From the natural environment to mesocosms: Biofilm as a bioindicator of metal contamination of rivers

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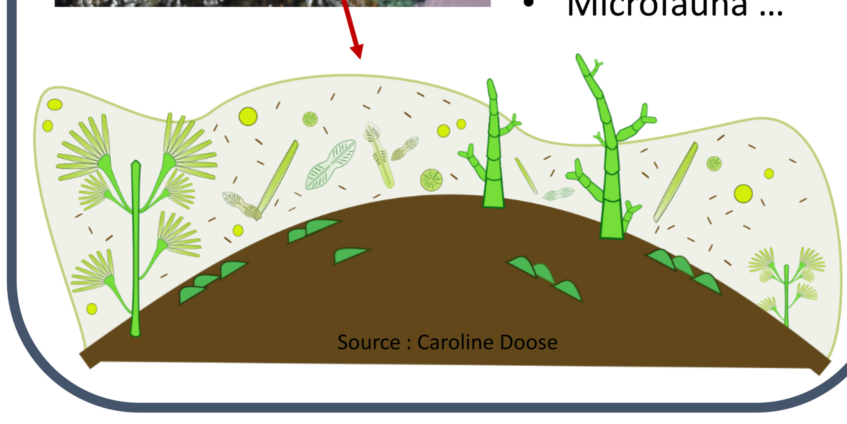
Introduction

Canada has large mining resources and their booming exploitation may lead to environmental degradation. In this context, the use of bioindicators such as biofilms represents a complementary tool to the traditional physico-chemical assessment, and provides a more complete and integrated portrait of an ecosystem's health. Stream biofilms are sessile and ubiquitous, which are valuable characteristics for biomonitoring and they are at the base of the trophic chain (and thus a key entry point for contaminants into the trophic chain). Moreover, they integrate the inherent variability of element concentrations in their ambient environments. Biofilm biodiversity, bioaccumulation of metals or other contaminants and occurrence of diatom teratologies (deformations) are biological descriptors that bring additional information on ecosystems integrity. The goal of this study is to bring insight on the use of biofilms to develop an approach incorporating physical, chemical and biological information to assess the impacts of metals on freshwater ecosystems in an ecologically integrated perspective.

Biofilms are a complex mixture of:
- Bacteria
- Microalgae
- Fungi
- Microfauna ...



Objectives

(1) Investigate the correlation between the biofilm metal content and the dissolved metal concentrations in rivers surrounding mining sites
(2) Add biological descriptors to improve the understanding of the effects of metals on biofilms, focusing on diatom assemblages
(3) In artificial streams, study the links between the biofilm Ni content and the free Ni^{2+} concentrations in exposure media and investigate how physical parameters such as luminosity and temperature can modulate Ni bioaccumulation in biofilms

Methods

Two approaches :

(1) In the field → comparaison of 2 mining regions:
- North of Nunavik, QC, Canada
- Region of Sudbury, ON, Canada

