Dissolved organic matter (DOM) - microbe interactions

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Overview

• DOM introduction and why do we care?

• Case studies:  1. Bacterial DOM degradation
  2. Bacterial and UV DOM degradation

• Research needs
What is dissolved organic matter (DOM)?

Particulate organic matter
- Zooplankton
- Phytoplankton
- Bacteria

Dissolved organic matter
- Colloids
- Truly Dissolved
  - Viruses
  - Macromolecules
  - Small Molecules

Sizes:
- Meters
  - 10^-3
  - 10^-4
  - 10^-5
- Micrometers
  - 10^-6
- Nanometers
  - 10^-7
  - 10^-8
  - 10^-9
  - 10^-10
Why dissolved organics matter?

- 60% of nitrogen and phosphorus are in DOM
DOM composition

~15% of the bulk DOM pool in coastal ocean

Glucose

Fructose
DOM

Dissolved organic carbon (DOC)
  e. g. Carbohydrates

Dissolved organic nitrogen (DON)
  e. g. Proteins

Dissolved organic phosphorus (DOP)
  e. g. DNA

1164

150

1
DOM bioavailability

 Degraded = Bioavailable (BDOM)

 Non-degraded = Refractory (RDOM)
Case study 1: Bacterial DOM degradation
Coastal DOM database

30 sites
394 cases: 359 DOC, 82 DON, 80 DOP

River- vs ocean-dominated
Low vs high DOM rivers
Ample latitudinal range
Seasonal range

Lønborg & Álvarez-Salgado (2012)
Microbial degradation of DOM

\[ \text{DOC (t)} = \text{BDOC} \cdot \exp(-k_c \cdot t) + \text{RDOC} \]

Included only incubations > 40 days
Bioavailability of DOM

Bioavailability gradient: P > N > C

Lønborg & Álvarez-Salgado (2012)
Refractory DOM

River DOM more refractory → moves conservatively

Lønborg & Álvarez-Salgado (2012)
C:N:P stoichiometry of DOM

<table>
<thead>
<tr>
<th>Ratio</th>
<th>C:</th>
<th>N:</th>
<th>P:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioavailable DOM</td>
<td>195</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>Phyto. DOM</td>
<td>170</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Refractory DOM</td>
<td>2835</td>
<td>159</td>
<td>1</td>
</tr>
<tr>
<td>River DOM</td>
<td>3495</td>
<td>118</td>
<td>1</td>
</tr>
</tbody>
</table>

River and plankton main contributor to DOM pool

Meybeck (1982); Lønborg & Álvarez-Salgado (2012)
Kinetics of BDOM degradation

Reactivity gradient: $P > N > C$

$k_{C}$ $k_{N}$ $k_{P}$

$n = 127$ $n = 68$ $n = 42$

$k (d^{-1})$
Modelling the BDOM degradation

Longer flushing time less BDOM exported

Lønborg & Álvarez-Salgado (2012)
Modelling the BDOM degradation

C/N of BDOM

C/P of BDOM

Longer flushing time - more carbon rich BDOM exported

Lønborg & Álvarez-Salgado (2012)
Conclusion

• DOM bioavailability and reactivity (P>N>C)
• Refractory DOM is conservatively mixed
• Plankton main contributor to BDOM
• Bioavailable DOM is exported
Case study 2: Bacterial and UV DOM degradation
Photochemical DOM degradation

Moran & Covert (2003)
Microbes and photochemical processes

60% of river DOM is coloured (Aiken et al. 1985)

Sunlight - 96% of colour and 41% of DOC (Vahatalo & Wetz 2004)

Photodegradation 5-fold greater (Opsahl & Benner 1998)

Combined microbial and photodegradation - 60% decrease in River DOM (Miller & Moran 1997)

Microbial and photodegradation together degrade DOM
Microbes and photochemical processes

DOC degradation also lower (Lønborg et al. 2013; Lønborg et al. in-prep)

UV-light negative impact on DOM degradation (Lønborg et al. 2013; Lønborg et al. in-prep)

Plankton DOM negative effect DOM degradation
River DOM positive effect DOM degradation
Conclusions

- Sunlight exposure degradation of DOM
- Microbial and photodegradation more efficient
- UV-light:
  - **negative** effect on plankton DOM degradation
  - **positive** effect on river DOM degradation
Research needs
River DOM in marine systems

0.3 Gt y\(^{-1}\) DOC to ocean (Bianchi 2011)

DOC in lakes and rivers has increased ~ 91\% (Evans et al. 2006)

What is the effect for the coastal carbon cycle?
Temperature impacts

Global ocean warming – Impact on DOM degradation?

$Q_{10}$ rate change with 10°C normally assumed to be 2

<table>
<thead>
<tr>
<th></th>
<th>$Q_{10}$</th>
<th>Half-life (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytoplankton-derived DOC</td>
<td>1.7</td>
<td>6.3</td>
</tr>
<tr>
<td>Natural marine DOC (spring)</td>
<td>1.7</td>
<td>11</td>
</tr>
<tr>
<td>Natural marine DOC (summer)</td>
<td>1.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Natural marine DOC (winter)</td>
<td>2.1</td>
<td>53</td>
</tr>
<tr>
<td>Humic DOC</td>
<td>2.7</td>
<td>152</td>
</tr>
<tr>
<td>Semirefractory DOC</td>
<td>3.8</td>
<td>3500</td>
</tr>
<tr>
<td>Semirefractory DOC</td>
<td>4.8</td>
<td>3500</td>
</tr>
</tbody>
</table>

- $Q_{10}$ for DOM degradation varies between 1.7 – 4.8

What is the impact on foodweb and carbon cycle?

Lønborg et al. in-review
DOM

Zooplankton

Antropogenic

Phytoplankton

Macrophytes

Bacteria

Rivers

Priming

Sediment

UV-light

Aggregation
Priming effects in marine systems

- Refractory soil organic matter degradation – increase up to 600% when glucose added (Hamer et al. 2004)

- Some marine studies show effect on DOM degradation (Lønborg et al. unpubl. Results)

Does different DOM respond differently?
Summing up.....

• DOM bioavailability and reactivity (P>N>C)

• Bioavailable DOM is exported

• Microbial and photodegradation more efficient

• Plankton/river DOM respond differently

Research needs
• Increased flow of river DOM

• Temperature effects on DOM degradation

• Priming effects on DOM degradation
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Thank you for your attention!