Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25980

Bacterial Release of Mineral-Bound Phosphorus: Unlocking P nutrient Bioavailability

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Phosphorus (P), an essential element in DNA, RNA, ATP and phospholipids, is vital for the growth, functioning and reproduction of all life forms on earth. As a key nutrient for plants phosphorus fertilizers plays a central role in food security and societal development. Many low- and middle-income countries face difficulties accessing mineral phosphorus, putting agricultural productivity at risk [1]. This issue is particularly critical for India, home to nearly 17% of the world population, which relies heavily on phosphate imports (90%) to sustain agricultural output. A significant challenge arises from transforming phosphate fertilizers into inaccessible 'legacy phosphorus' or their loss to the hydrosphere, resulting in water pollution [2]. This underscores the importance of understanding the biogeochemical processes that governs the fate of phosphorus in soil ecosystem. Despite extensive research, the information derived from pure minerals cannot fully elucidate phosphate fixation in natural soils because of the complex interactions between minerals and bacteria in soil.

This study investigates the mineralogical and geochemical factors affecting phosphorus adsorption onto mineral surfaces. We conducted controlled batch experiments to assess phosphorus adsorption on environmentally relevant minerals, such as iron oxides and clays, under varying pH and ionic strength. As studies on pure minerals cannot fully explain phosphate fixation in natural soils due to complex mineral-bacteria interactions, we investigated the potential of two phosphate solubilizing bacteria to release phosphorus bound to mineral surfaces. The results show that bacteria enhanced the solubility of phosphorus associated with iron oxyhydroxide by a factor of four within 24 hours, sustaining this effect over time. This study indicates that microorganisms can be vital in solubilizing phosphorus from less bioavailable forms, thereby improving plant nutrient uptake. Additionally, we employed spectroscopic techniques to analyze mineral surfaces before and after bacterial treatment to investigate the phosphorus bonding with the mineral surface. This work emphasizes the role of bacteria in modifying phosphorus sorption and enhancing its bioavailability, which has implications for improving fertilizer efficiency and minimizing environmental impact.

References:

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