IECMS 2020

The 2nd International Electronic Conference on Mineral Science

16–30 NOVEMBER 2020 | ONLINE

minerals MDPI

Feasibility of Bio-mobilization of Rare Earth Elements from Bauxite Residual Red Mud

Sadia Ilyas[1], Hyunjung Kim[1,2], Rajiv R. Srivastava[3,4]

[1]*Mineral Resources and Energy Engineering, Jeonbuk National University, Jeonju, Jeonbuk 54896, Republic of Korea*

[2]*Department of Environment and Energy, Jeonbuk National University, Jeonju, Jeonbuk 54896, Republic of Korea*

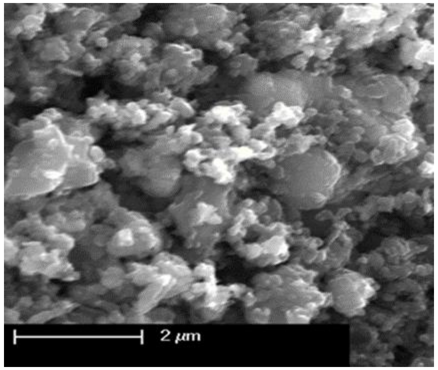
[3]*Center for Advanced Chemistry, Institute of Research and Development, Duy Tan University, Da Nang 550000, Vietnam*

[4]*Faculty of Natural Sciences, Duy Tan University, Da Nang 550000, Vietnam*

Abstract: Current work was conducted to evaluate bioleaching feasibility of red mud with *Penicillium chrysogenum strain KBS3* in the presence of glucose, sawdust, and molasses as substrate and in various leaching modes. One-step bioleaching involving 12 mM citric acid, 2.5 mM oxalic acid, 1.8 mM tartaric acid, and 1162 mM gluconic acid with glucose as substrate. Whereas, the respective biogenic acid production was observed to be 15 mM, 1 mM, 0.5 mM, and 152 mM in two-step bioleaching, which were 63 mM, 29 mM, 23 mM, and 3 mM in the spent medium bioleaching while using glucose as the substrate and pulp density at 3%. Concomitant bio-mobilization was analyzed to be 79% Y, 28% La, and 28% Ce in a one-step bioleaching system. In the spent medium bioleaching 63% Y, 28% La, and 28% Ce were mobilized, which was 67% Y, 20% La, and 15% Ce in a two-step leaching mode. Using molasses as the substrate, bio-mobilization was analyzed to be 57% Y, 13.5% La, and 12.77% Ce in one-step; 57% Y, 14% La, and 12% Ce in a two-step, and 49% Y, 6.3% La, and 2.9% Ce in the spent-medium bioleaching system. While insignificant results were observed with sawdust as substrate.

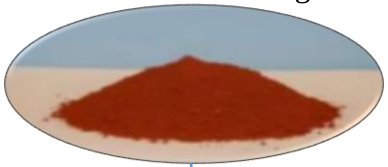
Keywords: Bauxite processing; Red mud; Rare earth elements; Bio-hydrometallurgy

Results and Discussion



Red Mud

Dried at 105 °C for 12 h and passed through 500 µm



Saw Dust

Glucose

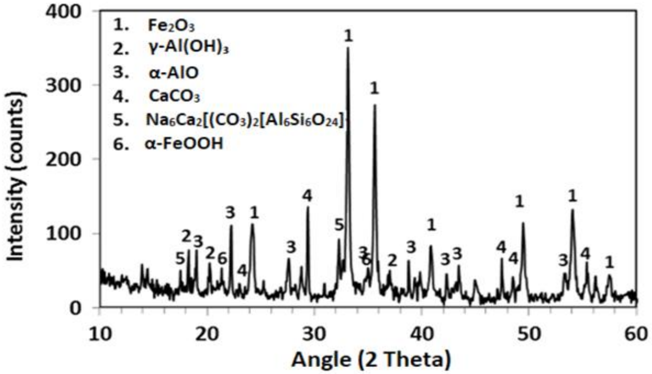
Molasses

Penicillium chrysogenum strain KBS3

Bioleaching
(1-step, 2-step, spent medium)

S L

Mobilized rare earth elements



IECMS 2020

Results and Discussion

Substrates	Pretreatment	Quantity used (g/L)
Glucose	Dissolved,Filter sterilized	100
Molasses	Autoclaved	100
Saw dust	Soaked in sulfuric acid, dried, homogenized	100

