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

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Scientific context:

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 AsIII oxidation tends to reduce the toxicity of arsenic in soils and the risk of transfer toward underlying aquifers.

Previous results suggest that **organic matter may affect kinetics or efficiency of bacterial AsIII-oxidation in presence of oxygen**, thus in conventional physico-chemical conditions of a surface soil. 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 AsIII oxidation has not yet been determined in natural soils. In this context, soil amendment with organic matter during operations of phytostabilization or through agricultural practices, may affect the mobility and bioavailability of this toxic metalloid.

What is the influence of the concentration and the nature of organic matter on arsenic speciation by the microflora of contaminated soils ?

Aims:

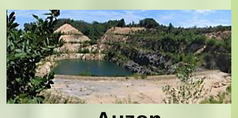
1. To quantify the influence of organic matter on the bacterial speciation of arsenic in contaminated soils

2. To study the biogeochemical consequences of this phenomenon on the mobility and ecotoxicity of this metalloid

Scientific strategy:

1. Investigation of the **influence of different types and concentrations of organic matters** (simple substrates: aspartate, acetate ; complexes substrates: yeast extract, reference humic and fulvic acids) **on the activity of:**
   - **AsIII-oxidizing pure strains**
   - **Bacterial communities extracted from polluted soils**
2. Monitoring of the **expression of genes** involved in the speciation of arsenic, i.e. **arsenite oxidase** (*aio*) and **arsenate cytoplasmic reductase** (*ars*) genes
3. Experiments on three real contaminated soils:
   - A former mining site (Salsigne, France)
   - An impacted industrial site (Auzon, France)
   - A forest soil heavily contaminated with As (Verdun, France)


Salsigne

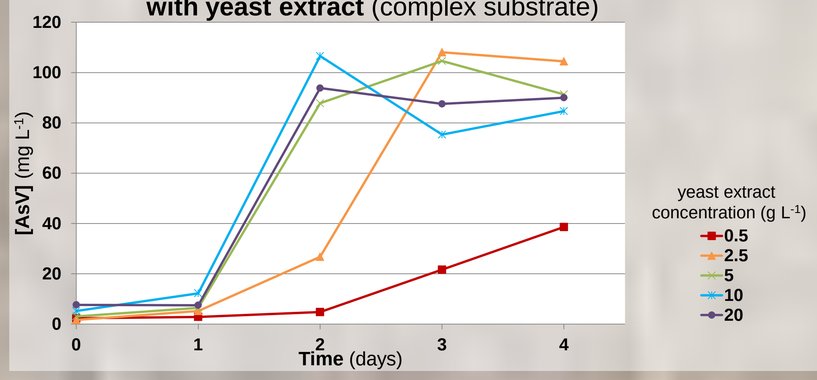

Auzon

   - Monitoring of the **speciation** and **the bioavailability** of arsenic in pore water
   - Monitoring of the bacterial activities of **arsenite oxidation**
   - **Ecotoxicity** assays

Preliminary results:

→ Influence of organic substrates on arsenic oxidation by an heterotrophic bacteria *(Herminiimonas arsenicoxydans)*

As(III) oxidation by *Herminiimonas arsenicoxydans* with yeast extract (complex substrate)

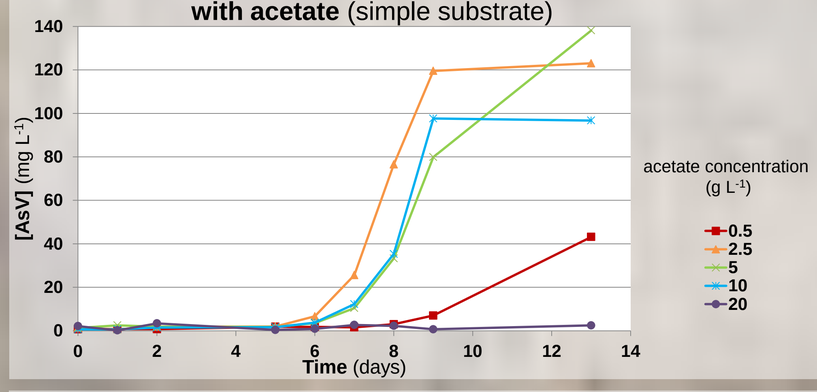


- Inhibitory effect of low concentrations of yeast extract (below 5 g L^{-1}) on AsIII oxidation by *H. arsenicoxydans* (slower AsIII oxidation kinetics)
- Possible subsequent reduction of AsV by *H. arsenicoxydans*

