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COMPOSITION AND LEACHING CHARACTERISTICS OF MINING ASHES

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Introduction

The present study aims to evaluate the chemical and mineralogical compositions of ash samples from mining activities. Various experimental and theoretical studies have been carried out to correlate the chemical and mineral composition of coal ash with the determination of their behavior in the leaching process. Experimental techniques used included XRF (X-ray fluorescence) analysis of the ash used to determine the elemental composition of the major oxides. The leaching behavior of the ash samples was determined by investigating the influence of pH, TDS and Redox Oxidation Potential (ROP) at different values of contact time. The contour plot determined the evolution of the factors influencing the variation of ROP in the leachate samples. PCA analysis was used to evaluate the elements that may indicate the potential for contamination and stabilization of the samples and to understand the behavior of the mining ashes and the phase transformations that occur during the leaching process.

Materials and methods

Ash samples from industrial mining activities were collected from dumps stored in abandoned areas. The oxide composition of the calcined ashes was determined using a Rigaku X-ray fluorescence spectrometer. The analysis of metals in the solid samples and the extractable fraction was performed with the ICP-OES technique. The gravimetric (TDS, SO_4^{2-}), electrochemical (pH, F^-, ROP), combustion (Ntot, DOC), volumetric (TOC, Cl^-) methods were used to determine the parameters characteristic of the solid content and leachates of the analyzed ash samples. PCA analysis and contour plots were generated with Number Cruncher Statistical Systems statistical software (NCSS 2021 v21.0.3).

Results and Conclusions

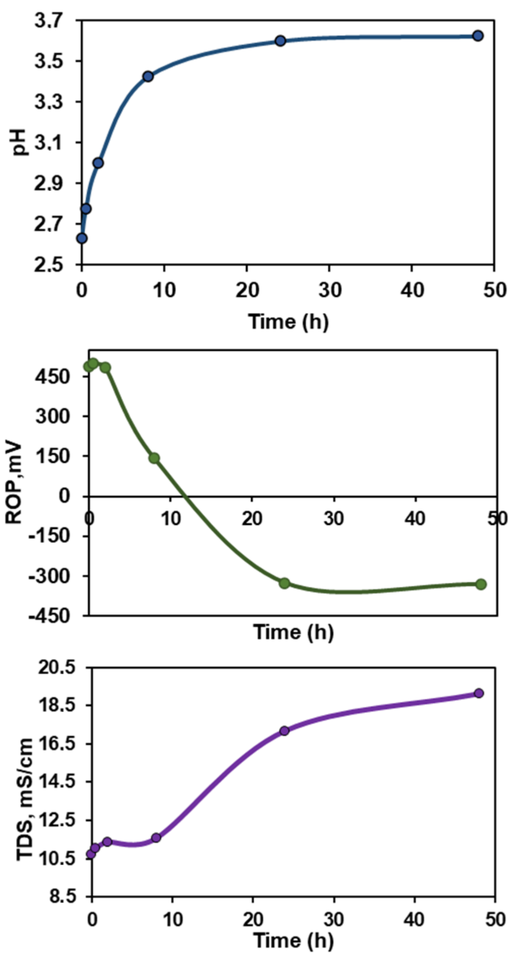

Figure 2. The evaluation of the pH, TDS and ROP at different contact times (0 min., 30 min., 2h, 8h, 24h and 48h).

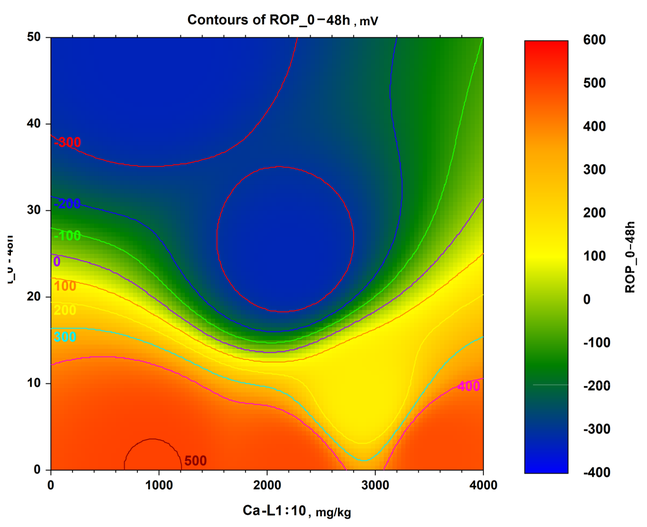

Figure 3. The contour plot of the influence of the concentration of soluble Ca in time on the evolution of ROP.

The contour plot of the influence of the concentration of soluble Ca over time on the evolution of ROP showed an increase in the oxidant potential proportional to the increase in the concentration of soluble Ca at contact time values greater than 24h.

The results obtained in the study of the leaching behavior of some ash samples from mining activities showed an increase in the concentrations of soluble species SO_4^{2-}, Cl^-, F^-, DOC, Ntot, Ca^{2+}, Mg^{2+}, Na^{2+}, K^+ in the two extracts correlated with the decrease in the concentrations of toxic metals in the analyzed leachates.