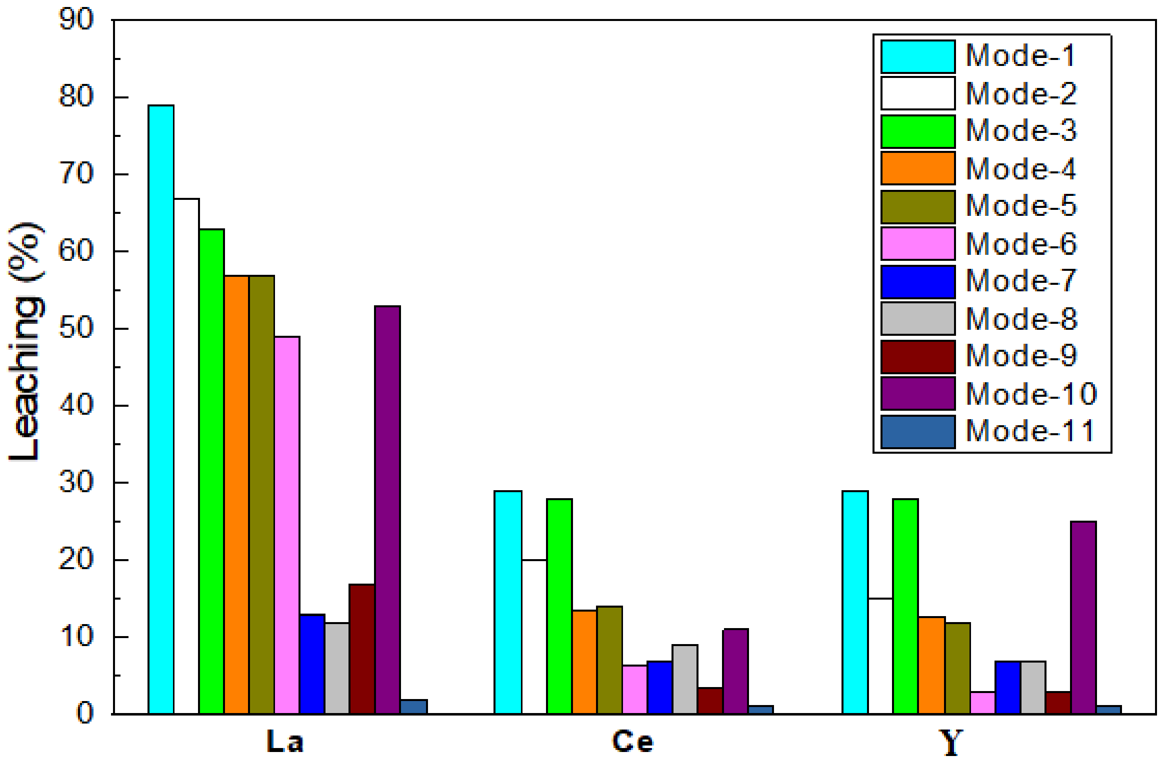
IECMS 2020

Results and Discussion

Characterization of residual waste

WET Analysis	
Rare earth elements (mg/kg)	
Y	251
La	386
Ce	792
Major elements (%)	
Al	2.9
Ca	12
Fe	7
K	1.2
Mg	0.5
Na	5.1
Si	5.5
Radioactive elements (mg/kg)	
Th	185
U	53

Results and Discussion



IECMS 2020

Results and Discussion

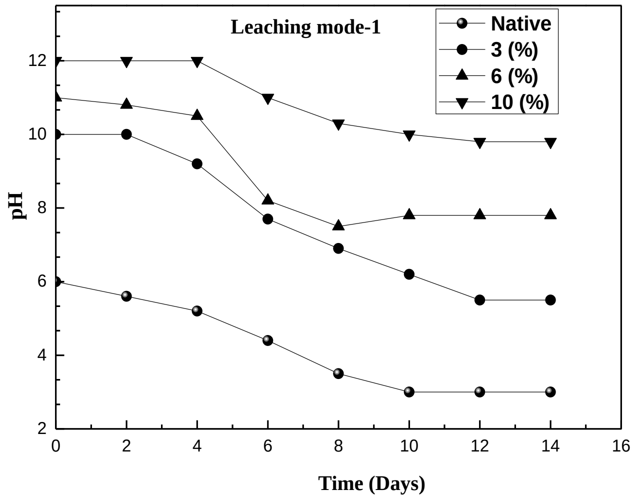
Concentration of organic acids in fermented media

