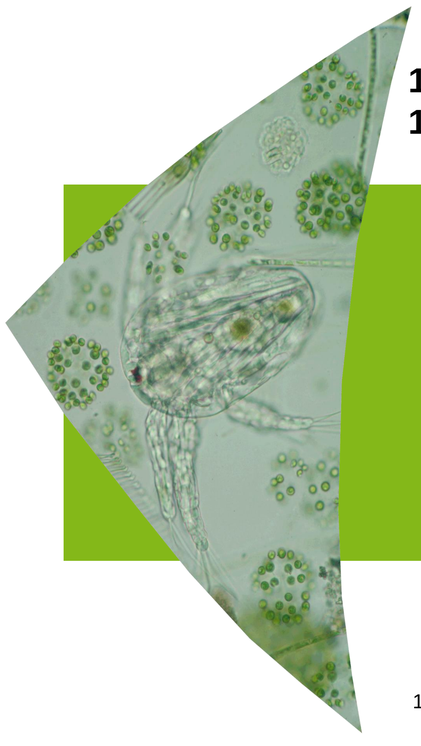

10th International SedNet Conference
14-17 June 2017, Genoa, Italy

Use and relevance of artificial organic matter substrates to assess the functional effects of metals on natural sediment communities

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Background

- Sediment provide a habitat for very diverse communities of organisms and considerably contribute to the functioning of aquatic ecosystems.
- Decomposition of organic matter and detritus is a vital ecosystem process driven by microorganisms and invertebrate detritivores.
- Contaminants that can reach the sediment may affect decomposer organisms and thus ecosystem functioning.
- Establishing links between toxic pressure and functional effects at the benthic community level remains a challenge.

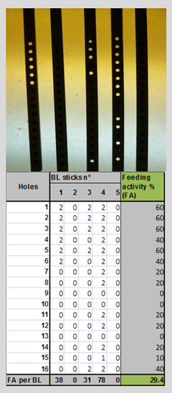
Objectives…

1. Assess organic matter decomposition as a functional descriptor of ecotoxicological effects on natural sediment communities of microorganisms and invertebrates.
2. Test artificial organic matter substrates (bait lamina method (ISO 18311 [1]) and artificial tablets modified from DECOTABs [2]) to address the issue.
3. Assess their suitability to evaluate the impact of Cu, As and a mixture of Cu/As.

Design, Implementation and Results

Bait Lamina Method ISO 18311 [1] adapted for sediment:

- Bait lamina sticks (16 cm) filled with bait material - cellulose, bran flakes and active coal (70:27:3)
- 5 sticks / channel deployed horizontally at the subsurface of the sediment
- Qualitative measurement (0: not eaten; 1:partially eaten; 2: eaten) ➡ % of bait eaten



Adapted DECOTAB Method [2]:

- Artificial tablets (d=20 mm; h=5 mm) of agar-agar containing cellulose, bran flakes and active coal (73:24:3), dried and individually covered by a 5 mm mesh-size plastic net
- 5 tablets / channel deployed at the subsurface of the sediment
- Quantitative measurement (% dry mass loss normalized to the loss of dry mass in a sterile microcosm) ➡ % of tablet decomposed

Experimental design

- Uncontaminated sed. (<2 mm) 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 of exposure

Analysis:

- **Cu and As concentrations** in sediments
- **Ecotoxicological evaluation** with the ostracod test (ISO 14371 [3])

Results – Exposure description

Tab. 1. Actual metal concentrations and ecotoxicity toward the ostracods

Treatment	Day 0 (after spiking) As (mg.kg dw^{-1})	Day 0 Cu (mg.kg dw^{-1})	Day 0 Ostracods mortality (%)	Day 21 (n=3) As (mg.kg dw^{-1})	Day 21 Cu (mg.kg dw^{-1})	Day 21 Ostracods mortality (%)
Ref	2.89	1.81	0.0	3.12 ± 0.10	1.30 ± 0.16	4.3 ± 7.5
Cu	3.24	56.56	100	2.96 ± 0.13	43.60 ± 2.60	100
As	31.33	1.75	16.6	26.20 ± 1.20	2.60 ± 1.20	2.0 ± 5.0
Mix	31.24	55.07	100	24.66 ± 0.45	47.80 ± 2.50	100

