Assessing The Effectiveness of an Organic Chelator For Metal Recovery from Different Solids

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1. Introduction

The growing global need for critical metals, coupled with the environmental burden of waste disposal, has driven research towards efficient metal recovery from unconventional sources. Municipal solid waste incinerated (MSWI) fly ash, limestone and basaltic materials are promising candidates due to their abundance and potential metal content. Extracting these metals often requires organic ligands, such as organic acids which present unique advantages compared to traditional inorganic acids. The aim of this study is to assess the effectiveness of sodium ethylenediaminetetraacetic acid (Na-EDTA) in metal recovery from MSWI fly ash, commercial limestone and lava basalt. This project has been designed to understand the effect of Na-EDTA on the release of metals (Al, Ba, Ca, Cr, Cu, Fe, K, Mg, Pb, Si, Sr and Zn) from the above mentioned solids.

2. Methods

This research employs a combination of laboratory experiments, and analytical techniques. Duplicate experiments are conducted to assess reproducibility.

➢ Experimental Design

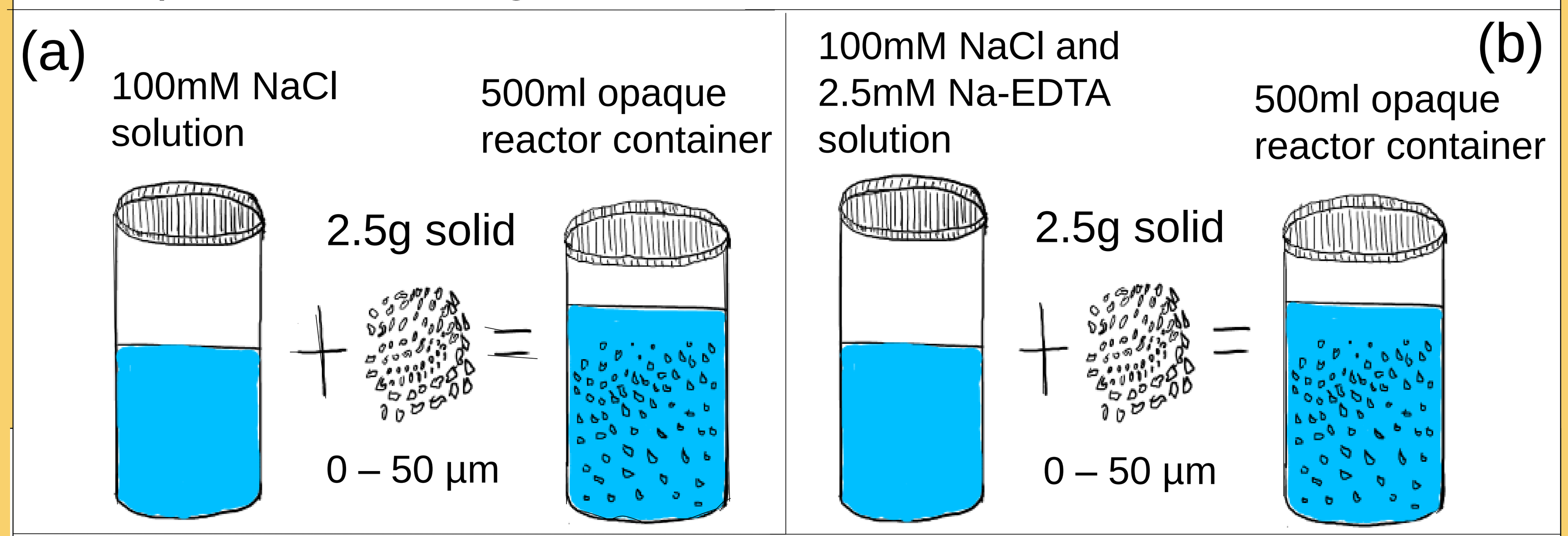

Figure 1: Experimental design (a) without Na-EDTA and (b) with Na-EDTA

❑ Solids used: MSWI fly ash, commercial Limestone and lava basalt.

➢ Analytical Techniques:

✓ Brunauer-Emmett-Teller (BET), Wavelength-dispersive X-Ray Fluorescence (WD-XRF), Inductively coupled plasma - Optical emission spectrometry (ICP-OES), X-Ray powder diffraction (XRD), Scanning electron microscopy (SEM), and Dissolve organic carbon (DOC).