Table 1. Component Loadings after Varimax Rotation for major oxides

Variables*	PC1	PC2
As_2O_3	-0.7487	0.6623
BaO	0.5217	-0.5220
CuO	**-0.8635**	0.4682
PbO	**-0.9519**	-0.0248
Sb_2O_3	**-0.9077**	0.3071
ZnO	**-0.9222**	0.3203
CaO	0.0900	**0.9475**
Na_2O	**-0.8085**	0.5596
MnO	**-0.9615**	0.2686
Fe_2O_3	-0.7357	0.6769
Al_2O_3	**-0.9513**	0.2032
TiO2	0.6160	**-0.7522**
MgO	**-0.8294**	0.5443
K_2O	**-0.9018**	0.3366
Variance	67.2%	35.6%

*mg/kg

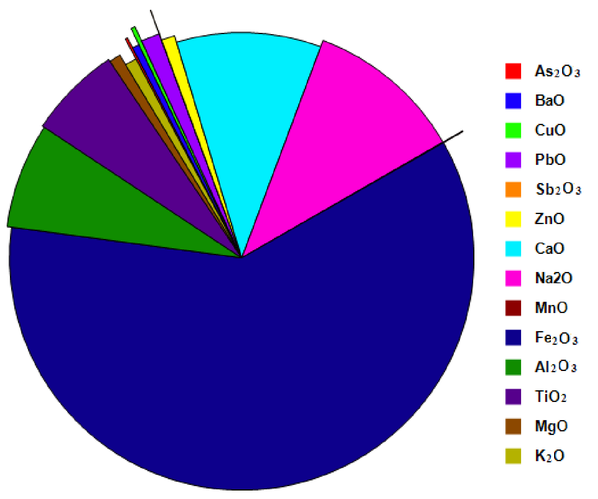

Figure 1. Analysis of the major oxides in the processed ash samples (37.1% Fe_2O_3, 5.16% Na_2O, 2.20% Al_2O_3 and 2.16% CaO).

PCA analysis generated PC1 indicating a supported contamination potential by oxide minerals such as CuO, PbO, Sb_2O_3, ZnO, Na_2O, MnO, Al_2O_3, MgO and K_2O. PC_2 showed strong correlations between TiO_2 and CaO, elements used in the stabilization process of fly ash in the mining industry.

Table 2. Component Loadings after Varimax Rotation for solid ashes, leachat 1:2 and leachat 1:10.

Variable*	Solid ashes		Leachat 1:2(24h)		Leachat 1:10(24h)	
	PC1	PC2	PC1	PC2	PC1	PC2
As	**0.9551**	0.2427	-0.0896	**0.9660**	-0.1809	**0.9808**
Cr	-0.6467	-0.7433	-0.1245	**0.9837**	-0.0241	**0.9971**
Pb	**0.8058**	-0.4012	0.2115	**0.8184**	0.5882	-0.3211
Sb	**0.9588**	-0.2352	-0.6860	-0.7186	0.0839	**0.9844**
Zn	-0.0626	0.9979	-0.7124	-0.7017	-0.6140	0.7869
Cu	-0.5460	0.2747	-0.2511	**-0.9679**	-0.7264	-0.3765
Mn	**-0.9956**	0.0939	**-0.9995**	0.0252	**-0.9922**	0.0536
Al	**-0.9768**	0.1390	-0.3251	**0.8806**	-0.2259	**0.9585**
Fe	**0.9340**	0.1562	**-0.9474**	-0.2570	-0.5600	**0.8187**
K	**-0.9762**	0.1883	**-0.9252**	-0.2722	**-0.9144**	0.4046
Na	**-0.9430**	0.3270	**-0.9883**	-0.1516	**-0.9605**	0.2657
Ca	**-0.9865**	0.1045	**-0.8598**	0.2786	**-0.9326**	0.0355
Mg	**-0.9774**	0.2009	**-0.9988**	0.0456	**-0.9917**	0.0378
F^-	**0.8158**	-0.5773	**0.9272**	0.3175	**0.8817**	-0.3885
SO_4^{2-}	-0.6192	0.7712	**-0.9514**	-0.1758	**-0.7343**	0.6493
Cl^-	-0.4951	0.6039	**-0.7674**	-0.6114	**-0.7872**	0.5946
TOC/DOC*	0.3817	**-0.8667**	**-0.9841***	-0.1770*	**-0.9289***	0.2841*
Ntot	-0.2953	**-0.8530**	**-0.9371**	-0.3450	**-0.9472**	0.3170
TDS	-0.6528	0.7547	**-0.9000**	-0.3758	**-0.7163**	0.6774
% of variance	92.60%	6.32%	62.30%	27.50%	61.40%	35.70%

*mg/kg

The PCA analysis for the ash solid content showed a strongly positive correlation As, Pb, Sb and Fe grouped in PC1 band a strongly negative correlation of Mn, Al, K, Na, Ca, Mg and F^- and a decrease in TOC and Ntot grouped in PC2. For the leachates, PCA analysis showed the suppression of the leaching potential of the toxic metals grouped in PC2 and the soluble species were grouped in PC1. Fe leaches into the first extract, but this process is stopped at a higher dilution.

References:

1. Erbert, B.A.R., Stwwnari, B.M., Geiker, M.R., Kikerlund, G.M., Screening of untreated municipal solid waste incineration fly ash for use in cement-based materials: chemical and physical properties, SN Applied Sciences, 2020, 2:802202.
2. Komonweeraket, K., Cetin, B., Benson, C. H., Aydilek, A. H., Edil, T. B., Leaching characteristics of toxic constituents from coal fly ash mixed soils under the influence of pH, Waste Management, 2015, 38, p. 174-184.