Urban lakes: interaction between phytoplankton dynamics and trace metal speciation

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Outline

• Scientific context and problematic
• Objectives
• Material & Methods
• Preliminary results
• Conclusion and perspectives
Urban lakes

- Small, shallow and frequently man-made
- Key role in recreation and storing rainwater
- Mitigation of urban heat islands
- Highly impacted by watershed urbanization and by urban activities (Friese et al., 2010)
- Respond rapidly and strongly to climatic fluctuations (Whitehead et al. 2007).

(Photo Leesu 2011)
Trace metals (1)

- 2 sources in aquatic systems
  - Natural sources: erosion and physical-chemical or biological alteration processes
  - Anthropic sources: industrial and domestic wastewater discharge, agricultural activities or storm water runoff

Volcanic eruptions  Agriculture  Industry
Trace metals (2)

- Essential to growth and reproduction of organisms: Cu, Zn, Co, Fe, Mn, Ni, Cr, V, Mo, Se, Sn
- Toxic with high concentration

- Non essential to living organisms and high toxicity: Cd, Pb and Hg

Ecotoxicity depends on trace metal speciation and not on their concentration.
Trace metal speciation

- **Dissolved / Particulate**: Separation by 0.45 µm filtration
- **Labile / Inert**: dissolved phase
  - **Labile**:
    - free or weakly linked to organic or inorganic ligand
    - highly bio-available
  - **Inert**:
    - no interaction with surrounding environment
Trace metal speciation (Buffle, 1988)

Speciation of trace metals in aquatic systems to evaluate their ecotoxicity
Dissolved organic matter (DOM) & trace metal speciation

DOM in freshwaters

- 70% Humic
- 30% Non humic
Dissolved organic matter (DOM) & trace metal speciation

**Humic:**
- humic and fulvic substances
- complexing free metal ion

**Non Humic:**
- Treated or untreated wastewater discharge (Pernet-Coudrier et al., 2011)
  - Lake autochtonous production: phytoplankton and bacteria
    (Extracellular polymeric substances (EPS))
  - complexing ability to free metal ion.

Focus on one type of EPS: Transparent Exopolymer Particles (TEP)
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Objectives

The aim of this research is two fold:

1. analyze the driving processes of the phytoplankton production in an urban lake through physical-chemical and biological field data collection
2. survey the chemical speciation of trace metals in urban lake

How are the TEPs generated by phytoplankton during bloom events influencing the trace-metal speciation in an urban lake?
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Study site: Lake Créteil

Figure 3 Lake Créteil location (Créteil, France) (www.geoportail.fr)

<table>
<thead>
<tr>
<th>Surface</th>
<th>40.8 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>$1.5 \times 10^6 \text{ m}^3$</td>
</tr>
<tr>
<td>Mean depth</td>
<td>4.5 m</td>
</tr>
<tr>
<td>Max depth</td>
<td>6 m</td>
</tr>
<tr>
<td>Input</td>
<td>Water table input &amp; Stormwater outlet</td>
</tr>
<tr>
<td>High major ion concentrations</td>
<td>$[\text{Na}^+], [\text{SO}_4^{2-}], [\text{Ca}^{2+}], [\text{Cl}^-]$</td>
</tr>
</tbody>
</table>
Field data collection (1)

Three monitoring points:

- **Point S**: Close to Stormwater outlet
- **Point C**: Central pelagic point
- **Point R**: Next to a rich organic reedbed area

Figure 4 Localisation of monitoring points
Two types of field data collection:

• High frequency measurements:
  • Water temperature:
    • continuous time series at 3 depths (2011-2012)
    • From May 2012: 5 depths, T, Fluo, PAR
  • Meteorological variables

• Monthly fields campaigns:
  • Vertical profiles of physical parameters: temperature, pH, conductivity, photosynthesis active radiations (PAR).
  • Vertical profiles of parameters associated to the phytoplankton biomass: Chlorophyll a and oxygen concentrations
  • Water sampling: analysis of nutrients, TEPs concentrations and trace metal speciation
For each campaigns, 6 samples are collected for laboratory analysis (trace metal, TEP, Chl, DOC POC, TSP, total phosphorus, phosphates, NO3) :

- 5 samples at 5 sampling depths (black rectangle)
- 1 « lake average sample » mixed from S1, 2, 3, C1,2,3, R1,2,3
Trace metal speciation

- Particulate and Dissolved: separation using acetate cellulose 0.45 µm filtration
- Labile and Inert: separation using chelating disk (EMPORE™) - a chelating resin Chelex 100

raw water = total metal

0.45 µm filtration

total dissolved metal

chelating disk

particulate + dissolved

dissolved

inert metal
Transparent exopolymer particles (TEP)

- TEP: retained on polycarbonate filters (0.45µm) and stained with the cationic dye alcian blue
- Acid polysaccharides
- Spectrophotometric measurement at 787nm
- Produced during phytoplankton blooms especially diatom blooms
- 40-90% of trace elements can be adsorbed by the TEPs in marine systems (Passow, U. 2002)
Summary

Driving processes of phytoplankton production

TEP production

Trace metal speciation
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Preliminary results

Water temperature

- In general, water column is well mixed
- 5 stratification periods observed:
  ✓ Well stratified between middle of July and August: 20 days periods
Preliminary results

Chlorophyll a from September 2011 to April 2012

- Maximal in September 2011: ~ 14 µg chl a /L
- Minimal from Nov 2011 to Jan 2012: ~ 2 µg chl a /L
- 2012 Spring increasing trend
Preliminary results

Trace metal speciation

• First results of metal concentration by ICP-MS obtained very recently (30th March 2012)

• Shortcomings
  ✓ water matrix (high sulfate and calcium concentration): interference with metal analysis
  ✓ Using collision cell technology (CCT) to improve results
  ✓ New analysis planned for 29, 30, 31 May 2012
Preliminary results

TEP analysis

• In progress to validate our final protocol.
• Planned for monthly field campaigns from June 2012
Conclusion and perspectives

• Monitoring of physical parameters and laboratory analysis: understand hydrodynamical and environmental conditions of the lake
• Using a hydrodynamical and biological model to simulate and explain phytoplankton development in the lake
• Assessing phytoplankton dynamics helps us to understand better TEP production, which can explain trace metal speciation and bioavailability
Thank you for your attention