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Evaluating Enhanced Rock Weathering for Methane Mitigation in Flooded Rice Systems

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Enhanced rock weathering (ERW) is widely recognized for its role in atmospheric CO_2 removal, yet its broader effects on soil biogeochemistry and greenhouse gas fluxes remain underexplored. In flooded rice systems, where methane (CH_4) emissions are a major concern, ERW may provide co-benefits by modifying soil chemistry to suppress CH_4 emissions. This study examines how metabasalt amendments impact CH_4 emissions, soil geochemistry, and plant performance in rice paddies.

We conducted a controlled greenhouse experiment, applying metabasalt at application rates of 0, 30, and 300 tons/ha to flooded rice soils. Throughout the growing season, we measured:

- CH_4 and CO_2 fluxes
- Soil chemistry (pH, alkalinity, and pore water ion concentrations)
- Plant traits (height, tiller emergence, grain yield)

Metabasalt application significantly reduced cumulative CH_4 emissions, with a 33.55% decrease at 300 t/ha. Control soils emitted 67±7 g CH_4, while emissions dropped to 65±5 g at 30 t/ha and 44±5 g at 300 t/ha. The most pronounced suppression (66%) occurred 48 days post-transplantation. A reactive transport model suggests CH_4 reductions depend on flooding conditions and application rates..

Pore water analysis revealed higher Fe, Mn, and Mg availability, particularly during peak root water uptake, suggesting metabasalt dissolution is driven by rhizosphere activity and transpiration. Additionally, soil bicarbonate alkalinity increased by 141% in high-rate flooded soils, while controls showed a net decline. These results suggest that metabasalt amendments facilitate carbon sequestration and alter microbial pathways, potentially influencing methane cycling by modifying competitive interactions among microbial functional groups.

However, CH_4 mitigation came with potential trade-offs: grain yield declined at 300 tons/ha (24±1 g vs. 28±2 g in controls). We will explore whether these yield reductions are linked to nutrient availability, soil pH shifts, or altered microbial interactions. This study provides new insights into the geochemical and microbial mechanisms governing methane fluxes in rice agriculture and evaluates the dual role of silicate amendments in both CO_2 sequestration and methane mitigation as a climate strategy.