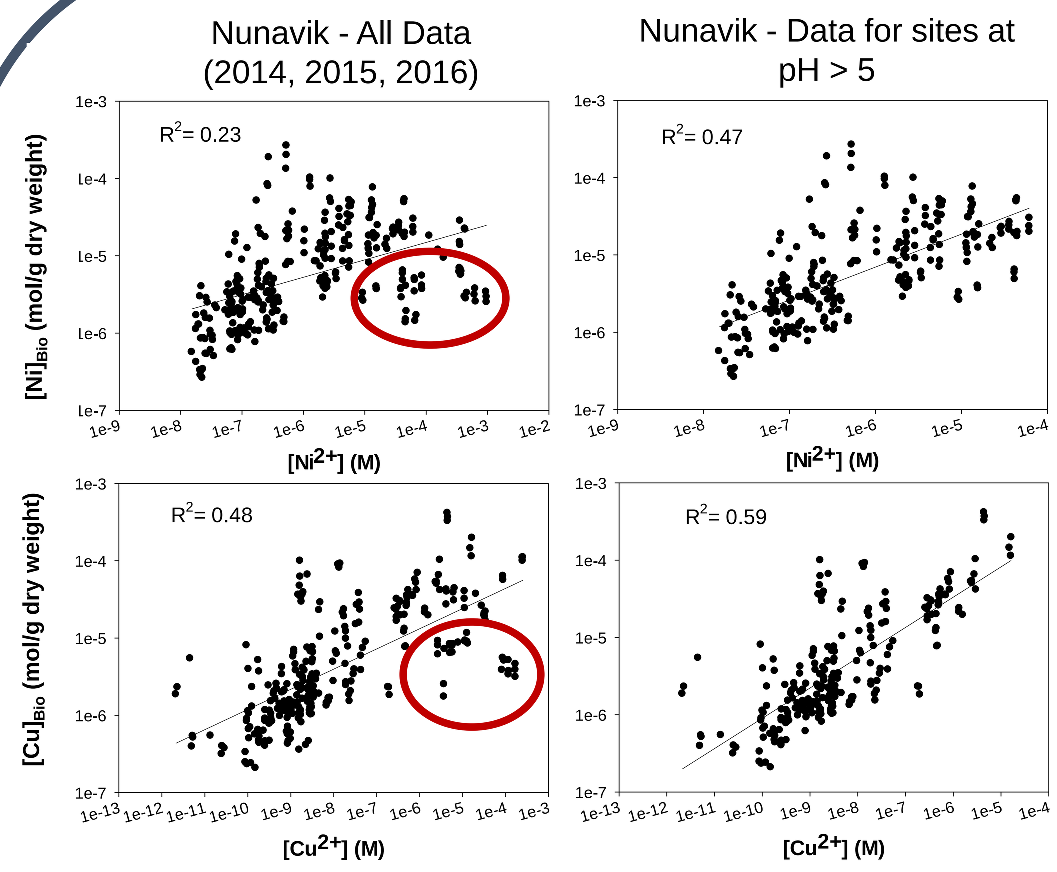
(2) In the laboratory → use of artificial streams and synthetic culture media:

- Different concentrations of [Ni^{2+}] (0, 5, 20, 50 and 100 µM) (n=2)
- Two dark/light periods (16/8 vs 12/12)
- Two temperatures (14°C and 20°C)
- 28 days of exposure
- 6 sampling times (n=3) T_0 - T_4 - T_7 - T_{14} – T_{21} - T_{28} (d)

Water quality monitoring	Bioaccumulation in biofilms	Structure of biofilms
Traditionnal physico-chemical analyses (pH, χ, T°, C+, A-, DOC, PT...)	EDTA washing step, lyophilisation and acid digestion	Taxonomy and deformation rate (diatoms)
Analyses (ICP AES & MS)	Analyses (ICP AES & MS)	Microscopy
Speciation calculations using WHAM7 & MINEQL		

Develop a multi metric index

Results



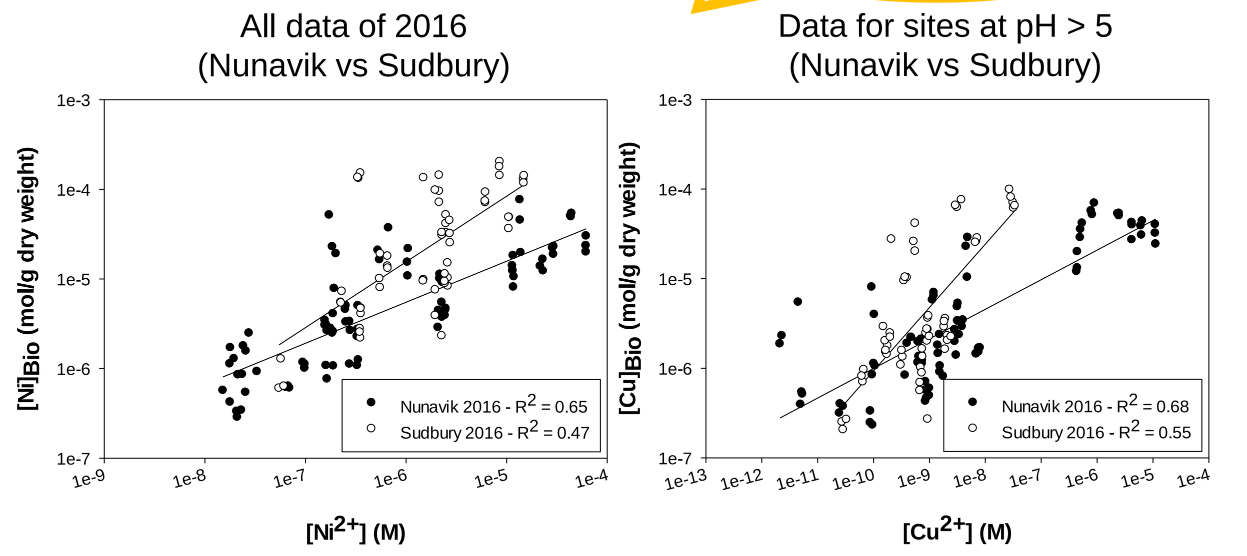
- Clear relationships between free Ni^{2+} and Cu^{2+} concentrations and their bioaccumulation in biofilms
- Better correlation without acidic sites

