Cyanobacteria: their impact on Queensland’s water security and aquatic ecosystems

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Cyanobacteria in Queensland

- HABs are common seasonal phenomena occurring throughout Queensland in both fresh and coastal marine waters.
- Typically cyanobacterial blooms have been associated with:
  - reservoirs and weir pools
  - riverine reaches and waterholes (no or low flow periods)
  - farm dams
  - recreational and ornamental lakes and ponds
  - marine and estuarine systems
### Toxicogenic cyanobacteria known from Queensland waters

<table>
<thead>
<tr>
<th>Name</th>
<th>Toxin/Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrospermopsin</td>
<td>Lyngbya toxins</td>
</tr>
<tr>
<td><em>Aphanizomenon ovalisporum</em></td>
<td>Lyngbya majuscula</td>
</tr>
<tr>
<td><em>Cylindrospermopsis raciborskii</em></td>
<td></td>
</tr>
<tr>
<td><em>Lyngbya wollei</em></td>
<td></td>
</tr>
<tr>
<td>PSPs</td>
<td>Microcystins</td>
</tr>
<tr>
<td><em>Anabaena circinalis</em></td>
<td><em>Microcystis aeruginosa</em></td>
</tr>
<tr>
<td>Nodularin</td>
<td><em>Microcystis panniformis?</em></td>
</tr>
<tr>
<td><em>Nodularia spumigena</em></td>
<td></td>
</tr>
</tbody>
</table>
Qld Harmful Algal Bloom Response Plan

- The HAB Plan outlines the Queensland Government’s contingency plan for responding to HAB incidents.
- Coordinates the roles of the various state agencies (4 departments), local government, and water storage operators.
- Water storage operators have traditionally taken the lead role in monitoring and management of CyanoHABS.
Cylindrospermopsis raciborskii

- Most common and widespread toxicogenic freshwater planktonic cyanobacteria in Queensland
- Distribution
- Spatial and temporal variability
- Long-term temporal variability
C. raciborskii - Distribution

- *Cylindrospermopsis raciborskii* is widespread throughout Queensland including sub-tropical and tropical regions – recorded in 54 of the 69 reservoirs monitored
- Cell concentrations are generally an order of magnitude higher in reservoirs than in weir pools
C. raciborskii - Temporal variation

- *Cylindrospermopsis raciborskii* shows a marked seasonal pattern of abundance in all the reservoirs, however in general this is less pronounced in weir pools
- Seasonal pattern tracks the annual reservoir stratification
Summary of 8 reservoirs seasonal thermal stratification pattern

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature difference (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>0</td>
</tr>
<tr>
<td>Feb</td>
<td>2</td>
</tr>
<tr>
<td>Mar</td>
<td>4</td>
</tr>
<tr>
<td>Apr</td>
<td>6</td>
</tr>
<tr>
<td>May</td>
<td>8</td>
</tr>
<tr>
<td>Jun</td>
<td>10</td>
</tr>
<tr>
<td>Jul</td>
<td>12</td>
</tr>
<tr>
<td>Aug</td>
<td>14</td>
</tr>
<tr>
<td>Sep</td>
<td>12</td>
</tr>
<tr>
<td>Oct</td>
<td>10</td>
</tr>
<tr>
<td>Nov</td>
<td>8</td>
</tr>
<tr>
<td>Dec</td>
<td>6</td>
</tr>
</tbody>
</table>
C. raciborskii - Long term temporal variability

- Has there been a change in the magnitude, frequency, timing and duration of *Cylindrospermopsis raciborskii* blooms in Queensland over the past 10 years?
- Reservoirs from north, central, south-east, and southern Queensland
Tinaroo Falls Dam – Northern Qld

cells mL⁻¹

0
50000
100000
150000
200000
250000
20/10/1997
20/04/1998
20/10/1998
20/04/1999
20/10/1999
20/04/2000
20/10/2000
20/04/2001
20/10/2001
20/04/2002
20/10/2002
20/04/2003
20/10/2003
20/04/2004
20/10/2004
20/04/2005
20/10/2005
20/04/2006
20/10/2006
20/04/2007
20/10/2007
20/04/2008
20/10/2008

