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Structural and functional response of river sediment microbial communities to environmental concentrations of copper and arsenic, alone or in mixture



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Introduction

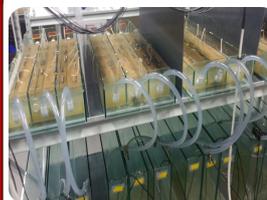
Sediments are an essential component of aquatic ecosystems in terms of biodiversity and ecological functions. They receive direct or indirect inputs from the water column or from the watershed including some toxic and persistent contaminants such as metals.

In sediments, microbial communities are major players in various key ecological functions (biogeochemical cycles). The accumulation of metals in sediments or their continuous input via the surface water can result in a chronic exposure of benthic microbial communities. It can impact microbial biodiversity thus leading to the selection of tolerant species and altering microbial functions. However there is a lack of knowledge about ecotoxicological effects of metals on natural sediment microbial communities.

In this context, this microcosm study investigated the effects of environmental concentrations of copper (Cu) and arsenic (As), alone or in mixture on microbial communities from river sediment. Microbial responses were evaluated in terms of structure, functions, and pollution induced community tolerance (PICT).

Material and Methods

Experimental design:



- uncontaminated sediments from the Ain River
- 12 artificial streams, 4 treatments:
 - REF: without metal
 - Cu: 40 mg Cu/kg
 - As: 40 mg As/kg
 - Mix: 40 mg Cu/kg + 40 mg As/kg
- 21 days, 4 sampling times (days 0, 7, 14, 21)



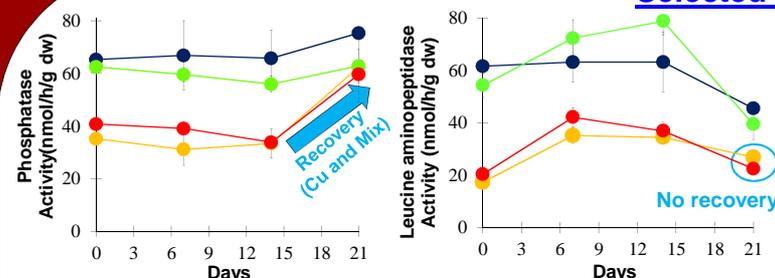
Microbial parameters:

- Functions (C, N, P cycles): enzymatic and metabolic activities, genetic potential
- Structure: bacterial abundance (qPCR) and community composition (ARISA)
- Pollution Induced Community Tolerance (PICT) measurements

Chemical analyses:

- Cu and As concentrations in sediments

Selected Results

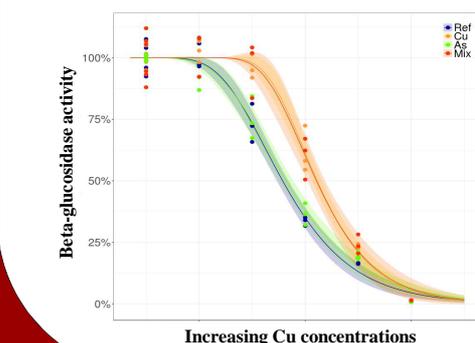
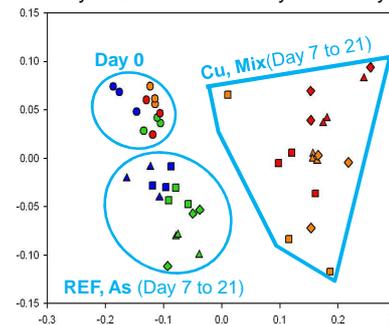


Effects on Functions

- No effect of As on microbial functions
- Fast and significant (Tukey test, $p < 0.05$) inhibition of phosphatase and leucine aminopeptidase under Cu and Mix exposure:
 - ✓ Phosphatase: recovery at 21 days
 - ✓ Leucine aminopeptidase: no recovery

Effects on Structure

- No effect of As on bacterial community composition (BCC)
- Significant changes of BCC from the first week of exposure to Cu and Mix (ANOSIM, $p < 0.05$)
- No recovery of BCC between day 7 and day 21



Pollution Induced Community Tolerance (after 21 days of exposure)

- No effect of As on community tolerance to Cu (i.e. no cotolerance)
- Significant increase of Cu tolerance on communities exposed for 21 days to Cu and Mix

Effective concentrations (EC) inhibiting 50% of beta-glucosidase activity after acute Cu exposure (4h)

	EC ₅₀ g/kg	Confidence Interval
REF	3.9	[2.8 ; 5.0]
As	4.1	[2.8 ; 5.4]
Cu	18.1	[12.6 ; 23.6]
Mix	10.7	[5.5 ; 16.0]

Conclusions

- Environmental concentrations of As had undetectable or very limited effect on microbial community functions, structure and tolerance induction.
- Environmental concentrations of Cu had rapid and marked effects on the structure and most of the measured functions.
- Most of the mixture effects were similar to individual effects of Cu.
- No structural recovery was observed and functional recovery at day 21 was dependent of the function tested and the exposure condition (i.e. Cu or Mix).
- The PICT response (Cu tolerance under Cu and Mix exposure) was consistent with bacterial community composition changes.
- These findings reveal that metals accumulation in sediments can impact exposed microbial communities thus potentially affecting their functional role in aquatic ecosystems.

Perspectives

- PICT: these first results open perspectives for the application of PICT in the sediment compartment as a biomonitoring tool for environmental risk assessment (protocols standardization and field validation under process).
- Sediment microbial ecotoxicology: further studies are needed to better understand the ecotoxicological impacts of contaminants on natural sediment communities and improve the evaluation of the ecological quality of sediments in a context of pollution.

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