



Combined effects of clogging and copper-contaminated water on microbial communities in the hyporheic zone

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EcotoxicomicYR 2021

December 6th 2021

Combined effects of clogging and copper-contaminated water on microbial communities in the hyporheic zone

Laura Kergoat¹, Aymeric Dabrin¹, Thibault Datry¹,
Abdelkader Azougui¹, Bernadette Volat¹, Bernard
Motte¹, Christophe Rosy¹, Chloé Bonnineau¹

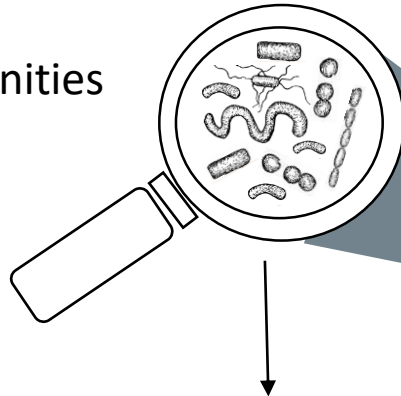
¹ INRAE, UR Riverly, Lyon-Villeurbanne, France

Hyporheic zone : “the saturated interstitial areas beneath the stream bed and into the stream banks that contain some proportion of channel water” ¹



¹ White, D. S. (1993). Journal of the North American Benthological Society 12, 61–69.

Microbial communities



Mineralization of **organic matter**²
Retention and degradation of **pollutants**^{3,4}

Filter for the river !

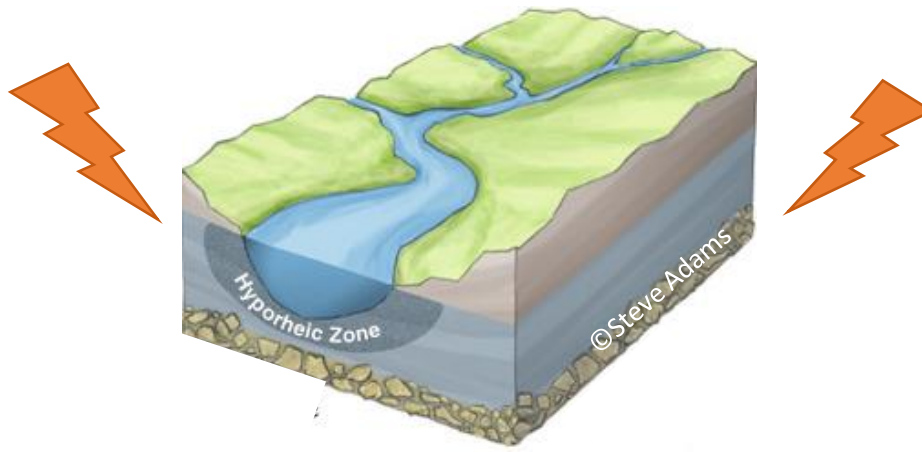


² Piscart, C. (2011). Science of The Total Environment 409, 4373–4380.

³ Gandy, C. J. (2007). Science of The Total Environment 373, 435–446.

⁴ Peralta-Maraver, I. (2018). Science of The Total Environment 610–611, 267–275.

Anthropogenic
stressors



Anthropogenic
stressors



Clogging

- **Fine sediment** deposition ⁵
- **Infiltration** into the hyporheic zone ⁵
- In part due to **soil erosion**



Anthropogenic
stressors



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Copper

- **Fungicide** used in agriculture
- Transferred to aquatic systems by **leaching**
- [Cu] = **22 mg/kg** in sediment (France) ⁶
Maximum > 4000 mg/kg

Anthropogenic stressors



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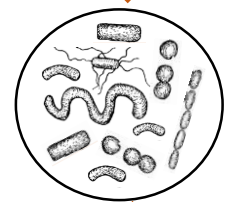
Ex : Stimulation of **denitrification** ⁷



Copper

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Maximum > 4000 mg/kg

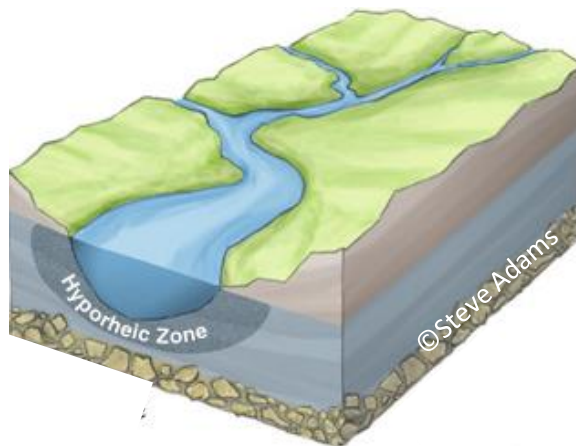
Ex : inhibition of **exoenzymatic activities** ⁸



⁷ Navel, S. (2011). *Microb Ecol* 61, 968–979. - ⁸ Mahamoud Ahmed, A. (2018). *Front. Microbiol.* 9, 1852.

⁵ Wood, P. J. (1997). *Environmental Management* 21, 203–217. - ⁶ INERIS 2010, Rapport d'étude

Anthropogenic stressors

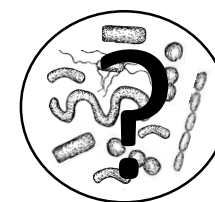


Clogging



Copper

- **Fine sediment** deposition ⁵
 - **Infiltration** into the hyporheic zone ⁵
 - In part due to **soil erosion**
-
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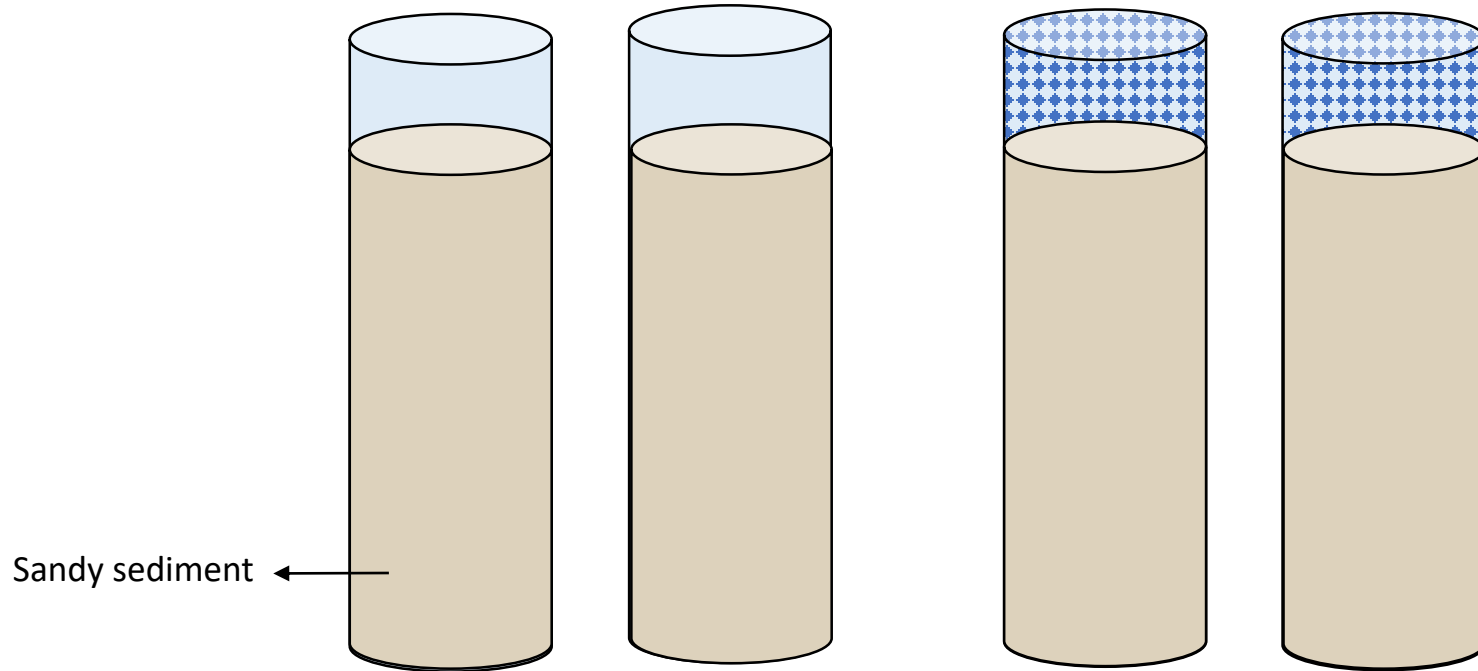
Combined effects