3. Results

❖ Experiment without Na-EDTA

➢ pH over time

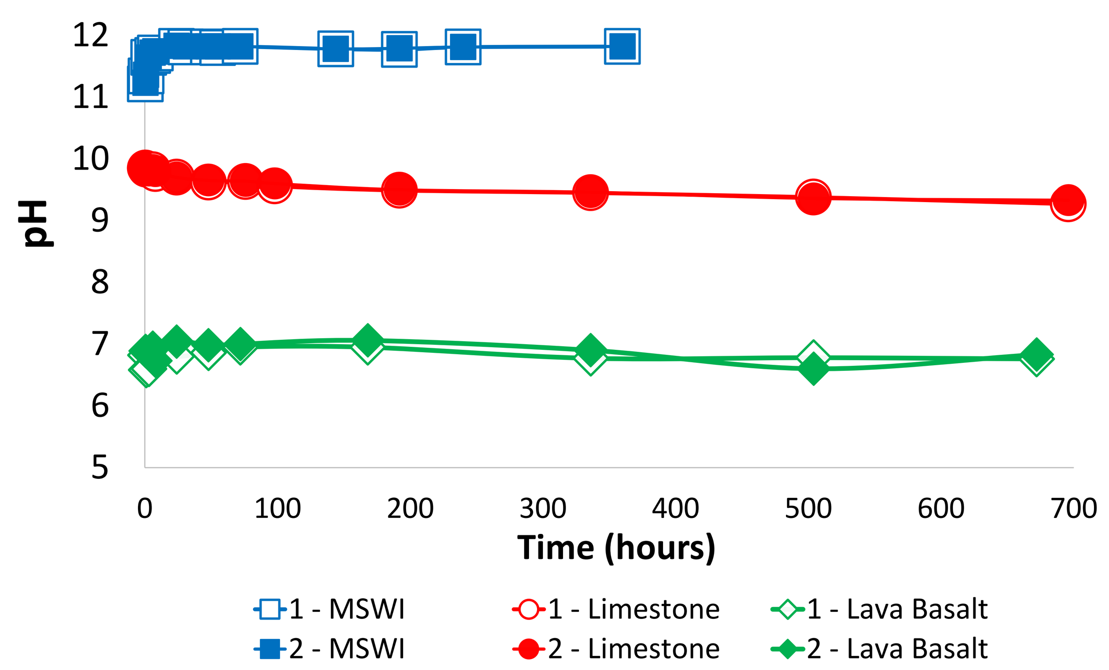

Figure 2: pH values as a function of time MSWI fly ash had a higher pH followed by limestone and then lava basalt.

Table 1: Bulk chemical composition by WD-XRF.

Major Oxides (Wt %)		
	Limestone	Lava basalt
SiO_2	2.836	49.90
TiO_2	0.041	2.16
Al_2O_3	0.731	15.50
Fe_2O_3	0.317	10.00
MnO	0.002	0.13
MgO	2.552	6.79
CaO	50.095	7.68
K_2O	0.024	2.58
P_2O_5	0.154	0.58
LOI	42.628	-0.01
Trace Elements (ppm)		
Ba	146.20	1004.50
Sr	5258.30	885.50
Zn	9.30	113.00
Cu	69.70	132.20
Ni	63.70	136.10
Co	18.60	178.70

