The Cooperative Research Centre for Water Quality and Treatment (CRC) is Australia's national drinking water research centre. It is an unincorporated joint venture between 29 different organisations from the Australian water industry, major universities, CSIRO, and local and state governments. The CRC combines expertise in water quality and public health.

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- ACTEW Corporation
- Australian Water Quality Centre
- Australian Water Services Pty Ltd
- Brisbane City Council
- Centre for Appropriate Technology Inc
- City West Water Ltd
- CSIRO
- Curtin University of Technology
- Department of Human Services Victoria
- Griffith University
- Melbourne Water Corporation
- Monash University
- Orica Australia Pty Ltd
- Power and Water Corporation
- Queensland Health Pathology & Scientific Services
- RMIT University
- South Australian Water Corporation
- South East Water Ltd
- Sydney Catchment Authority
- Sydney Water Corporation
- The University of Adelaide
- The University of New South Wales
- The University of Queensland
- United Water International Pty Ltd
- University of South Australia
- University of Technology, Sydney
- Water Corporation
- Water Services Association of Australia
- Yarra Valley Water Ltd

Cyanobacteria
Management and Implications for Water Quality

Outcomes from the Research Programs of the Cooperative Research Centre for Water Quality and Treatment
**Fact Sheet Objective**

The Framework for Management of Drinking Water Quality contained in Chapter 2 of the Australian Drinking Water Guidelines (ADWG), outlines the methodology for providing safe drinking water by managing the complete catchment to tap water supply system. This document is achieving global recognition as the best way to manage our drinking water as we move into the 21st Century and is being incorporated into National and State Health Guidelines.

It is important to understand the level of risk that the different cyanobacteria and toxins pose to drinking water. This allows managers of catchments and urban water utilities to focus their efforts on policies, works and operational practices to not only lower risks to public health but also improve the environmental health of these waters.

These fact sheets present the findings of a major research program carried out by the Australian Cooperative Research Centre (CRC) for Water Quality and Treatment into areas such as understanding cyanobacterial growth, detection methods for cyanobacterial toxins and water treatment options for cyanobacterial cells and toxins.

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**ADWG Framework Elements**

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| FS 2 | Detection of cyanobacterial toxins |
| FS 3 | Molecular techniques are becoming available for rapid detection of cyanobacteria |
| FS 4 | Cyanobacteria are identified and counted by microscopy |
| FS 5 | Toxin occurrence data reviewed with respect to guideline values |
| FS 6 | Cell count data provides the context for cyanobacteria risk assessment |
| FS 7 | Data sets used to determine what toxins are likely to occur and the appropriate treatment technology to apply |
| FS 8 | Rapid degradation of cyanobacteria risk assessment |
| FS 9 | Historical data provides a validation for modelling studies |

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**Summary of fact sheet findings and relationship with ADWG Framework elements**

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<th>Key research findings and reference to fact sheet number</th>
</tr>
</thead>
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<td>Water Supply System Analysis</td>
<td>All fact sheets provide information necessary for control and management of cyanobacteria</td>
</tr>
<tr>
<td>Review of Water Quality Data</td>
<td>FS 6 Data sets used to determine what toxins are likely to occur and the appropriate treatment technology to apply</td>
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<tr>
<td>Hazard Identification and Risk Assessment</td>
<td>FS 7 Toxin occurrence data reviewed with respect to guideline values</td>
</tr>
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<td>FS 8 Cell count data provides the context for cyanobacteria risk assessment</td>
<td></td>
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<td>FS 9 Historical data provides a validation for modelling studies</td>
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<tr>
<td>Planning-preventative Strategies for Drinking Water Quality Management</td>
<td>FS 13 Nutrients exported from catchments can be reduced with soil amending chemicals</td>
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<td>Multiple Barriers</td>
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<td>FS 6 Coagulation and the removal of intact cell is the first treatment barrier</td>
<td></td>
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<td></td>
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<td>FS 11 Algicides can be applied in response to cyanobacterial blooms</td>
<td></td>
</tr>
<tr>
<td>Verification of Drinking Water Quality</td>
<td>FS 1 Appropriate sampling is critical to obtain a representative overview of water quality</td>
</tr>
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<td>FS 4 Accurate identification of problem algae is achievable with microscopy</td>
</tr>
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<td></td>
</tr>
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<td>Research and Development</td>
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</tr>
<tr>
<td>Investigative Studies and Research Monitoring</td>
<td>FS 3 Rapid genetic tests are being developed to improve identification of cyanobacteria and reduce operational response time</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>FS 7 Rapid degradation of microcystin in biofilters shows promise as a low cost alternative for treatment of toxins</td>
<td></td>
</tr>
<tr>
<td>FS 12 Reservoir and cyanobacterial growth models transfer knowledge from science to operations and allows the outcome of management options to be predicted</td>
<td></td>
</tr>
</tbody>
</table>

