Phosphorus recovery from low-grade ores and waste materials via bioleaching as a function of poorly crystalline Fe/Al mineral content

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Objectives:

1. Identify and isolate phosphorus-solubilizing microorganisms (PSMs) from apatite ore
2. Quantify rate and extent of phosphorus solubilization from a range of apatite minerals via bioleaching
3. Assess the role of mineral composition and poorly crystalline Fe/Al oxide/(oxy)hydroxide content on biological P solubilization

Introduction

Efficient, cost effective treatment technologies for recovery of fertilizer-grade P from unexploited resources (i.e. low-grade phosphate reserves or P-containing waste materials) are important to overcome the possible limitation in the supply of high-quality rock phosphate in the near future. We measured P solubilization from a range of apatite ores using the known PSM *R. leguminosarum* and an endemic fungal isolate, respectively, as a function of poorly crystalline Fe/Al oxide/(oxy)hydroxide mineral content. Bioleaching results were compared to P release via stoichiometric partial H_2SO_4 acidulation. Results will contribute to the optimization of bioleaching technologies for efficient P recovery.

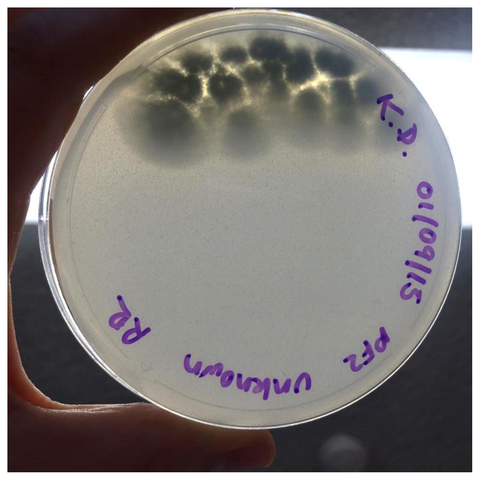


Image 1. PSM isolate showing solubilization of $Ca_3(PO_4)_2$ in NBRIP agar growth medium

