Biofilm response to metal contaminated sediment and indirect effects on grazers

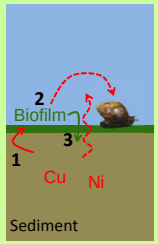
David M. Costello (dcostel@umich.edu) and G. Allen Burton
School of Natural Resources & Environment, University of Michigan

Background

- In streams, biofilms drive ecosystem functions and fuel food webs, yet are rarely examined in ecotoxicology
- Physical and geochemical interactions between biofilm and sediment can potentially expose biofilms and grazers to toxic metals.
- Many metal/biofilm interactions may be modified by the abiotic stream context (e.g., light, nutrients)

Research Questions

1. Do sediment metals affect biofilm biomass and function?
2. Can sediment metals indirectly affect grazers through trophic interactions with biofilms?
3. Can primary production increase DO penetration and potentially release sediment metals?
4. Are biofilm/sediment metal interactions context dependent?



Schematic of direct and indirect interactions between biofilm, grazers, and metal-contaminated sediments

Study Location

- Field experiments were conducted in four streams on the south shore of Lake Superior (Big Bay, MI, USA)
  Elm, Rush, Pine, and Salmon-Trout R.
- The Eagle Mine is a new (excavation began Fall 2011) nickel-copper mine on the Yellow Dog Plains just upstream of the study streams

Location of streams in which experiments were conducted (pins) and the location and overhead photograph of the Eagle Mine

Methods

- A single sediment was spiked with Ni and Cu (Table 1) and equilibrated under anoxic conditions for 4 weeks.
- Sediment was placed in chemical exposure cups (CES), covered with nylon mesh for biofilm attachment, and deployed into the streams.
- After 6 weeks, mesh was separated from the sediment and endpoints were measured:
  - Biofilm net primary production (NPP) and biomass
  - *Lymnaea stagnalis* feeding rates
  - Sediment Cu, Ni, and AVS
  - Sediment DO with microelectrodes (Rush and Elm)

Table 1. Initial sediment metal concentrations
Acid volatile sulfide (AVS) is 3.5 µmol/g

Treatment	Copper (mg/kg)	Nickel (mg/kg)	Total Me (µmol/g)
Ref.	22	7	0.5
Low	123	68	3.1
Med	237	93	5.3
High	432	238	10.9

L to R: A single CES cup, CES cups secured to the streambed, biofilm mesh incubated for NPP, and microelectrode profiling of a CES cup

Results

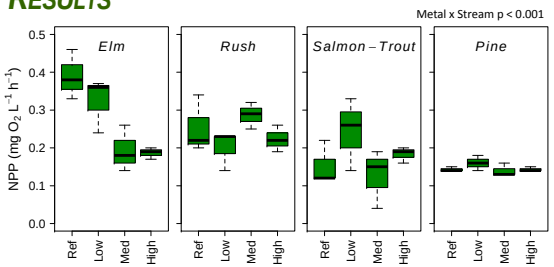


Figure 1. Biofilm NPP response to sediment Cu and Ni in four streams

- Biofilm growth and production (Fig. 1) was reduced by sediment metal only in a single stream (Elm)

Results

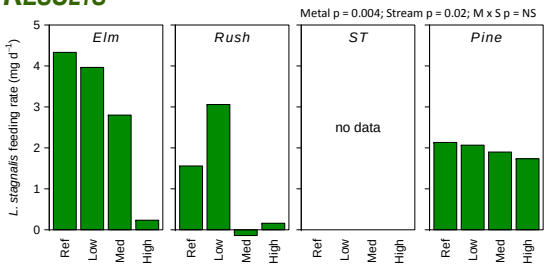


Figure 2. Mean snail feeding rates on biofilm grown on Cu and Ni contaminated sediment in four streams

- Snail feeding rates were reduced in all streams when fed biofilms grown on high metal sediment (Fig. 2)
- Biofilms photosynthesis increased DO penetration into sediments (Fig. 3)
- Cu and Ni in the sediment reduced DO penetration only in Elm, consistent with reduced NPP (Figs. 1 & 3).
- Biofilms that do not exhibit a toxic response to metals may increase oxidation of metal sulfides

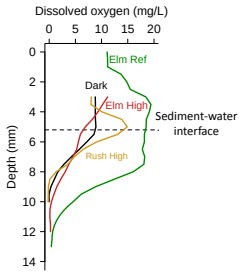


Figure 3. DO concentration at depth in four CES cups.

Conclusions

- Sediment metals can affect biofilm growth and function, but the response is context dependent.
- Indirect effects on grazers were observed in all streams suggesting that indirect effects of toxic chemicals are more common than direct effects.
- Biofilm primary production can increase depth of DO penetration in sediment potentially oxidizing metal sulfides and releasing metals to overlying waters.
- Biofilms interact dynamically with sediment metals and are an important controlling factor in the toxicity of metals to ecosystem structure and function.

Acknowledgements. Thanks to Anna Harrison, Megan Wiitala, Shelly Sawyers, Lauren Kinsman-Costello, Kyle Fetters, Kathleen Presley, Maggie Grundler, Cori Cramer, Shahara Waas, Meghan Myers, and Raíssa Medonça for field and lab help. Financial and logistical support for this work was provided by Huron Mountain Wildlife Foundation, NiPERA, and Rio Tinto.