Department of Environment and Resource Management

Queensland Government
New and emerging issues

Toxicogenic benthic cyanobacteria

- *Lyngbya majuscula*
  - Seasonal blooms in Moreton Bay, S.E. Queensland
  - Impact on fisheries, tourism, aquatic ecosystems (seagrass communities, turtles, dugongs)
  - Also reported from Hervey Bay and more recently in Shoalwater Bay, Hinchinbrook Island and Great Keppel Island.
Lyngbya wolleti

- Freshwater filamentous benthic cyanobacteria
- Known from riverine and reservoirs systems
- Identified as producing PSPs in the USA
- Identified as producing CYN and deoxy-CYN from Queensland
Comparison of CYN and deoxy-CYN concentrations ($\mu$g g$^{-1}$ dry weight) in selected cyanobacteria

<table>
<thead>
<tr>
<th>Species</th>
<th>CYN</th>
<th>deoxy-CYN</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aphanizomenon ovalisporum</em></td>
<td>500</td>
<td></td>
<td>Shaw et al 1999</td>
</tr>
<tr>
<td><em>Aphanizomenon flos-aquae</em></td>
<td>2300 – 6600</td>
<td></td>
<td>Preubel et al 2006</td>
</tr>
<tr>
<td><em>Cylindrospermopsis raciborskii</em></td>
<td>5500</td>
<td></td>
<td>Hawkins et al 1997</td>
</tr>
<tr>
<td></td>
<td>600 – 3500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1020</td>
<td>102</td>
<td>Li et al 2001a</td>
</tr>
<tr>
<td></td>
<td>6600</td>
<td></td>
<td>Saker &amp; Eaglesham 1999</td>
</tr>
<tr>
<td></td>
<td>1400 – 2000</td>
<td></td>
<td>Saker et al 1999</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td></td>
<td>Shaw et al 1999</td>
</tr>
<tr>
<td><em>Raphidiopsis curvata</em></td>
<td>56</td>
<td>1300</td>
<td>Li et al 2001b</td>
</tr>
<tr>
<td><em>Lyngbya wolfei</em></td>
<td>0 – 33</td>
<td>0.5 – 546.8</td>
<td>Queensland material</td>
</tr>
</tbody>
</table>
Lyngbya wollei - Significance

- *Lyngbya wollei* represents a hitherto unrecognised source of CYN and deoxy-CYN in the freshwater environment
- Benthic algae and cyanobacteria are not routinely monitored in rivers, lakes and reservoirs
- The mortality of domestic and wild animals has been reported following the consumption of benthic cyanobacterial mats; notably marine and freshwater members of the Oscillatoriales
Current and future challenges

- **Increased urban/agricultural footprint and subsequent water demand**
  - increased reservoir draw down and water residence time
  - catchment generated nutrient and contaminant loads

- **Climate change**
  - rainfall variability
  - reservoir stratification dynamics
  - HAB frequency, intensity and duration

- **Inter-basin transfers and recycled water reuse**
  - movement of bloom inoculum (akinetes)
  - alteration of physico-chemical/hydrological environment
Current and future challenges

- **Currently unrecognised toxicogenic species and range expansion of known species**
  - under estimation of potential risk
  - adequacy of current monitoring strategies
  - adequacy of current water treatment processes

- **Consistent application of current guidelines**
  - Cell concentration vs cell biovolume for recreational risk assessment
  - Consistent risk communication
Current and future challenges

- **Solutions to support regional and remote individuals and communities**
  - Translation of reservoir scale monitoring and management techniques to the farm dam, agricultural system scale

- **Continued support for the ongoing development of a regional (Australasian) cyanobacteria taxonomy**
  - Development of tools to facilitate the accurate, reliable and timely identification of cyanobacteria from a range of habitats (morphological, molecular and ecological)