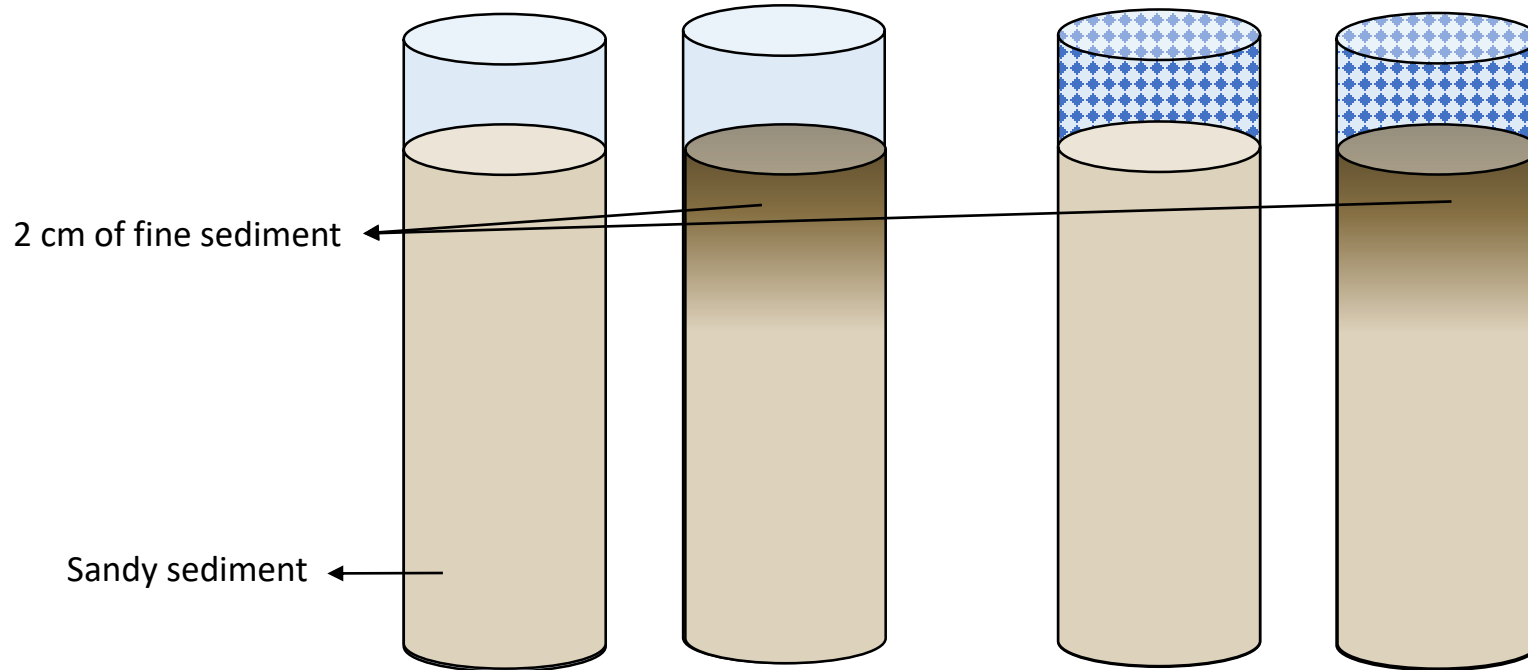
Anthropogenic
stressors

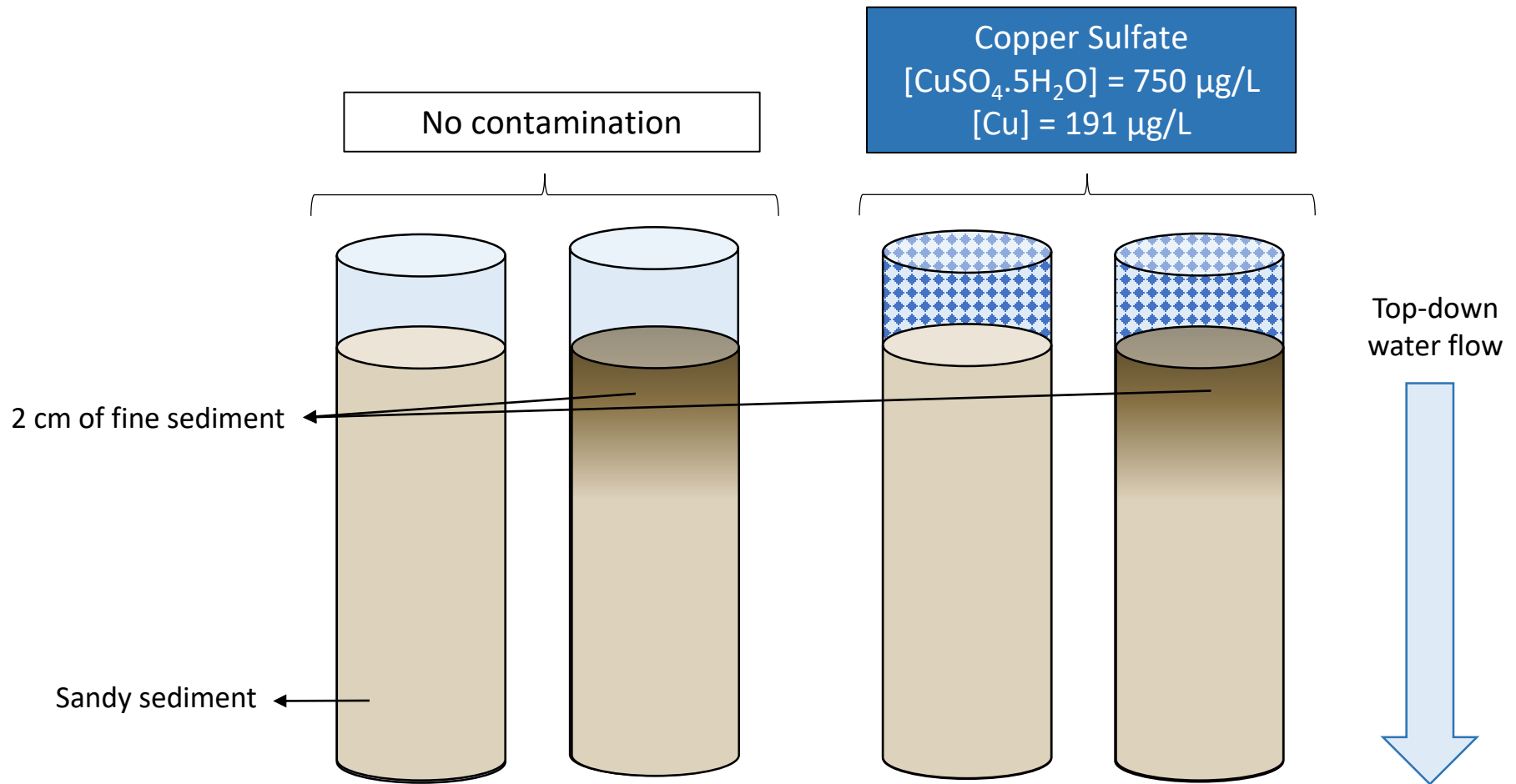


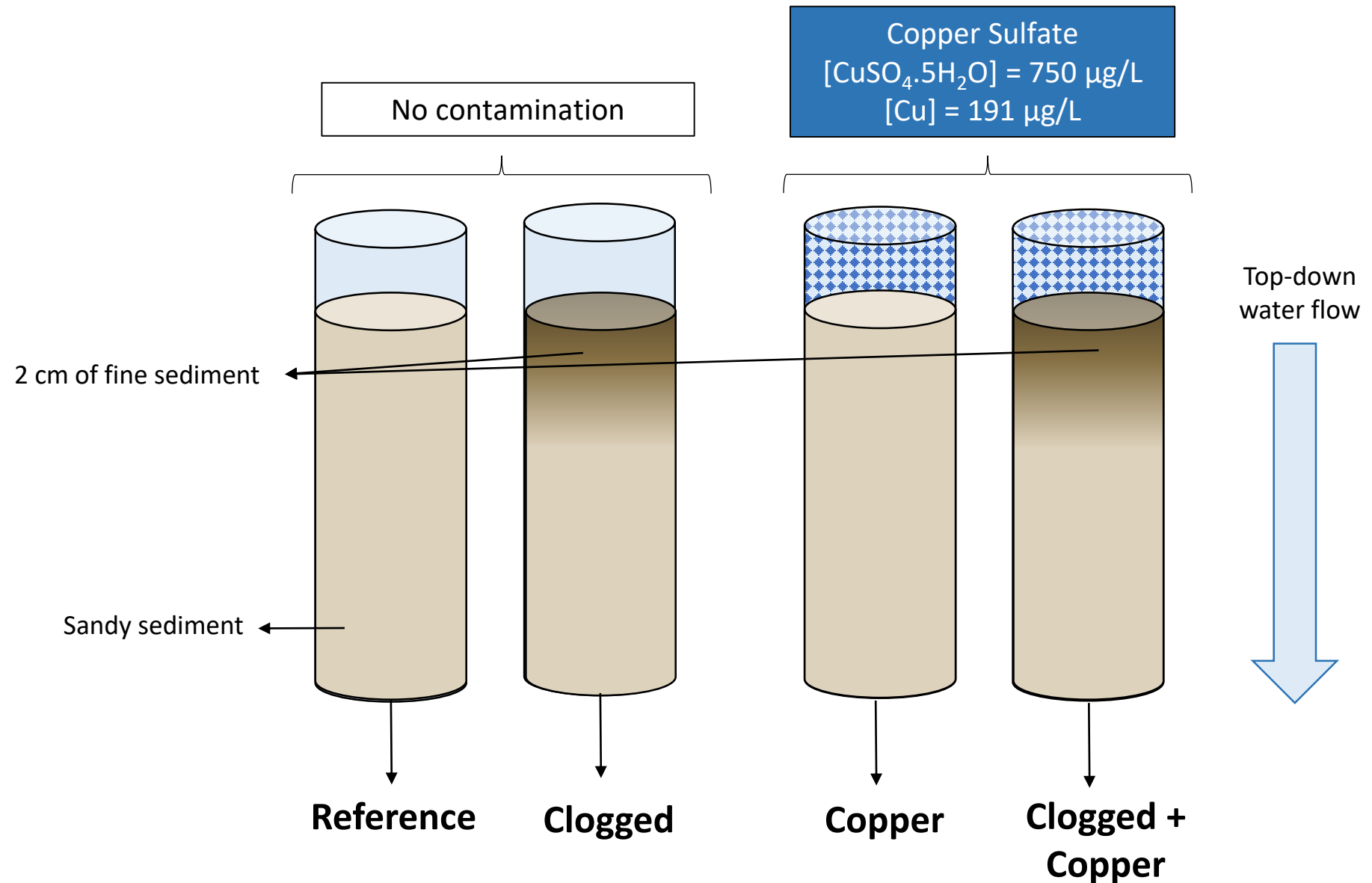
What are the combined effects of clogging and copper contaminated water on hyporheic microbial communities ?

