Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36249

Geochemical and Microbial Assessment of Coal Combustion Residues for Rare Earth Element Recovery

ANURAG SINGH YADAV, PRIYA SONKER, GEORGE MATHEW AND KIRAN KONDABAGIL

Indian Institute of Technology Bombay

Coal ash is a waste produced after the combustion of coal in thermal power plants to generate electricity. Indian coal, which has a high ash content (30%-60%), with 298 coal-based thermal power plants, produces around 314 million tons of coal ash in the year 2023-24. With a global average REE concentration of 403.5 ppm in coal ash, it is not just an environmental hazard but also a secondary source of REEs. A REE mobilisation study has been done using microbial leaching in addition to mineralogical and geochemical characterisation.

Bulk characterisation using XRD, XRF, SEM-EDS, and ICP-MS of samples collected from three different thermal power plants shows that coal ash can have variable concentrations of REEs, depending on the source coal concentration and combustion conditions. Studies show that REEs are mainly hosted in aluminosilicate glass and Fe-bearing phases, which form hollow spheres known as cenospheres. Since these cenospheres are mainly composed of mullite, it is difficult to leach REEs under mild leaching conditions.

An initial metagenomic study of coal ash, slurry, and water samples collected from ash ponds and coal mines revealed the presence of diverse acid-producing and metal-tolerant bacteria. Three similar bacteria from a metagenomics study have been procured from international culture collections for a bioleaching study.

A direct bioleaching experiment with untreated Coal ash resulted in a sharp pH reduction but negligible REE mobilization. In Contrast, pretreatment of samples with NaOH increases the mobility of REE manyfold. Pretreatment indicates matrix modification confirmed by SEM-EDS, dissolution of aluminosilicate phases controls subsequent microbial leaching. Experiment using pure organic acids of comparable concentration showed that proton activity alone does not govern REE leaching. Structural and compositional alteration of the ash matrix is required.

These results show that REE recovery from coal combustion residues is primarily controlled by mineral host phases and their structural alteration prior to microbial leaching.