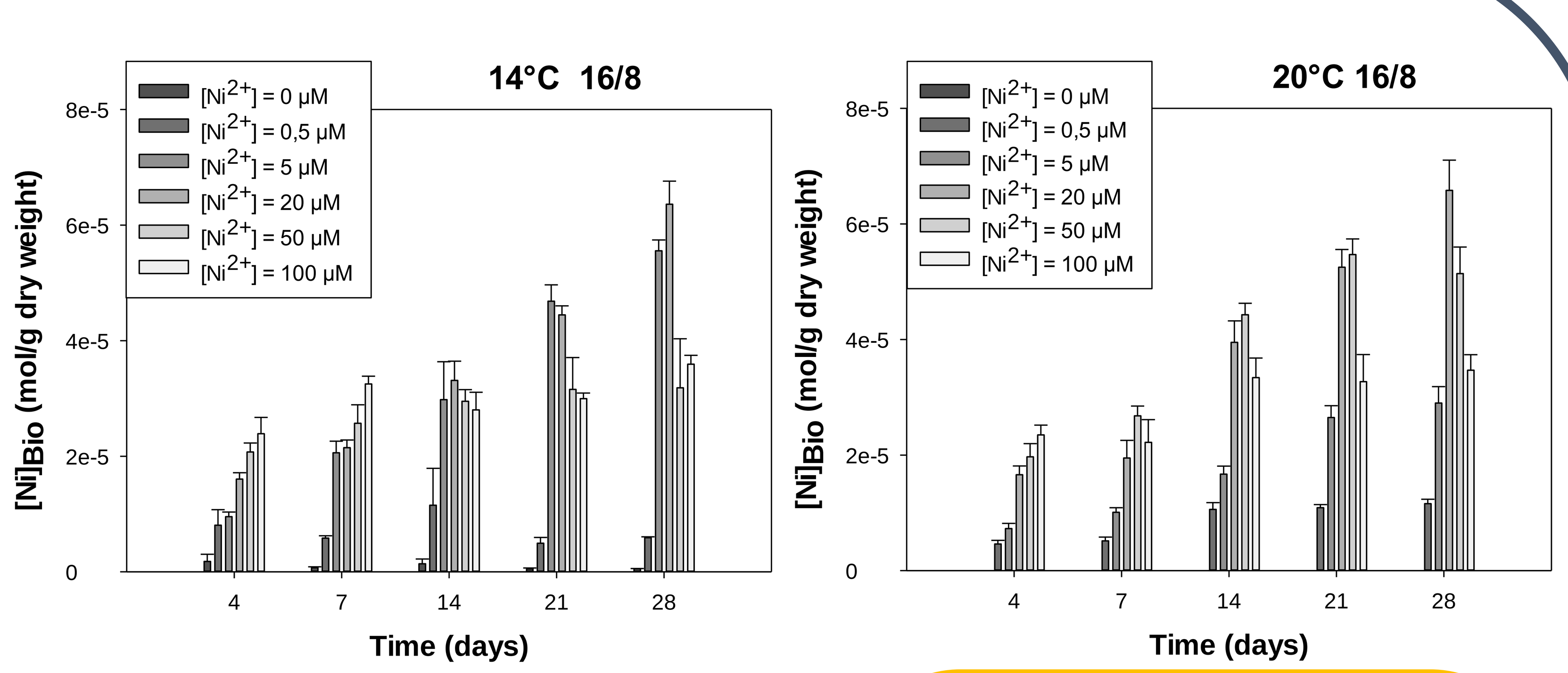
Effect of ionic competition ?