Copper



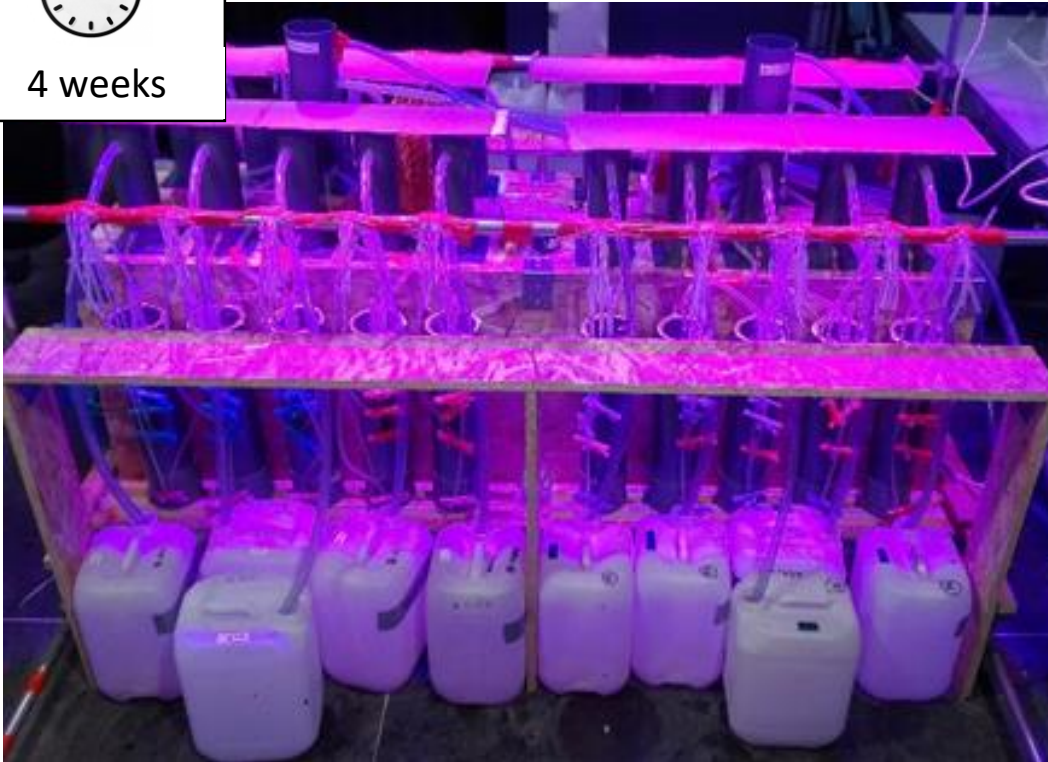




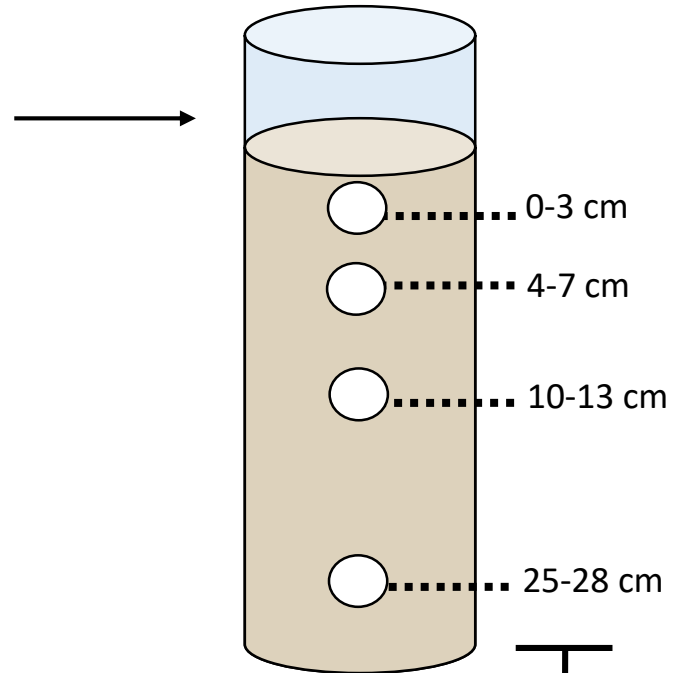




4 weeks



Sediment sampling

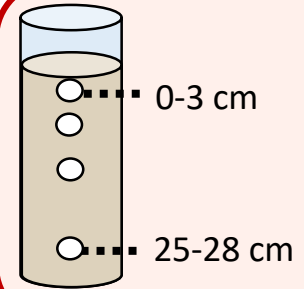
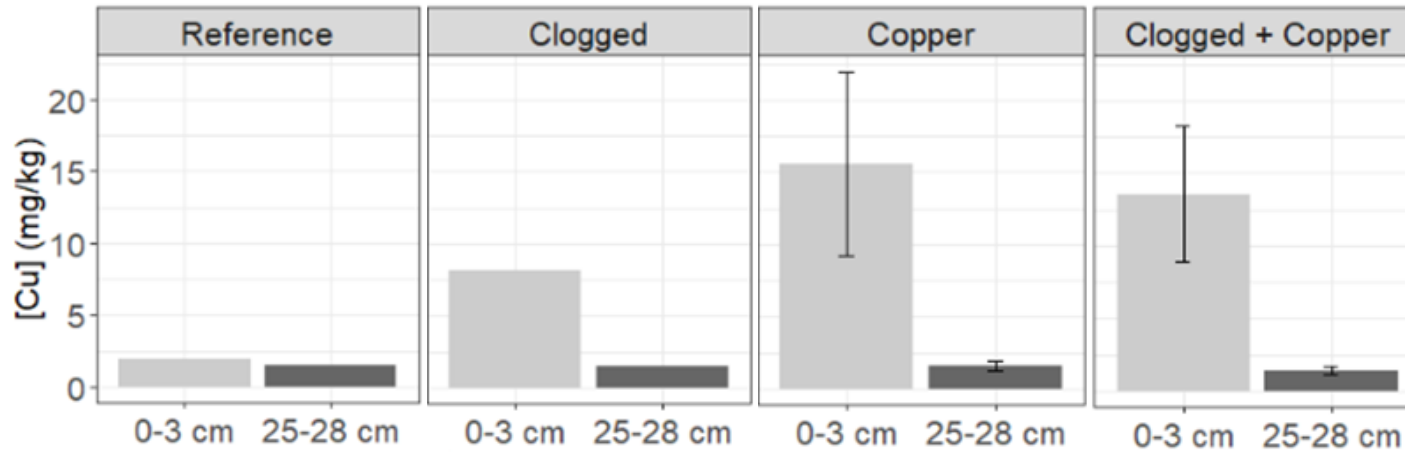


Physical and chemical parameters

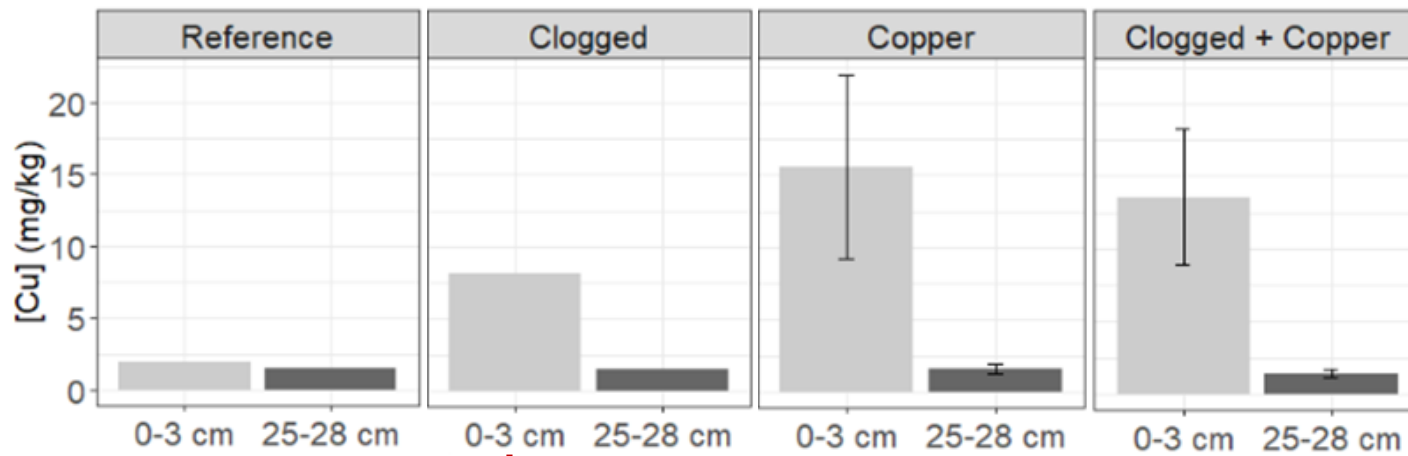


Microbial communities

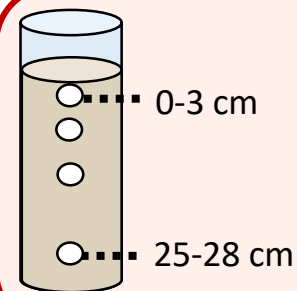
❖ Copper distribution in sediment



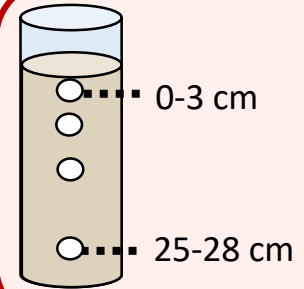
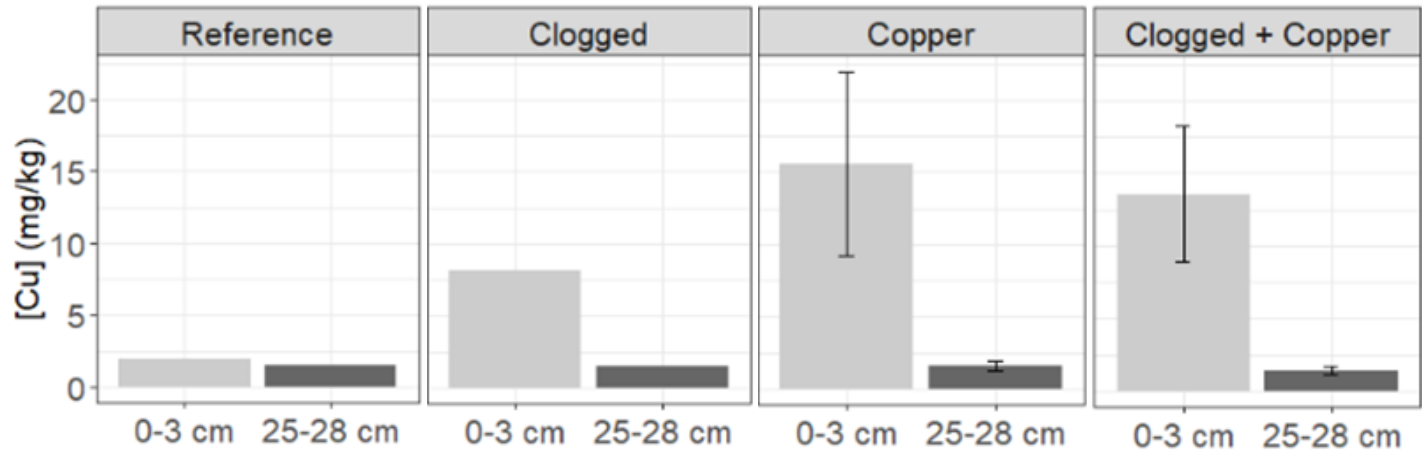
❖ Copper distribution in sediment



Sediment used for clogging was
copper contaminated
(30.19 mg Cu/kg in dry sediment)



