Biogeochemical cycling of polybrominated diphenyl ethers (PBDEs) in the Strait of Georgia

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Biogeochemical Cycling of Polybrominated Biphenyl Ethers (PBDEs) in the Strait of Georgia

Presenter: Yuanji Sun (ysun@eoas.ubc.ca)
Supervisor: Dr. Roger Francois & Dr. Maria Maldonado
Apr 5th, 2018
Why PBDEs?

• POPs with 209 congeners (tri-, tetra-, penta-, hexa-, etc.)
• Increasingly used in recent decades as flame retardants in many consumer products

• Wide dispersal, persistence, toxicity, and tendency to bioaccumulate up the trophic chain

(Image credit: Gadget Review, Independent Balkan News Agency, Herman Miller)
• Have been found everywhere in the world

Lack quantitative understanding of their biogeochemical cycling in the environment, particularly in the marine environment
Key Questions

Quantify the sources, sinks and biogeochemical cycling of PBDEs in the coastal waters of British Columbia

- Compare the relative importance of main sources of PBDEs to the Strait of Georgia

- Contrast their removal to sediments by adsorption on sinking particles, bioaccumulation in the food chain, and export to the Pacific by circulation
PBDE sampling in the Strait of Georgia

Methods
Tetra-brominated Dissolved PBDEs

BDE-47

Concentration (pg/L)

Depth (m)

Outfall; Dec 2013
St2 (Bowen); Dec 2013
St2 (Bowen); Oct 2014
St3 (Burrard); Dec 2014
St2 (Bowen); Dec 2015
St3b (Burrard); Dec 2015
S4-1.5; May 2017

BDE-49

Concentration (pg/L)

Depth (m)

Outfall; Dec 2013
St2 (Bowen); Dec 2013
St2 (Bowen); Oct 2014
St3 (Burrard); Dec 2014
St2 (Bowen); Dec 2015
St3b (Burrard); Dec 2015
S4-1.5; May 2017

Tetra-brominated Dissolved PBDEs
Penta-brominated

Dissolved PBDEs

BDE-99

Concentration (pg/L)

Outfall; Dec 2013
St2 (Bowen); Dec 2013
St2 (Bowen); Oct 2014
St3 (Burrard); Dec 2014
St2 (Bowen); Dec 2015
St3b (Burrard); Dec 2015
S4-1.5; May 2017

BDE-100

Concentration (pg/L)

Outfall; Dec 2013
St2 (Bowen); Dec 2013
St2 (Bowen); Oct 2014
St3 (Burrard); Dec 2014
St2 (Bowen); Dec 2015
St3b (Burrard); Dec 2015
S4-1.5; May 2017
Hexa-brominated

**BDE-153**

**Concentration (pg/L)**

- Outfall; Dec 2013
- St2 (Bowen); Dec 2013
- St2 (Bowen); Oct 2014
- St3 (Burrard); Dec 2014
- St2 (Bowen); Dec 2015
- St3b (Burrard); Dec 2015
- S4-1.5; May 2017

**Depth (m)**

**BDE-154**

**Concentration (pg/L)**

- Outfall; Dec 2013
- St2 (Bowen); Dec 2013
- St2 (Bowen); Oct 2014
- St3 (Burrard); Dec 2014
- St2 (Bowen); Dec 2015
- St3b (Burrard); Dec 2015
- S4-1.5; May 2017

**Dissolved PBDEs**
BDE-209 cannot be discussed due to high and variable blanks
Depth Profiles in May 2017 in Strait of Georgia

Dissolved PBDEs

BDE-28+33
Concentration (pg/L)

BDE-47
Concentration (pg/L)

BDE-99
Concentration (pg/L)

BDE-153
Concentration (pg/L)

Depth (m)
Slower desorption allows the particles to rise towards the surface as a result of the general estuarine circulation of SoG.
Particulate PBDEs

- Low concentration.
- High temporal & spatial variability.
Fraser River is an important source of particulate PBDEs into SoG.
Particulate PBDE Flux

The PBDE discharge is increasing during the past 10 years

<table>
<thead>
<tr>
<th>Depth [m]</th>
<th>Part. BDE-209 [pg/m³]</th>
<th>²³⁴Th Flux [dpm/(m²d)]</th>
<th>BDE-209 Flux [pg/(cm²yr)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1054 ± 838</td>
<td>1286 ± 36</td>
<td>79 ± 64</td>
</tr>
<tr>
<td>150</td>
<td>2250 ± 1405</td>
<td>7186 ± 193</td>
<td>380 ± 243</td>
</tr>
</tbody>
</table>

Particulate PBDE flux calculated from literature between 2003 and 2005 (Grant et al 2011)

<table>
<thead>
<tr>
<th>Congener</th>
<th>PBDE concentration in surface sediment [pg/g]</th>
<th>Sedimentation rate [g/cm²/year]</th>
<th>PBDE sedimentation rate [pg/(cm²yr)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDE-209</td>
<td>726</td>
<td>0.1</td>
<td>73</td>
</tr>
</tbody>
</table>
Box Model Simulation

Iona Plume Input data (10 years ago)

<table>
<thead>
<tr>
<th>Congener</th>
<th>Flux (g/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDE-47</td>
<td>4100</td>
</tr>
<tr>
<td>BDE-99</td>
<td>4800</td>
</tr>
<tr>
<td>BDE-209</td>
<td>12000</td>
</tr>
<tr>
<td>Total PBDEs</td>
<td>24000</td>
</tr>
</tbody>
</table>

+ Fraser River input

(Dinn et al 2012, Johannessen et al 2015)

(Wang 2015)
Total PBDEs measured in SoG:
280 pg/L

Total PBDEs in Haro Strait:
6.18~29.7 (average 18.1±10.4) pg/L upper box
1.75~14.7 (average 6.46±5.66) pg/L lower box
(Frouin et al 2013)
Conclusion

1. Dissolved PBDEs: high concentration, low temporal & spatial variability
   Particulate PBDEs: low concentration, high temporal & spatial variability
2. Slower desorption allows the particles to rise towards the surface as a result of the general estuarine circulation of SoG
3. Fraser River & atmospheric deposition are important sources to SoG
4. PBDE flux and box model confirm higher PBDE discharge in recent years, and/or an additional yet unidentified source (maybe run-off from roads).
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