➢ ICP-OES Analyses

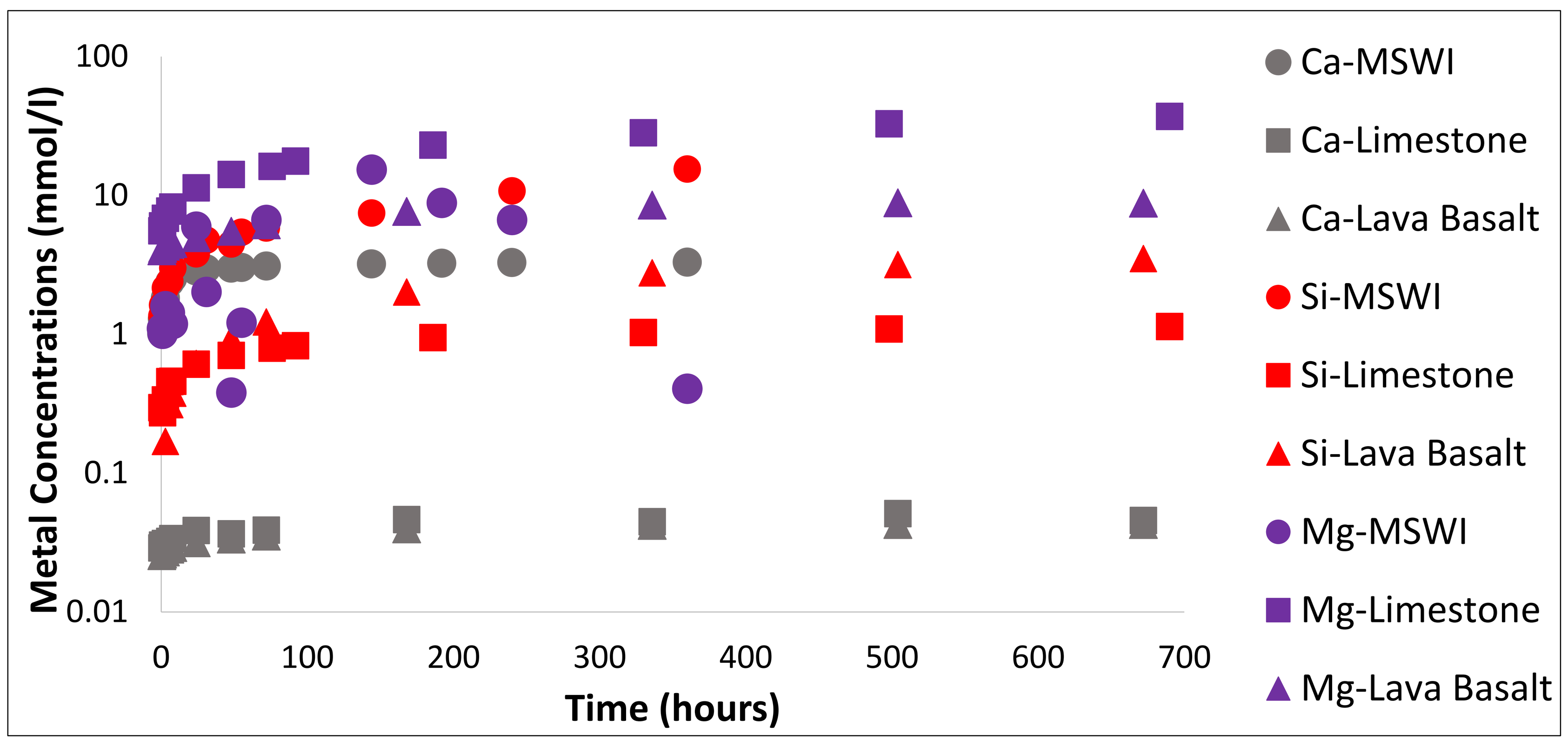

Figure 3: Concentrations of major elements from MSWI fly ash, limestone and lava basalt as a function of time.