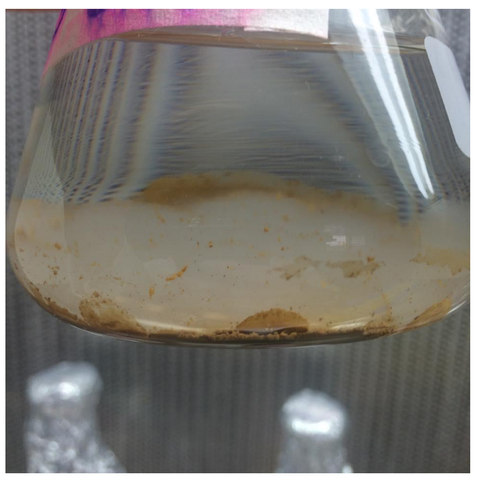


Image 2. PSM growth on low-grade apatite ore at day 15 of the bioleaching trial

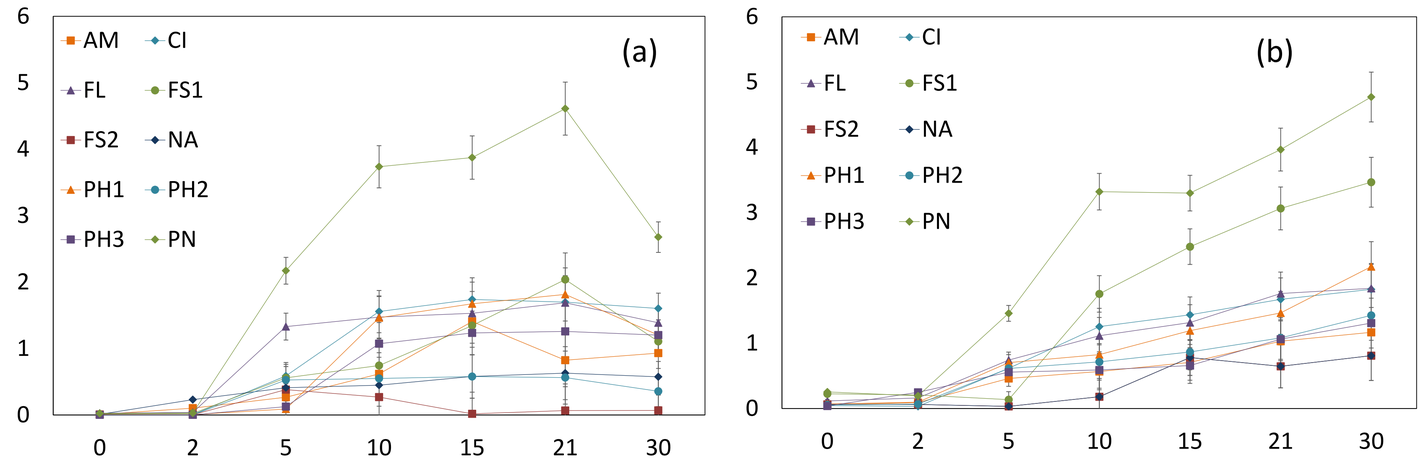
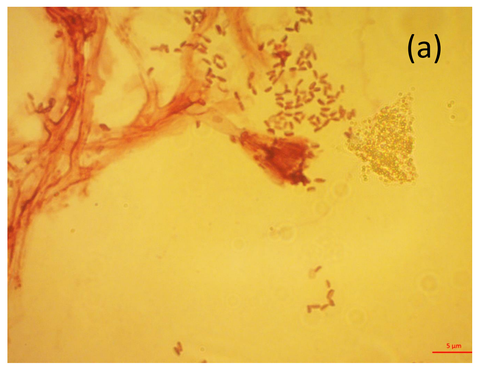


Figure 1. Percent P solubilized with time (0-30 d) by (a) *R. leguminosarum* and (b) unidentified fungal isolate.



Images 3. Phosphorus-solubilizing fungi observed under a light microscope at 1000X magnification. The distinctive conidial heads, associated spores and mycelia identify this P-solubilizing microorganism as a fungus.

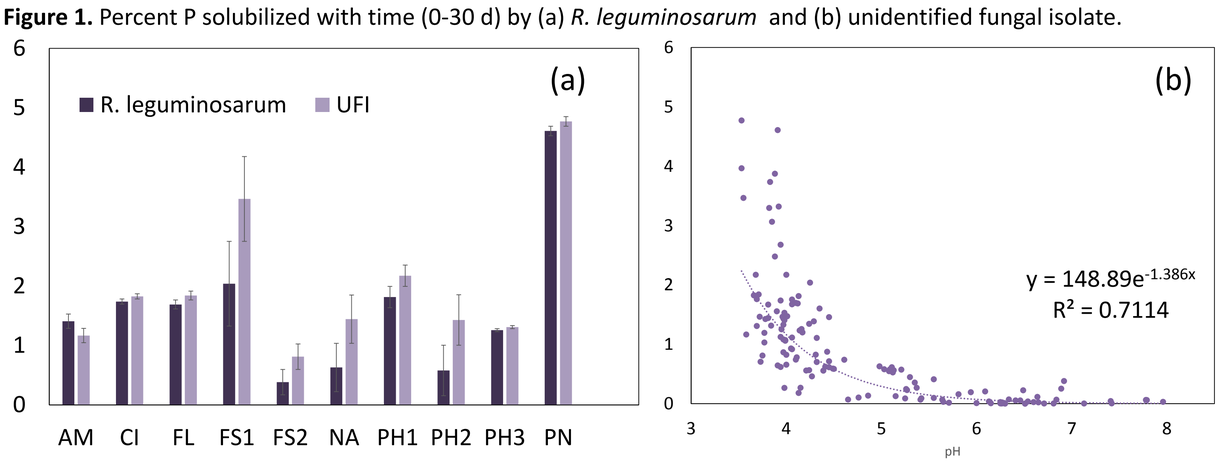


Figure 2. (a) Percent P solubilized from apatites at 21 d by *R. leguminosarum* and unidentified fungal isolate (UFI); and (b) P solubilization as a function of solution pH.