Optimal yeast extract concentration = 0.2 g L^{-1}

Increasing of the lag phase of *T.delicata* with 5 g L^{-1} yeast extract

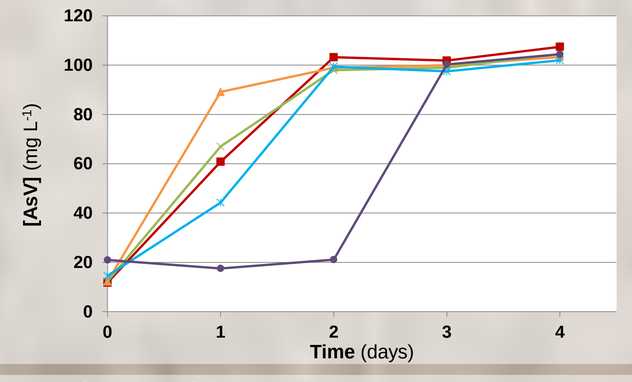
As(III) oxidation by *Herminiimonas arsenicoxydans* with acetate (simple substrate)

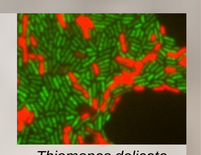


- Greater lag phase and slower arsenite oxidation kinetics on acetate compared to those obtained on yeast extract
- Optimal acetate concentration = 2.5 g L^{-1} (Inhibitory effects for 0.5 and 20 g L^{-1} acetate)
- No observed decreasing of AsV concentration

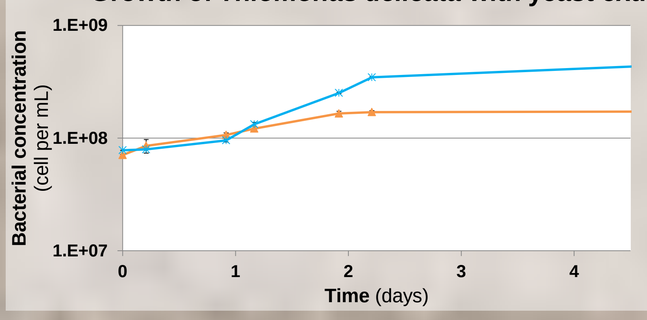
→ Influence of yeast extract on arsenite oxidation by a mixotrophic bacteria *(Thiomonas delicata)*

As(III) oxidation by *Thiomonas delicata*

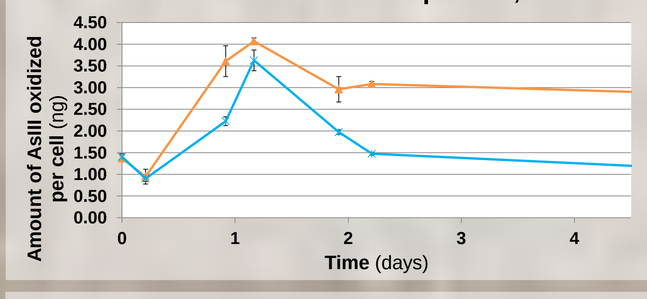



Thiomonas delicata

Growth of *Thiomonas delicata* with yeast extract



Amount of AsIII oxidized per cell, over time



- Simultaneous bacterial growth and AsIII oxidation for the both conditions
- Start of AsIII oxidation a few hours after the beginning of the experiment
- Lower specific AsIII oxidation with 1 g L^{-1} compared to with 0.2 g L^{-1} yeast extract

Discussion:

A small concentration of organic substrates seem to enhance AsIII oxidation by both the two bacterial strains, despite a lower growth in that condition. However, at greater concentrations, organic substrates seem to inhibit AsIII oxidation. Those concentrations depend on the metabolism of the strains.

Two hypothesis:

→ Arsenite oxidation is a potential energy source for bacteria. There may be competition between organic matters mineralization and AsIII oxidation processes as an energy source.

→ The bacterial system of resistance to arsenic (Ars), stimulated by the presence of organic matter, may compete with the system of arsenite oxidation (Aio), delaying AsIII oxidation or inducing AsV reduction.

This poster participates in OSP
Outstanding Student Poster Contest

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This work is co-funded by BRGM and ADEME (convention TEZ 11-16).
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