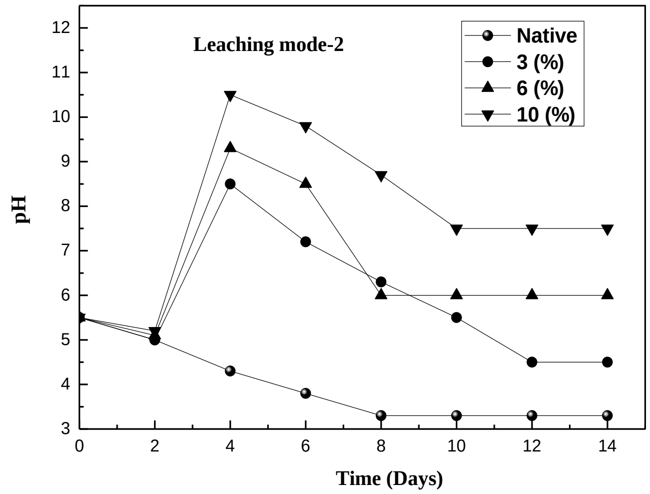
Organic acid production by using glucose as substrate			
Organic acid production (mM)	mode-1	mode-2	mode-3
Citric acid	12	15	63
Oxalic acid	2.5	1	29
Tartaric acid	1.8	0.5	24.5
Gluconic acid	1162	152	123
Organic acid production by using molasses as substrate			
Organic acid production (mM)	mode-4	mode-5	mode-6
Citric acid	4.21	3.57	44.8
Oxalic acid	1.55	1.0	15.0
Tartaric acid	1.18	0.95	14.8
Gluconic acid	210.19	52.5	11
Organic acid production in absence of red mud			
Organic acid production (mM)	glucose	Molasses	Saw dust
Citric acid	63	45	0.67
Oxalic acid	28	15	07
Tartaric acid	25	15	03
Gluconic acid	122	11	0.75

