Developing waste-based inorganic polymers for radioactive waste encapsulation: a leaching study

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Topics of today

What is alkali-activation? **Experimental set-up Developping IPs** Leaching **Results of experiments** Leaching of Cs Leaching of Sr Effect of curing time **Review & conclusion** Future work & research paths

What is alkali-activation?



Experimental set-up Developping IPs

Waste materials



Experimental set Developping IPs	-up S
Waste materials	Bauxite Residue (BR) Fly Ash (FA) Sand (SA) Silicon dioxide Waste (SW)
Cement	CEM III/A 42.5 N LA (CEM)

Experimental set-up Developping IPs		
All precursors	Homogenized < 63 μm except SA (> 125 μm) Dried 110 °C	
Activating solution	8 M NaOH-solution	
Cs & Sr (nitrates)	Introduced 0.5 wt% of final IP mass	

Experimental set Developping IPs	-up s
Solid/Liquid	0.5
Mixing	Bench mixer => homogeneous slurry
Casting	Cylindrical moulds d = 25 mm; l = 100 mm
Curing	3 d ambient conditions 24 h 60 °C Demoulded, cut, 4 weeks curing at ambient conditions

Experimental set-up Developping IPs





Experimental set-up

Developping IPs

	BR	FA	SA	SW	CEM	NaOH (8 M)	H ₂ O
MM			48.7		32.1		19.2
IP1	8.5	16.6	40.2	1.6		33.0	
IP2	8.3	16.3	38.4	1.0	3.5	32.3	
IP3	8.1	16.0	38.3	1.8	3.2	32.7	
IP4	7.8	15.0	40.8		4.5	31.9	
IP5	7.5	15.0	39.3	3.7		34.5	



Leaching

Experimental set-up Leaching

Standards	ASTM C1220-98 & CEN/TS 15863:2015
Sample	d = 25 mm; l = 33 mm Suspended in leachate by PTFE wire
Leachate	500 ml AD
Container	Quartz-glass 1-l-bottle with HDPE cap
Leaching	90 °C; 7 d Aliquots at 0, 2, 4, 24, 96, 168 h ICP-OES/MS

Experimental set-up Leaching

$$R_{i} = \frac{\sum_{0}^{n} \left[\left(C_{i,n} - B_{i,n} \right) \cdot V \right]}{A}$$

 R_i = cumulative release of element *i* (g/m²)

 $C_{i,n}$ = concentration of element *i* in the filtered aliquot *n* (g/ml)

 $B_{i,n}$ = concentration of element *i* in the filtered blanc aliquot *n* (g/ml)

V = initial volume of leachate in bottle containing sample matrix (ml)

A = surface of sample (m²)

Experimental set-up

Leaching





Results of experiments



Results of experiments Leaching of Cs

Results of ANOVA & Tukey HSD post hoc test (95 % confidence interval)

Source	F-ratio	P-value	R ²
ANOVA-model	48.7458	< 0.0001	0.9644

Level			
MM	А		
IP2	А	В	
IP1		В	
IP4		В	
IP3			С
IP5			С

Results of experiments Leaching of Sr





Results of experiments

Leaching of Cs – effect of curing time

Results of experiments

Leaching of Cs – effect of curing time



Results of experiments Leaching of Sr – effect of curing time



Results of experiments

Leaching of Na – effect of curing time



Results of experiments Leaching of Ca – effect of curing time



Review & conclusion

Cs – retention	Better than reference OPC-matrix
Sr – retention	Much better than reference OPC-matrix
Curing time	Positive effect on immobilisation
Leaching behaviour	More durable?
Improving waste management	Tackling two problems at once

Optimising composition

Testing of Cs & Sr retention in IPs of controled composition, with a variety of precursors (reproducibility?)

Optimising composition

Effect of waste loading

Testing of Cs & Sr retention in IPs of controled composition, with a variety of precursors (reproducibility?)

Testing how robust the IPs are using varying waste compositions & concentrations

Optimising composition

Effect of waste loading

Durability

Testing of Cs & Sr retention in IPs of controled composition, with a variety of precursors (reproducibility?)

Testing how robust the IPs are using varying waste compositions & concentrations

How durable are IPs regarding long-term management?