Recovering metals from waste incinerator ash with biohydrometallurgical methods

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Keywords: biomining, waste incinerator bottom ash, resource recovery.
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1. Introduction

In Austria and Germany the dependence on imports of raw materials rises (Wedig, 2015) and although current lower commodity prices prevail due to the difficult overall economic situation, those prices are subject to fluctuations and the principle of finiteness - facts that render a reliable market difficult to achieve (World Bank, 2015; Beinecke *et* al. 2012). Therefore, the development of alternative approaches to secure the supply of critical raw materials such as the metals of this project's concern is crucial for long-term economic stability. In addition, technologies for the recovery of metals from highly diffuse sources in a reasonable and economically relevant manner are virtually non-existent. Existing methods require large amounts of energy and chemicals, which are associated with environmental risks. The proposed project has great potential to make the recovery of metals energy efficient and environmentally friendly.

The aim of the project GRecoMet (Green Recovery of Metals, Austria FFG) is the development of new metallurgical processes that make an innovative, environmentally friendly and low-energy recovery of metals such as Co, Mg, Ga and LREE from waste incineration ash (as secondary raw material) possible. For this purpose, in the first step, metals are to be released from selected waste incineration ashes by 1) bioleaching methods, which has not yet been carried out so far in this form. Metals from the enriched leaching liquor or the leachate are accumulated by four different methods. These include 2) rhizofiltration, a phytoextraction method of metals from liquid medium; 3) biosorption with residual biomass, a physical process of accumulation of metals on the surface of mostly dead plants, biomass or dried algae biomass; 4) biosorption with algae, also a largely physical process with living and propagating microalgae; and 5) biosorption with peptides / polymers, a physical process of specific addition of particular metals to particular usually immobilised short-chain proteins (peptides) or other polymers. Further the metal enrichment from leaching effluents in biological systems also represents an innovation. In a further step, methods for these enriched organic materials to 6) recover metals will be developed. Mild chemical and innovative methods (hydrometallurgy) are tested in comparison with pyrometallurgical methods for this purpose. All technologies will be tested in a 7) process-integrated experimental setup.

First results, which will be presented at this conference, regard preliminary biosorption results of metals from bioleachate with agricultural residues, living microalgae.

2. Material and methods

Synthetic bioleachate was prepeared according to analytics (RFA, ICP-MS) of waste incineration ash and assumptions about leaching in optimised bioleaching systems (which will be developed during the project) by dissolving mineral salts of selected metals.

Agricultural residues (egg shells, potato peels, dried algae, bark, wheat spelts, hemp shives, sugar beet pulp) were collected from food producers, washed with deionised water, dried at 80°C in an oven, ground in mill to specific particle sizes und stored in closed containers.

Cultivation of microalgae

Selected microalgae strains were cultivated in 250ml Erlenmeyer flasks under supply of air in adapted growth media with LED irradiation.

Biosorption with biomass

Tests with the different dried and ground (according to results of literature search) residuals were carried out in fixed bed columns (in three replications). After initial tests for determination of the optimal pH, synthetic bio-leachate was pumped through the columns for one hour at room temperature. Samples of the eluent were taken after each test to calculate the biosorption in the biomass. Biomass was mostly used without pre-treatment.

Biosorption with algae

Defined amounts of living algal biomass were cultured in media with increasing addition of bio-leachate for adaption to the changing conditions. Samples of bio-leachate before and after biosorption and of the algal mass were taken for analysis of metal content and uptake. Each experiment was carried out in three replicates.

Analytics

Fluids were directly analysed by XRF spectroscopy and/or ICP-MS, biomass was extracted (chemical digestion) and analysed with the same methods. Additionally, rapid tests kits were used for some metals.

Desorption of metals from biomass

The best two agricultural residues and algae strains were put through desorption to gain a concentrate, enriched in the selected metals. Test with different desorption chemicals (in different concentrations) were carried out and compared for efficiency.

3. Results

Agricultural residues will be characterised for their sorption capacity (mg/g), pH optimum, removal efficiency in fixed bed columns and compared to find the two best biosorption materials. Accordingly, best algae strains and conditions of growth conditions will be examined and presented at the conference. Finally, the optimised desorption process will be described.

4. Discussion

Further steps during the project will be described and first assessments for up-scaling will be discussed, taking into account material flow of residuals in Austria.

5. References

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6. Acknowledgements

This project is co-funded by the Austrian Ministry of Innovation and coordinated through the Austrian Research Promotion Agency with the Grant Agreement Number 853480.