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In Australia, drinking water quality management is undertaken in the context of the Framework for Management of Drinking Water Quality contained in the Australian Drinking Water Guidelines (ADWG). In the table below the salient research findings are presented within the Framework to aid in their implementation by the Australian water industry.
Summary of Key Points

Cyanobacteria present a particular challenge to water utilities because of both aesthetic issues associated with taste and odour compounds and human health concerns surrounding cyanobacterial toxins. The research undertaken by the CRC for Water Quality and Treatment has examined cyanobacterial control strategies from catchment to tap. The research has revealed that a multi-barrier approach to the cyanobacteria hazards in the catchment, reservoir and treatment plant can reduce the risks associated with cyanobacteria.

An important outcome from the research has been the development of practical tools for identifying cyanobacterial risks, operation response guides for reservoir managers and appropriate treatment technologies to control tastes, odours and toxins. These tools are transferable to any catchment, reservoir or treatment plant. The fact sheets provide the initial information on cyanobacteria and a list of further information where a detailed understanding can be gained.

Fact Sheet Contents

These fact sheets are derived from the following CRC for Water Quality and Treatment research projects:

- 1.0.0.2.5.1  Destratification for Control of Cyanobacteria in Reservoirs
- 2.0.2.2.1.4  Reservoir Management Strategies for the Control and Degradation of Algal Toxins
- 1.0.0.3.2.6  ARMCANZ National Algal Manager
- 1.0.0.3.2.6  Optimisation of Adsorption Processes – Stage II
- 2.0.2.4.0.5  Biological Filtration Processes for the Removal of Algal Metabolites
- 2.0.2.4.1.3  Management Strategies for Toxic Blue-green Algae: A Guide for Water Utilities
- 2.0.1.2.0.2  Cylindrospermopsin Carcinogenicity, Genotoxicity and Mechanisms of Toxic Action – Development of Biomarkers of Human Exposure
- 2.0.1.2.0.5  Development of Screening Assays for Water-Borne Toxicants
- 1.0.2.3.2.4  Regulation of cylindrospermopsin production by the cyanobacterium Cylindrospermopsis raciborskii
- 2.0.2.3.3.2  Rapid methods for the detection of toxic cyanobacteria
- 2.0.2.3.0.4  Early detection of cyanobacteria toxins using genetic methods

The fact sheets are comprised of four sections: Research Findings, Implementation, More Information and Contact Details.
Cyanobacteria have existed on earth for three billion years, however there is a general opinion that ‘cyanobacterial blooms’ are increasing in frequency due to eutrophication.

The building of dams and regulation of rivers has also created more habitats suitable for cyanobacteria.

There are three general constraints on cyanobacterial growth: light, nutrients and temperature.

**Research Findings**

**Light**

- The amount of light available to a colony of cyanobacteria is determined by the latitude, the time of year and the degree of mixing relative to the depth of light penetration.
- Species such as *Microcystis aeruginosa* and *Anabaena circinalis* have maximum growth rate when cells are mixed to the depth of the euphotic zone (1% of surface irradiance). Deeper mixing causes light limitation to growth.

**Nutrients**

- There is a direct correlation between the amount of phosphorus in a lake and the quantity of phytoplankton the lake can support. Therefore, any intervention that reduces the load of nutrients entering a lake will eventually reduce the magnitude of the algal bloom.
- Concentrations of filterable reactive phosphorus less than 0.01 mgL\(^{-1}\) are considered to be limiting for growth.
- A concentration of 0.1 mgL\(^{-1}\) of soluble inorganic nitrogen is considered the minimum concentration to maintain growth during the growing season.

**Buoyancy regulation**

- The success of some cyanobacteria is, in part, attributable to the presence of gas vesicles that provide buoyancy.
- During stratified conditions the ability of some cyanobacteria to float provides the opportunity to be in the illuminated surface layers and access the light required for productivity, nitrogen fixation and growth.
- The classic hypothesis is that cyanobacteria migrate to access the vertically separated resources, light and nutrients (Figure 1).

**Implementation**

Limiting light and nutrients can create conditions that limit cyanobacteria. This can include destratification (see FS 10) and catchment management (see FS 14).
Figure 1 “A day in the life of Anabaena” is a cartoonist’s impression of the buoyancy regulation mechanism used by cyanobacteria to migrate vertically and overcome the vertical separation of light (near the surface) and nutrients near the sediment. Cells near the surface photosynthesize and accumulate carbohydrate (CHO) which makes them heavy and they sink. Away from light the CHO is respired and buoyancy is restored.