❖ Copper distribution in sediment



similar copper distribution profiles

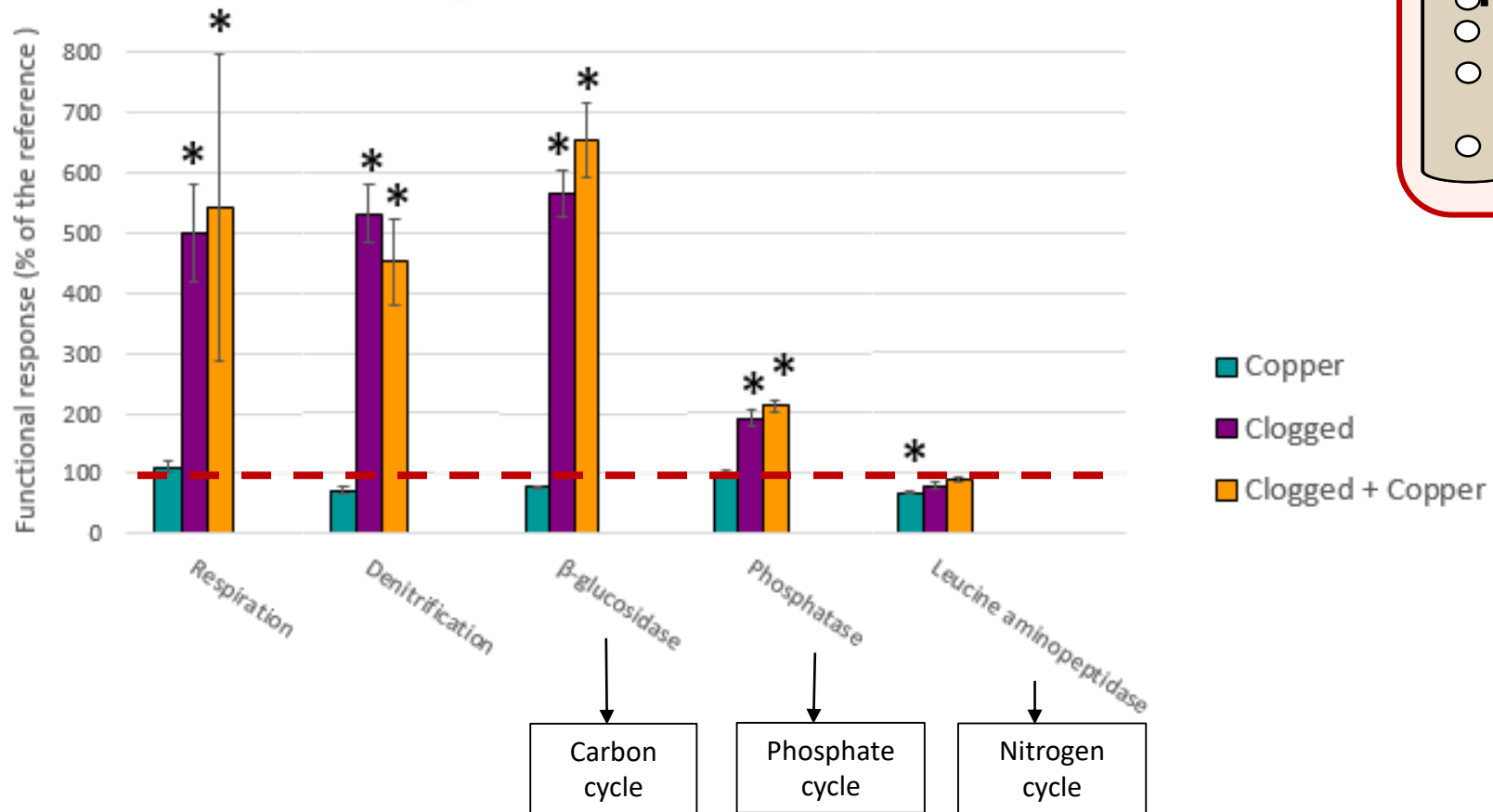
- Copper gets trapped in the first few centimeters regardless of clogging addition
- No diffusion of copper in depth in the presence or not of clogging sediment



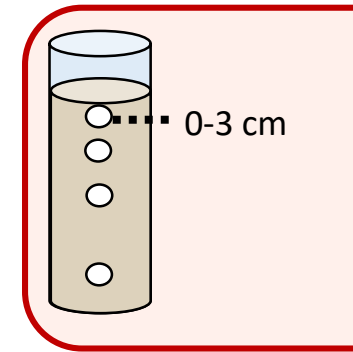
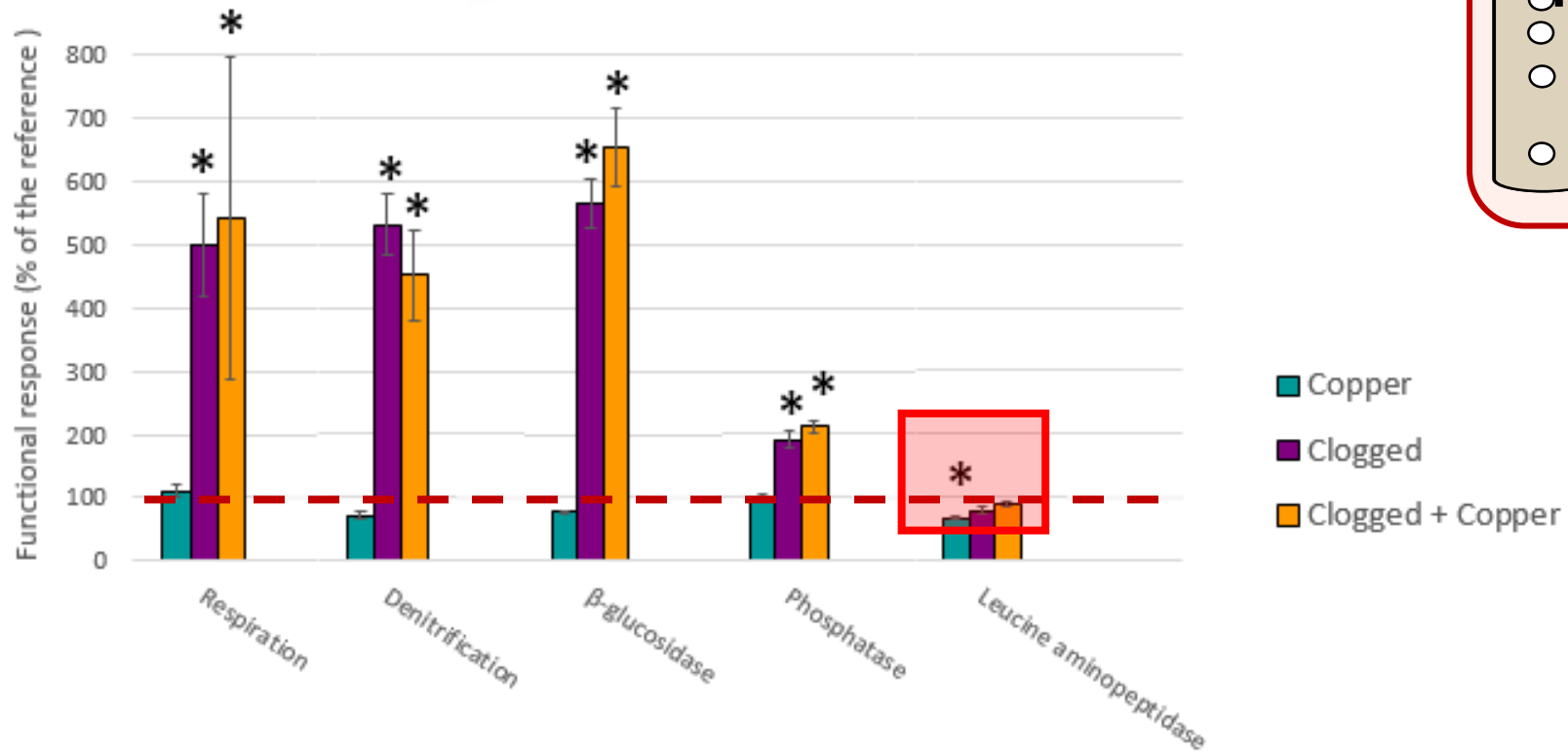
Filter role of hyporheic zone for copper !



❖ Microbial functions



❖ Microbial functions

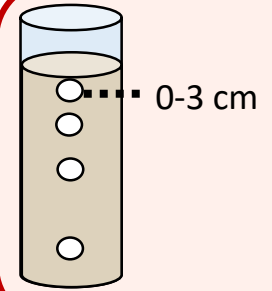
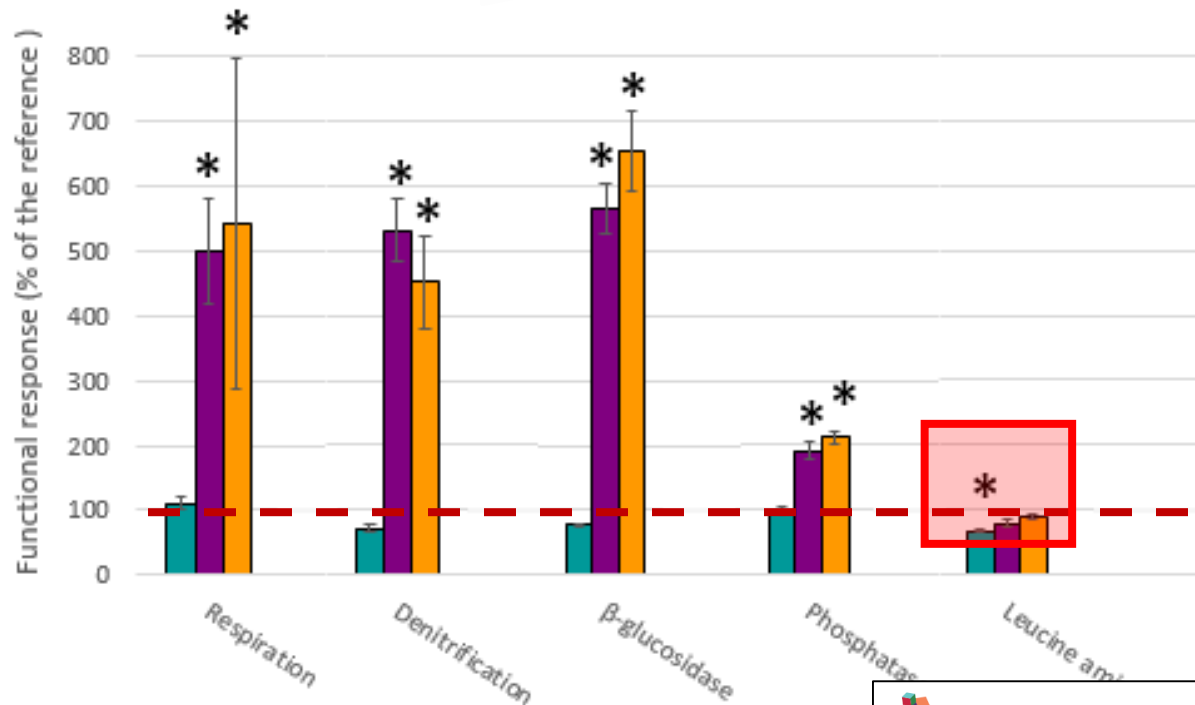


No effect of copper except for leucine aminopeptidase

Copper concentration ?

Adaptation of microbial communities ?

❖ Microbial functions

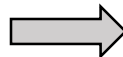


■ Copper
■ Clogged
■ Clogged + Copper

No effect of copper except for leucine aminopeptidase

Copper concentration ?