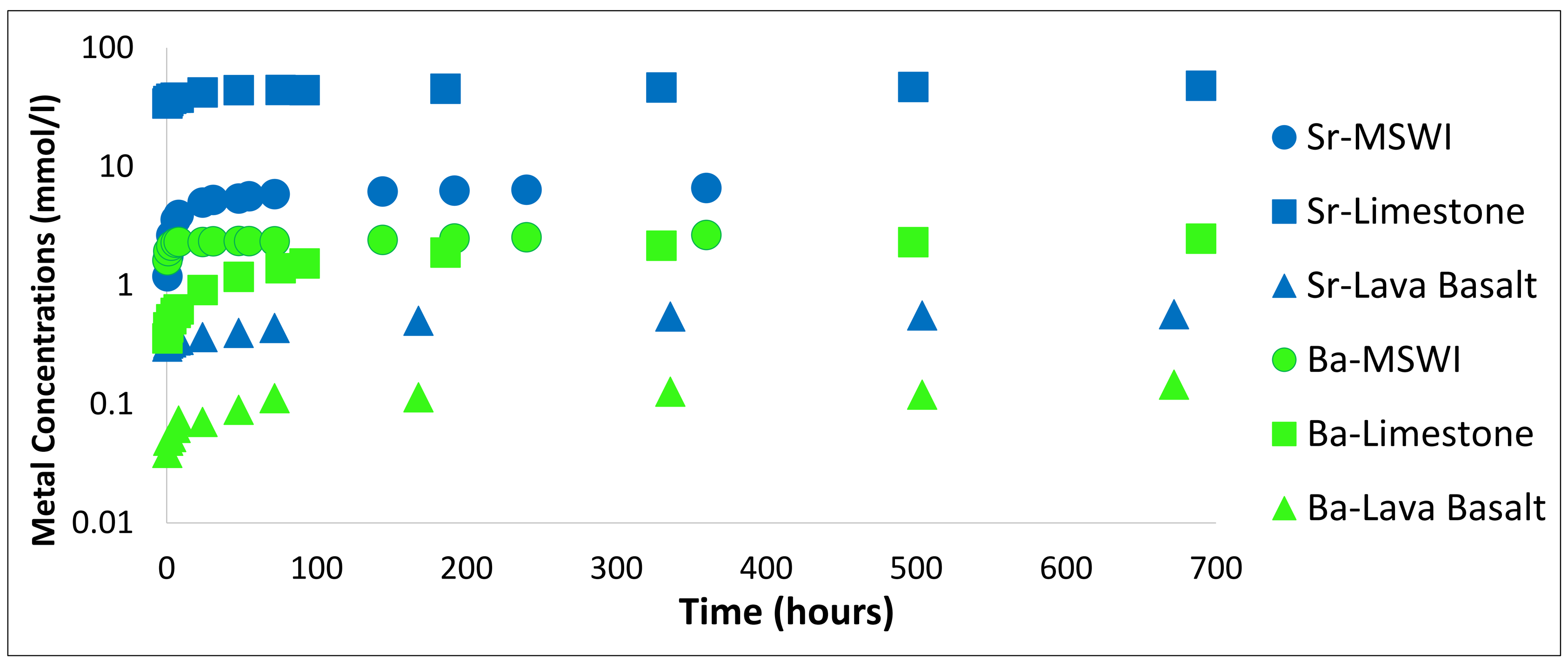

Figure 4: Concentrations of trace elements from MSWI fly ash, limestone and lava basalt as a function of time.

4. Discussion

- The highest concentration of Ca was seen in MSWI, limestone and lava basalt exhibit more or less the same concentration (see figure 3). The high amount of Ca can be related to the incineration process for removal of acid gases and its alkaline as reflected from it's high pH values (Huang et al., 2011)
- Experiment with limestone resulted in much higher Mg concentrations, followed by lava basalt, and then MSWI (see figure 3).
- In all three experiment, Si concentration increases and level up after 100hrs, with high concentrations measured in MSWI followed by lava basalt and limestone (see figure 3).
- The highest concentration of Sr was observed during limestone dissolution, followed by MSWI and lava basalt. Interestingly, Sr concentration does not exhibit temporal changes in limestone and lava basalt experiments, however in MSWI an increase of ~1 order of magnitude in Sr can be seen during the first 100hr (see figure 4).
- The concentration of Ba in MSWI and limestone are about the same after 200hr. In contrast, experiment with lava basalt resulted in much lower Ba concentrations. In all the experiment, Ba concentration in the fluid is increasing over the first ~100hrs (see figure 4).