More Information

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The Cyanobacterial Toxins

Research Findings
The main cyanobacterial toxins of concern in Australia are cylindrospermopsins, microcystins, and saxitoxins (paralytic shellfish toxins). In Australia cylindrospermopsins are produced by *Cylindrospermopsis raciborskii* and *Aphanizomenon ovalisporum*, microcystins by various *Microcystis* species but predominantly by *Microcystis aeruginosa*, and the saxitoxins are produced by *Anabaena circinalis*.

Cylindrospermopsins (3 types currently known) are alkaloid toxins that inhibit protein synthesis and can disrupt the structure of DNA. The first of these actions can cause death in exposed animals but the second also suggests the possibility of cancer initiation.

Microcystins (>80 types currently known) are cyclic peptides that inhibit enzymes called protein phosphatases, which are involved in the regulation of many important cellular processes. This can lead to rapid death if the dose is high enough. At lower doses, the effects on cell regulation may allow cancers to escape normal controls, increasing their growth rate.

Saxitoxins (~30 types currently known) are also alkaloids. These toxins block nerve transmission and so cause death by inhibiting the muscles required for respiration. There are no known long-term effects of a non-lethal dose.

Implementation
The CRC has concentrated its toxicological research efforts on:

- Explaining the mechanisms of action of the toxins.
- Conducting animal studies of toxic effects as a basis for guideline setting.
- Developing and assessing toxicity based assays for detection of cyanotoxins in source and drinking waters.

The outcomes from the research have been implemented by:

- Providing the data to NH&MRC, WHO and IARC (International Agency for Research on Cancer) along with recommendations for guideline safety values for microcystin and cylindrospermopin (both at 1 μg/L). A guideline value for microcystin has been published by WHO. CRC researchers wrote the draft Summary Document on Cylindrospermopin that will be circulated by WHO, and are key authors in a well-respected WHO book entitled “Toxic Cyanobacteria in Water: A Guide to their Public Health Consequences, Monitoring and Management”.

- Development of an assay for cylindrospermopin based upon its mechanism of toxic action, that is, protein synthesis inhibition. This provides a sensitive assay that detects all three known cylindrospermopin analogues, plus any others that are yet to be discovered, providing a measure of total cylindrospermopin-like toxicity in a water sample. A rapid cell-based reporter gene assay is also nearing completion.

- Evaluation of cell and antibody based assays for detection of saxitoxins. The neuroblastoma cell-based assay was found to be specific for these toxins and was able to detect new toxin analogues that cannot be detected yet by chromatography. Specific recommendations are contained in the report for AwwaRF Project 2789.

More information


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Sampling Waterbodies for the Detection of Cyanobacteria

Recommended procedures based upon best practice

- The type of sampling required depends upon the aims of the monitoring program, the waterbody type and on the current health alert status of the waterbody.
- Collecting samples to determine the ‘true’ cyanobacterial population in a waterbody to detect population changes is difficult. Samples need to be representative of the whole waterbody remembering that cyanobacteria can have patchy distribution.
- The recommended sample method to detect population size is the depth-integrated sample. This integrates vertical variation and is regarded as generally providing good representation of the cyanobacterial population.
- To assess the potential cyanobacterial contamination of the drinking water system, the samples should be taken adjacent to the water offtake tower and at the same depth as the offtake.
- Where toxin monitoring is required, it is recommended that toxin analysis be performed on the same sample used for cyanobacterial identification and counting.
- Different sampling techniques are required to assess for benthic cyanobacteria.
- For toxicity assessment it may be necessary to collect a highly concentrated sample of cells or scum rather than a water sample.
- To prevent any changes to a sample from when it was taken to when it is analysed, transport in the dark (e.g. in an esky with a lid) and on ice, unless other transport requirements are indicated.