Adaptation of microbial communities ?



frontiers
in Microbiology

ORIGINAL RESEARCH
published: 14 August 2018
doi: 10.3389/fmicb.2018.01852



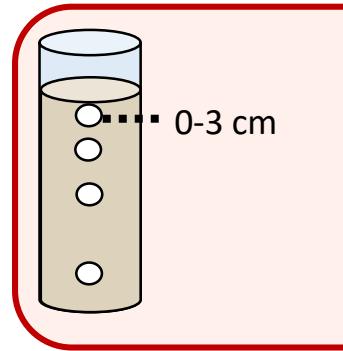
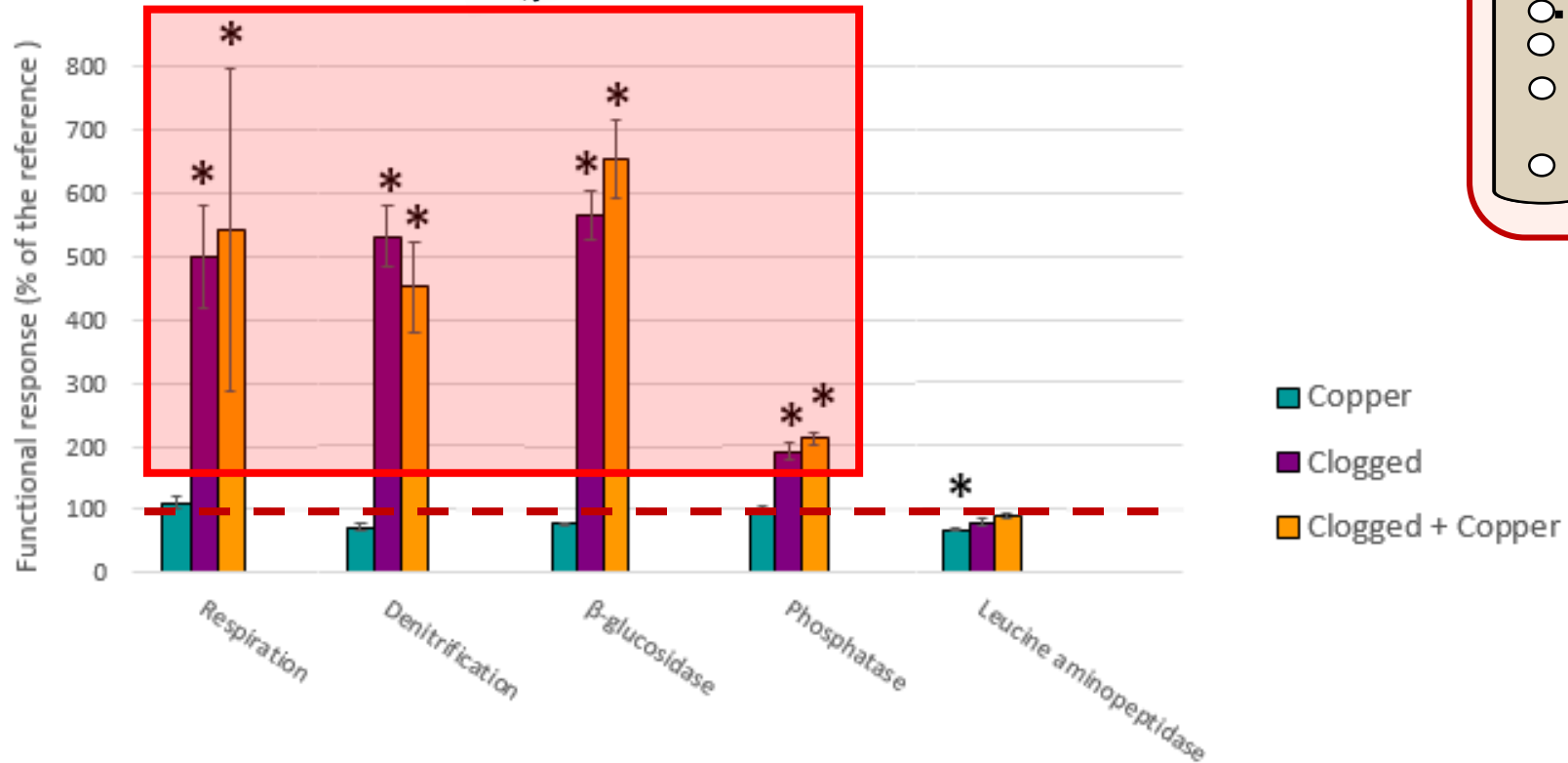
Environmental Concentrations of Copper, Alone or in Mixture With Arsenic, Can Impact River Sediment Microbial Community Structure and Functions

Ayanleh Mahamoud Ahmed^{1,2,3}, Emilie Lyautey², Chloé Bonnineau¹, Aymeric Dabrin¹ and Stéphane Pesce^{1*}

¹ Irstea, UR RiverLy, Centre de Lyon-Villeurbanne, Villeurbanne, France, ² CARTELE, Univ. Savoie Mont Blanc, INRA, Chambéry, France, ³ Centre de Recherche, Université de Djibouti, Djibouti, Djibouti

(Stars indicate significant differences from Reference for a given depth after a Tukey post hoc test)

❖ Microbial functions



No effect of copper except for leucine aminopeptidase

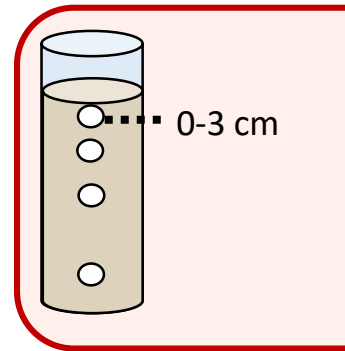
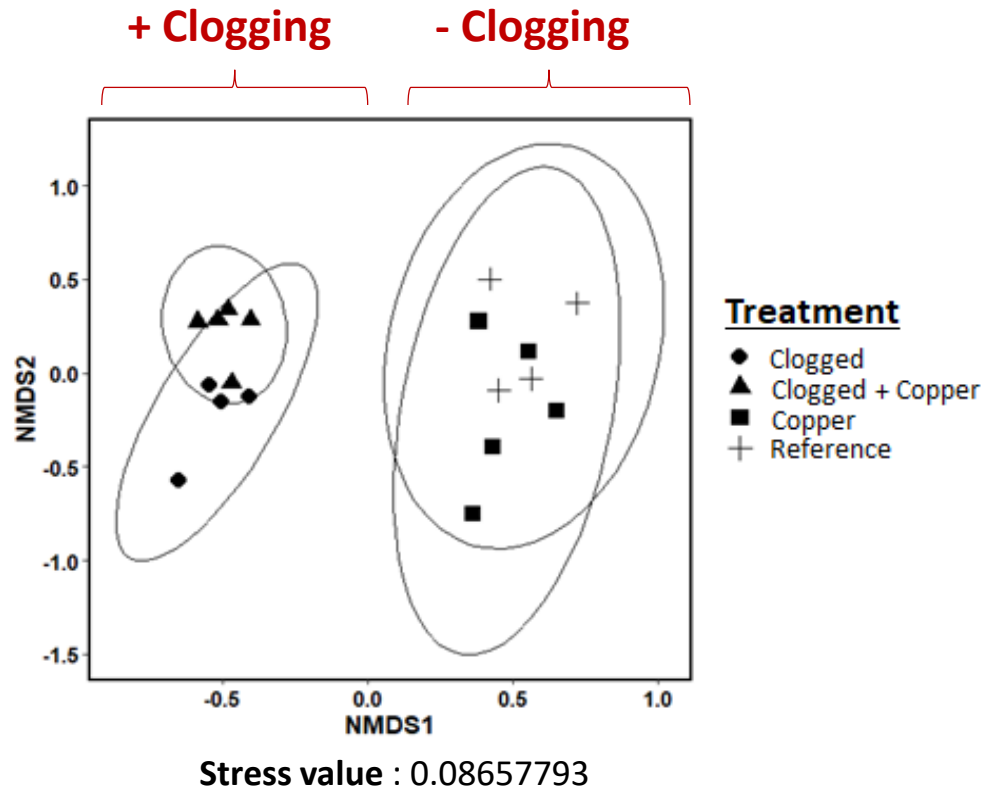
Stimulation of microbial activities in the presence of clogging

Copper concentration ?

Adaptation of microbial communities ?

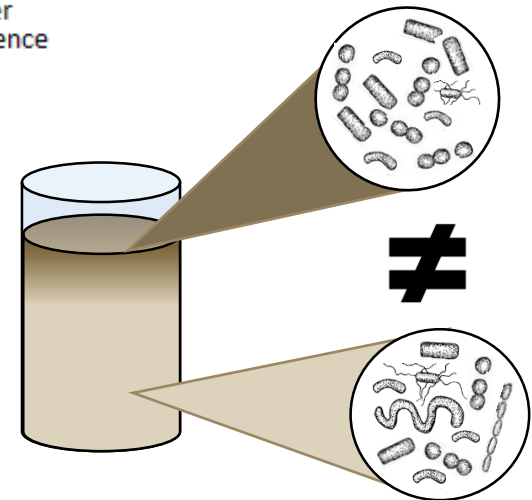
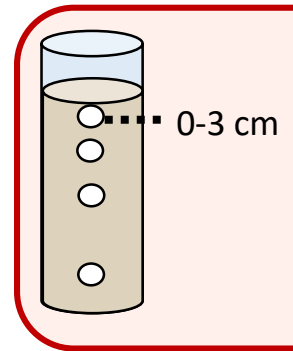
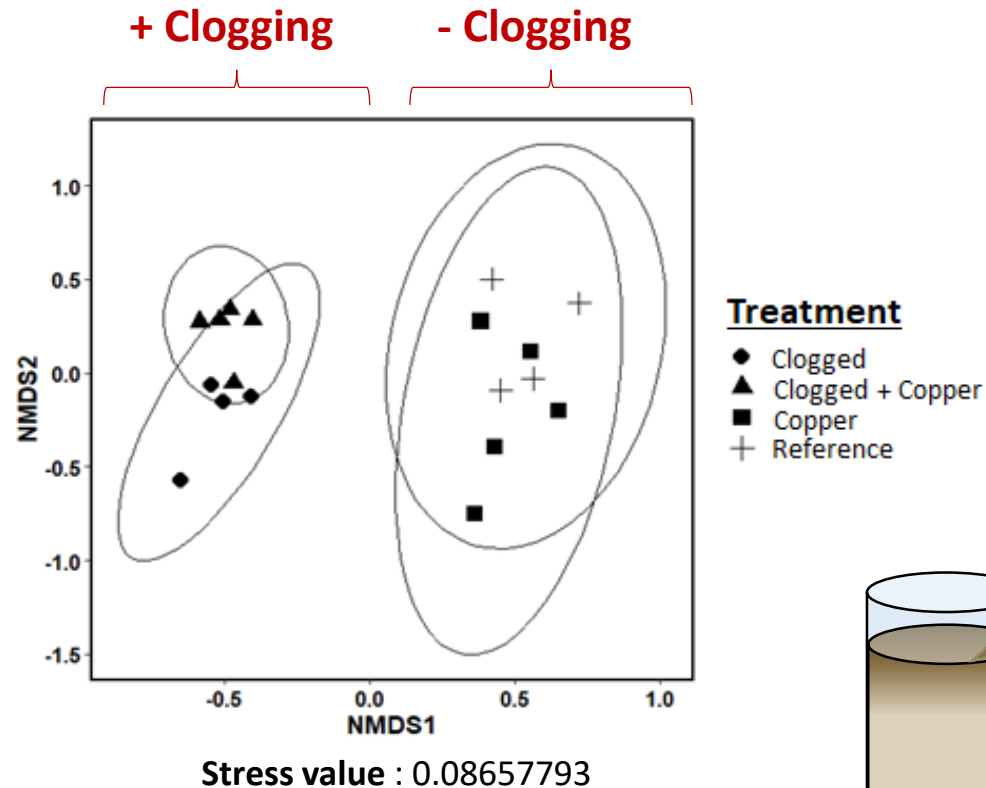
High organic matter content (16.8%)?