➢ XRD Analyses

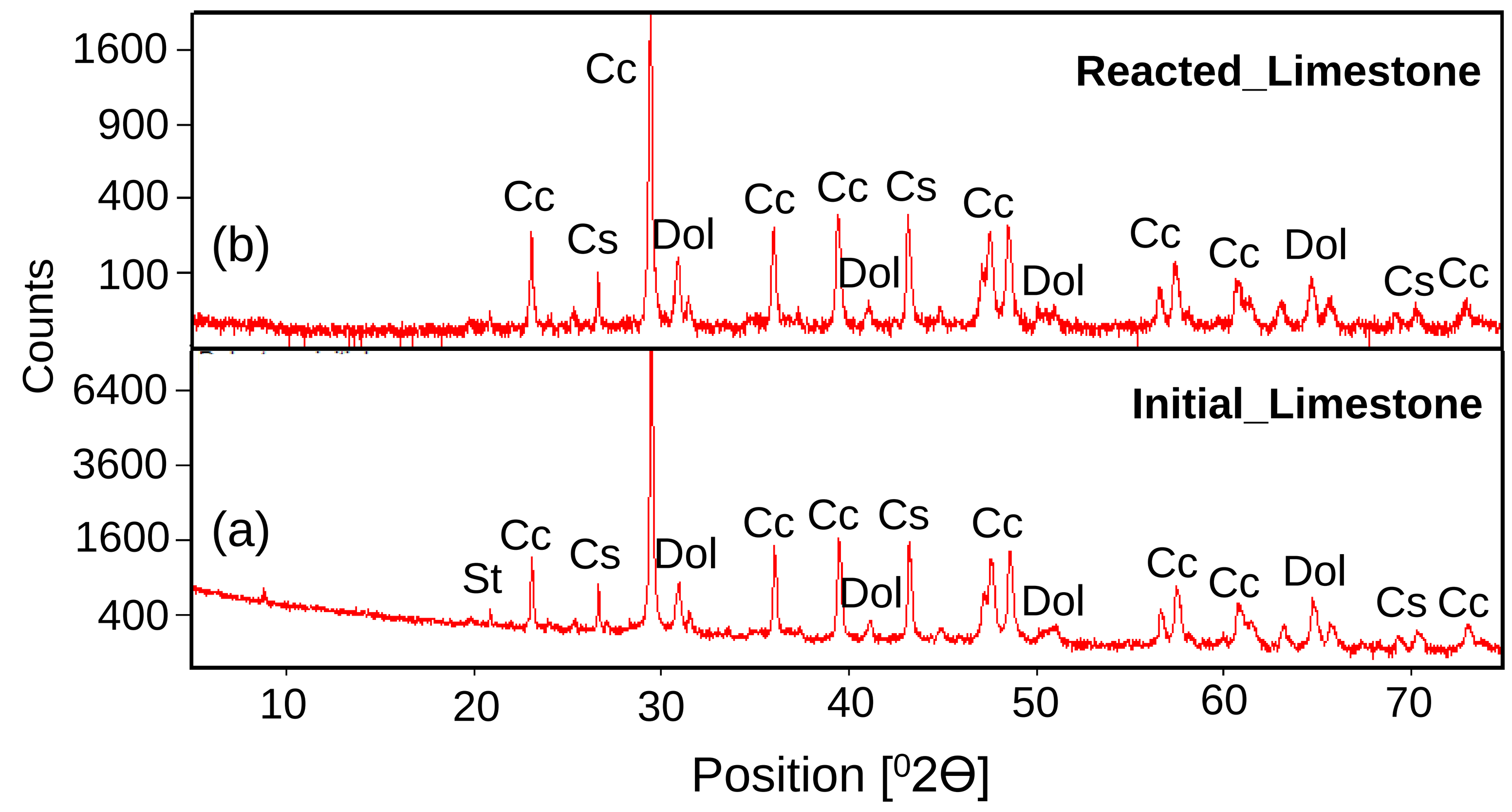

Figure 5: X-ray powder diffractograms of limestone (a) before and (b) after experiment without Na-EDTA. St (strontianite), Dol (dolomite), Cc (calcite) and Cs (coesite).

5. Preliminary Conclusion:

Conclusively, limestone yielded high concentrations of Mg and Sr, perhaps extraction using Na-EDTA will give greater yields compare to NaCl due to its chelating characteristics to enhance dissolution by improving metal solubility and mobility (Wang and Dreisinger, 2023). The XRD results indicates no mineral change after experiment.

Future Work: Finalizing the experiment with Na-EDTA and comparing with that of non-EDTA

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References: Huang, K., Inoue, K., Harada, H., Kawakita, H., & Keisuke, O. H. T. O. (2011). Leaching behavior of heavy metals with hydrochloric acid from fly ash generated in municipal waste incineration plants. Transactions of Nonferrous Metals Society of China, 21(6), 1422-14; F. Wang, D. Dreisinger. (2023) Enhanced CO2 mineralization and selective critical metal extraction from olivine and laterites. Separation and Purification Technology 321, 124268.