Implementation

Table 2
Scale of sampling effort and recommended procedures for monitoring cyanobacteria (for operators)

<table>
<thead>
<tr>
<th>Water Body Type</th>
<th>Priority</th>
<th>Sampling Site and Access</th>
<th>Sample Type (method)*</th>
<th>Number of Samples†</th>
<th>Frequency of Sampling‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoirs and lakes</td>
<td>High</td>
<td>Open water by boat</td>
<td>Integrated depth</td>
<td>Multiple sites</td>
<td>Weekly or bi-weekly</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Water Supply offtake</td>
<td>Offtake depth or integrated depth</td>
<td>Single site</td>
<td>Weekly or bi-weekly</td>
</tr>
<tr>
<td></td>
<td>Moderate-Low</td>
<td>Shoreline</td>
<td>Surface</td>
<td>Single or multiple sites</td>
<td>Weekly or fortnightly</td>
</tr>
<tr>
<td>Rivers and weir pools</td>
<td>High</td>
<td>Midstream by boat or bridge or weir</td>
<td>Integrated depth</td>
<td>Multiple sites</td>
<td>Weekly or bi-weekly</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Water Supply offtake</td>
<td>Offtake depth or integrated depth</td>
<td>Single site</td>
<td>Weekly or bi-weekly</td>
</tr>
<tr>
<td></td>
<td>Moderate-Low</td>
<td>River bank</td>
<td>Surface</td>
<td>Single site or multiple sites</td>
<td>Weekly or fortnightly</td>
</tr>
<tr>
<td>All water bodies</td>
<td>Low</td>
<td>Near to offtakes, bank or shorelines</td>
<td>Visual inspection for water discoloration or surface scums</td>
<td>Single or multiple sites</td>
<td>Fortnightly to daily depending on season and frequency of use</td>
</tr>
</tbody>
</table>
*Depth-integrated samples are collected with a flexible or rigid hosepipe, depth (2-5m) depending on mixing depth; surface or depth samples collected with a van Dorn or Niskin sampler; shoreline or bank samples collected with a 2m sampling rod and bottle.

†Multiple sites should be suitably spaced (e.g. a minimum of 100m apart, except in smaller water bodies such as farm dams), and should include one near the offtake. Multiple samples can also be pooled and one composite sample obtained. River monitoring should include upstream sites for early warning. Samples from recreational waters should be collected within the water contact area.

‡Sampling should be programmed at the same time of day for each location. Visual inspection for surface scums should be conducted in calm conditions, early in the morning.

More information


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FS 4  Microscopic Identification of Potentially Toxic Cyanobacteria in Australian Freshwaters

Background
Cyanobacterial (blue-green algae) blooms are a public health concern due to their ability to produce potent toxins. These toxins have been implicated in episodes of human illness in Australia and deaths overseas. Monitoring of cyanobacterial taxa, cell numbers (or equivalent cell biovolume) and toxin concentrations provides an excellent basis for assessing health risks associated with toxic blooms.

Implementation
Phase contrast light microscopy, at magnifications greater than 100 times, is typically used for the identification and enumeration of cyanobacteria and provides the first indication of potentially toxic species in source waters. Toxicity is species specific and considerable taxonomic expertise is required to differentiate the potentially toxic species.

The following describes the morphological characteristics of the potentially toxic cyanobacterial species recognised from Australia’s freshwater habitats.

Anabaena circinalis (order Nostocales)
A. circinalis is a planktonic cyanobacterium morphologically presented as open spirally coiled trichomes, greater than 50 µm in diameter. The vegetative cells are spherical or compressed at the poles, breadth 7-8.5 µm. Vegetative cells contain aerotopes (gas vesicles). Heterocytes (nitrogen fixing cells) are spherical, breadth 7.5-9 µm. Mature akinetes (resting cells or spores) are cylindrical, slightly curved and remote from the heterocytes, length 27 µm, breadth 14 µm.

Figure 2 Anabaena circinalis

Aphanizomenon ovalisporum (order Nostocales)
A. ovalisporum is a planktonic cyanobacterium morphologically presented as straight or slightly curved trichomes. Trichomes taper towards the ends. The vegetative cells are clearly constricted at the cross walls, cylindrical, length 3.1-9.8 µm, breadth 2.3-5.2 µm. Vegetative cells contain aerotopes. Apical cells (end cells) are distinctly narrowed and elongated, largely hyaline (clear), 6.7-17.3µm long, 1.2-4.3 µm broad. Heterocytes are solitary, spherical or ellipsoid, length 3.4 - 8.2 µm, breadth 2.2 - 6.5µm. Mature akinetes are solitary or commonly 2 - 3 in series, oval, usually removed from the heterocytes by one or more cells, length 6.2-16.8 µm, breadth 5.3 -11.8 µm.
Cylindrospermopsis raciborskii (order Nostocales)

*C. raciborskii* is a planktonic cyanobacterium morphologically presented as either straight, slightly curved or spirally coiled trichomes. Trichomes are cylindrical or slightly narrowed or tapered towards the ends. The vegetative cells are cylindrical or slightly barrel-shaped when constricted, length 2.0-8.5 µm, breadth 2.5-4.0 µm. Vegetative cells contain aerotopes. Heterocytes, which develop only from terminal narrowed cells, are short to conical and pointed to rounded at the ends, length 3.5-10.5 µm, breadth 2.5-4.0 µm. Akinetes, which develop beside or slightly distant from the heterocytes, can be present singularly, in pairs or in a short series. Mature akinetes are oval, length 7.5-16.0 µm, breadth 3.5-4.5 µm.