- **Cu and As concentrations in sediment decreased by 13% to 23%, depending of the metal and the treatment (single or in mixture) at Day 21**
- **Concentrations were between the TEC and PEC for benthic invertebrates (9.79 - 33 mg kg dw^{-1} for As; 31.6 – 149 mg kg dw^{-1} for Cu [4])**
- **The ostracod toxicity tests showed high toxicity of Cu-spiked and mixture-spiked sed. and low toxicity of As-spiked sed. (decreasing at Day 21)**

Results - Effects on functional parameters

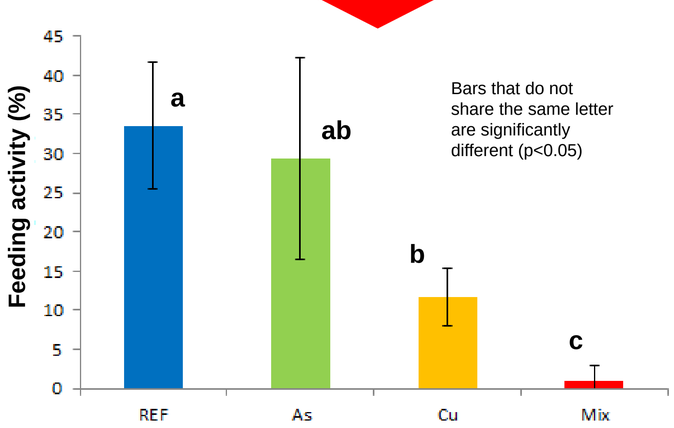


Fig. 1. Bait Lamina responses (n=3)

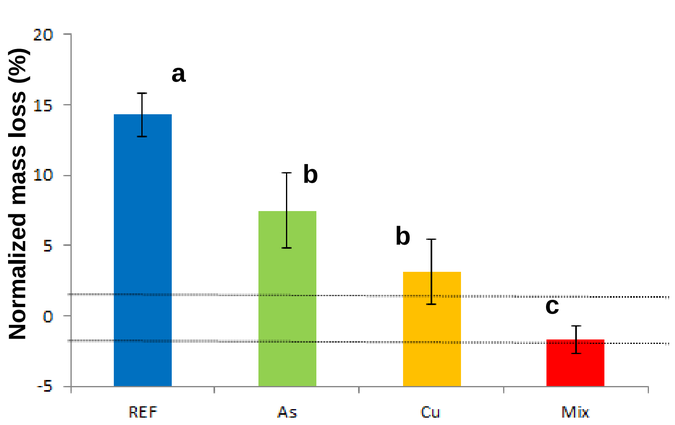


Fig. 2. Artificial tablet responses (n=3)

- **The two tested methods (i.e. bait lamina and artificial tablets) showed similar results under toxic pressure: strong effect of Cu and lowest effect of As on organic matter breakdown at environmentally relevant concentrations**
- **When testing the mixture, the combined effect of Cu and As was significantly higher than the effect of metals alone**
- **A higher variability among replicates was observed by using the bait lamina method ➡ qualitative vs. quantitative measurement**

Conclusions and Perspectives

- ✓ Using a laboratory microcosm study, we showed that environmentally realistic concentrations of Cu (alone or mixed with As) could exert a functional impact on sediment communities.
- ✓ Our results highlight the suitability of artificial organic matter substrates such as bait laminas or artificial tablets to assess the functional effects of metals on sediment communities (microorganisms and invertebrates)
- ✓ These results open new perspectives to assess the ecological quality of sediments and confirm the need for developing studies to better understand the ecotoxicological impact of contaminants on natural sediment communities.

References:
[1] ISO 18311, 2016. Soil quality -- Method for testing effects of soil contaminants on the feeding activity of soil dwelling organisms - Bait-lamina test.
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[4] MacDonald et al. (2000) *Arch. Environ. Contam. Toxicol.* **39**:20-31.

Acknowledgements: The authors thank Bernadette Volat, Josiane Gahou, Bernard Motte and Christophe Rosy for their technical support. Funding was provided by a grant from la Région Rhône-Alpes-Auvergne (France).

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