IF-3

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Leaching behavior of elements in recycled roadbed material using solidified boiler fly ash

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1. Background and Introduction

- Large amounts of incinerated ashes are produced worldwide and are considered hazardous waste.
- Research has shown great potential in recycling of incinerated fly ashes into civil engineering application material due to its physical properties (*Choi, 2019*).
- The major concern of recycling these kind of materials is the potential release of contaminants through leaching throughout time.
- There is a demand of long-term prediction models To guarantee the environmental safety of using recycled materials.



2. Aim of this study

1. Characterize the mineral and chemical composition of the recycled roadbed aggregate material made from tired derived fuel boiler fly ash .
2. Predict the mobility of heavy metals through different leaching tests.
3. Using geochemical modeling tools to determine pH controlling minerals and compare column leaching test results.
4. Evaluate the impact of solidified boiler fly ash on the environment.

Limited information on recycled materials using waste tire fly ashes for this type of application scenario.

3. Materials and methods

The boiler fly ash (BFA) was mixed with cement, sand, and water to produce the recycled roadbed aggregate by cement solidification.

Boiler fly ash (BFA)

Solidified Boiler Fly Ash (SBFA)			
Solid content mass ratio (%)			Moisture ratio (%)
BFA	Cement	Fine sand	
30	30	40	48.6

Solidified Boiler fly ash (SBFA)

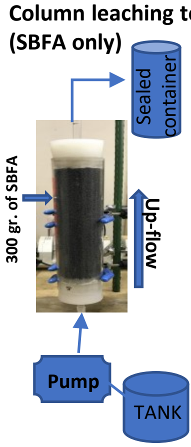
- Determination of mineral composition: X-ray Diffraction pattern analysis (XRD) and X-ray Fluorescence spectrometry (XRF)
- Measurement of concentration in liquid samples: AAS and ICP analysis

Leaching tests conducted on BFA and SBFA samples

Method	Leaching solution
Japanese Batch leaching (JLT No. 46)	Distilled water with L/S 10
US EPA TCLP Toxicity Characteristic Leaching Procedure	pH 2.88 solution with Acetic acid with L/S 20


Sample size for all leaching tests was ≤2mm

Column leaching test (SBFA only)



ISO/TS 2126-8-3 Method

- Two different inflow solutions: Distilled water (DW) and Acid water pH3 (AW)
- Flow velocity: from 12 to 36mL/hr.
- Fractions collection: from 0.1 up to 118(AW) and 184(DW) of cumulative liquid /solid ratios (L/S)

pH-stat leaching test (SBFA only)

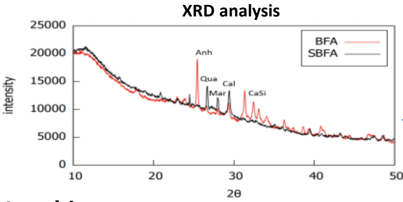
CEN/TS 14997 method

- Evaluate pH effect on HM leaching at 6 pH values: 2,4 ,6 ,8, 10 ,12.
- Constant stirring for 24 hr. with L/S 10

ALL leaching test Eluates where analyzed for major element (Ca, K, Mg, Na) and heavy metal concentration by Atomic Adsorption Spectrophotometry

4. Results and Discussion

Chemical and mineralogical composition



The SBFA is mainly composed of Ca (40%), Si (30%) and Al (10%), attributed to the mineral composition.

possibly identified mineral phases of BFA and SBFA samples. Abbreviations: Anh, anhydrite; Qua, quartz; Mar, margarite; Cal, calcite; CaSi, calcium silicate minerals.

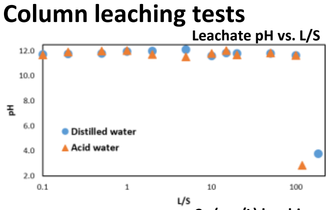
Leaching tests

The SBFA complies with Japanese soil contamination standards for soil pollution and US EPA for landfill disposal regulations

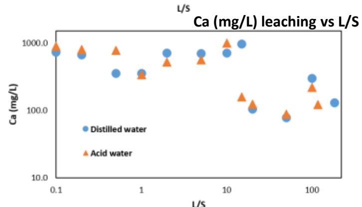
	JLT No. 46 BATCH LEACHING			TCLP		
Heavy Metal	BFA (mg/L)	SBFA (mg/L)	Std. (mg/L)	BFA (mg/L)	SBFA (mg/L)	Std. (mg/L)
Cd	0.07	0.004	≤0.01	0.13	4.23×10^{-4}	1.0
Pb	0.15	ND	≤0.01	ND	ND	5.0
T-Cr	0.62	0.073	≤0.05**	0.23	0.068	5.0
As	0.37	ND	≤0.01	0.79	1.22×10^{-3}	5.0
Ni	0.53	0.010	≤0.02	---	----	---

**Cr(VI)

Column leaching tests

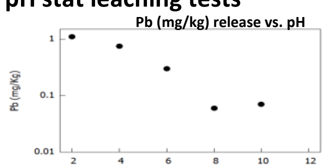


The high buffer capacity of the SBFA is maintained in different leaching conditions preventing heavy metal release



- The CaO and MgO compounds can be attributed the high buffer capacity of the material and the solubility of Ca-minerals are controlling the pH throughout the leaching period.
- Concentrations of Ni, As, Cd, and Pb for both column conditions are under limit values of ground water contamination

pH stat leaching tests



Pb, As, Ni, and Cd showed cationic leaching patterns due to Ca-mineral binding and incorporation to solubility controlled mineral phases.

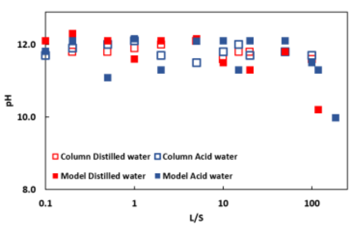
pH modelling

Initial L/S concentration from column leaching test where input into PHREEQC to estimate a set of pH controlling minerals, chosen based on mineral saturation index (SI≥1) and literature review.

Mineral name	Chemical formula	Amount (mol/cm^3)
Calcite	$CaCO_3$	10
Portlandite	$Ca(OH)_2$	5.5
Ettringite	$Ca_6Al_2(SO_4)_3(OH)_{12} \bullet 26H_20$	4
Margarite	$CaAl_2(Al_2Si_2)O_{10}(OH)$	2.8
Brucite	$Mg(OH)_2$	2
Anhydrite	$CaSO_4$	3.5

A quantitative approach considering the major element solubility was used to estimate mineral amount values.

Using HP1 default hydraulic parameters and thermodynamic database; modeled results show comparable results with column leaching test.



The acid neutralizing capacity of Ca-minerals in the SBFA are a fundamental factor controlling the period during which the SBFA can maintain a pH 11.

5. Conclusions

- Based on the results of the leaching tests, the SBFA has a high buffer capacity of pH, allowing it to maintain its alkalinity on the long-term.
- The leaching of elements is primarily attributed to solubility processes.
- The leachate pH is mainly controlled by the solubility of Ca minerals and the pH simulation showed correlation with the column leaching

For further research, the improvement of the geochemical modeling of the long-term leaching scenario new information such as physical parameters and thermodynamic equilibrium data will be incorporated

References:

-Choi, M.J, 2019. Performance evaluation of the use of tire-derived fuel fly ash as mineral filler in hot mix asphalt concrete. Journal of Traffic and Transportation Engineering (English Edition).