❖ Microbial structure (ARISA)



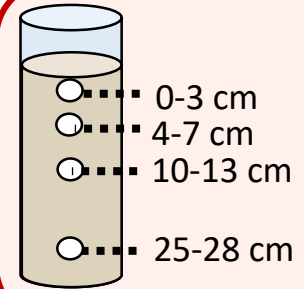
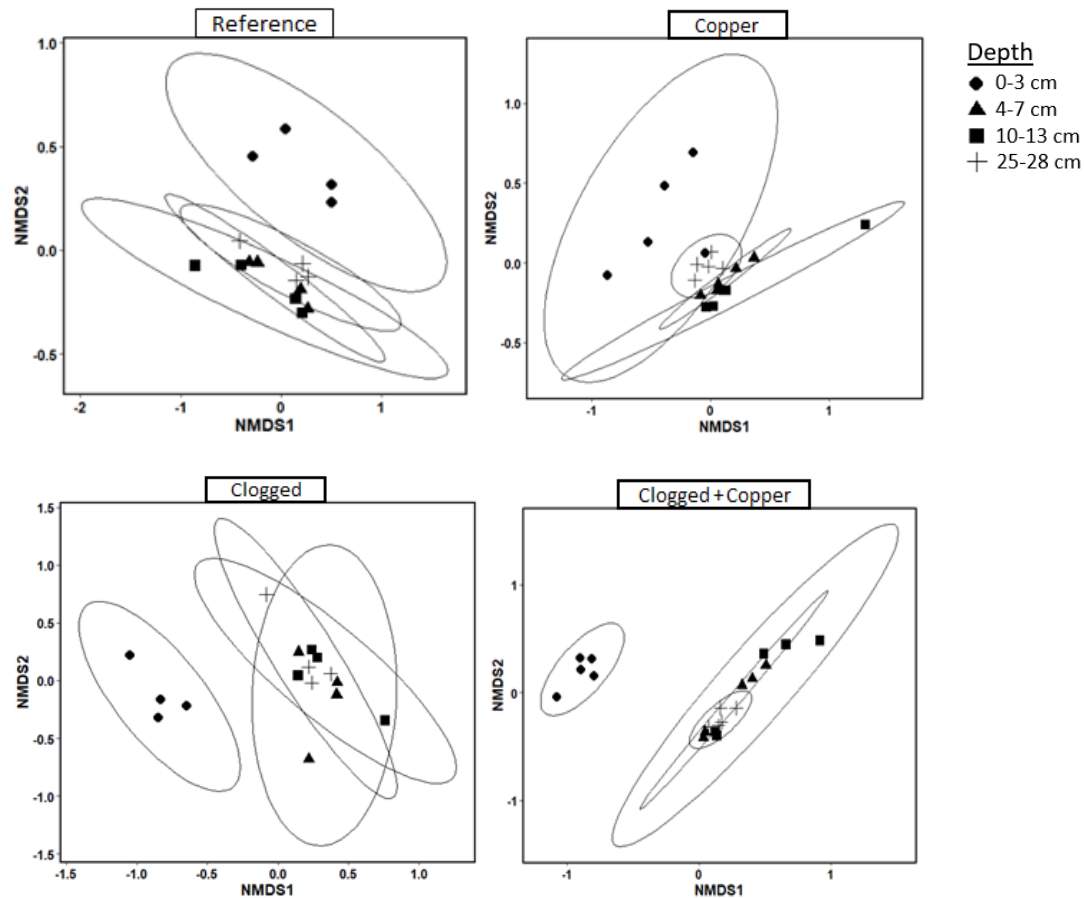
Separation in two groups : exposed or not exposed to clogging
Small effect of copper at the tested concentration

❖ Microbial structure (ARISA)

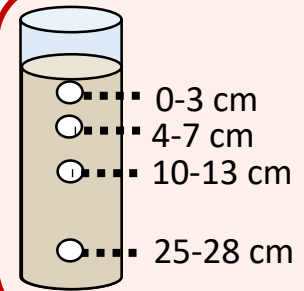
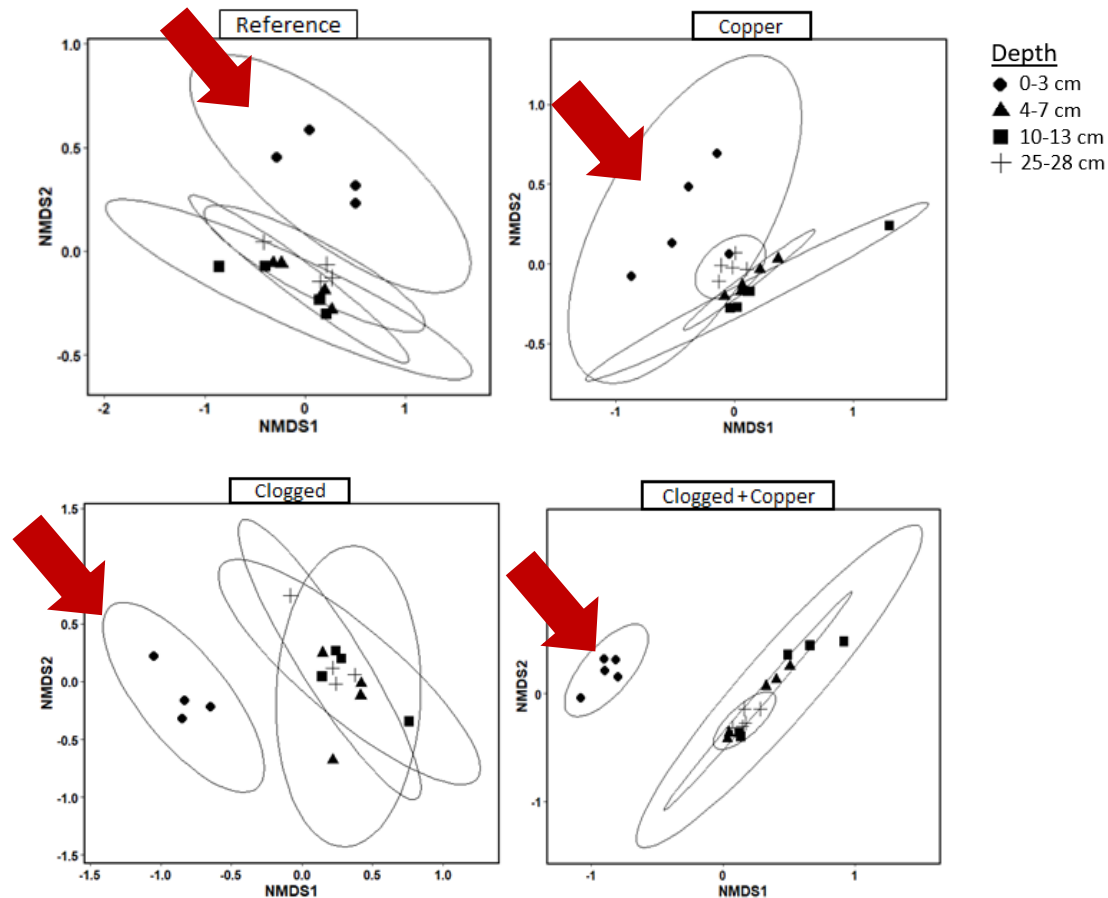


Separation in two groups : exposed or not exposed to clogging
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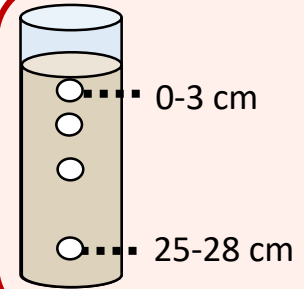
❖ Microbial structure (ARISA)



Distinction of the **first centimeters (0-3cm)** from the other depths
 -> **Particularity of the interface**

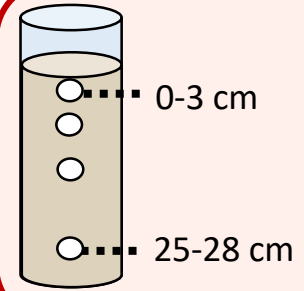
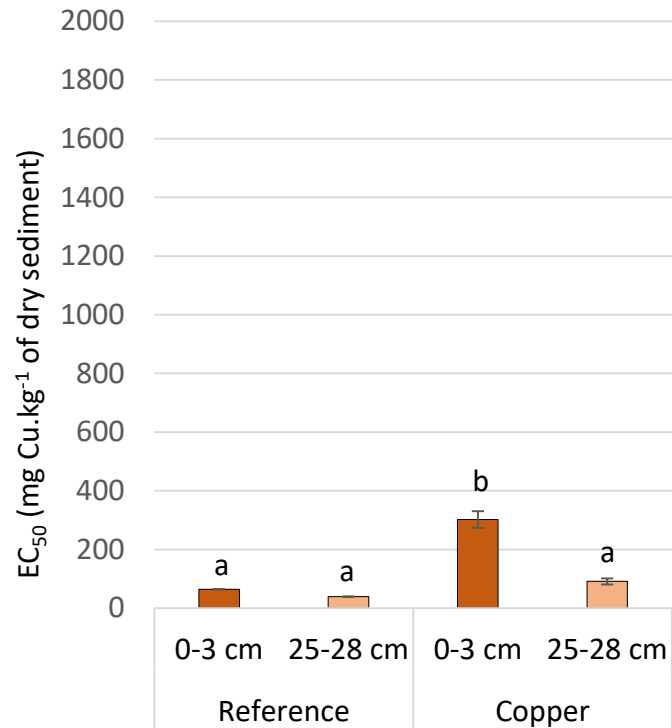
❖ Acquisition of copper tolerance in microbial communities

EC50 = Concentration causing 50% reduction in microbial activity (β -glucosidase) measured in an acute toxicity test (PICT method)