Table 1. Maximum P solubilised from selected ores (as % total P) by *R. leguminisarum*, the unidentified fungal isolate, and stoichiometric 20% and 50% H_2SO_4 acidulation .

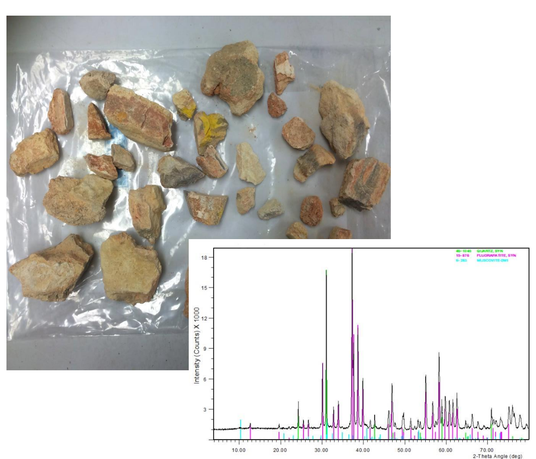
	Rhizobium leguminosarum	Unidentified fungal isolate	20% H_2SO_4 acidulation	50% H_2SO_4 acidulation
Apatite FS1	2.04%	3.47%	2.06%	2.37%
Apatite FS2	0.38%	0.81%	0.50%	0.72%

Key Findings

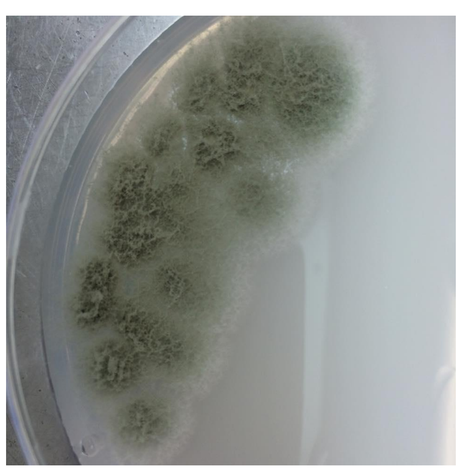
- Bioleached P strongly correlated with solution pH ($r_{R.leguminosarum}$=-0.75; r_{UFI}=-0.78) & with time in fungal leaching ($r_{R.leguminosarum}$=0.56; r_{UFI}=0.85)
- P solubilization was not significantly influenced by apatite ore poorly crystalline Fe/Al oxide/(oxy)hydroxide content (P = 0.000144)
- P recovery from low grade apatite ores was significantly greater compared to higher grade apatite with higher total P content
- Bioleaching (21-30 d) and partial acidulation (120 h) yielded similar quantities of soluble P
- Biological leaching using endemic PSMs may be a feasible alternative for P recovery from low-grade resources with additional process optimization

Methods

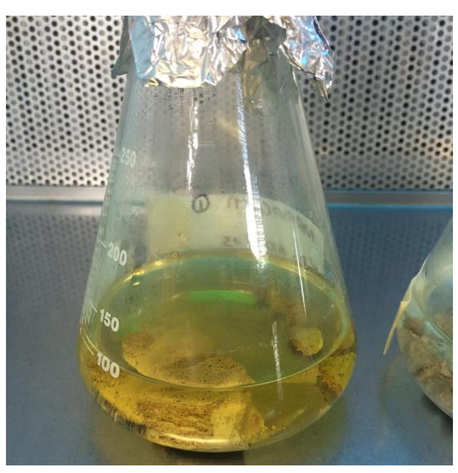
Mineralogical (XRD) & geochemical (XRF) apatite characterisation



Enrichment & isolation of endemic P-solubilizing microorganisms (PSMs)



Partial H_2SO_4 acidulation & bioleaching trials using 10 different apatite ores



Leaching solution pH & PO_4-P measurement with time (0-30 d bioleaching trials, 0-120 h H_2SO_4 partial acidulation)