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Influence of organic substrates on the kinetics of bacterial As(III) oxidation

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Soil microflora plays a major role on the behavior of metals and metalloids. Arsenic speciation, in particular, is related to the activity of bacteria able to oxidize, reduce or methylate this element, and determines mobility, bioavailability and toxicity of As. Arsenite (AsIII) is more toxic and more mobile than arsenate (AsV). Bacterial As(III)-oxidation tends to reduce the toxicity of arsenic in soils and the risk of transfer toward underlying aquifers, that would affect the quality of water resources. Previous results suggest that organic matter may affect kinetics or efficiency of bacterial As(III)-oxidation in presence of oxygen, thus in conventional physico-chemical conditions of a surface soil. Different hypothesis can be proposed to explain the influence of organic matter on As(III) oxidation. Arsenic is a potential energy source for bacteria. The presence of easily biodegradable organic matter may inhibit the As(III) oxidation process because bacteria would first metabolize these more energetic substrates. A second hypothesis would be that, in presence of organic matter, the Ars system involved in bacterial resistance to arsenic would be more active and would compete with the Aio system of arsenite oxidation, decreasing the global As(III) oxidation rate. In addition, organic matter influences the solubility of iron oxides which often act as the main pitfalls of arsenic in soils. The concentration and nature of organic matter could therefore have a significant influence on the bioavailability of arsenic and hence on its environmental impact. The influence of organic matter on biological As(III) oxidation has not yet been determined in natural soils. In this context, soil amendment with organic matter during operations of phytostabilization or, considering diffuse pollutions, through agricultural practices, may affect the mobility and bio-availability of the toxic metalloid.
The objective of the present project is to quantify the influence of organic matter on the bacterial speciation of arsenic in contaminated soils. Moreover, the biogeochemical consequences of this phenomenon on the mobility and ecotoxicity of this metalloid will be studied. The first task of this program is the precise and systematic investigation of the influence of different types and concentrations of organic matters on the activity of As(III)-oxidizing pure strains. Influence of aspartate, succinate (simple substrates) and yeast extract (complex substrate) on As(III)-oxidation kinetics has been studied. For each experiment, the bacterial growth and the expression of genes involved in the speciation of arsenic, i.e. aio and ars genes, has been monitored. A direct perspective of this work will be to perform experiments with humic and fulvic acids (complex organic matter commonly found in soils), and with water-extracted organic matter from polluted soils. Then the As(III)-oxidation activity of bacterial communities extracted from contaminated soils will be followed. These assays should allow the screening of conditions which will be applied in subsequent experiments with several real contaminated soils, including a former mining site, impacted industrial sites, and a forest soil heavily contaminated after arsenical ammunitions storage.
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