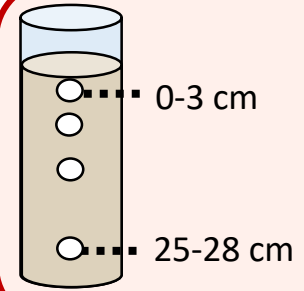
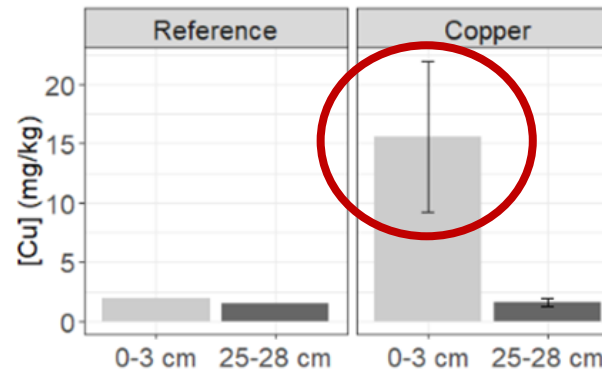
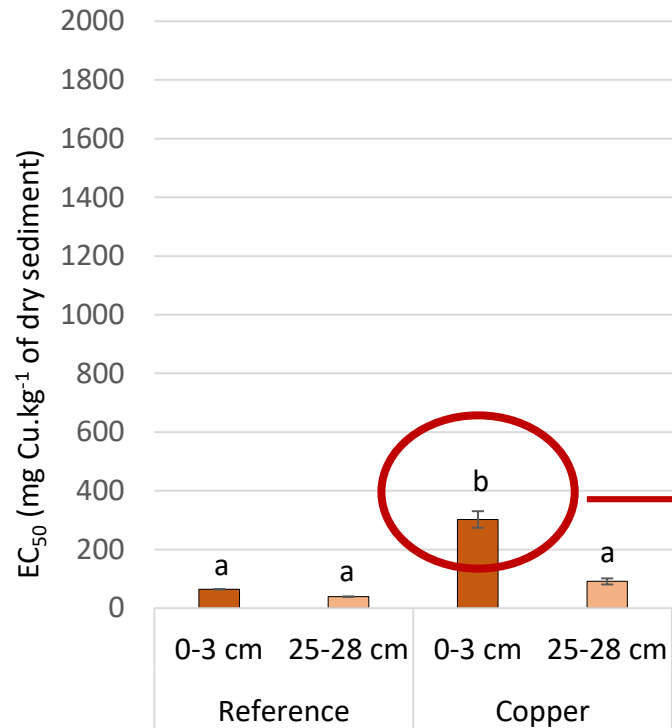
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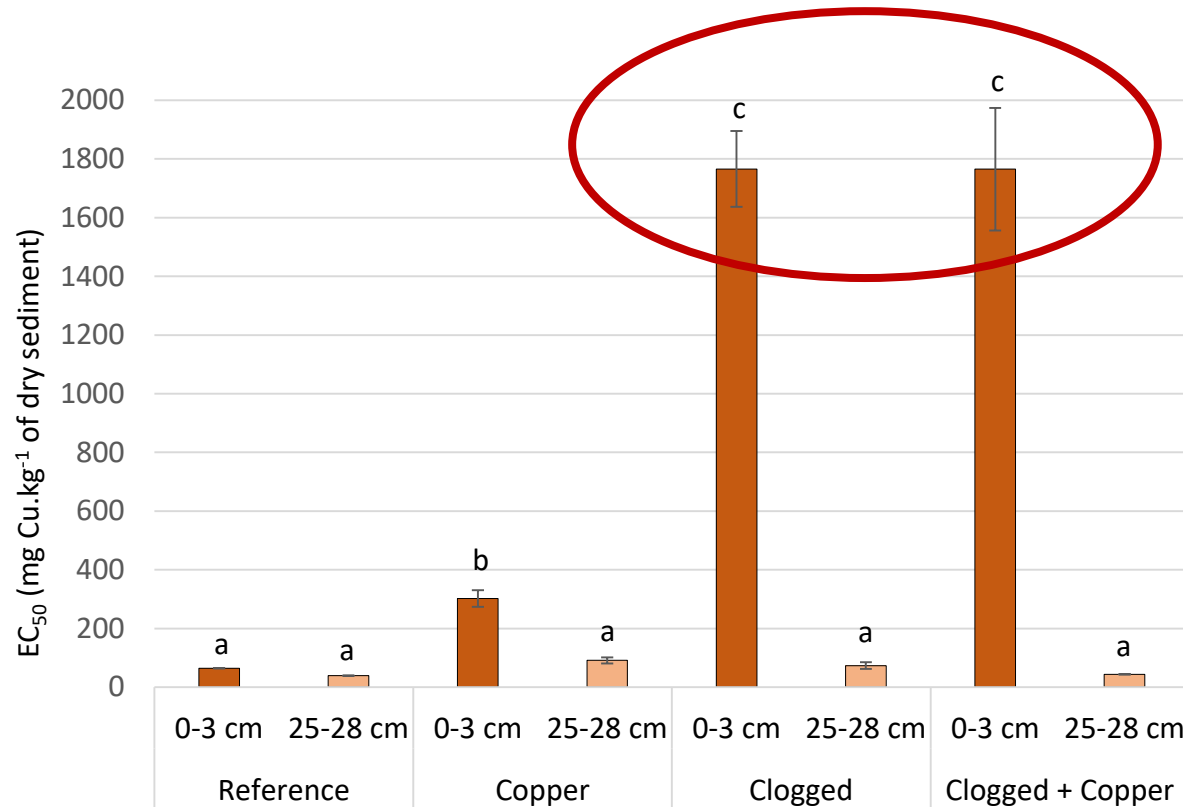
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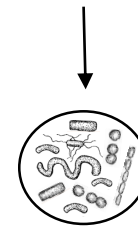


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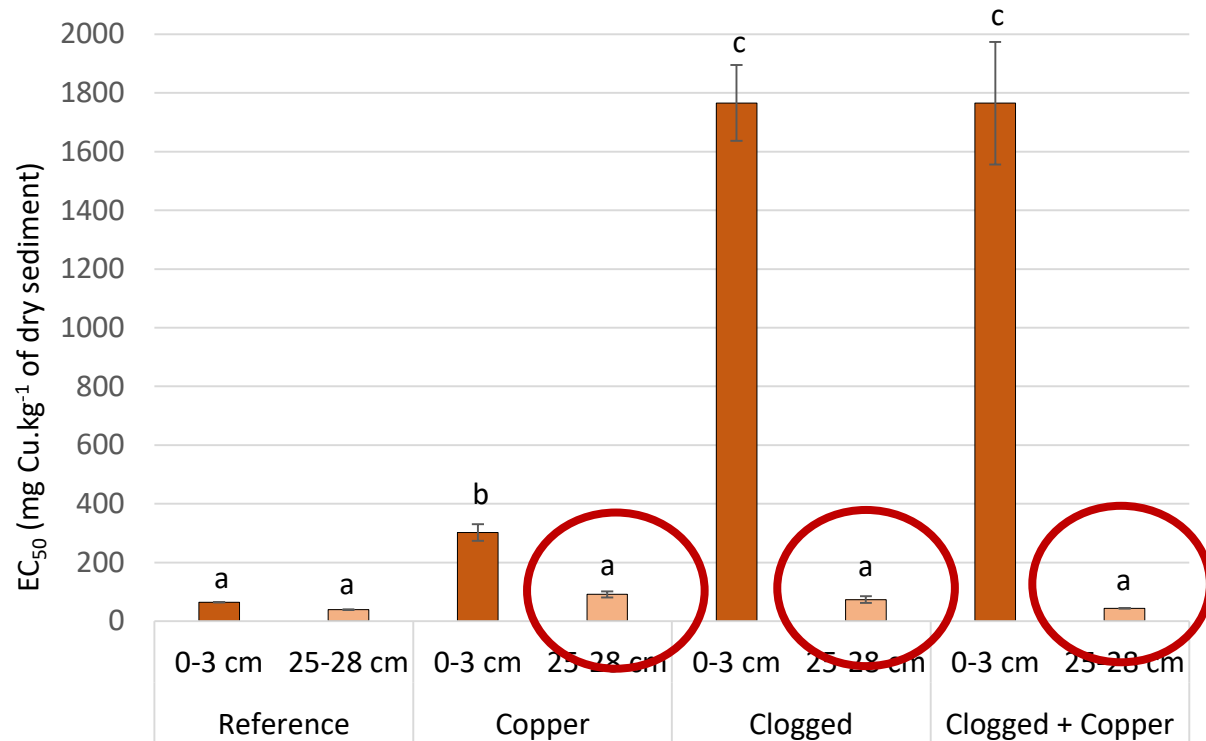
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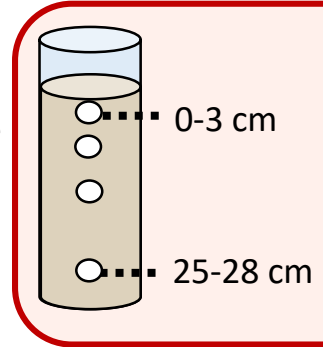
Already copper
tolerant?

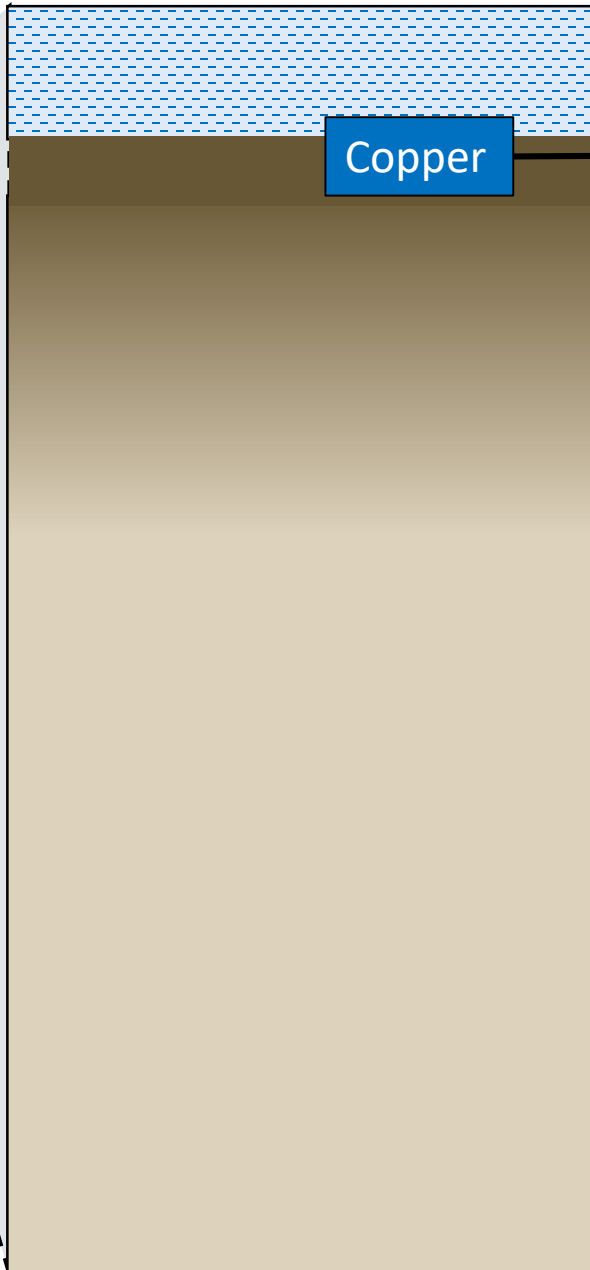
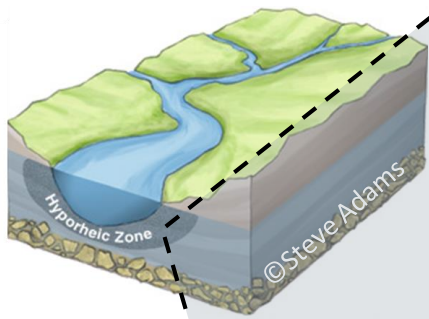
❖ Acquisition of copper tolerance in microbial communities