Microcystis aeruginosa (order Chroococcales)

*M. aeruginosa* colonies are highly variable in morphology, ranging from more or less spherical or elongated, to lobate, elongated or clathrate (net-like) or composed of sub-colonies. Mucilage broad forming a margin around colony 10-50 µm wide. Cells spherical, 5-7 µm in diameter, densely aggregated in the common mucilage. Cells contain numerous aerotopes. No specialised cells present.
More Information

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Detection of Toxigenic Cyanobacteria using Genetic Methods

Research Findings

Toxigenic cyanobacteria that produce cylindrospermopsin, microcystin, and nodularin can be detected by using the polymerase chain reaction (PCR) which identifies the genes responsible for toxin production. Tests for saxitoxin producing cyanobacteria are in progress.

Using real-time PCR the amplification of the toxin genes can be followed as the reaction proceeds, providing rapid assay turnaround (eg. 1-2 hr).

Real-time PCR can be used for screening water samples to detect the presence of toxigenic cyanobacteria. However, where standards are used, analysis is semi-quantitative and will indicate both the presence of the toxin gene and the approximate number of copies present in the starting sample (Table 3).

Table 3

<table>
<thead>
<tr>
<th>Sample points at one reservoir</th>
<th>Toxin gene (copies.mL⁻¹)</th>
<th>Cell count (cells.mL⁻¹)</th>
<th>Toxin (µg.L⁻¹) detected by LCMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>50028</td>
<td>27607</td>
<td>0.2</td>
</tr>
<tr>
<td>Site 2</td>
<td>43149</td>
<td>27950</td>
<td>0.8</td>
</tr>
<tr>
<td>Site 3</td>
<td>52793</td>
<td>57855</td>
<td>0.4</td>
</tr>
<tr>
<td>Site 4</td>
<td>58004</td>
<td>73670</td>
<td>0.9</td>
</tr>
<tr>
<td>Site 5</td>
<td>92866</td>
<td>77290</td>
<td>0.8</td>
</tr>
<tr>
<td>Site 6</td>
<td>54598</td>
<td>73625</td>
<td>0.9</td>
</tr>
<tr>
<td>Site 7</td>
<td>90401</td>
<td>66550</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3 shows that many sites around a reservoir can be sampled and rapidly analysed giving an overall assessment of the distribution of potentially toxic algae for the whole reservoir. This information can then be used for further management and water treatment decisions.

Environmental samples that may contain toxigenic cyanobacteria can be prepared for PCR analysis using simple and rapid methods that include the possibility of performing the test on the site where the sample was collected, giving rapid results.

At this stage we know that the absence of key genetic determinants will mean that the particular cyanobacteria analysed will not produce toxin, but because of the complexity of the genes involved in toxin production a positive PCR test does not guarantee the cyanobacteria will be toxic and follow up conventional confirmation is required.

Implementation

- Conventional or real-time PCR assays should be used to supplement existing monitoring strategies that include microscopic counts and toxin analysis by chemical methods (eg. HPLC etc)
- PCR can be used to confirm that a bloom is non-toxic, therefore avoiding the need for more complex toxin analysis.
- Real-time PCR should be made available in emergency, rapid-response or time critical situations to rapidly assess potentially toxic cyanobacterial blooms
More Information


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Research Findings

- The toxins of most concern to water suppliers in Australia are saxitoxins, microcystins and cylindrospermopsin.
- Conventional treatment processes such as coagulation, flocculation, sedimentation and filtration will remove up to 90% of the total toxin present if it is contained within healthy cyanobacterial cells (less for cylindrospermopsin).
- Dissolved toxin (i.e. toxin that has been released from the cells) must be removed using additional treatment such as powdered activated carbon (PAC), granular activated carbon (GAC), ozone or chlorine.
- The doses of oxidant and PAC, and the type of activated carbon required for treatment is dependent on the type of toxin and the water quality.

Implementation

Table 4 (over page) outlines the appropriate treatment techniques for treatment of cyanobacterial toxins.

More Information


Contact Details

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### Table 4
Techniques for treatment of cyanobacterial toxins.