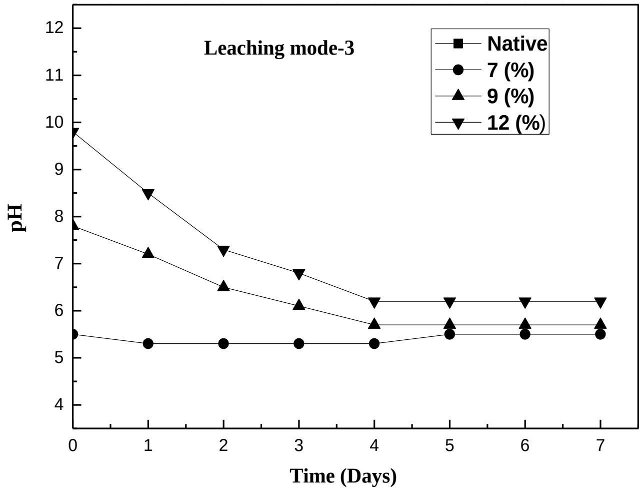
IECMS 2020

Results and Discussion

pH profile at different pulp densities for various leaching modes



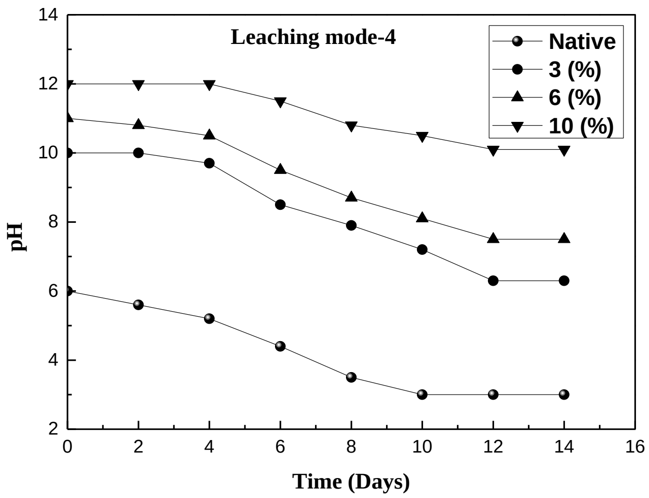


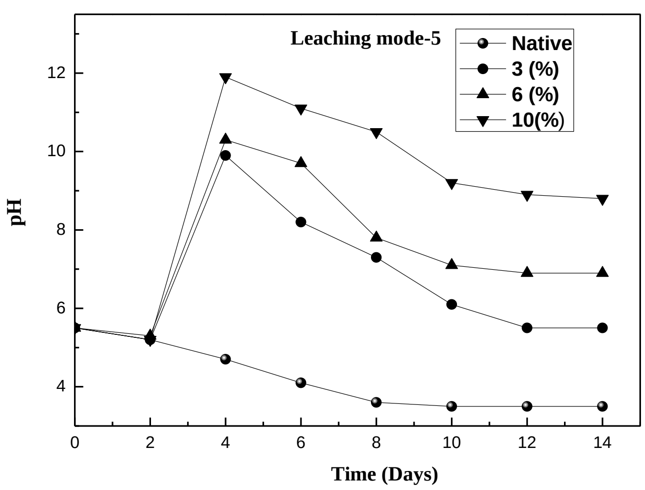


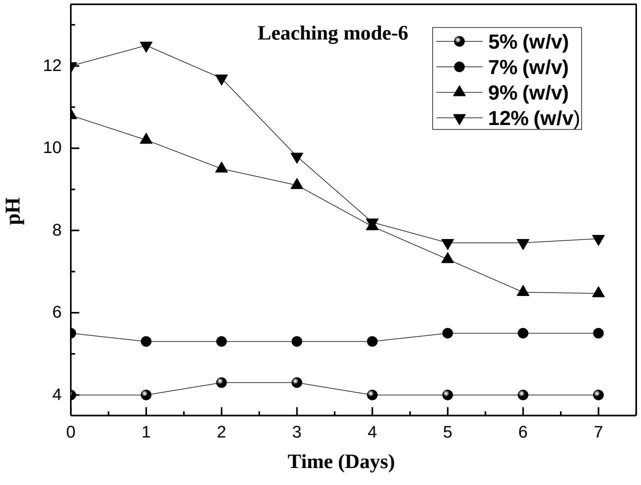
IECMS 2020

Results and Discussion

pH profile at different pulp densities for various leaching modes



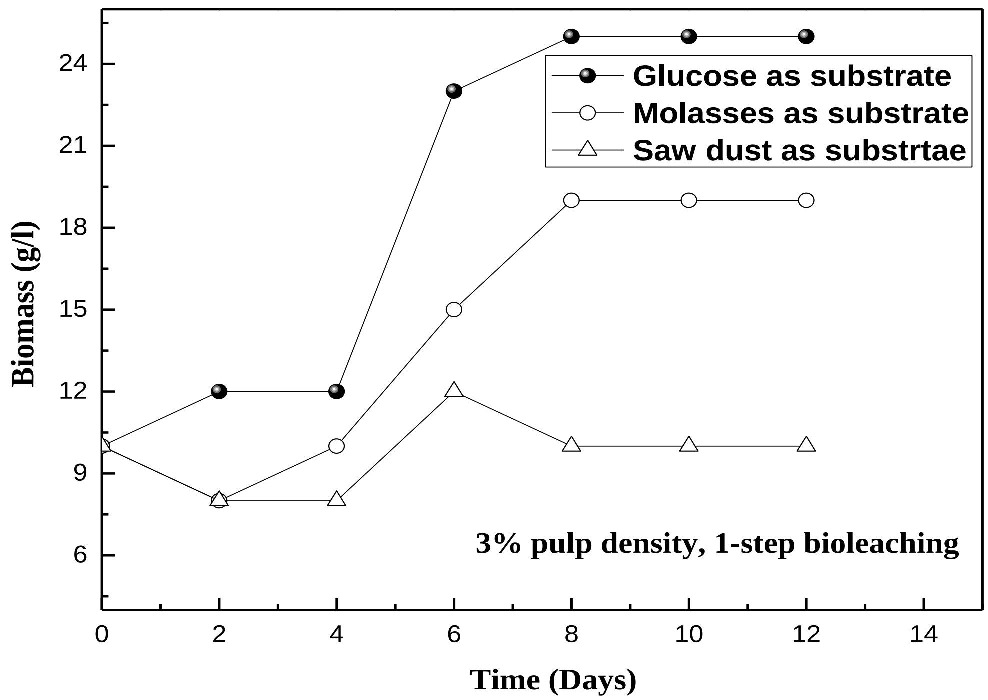




IECMS 2020

Results and Discussion

Biomass concentration with different substrates



IECMS 2020

Conclusions

- The present study elucidated the potential of bioleaching for REEs' extraction from its secondary reservoir red mud residue generated during the Bayer process of bauxite.
- One step bioleaching yielded a higher extraction efficiency of REEs from red mud as compared to the two step and spent medium bioleaching.
- Bioleaching is strongly influenced by the pulp density. The inhibition of fungal growth at higher pulp densities is due to the higher concentration of toxic components as well as an increase in the initial pH of the medium.
- The reverse solubility of REEs in the presence of metabolite organic acid excreted by *Penicillium chrysogenum strain KBS3* and glucose substrate with other than one step bioleaching can be the possible reason behind the exhibited phenomenon.
- More fundamental studies on metabolites and REEs' solubility is required.

IECMS 2020

Acknowledgements

National Research Foundation of Korea

This work was supported by the Brain Pool Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (Grant No. 2019H1D3A2A02101993) and Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (Project no. 2020R1I1A1A01074249).

IECMS 2020