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→ No diffusion of copper tolerance in deep zone

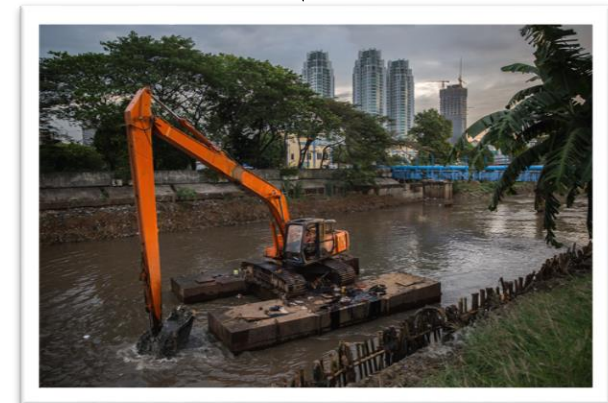




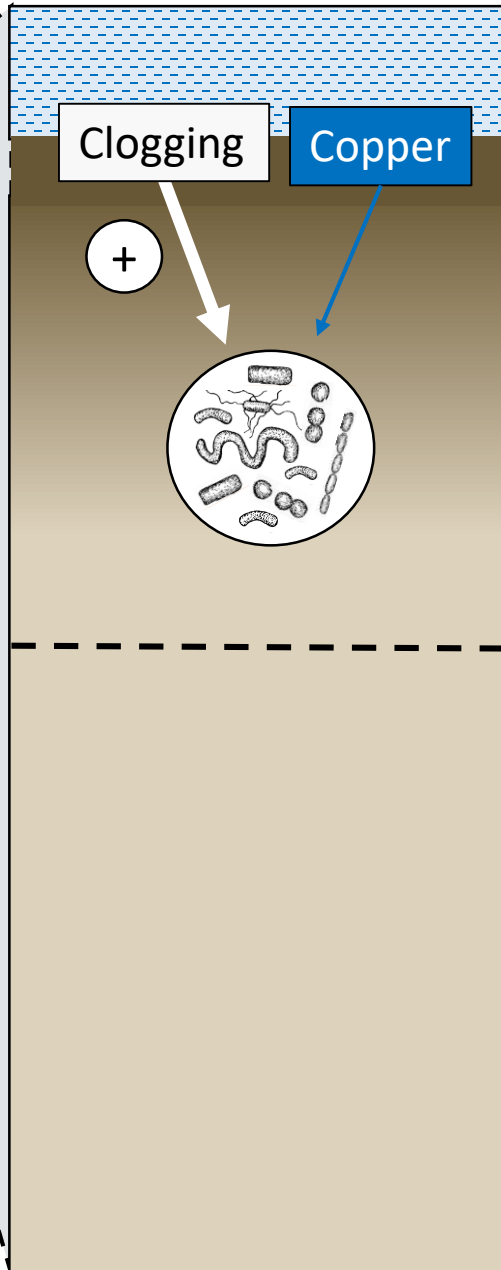
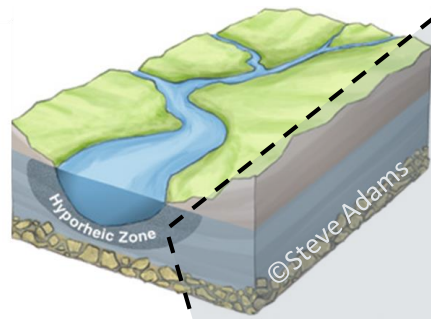
Copper

Copper fixation in the first centimeters
with or without clogging

Filter role of hyporheic zone

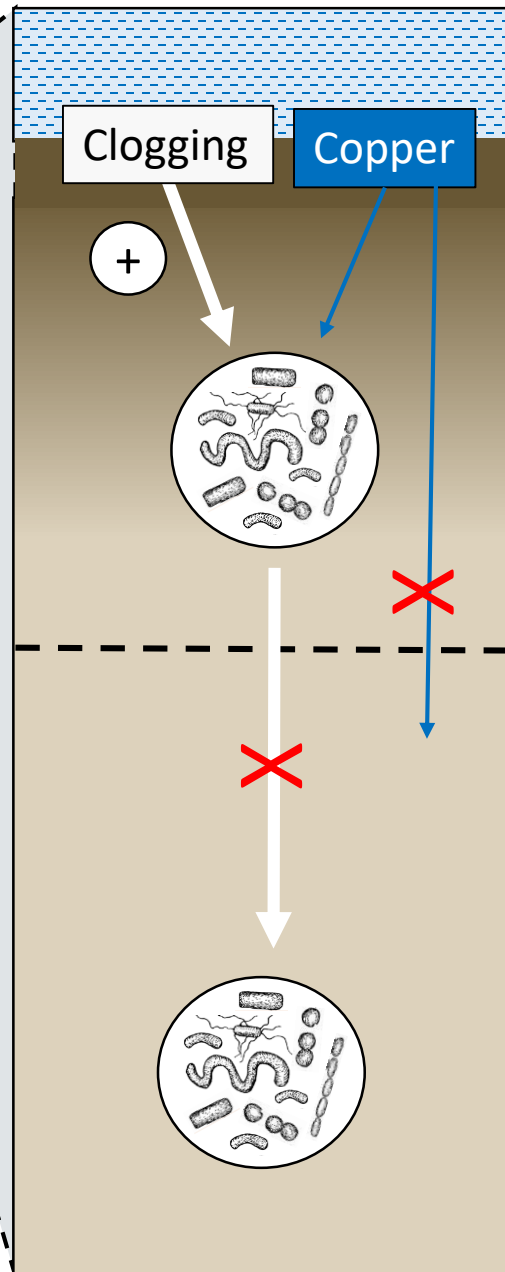
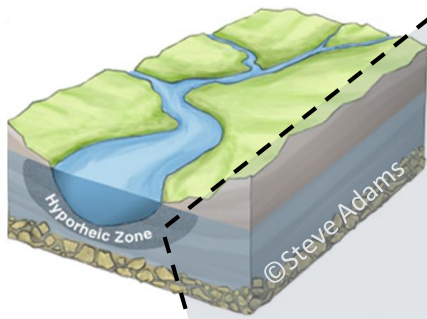


Remobilization of copper !



Subsurface = active microbial interface

- ✓ Clogging strongly affects microbial functions (stimulation) and microbial structure
- ✓ Copper had little effects on microbial function and structure
- ✓ Copper tolerance acquisition in relation with copper exposure



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- ✓ Clogging strongly affects microbial functions (stimulation) and microbial structure
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Deeper layers = protection of microbial communities

- ✓ No transfer of copper tolerance acquisition
→ Sensitive species reservoir -> recolonization after a major surface stressors (e.g. drying)

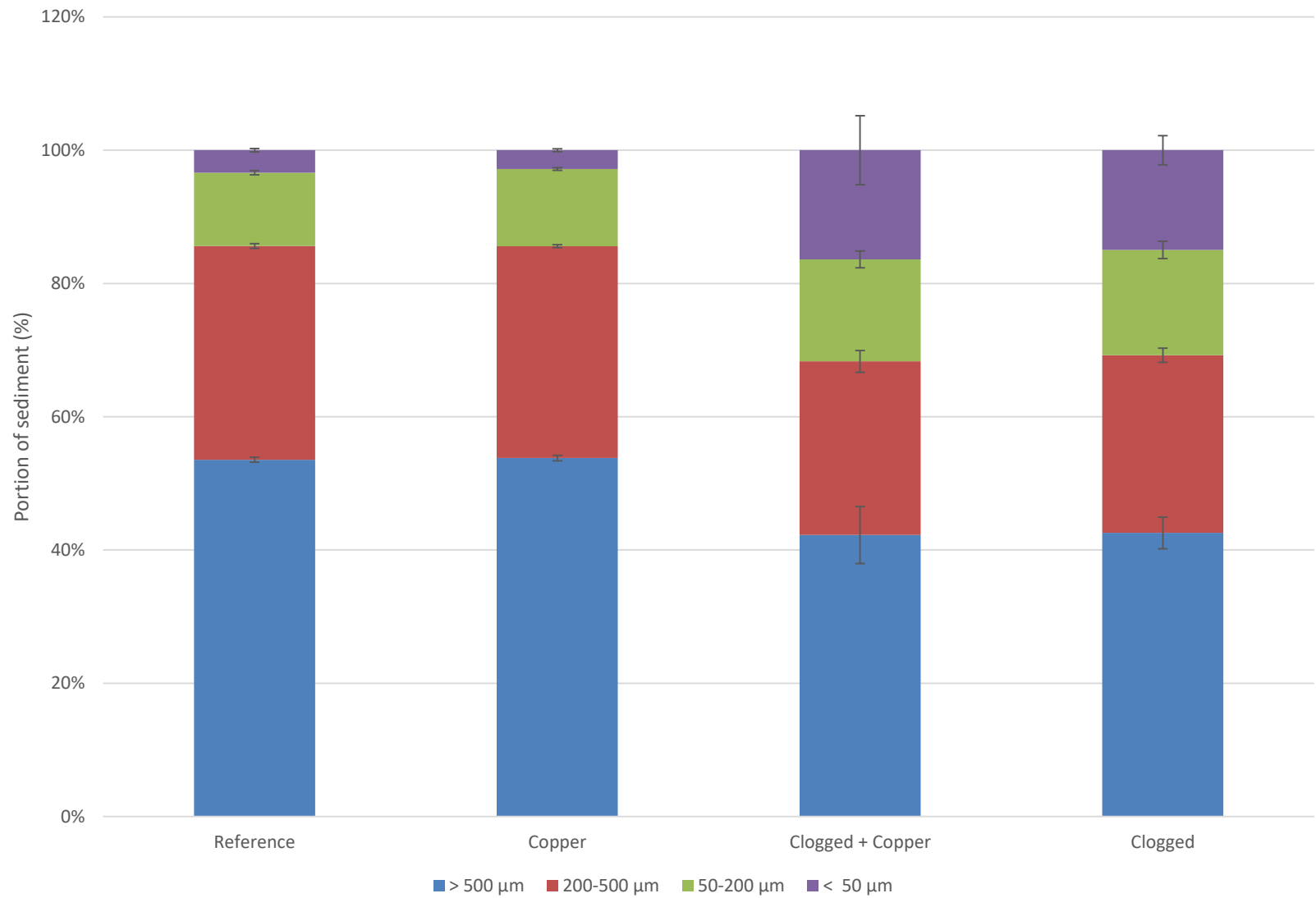




laura.kergoat@inrae.fr

> Thank you for your attention !





PICT method

