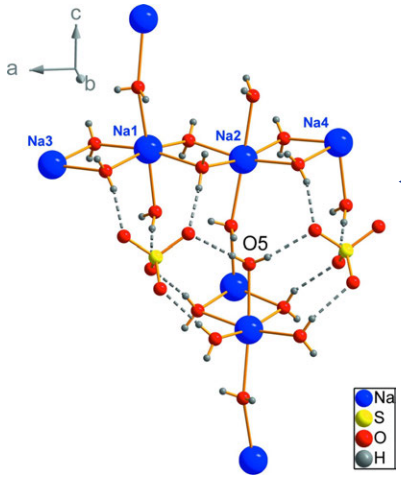
- BFS-based geopolymer performed better overall than the Metakaolin-based geopolymer or mixture of them from the viewpoint of salt immobilization.

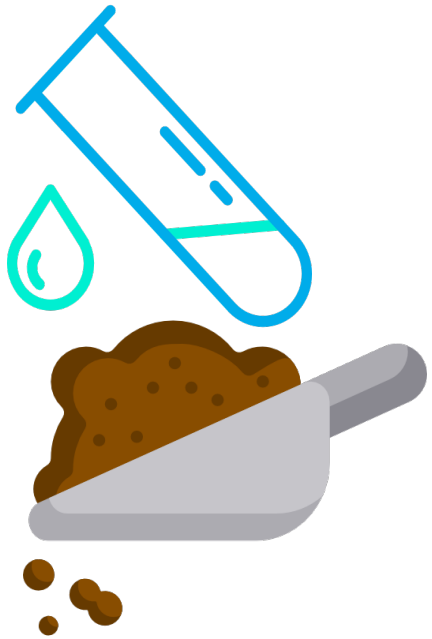
2

- Leaching test results indicates the effective immobilization of anions of chloride and sulfate in BFS-based geopolymer.