<table>
<thead>
<tr>
<th>Treatment process</th>
<th>Cyanobacteria/toxin</th>
<th>Treatment efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact cells</td>
<td>cyanobacterial cells</td>
<td>Very effective for the removal of intracellular toxins provided cells accumulated in sludge are isolated from the plant</td>
</tr>
<tr>
<td>Coagulation/sedimentation</td>
<td>cyanobacterial cells</td>
<td>Very effective for the removal of intracellular toxins provided cells are not allowed to accumulate on filter for prolonged periods</td>
</tr>
<tr>
<td>Rapid filtration</td>
<td>cyanobacterial cells</td>
<td>As for rapid sand filtration, with additional possibility of biological degradation of dissolved toxins</td>
</tr>
<tr>
<td>Slow sand filtration</td>
<td>cyanobacterial cells</td>
<td>As for rapid sand filtration, with additional possibility of biological degradation of dissolved toxins</td>
</tr>
<tr>
<td>Combined coagulation/sedimentation/filtration</td>
<td>cyanobacterial cells</td>
<td>Extremely effective for the removal of intracellular toxins provided cells accumulated in sludge are isolated from the plant cells and any free cells are not allowed to accumulate on filter for prolonged periods</td>
</tr>
<tr>
<td>Membrane processes</td>
<td>cyanobacterial cells</td>
<td>Very effective for the removal of intracellular toxins provided cells are not allowed to accumulate on membrane for prolonged periods</td>
</tr>
<tr>
<td>Dissolved Air Flotation (DAF)</td>
<td>cyanobacterial cells</td>
<td>As for coagulation/sedimentation</td>
</tr>
<tr>
<td>Oxidation processes</td>
<td>cyanobacterial cells</td>
<td>Not recommended as a treatment for cyanobacterial cells as this process can lead to cell damage and lysis and consequent increase in dissolved toxin levels</td>
</tr>
</tbody>
</table>

### Dissolved Toxins

**Adsorption**

<table>
<thead>
<tr>
<th>Adsorption -powdered activated carbon (PAC) (doses required vary with water quality)</th>
<th>Microcystins (except m-LA)</th>
<th>Wood-based, chemically activated carbon is the most effective, or coal-based carbon with similar pore distribution, 60 minutes contact time recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcystin LA</td>
<td>High doses required</td>
<td></td>
</tr>
<tr>
<td>Cylindrospermopsin</td>
<td>As for most microcystins</td>
<td></td>
</tr>
<tr>
<td>Saxitoxins</td>
<td>A microporous carbon (steam activated wood, coconut or coal based) 60 minutes contact time recommended effective for the most toxic of the variants</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adsorption -granular activated carbon (GAC)</th>
<th>All dissolved toxins</th>
<th>GAC adsorption displays a limited lifetime for all toxins. This can vary between 2 months to more than one year depending on the type of toxin and the water quality</th>
</tr>
</thead>
</table>

| Biological filtration                      | All dissolved toxins | When functioning at the optimum this process can be very effective for the removal of most toxins. However, factors affecting the removal such as biofilm mass and composition, acclimation periods, temperature and water quality cannot be easily controlled |


<table>
<thead>
<tr>
<th>Treatment process</th>
<th>Cyanobacteria/toxin</th>
<th>Treatment efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OXIDATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ozonation</td>
<td>All dissolved toxins</td>
<td>Ozonation is effective for all dissolved toxins except the saxitoxins. A residual of at least 0.3 mg L(^{-1}) for 5 minutes will be sufficient. Doses will depend on water quality</td>
</tr>
<tr>
<td>Chlorination</td>
<td>All dissolved toxins</td>
<td>If a dose of at least 3 mg L(^{-1}) is applied and a residual of 0.5 mg L(^{-1}) is maintained for at least 30 minutes, most microcystins and cylindrospermopsin should be destroyed. Microcystin LA may require a higher residual. Limited data suggest chlorination is only effective at elevated pH for saxitoxins</td>
</tr>
<tr>
<td>Chloramination</td>
<td>All dissolved toxins</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>All dissolved toxins</td>
<td>Not effective with doses used in drinking water treatment</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>All dissolved toxins</td>
<td>Effective for microcystin, limited or no data for other toxins</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>All dissolved toxins</td>
<td>Not effective on its own</td>
</tr>
<tr>
<td>UV Radiation</td>
<td>All dissolved toxins</td>
<td>Capable of degrading microcystin-LR and cylindrospermopsin, but only at impractically high doses or in the presence of a catalyst</td>
</tr>
<tr>
<td><strong>EXCLUSION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Membrane Processes</td>
<td>All dissolved toxins</td>
<td>Depends on membrane pore size distribution</td>
</tr>
</tbody>
</table>