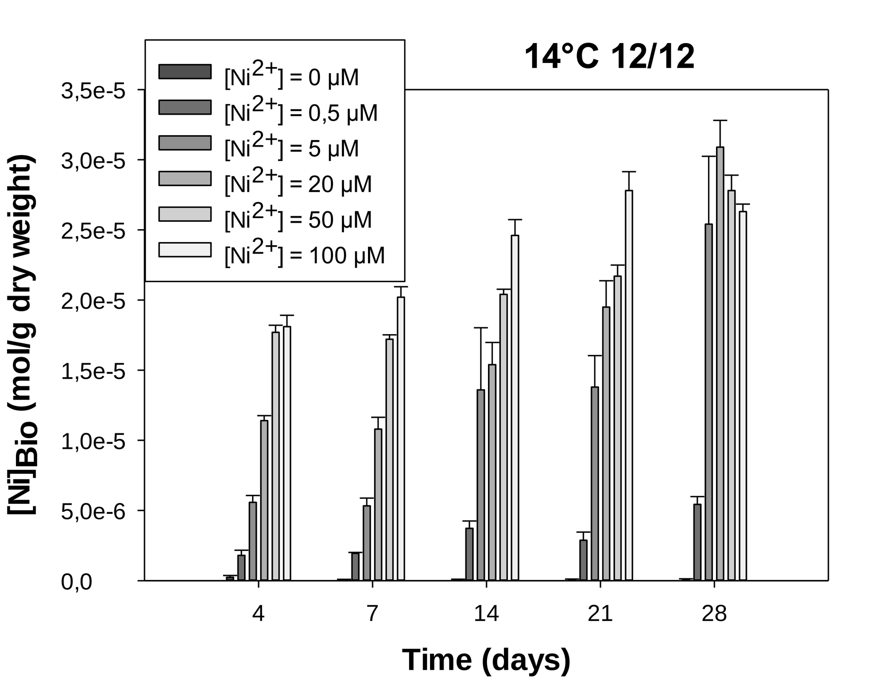
Nunavik	Sudbury
pH : 3.0 – 7.5	pH : 6.2 – 7.7
χ : 82 – 1912 µS/cm	χ : 50 – 4700 µS/cm
DOC : 0.5 – 4.2 mg/L	DOC : 1.4 – 13.4 mg/L

Different slopes on linear regressions between Sudbury and Nunavik data

Why ?







- [Ni] contents in biofilms increase with exposure time
- At 50 and 100 µM [Ni^{2+}] and 16/8 cycle, decrease in Ni accumulation: toxic effect?
- Luminosity seems to have an impact on Ni bioaccumulation
- Temperature does not modify Ni accumulation

Conclusions

- Both areas are strongly impacted by mining activities with high [Ni^{2+}] and [Cu^{2+}] (µM) measured at multiple sites in Nunavik and Sudbury
- Similar levels of Ni contents were measured in biofilms collected in both regions
- A relationship was observed between free [Ni^{2+}] in ambient water and bioaccumulated Ni in biofilms
- 50 and 100 µM of [Ni^{2+}] seem to lead to chronic effects in biofilms
- Luminosity seems to have an impact on Ni bioaccumulation but no difference was observed with the temperature range tested

Perspectives

(1) Further investigate the effects of metal contaminants on biofilms by microscopy (field and lab samples)
(2) Investigate the effects of ionic competition (under field and laboratory conditions)
(3) Test other biological parameters such as lipid content (fatty acids)
(4) Use the most promising biological end-point and evaluate the best approach to extend the use of biofilms to other metals for a routine monitoring in different geographic regions

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