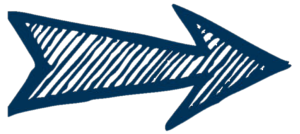
Experimental process

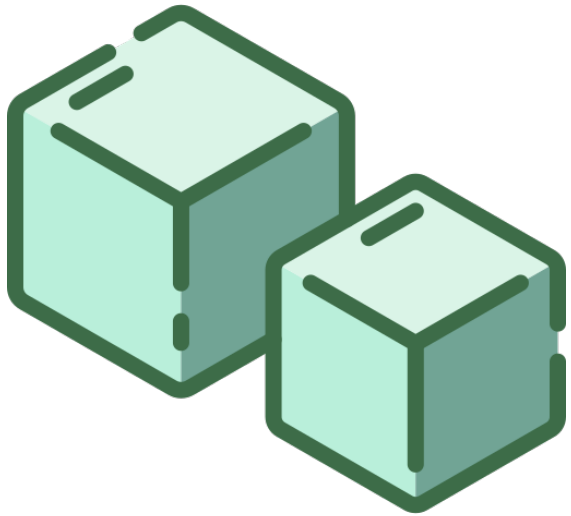






Blast furnace slag

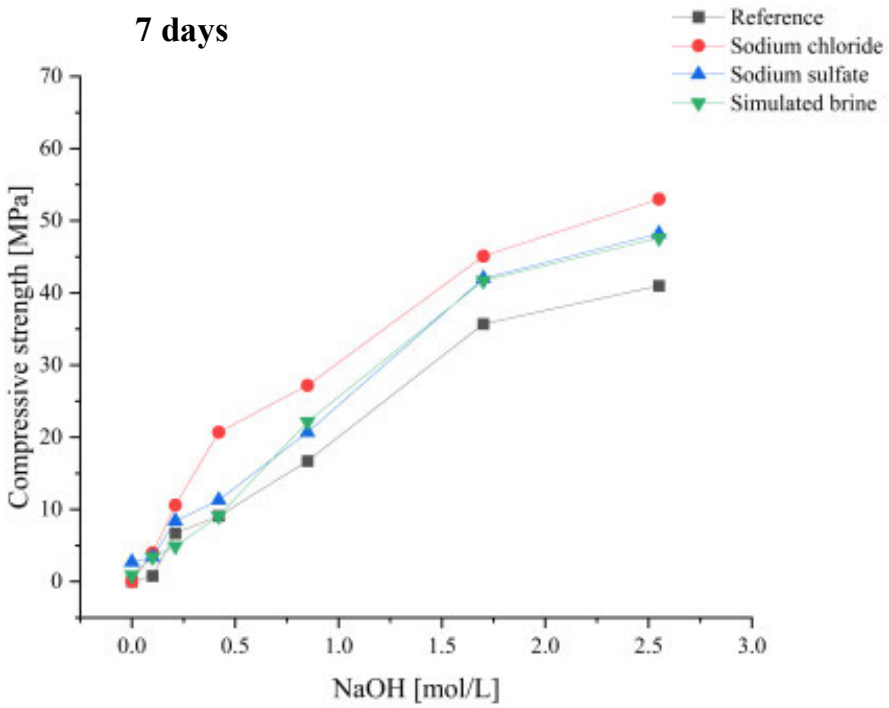


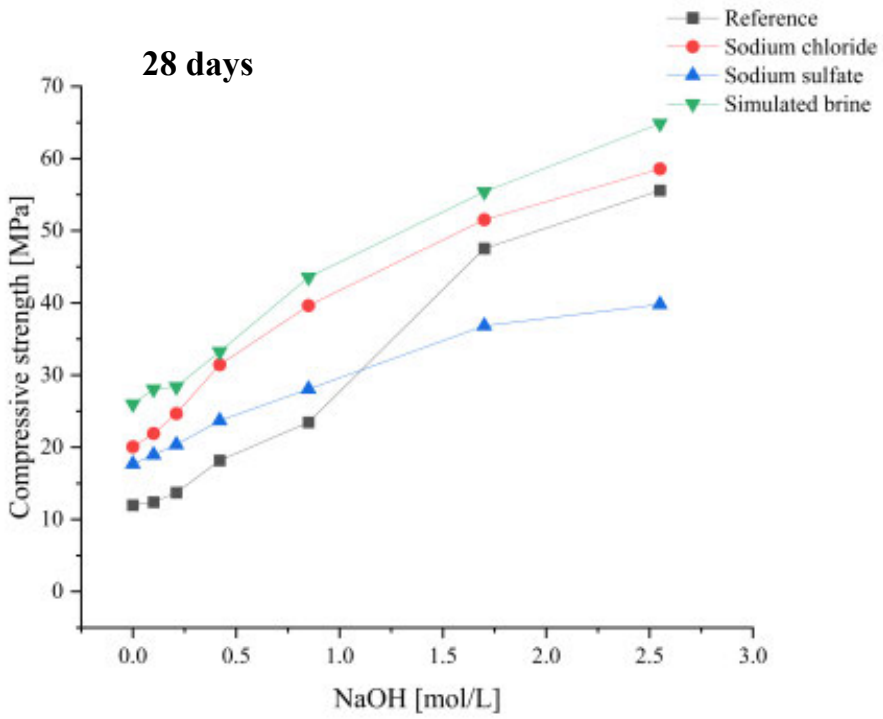


Study the materials:

- Compressive strength
- Dissolution test
- Microcalorimetry

Compressive strength





Dissolution test

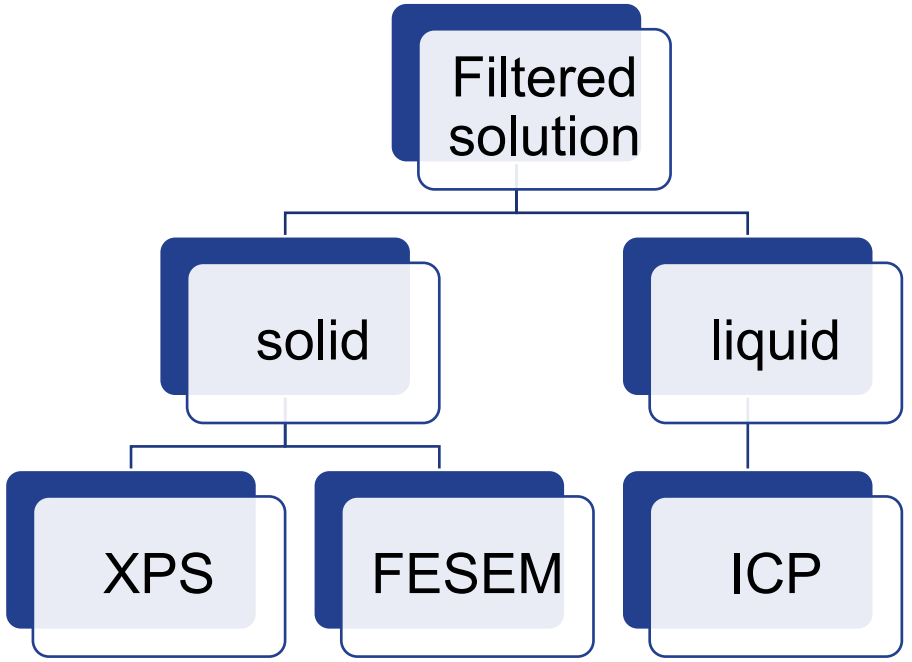
5 grams of BFS

+

100 grams 0.1 molar NaOH + salts

=

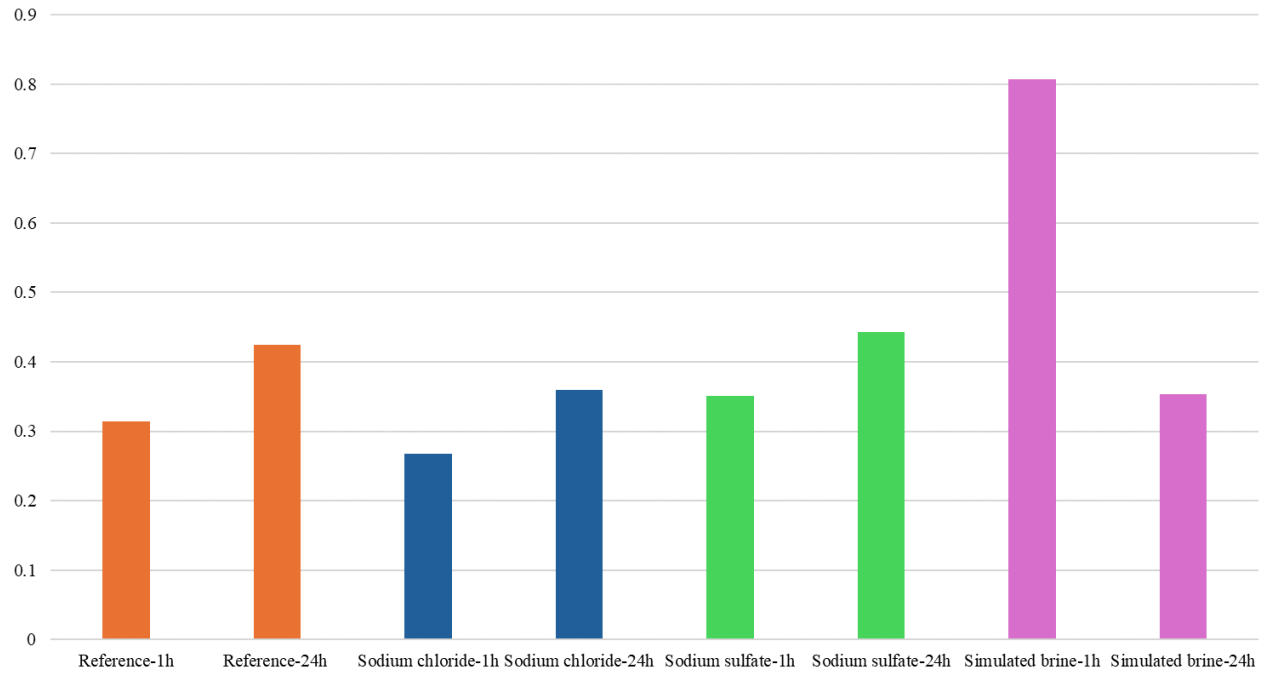
Solution ready for filtration after 1 hour and 24 hours



Dissolution test results

ICP results.

Sample ID	Al mg/L	Ca mg/L	Si mg/L	Fe mg/L	Mg mg/L
Deionized water-1h	1.8	2.6	2.5	<0.05	<0.125
Deionized water-24h	3.6	2.4	1.9	<0.05	<0.125
sodium chloride-1h	1.8	5.7	3.5	<0.05	<0.125
sodium chloride - 24h	3.8	3.6	5	<0.05	<0.125
sodium sulfate-1h	2	6.7	4.3	<0.05	<0.125
sodium sulfate - 24h	3.1	1.9	10	<0.05	<0.125



Ca/Al molar ration based on XPS results.

Conclusion

A combination of compression strength and dissolution tests results plus thermodynamic modelling show that simulated brine as a sample of high salinity water improves dissolution of BFS. Additionally, NaOH can partially be replaced by simulated brine. A possible explanation of increased dissolution of BFS when using simulated brine is formation of ion pair complexes such as CaCl and $CaSO_4$.

Thanks for your attention!