Research Findings

- Cyanobacteria can produce the taste and odour compounds geosmin and 2 methyl isoborneol (MIB) and these are a significant water quality issue (not a health issue).
- Conventional water treatment (coagulation/sedimentation/filtration) is an effective process for the removal of these compounds provided they are contained within the algal cells, however, in dissolved form, alternate treatment options are required.
- Ozone and activated carbon, in powdered and granular forms, are treatment options which are able to remove extracellular MIB and geosmin. The extent of removal is dependent upon the water quality, in particular, the natural organic matter (NOM) concentration and character.
- Procedures have been established to determine the best activated carbon for the removal of MIB and geosmin under treatment plant conditions, and to predict the PAC doses required to reach a satisfactory concentration of these compounds in finished water.
- Recently, biological treatment of geosmin has been explored. A number of projects within the CRC for Water Quality and Treatment are currently focussed on identifying the bacteria capable of degrading MIB and geosmin and applying this in both source waters and biologically active filters.

Implementation

Powdered activated carbon (PAC) is the major treatment option employed in the Australian water industry for the removal of geosmin and MIB. Figure 10.6 shows the results of laboratory tests revealing the extent of removal of MIB by four activated carbons as a function of time. This information can be used to determine the most cost effective carbon to purchase. The table gives a practical example of the doses required of each carbon and the costs associated with dosing PAC for 10 days. In this case the most expensive carbon produces the best results in terms of water quality, at only slightly higher cost overall than the cheapest carbon, and with the great advantage of lower amounts of PAC (8 tonnes compared with 15.5).

![Figure 6 Removal of MIB by four activated carbons as a function of time](image-url)
Table 5
Doses required for the removal of MIB from 20 to 10 ngL⁻¹ for four activated carbons, and costs associated with dosing at a 50 ML per day flow for 10 days in Myponga Reservoir water.

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC dose (mgL⁻¹)</td>
<td>16</td>
<td>31</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>PAC required for 10 days dosing (tonne)</td>
<td>8.0</td>
<td>15.5</td>
<td>13.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Cost for 10 days dosing (AUS$)</td>
<td>28 000</td>
<td>24 800</td>
<td>41 600</td>
<td>28 500</td>
</tr>
</tbody>
</table>

Table 6 gives a summary of the treatment options recommended for MIB and geosmin.

Table 6
Summary of water treatment options for removal of dissolved MIB and geosmin

<table>
<thead>
<tr>
<th>Treatment process</th>
<th>Intact cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulation sedimentation</td>
<td>Very effective for the removal of intracellular T&amp;O provided cells accumulated in sludge are isolated from the plant</td>
</tr>
<tr>
<td>Rapid filtration</td>
<td>Very effective for the removal of intracellular T&amp;O provided cells are not allowed to accumulate on filter for prolonged periods</td>
</tr>
<tr>
<td>Slow sand filtration</td>
<td>As for rapid sand filtration, with the additional possibility of biological degradation of dissolved T&amp;O</td>
</tr>
<tr>
<td>Combined coagulation/sedimentation/filtration</td>
<td>Extremely effective for the removal of intracellular T&amp;O provided cells accumulated in sludge are isolated from the plant and any free cells are not allowed to accumulate on filter for prolonged periods</td>
</tr>
<tr>
<td>Membrane processes</td>
<td>Very effective for the removal of intracellular T&amp;O provided cells are not allowed to accumulate on membrane for prolonged periods</td>
</tr>
<tr>
<td>Dissolved Air Flotation (DAF)</td>
<td>As for coagulation/sedimentation</td>
</tr>
<tr>
<td>Oxidation processes</td>
<td>Not recommended as a treatment for cyanobacteria cells as this process can lead to cell damage and lysis and consequent increase in dissolved T&amp;O levels</td>
</tr>
<tr>
<td>Adsorption -powdered activated carbon (PAC)</td>
<td>A microporous carbon (steam activated wood, coconut or coal based) 60 minutes contact time recommended</td>
</tr>
<tr>
<td>(doses required vary with water quality)</td>
<td>High doses may be required for high concentrations of T&amp;O</td>
</tr>
<tr>
<td>Adsorption -granular activated carbon (GAC)</td>
<td>GAC adsorption is an effective treatment for T&amp;O. The time required for breakthrough will depend on the contact time and water quality. Removal is not reliable in the presence of free chlorine</td>
</tr>
<tr>
<td>Biological filtration</td>
<td>When functioning at the optimum this process can be very effective for the removal of T&amp;O. However, factors affecting the removal such as biofilm mass and composition, acclimation periods, temperature and water quality cannot be easily controlled</td>
</tr>
<tr>
<td>Treatment process</td>
<td>Intact cells</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ozonation</td>
<td>A residual of at least 0.3 mg L⁻¹ for 10 minutes should result in up to 50% removal of the T&amp;O. Doses will depend on water quality</td>
</tr>
<tr>
<td>Chlorination</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Chloramination</td>
<td>Ineffective.</td>
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<td>Potassium permanganate</td>
<td>Have to check this</td>
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<tr>
<td>Hydrogen peroxide</td>
<td>Not effective on its own</td>
</tr>
<tr>
<td>UV Radiation</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Membrane Processes</td>
<td>Depends on membrane pore size distribution. Only the tightest RO or NF membrane could be expected to remove these T&amp;O compounds</td>
</tr>
</tbody>
</table>

