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The dissolution of apatite by phosphate-solubilizing microorganisms in soil: A balance between P supply and toxicity

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Apatite is the largest phosphorous reservoir on Earth. However, due to its low solubility, dissolved P is severely deficient in soil. Soil microorganisms play a significant role in P dissolution via excretion of organic acids and enzymes. We studied the bioweathering of fluorapatite by a typical phosphate-solubilizing fungus, *Aspergillus niger*. *A. niger* secrets organic acids and which enhance P release from apatite, leading to increased microbial growth. However, a simultaneous release of fluorine (F) causes toxicity to *A. niger* and significantly lowers the phosphate-solubilizing process. Additionally, the solubility of apatite is also limited by the abundance of carbonate and goethite, via pH buffering and production of reactive oxygen, respectively. The decreases in both the amount of biomass and the respiration rate of *A. niger* confirm the strong inhibitory effect on the microorganisms. Meanwhile, the solubility of organic phosphate is also degraded due to the low secretion of phosphatase and phytase. Therefore, even though phosphate-solubilizing microorganisms can facilitate P release, its solubilizing potential is constrained by F and some typical soil minerals. These toxicities might account for the low P availability in soil.