ENABLING LUNAR IN-SITU AGRICULTURE BY PRODUCING FERTILIZER FROM BENEFICIATED REGOLITH

Executive summary
Study

Discovery

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Activity summary: This study explores In-Situ Resource Utilization (ISRU) for sustainable agriculture on the Moon, focusing on mechanical and chemical beneficiation to extract elements and nutrients from lunar regolith to create a complete nutrient solution. Methodologies involved systematic pre-processing, leaching and characterization of lunar regolith simulants leachate using ICP-MS. Beneficiation methods in isolation and in combination improves extraction to varying degree depending on the selected element(s). Future research should focus on optimizing extraction strategies, explore bio-beneficiation and additional applications within lunar ISRU frameworks.

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Executive summary

Enabling Lunar In-Situ Agriculture by Producing Fertilizer from Beneficiated Regolith

Introduction: The exploration and prospecting of the Moon for prolonged human presence present challenges concerning the sustainability of agricultural practices. This report explores the concept of In-Situ Resource Utilization (ISRU) by investigating the role and potential of mechanical and chemical beneficiation to extract essential elements and nutrients from lunar regolith to create a plant nutrient solution.

Objectives: First, we aimed to assess the feasibility of aqueous leaching by evaluating its effectiveness in extracting nutrients from beneficiated lunar regolith simulants and molten regolith electrolysis by-products. Second, we sought to identify and propose optimized nutrient extraction methods by analyzing initial sample data, which then guided the creation of a second round of samples. Finally, we aimed to propose a system architecture for nutrient extraction based on the Alpha Samples data.

Methodology: The methodologies included systematic pre-processing strategies such as size separation, comminution, magnetic separation, and chemical treatments with acids and alkali. Initial extracts from leached samples were characterized using ICP-MS. Parameters for the second round of samples were optimized to enhance extraction efficiency. Post-leaching, analyses using ICP-MS and Ion chromatography enabled the development of an approach to evaluate and compare extraction strategies.

Key Findings: Aqueous leaching effectively extracts nutrients from lunar regolith simulants and MRE by-product. Mechanical beneficiation impacts extraction efficiency, while acid leaching significantly enhances it for certain elements. Combining these methods optimizes efficiency, depending on the targeted element and sequence of processing steps, including selective reduction of certain elements where needed. There are some elements missing or in too low concentrations to create a complete nutrient solution. However, several elements were successfully extracted, like K, Ca, Mg, in amounts that could serve as a supplement to a nutrient solution. Lastly, using well-documented lunar regolith simulants is important to ensure the reliability and reproducibility of research findings.

Conclusion: Our study demonstrates promising results using beneficiated lunar regolith to create plant fertilizer. These findings not only support the feasibility of lunar agriculture but also highlight the potential for sustainable resource utilization in future lunar missions.

Future work: Future research should focus on optimizing the extraction conditions and sequence of processing steps to enhance nutrient recovery further. Exploring bio-beneficiation techniques and investigating the applications of other extracted elements within the framework of ISRU can broaden the potential of lunar agriculture.