More Information


Contact Details

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Research Findings

- The microcystin toxins are the most commonly reported of algal toxins worldwide.
- Studies have shown that the microcystins are biodegradable by micro-organisms in both source waters and through biologically active filters (biofilters).
- To date only a few bacterial species of the genus *Sphingomonas* have shown the ability to effectively degrade microcystin. While these organisms are widespread, they are not present in all waters.
- Recently, genetic methods have identified the genes responsible for the degradation of microcystin.
- Degradation by bacteria is not known to produce any harmful by-products.
- Figure 7 shows the rapid biodegradation of microcystin LR in a reservoir water containing degrading bacteria compared with a water where the degraders were inactivated.

**Figure 7** Degradation of microcystin toxin by bacteria

Implementation

- Kinetic parameters extracted from data like that shown in Figure 7 can be used to estimate degradation of microcystins in reservoirs and lakes. Degradation to below detection could usually be expected in 2-3 weeks in the presence of sufficient numbers of degrading bacteria.
- An effective biofilter, with the appropriate biomass and microbial community, can reduce high levels of microcystin to below detection.
- By using genetic methods, such as the polymerase chain reaction, it will be possible to screen water sources and biofilters to determine whether they contain the bacteria which are able to degrade microcystin.
- In situations where the bacteria are not present it may be possible to "artificially seed" the degrading bacteria into the system to remove the toxin.
- Researchers within the CRC for Water Quality and Treatment are working to determine the feasibility of practical application of these techniques.

More Information


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Biodegradation of Cylindrospermopsin Toxins

Research Findings

- Microbial degradation of soluble cylindrospermopsin (CYN) was confirmed in natural waters with a previous history of toxic *Cylindrospermopsis raciborskii* blooms.

- Degradation of CYN typically began 3-11 days (lag phase) after addition to surface water samples. Once degradation had begun, CYN was completely removed within 10-33 days.

- The lag phase and hence the time taken for complete removal of CYN was reduced upon re-addition of the toxin to induced surface water samples.

- Degradation of CYN in a range of waterbodies with no recorded history of toxic *C. raciborskii* blooms begun approximately 64-125 days after the addition of CYN. Once degradation was detected, CYN was only 16-59% removed within 212 days.

Implementation

- The lag phase and the time taken for total degradation of CYN to occur varied between studies and waterbodies.

- The length of time required for complete removal of CYN may vary depending on a number of factors such as the local bacteria present, the presence of essential growth factors for degrading organisms and perhaps the presence of more readily metabolisable substrates in the waterbody.

- Thus, it is not yet possible to accurately predict a safe withholding period for a particular waterbody and each toxic bloom incidence must be treated separately.

- CYN levels must be monitored (refer to FS 3 on sampling) to ensure that degradation has occurred.

- The rate of CYN degradation is generally proportional to the concentration of CYN present, therefore it could be possible to estimate the time taken for complete CYN removal in some waterbodies.

- The reduction of the lag phase upon re-addition of CYN to water samples suggests that biodegradation may commence more rapidly in waterbodies that have frequent exposure to CYN producing cyanobacterial blooms.

- The induction of biodegradation in waterbodies with no previous recorded history of toxic *C. raciborskii* blooms is probable, however, the lag period and time taken for complete removal of the toxin is likely to be lengthy.

- This study has shown that biological activity has a role in the reduction of soluble CYN concentrations in waterbodies containing active CYN degrading organisms. Therefore, if water samples for CYN analysis are not correctly preserved and stored, there may be a reduction in the concentration of CYN by the time the sample is analysed.

- The most common method used for sample preservation to reduce microbial activity is to lower the temperature of the sample to approximately 4°C as soon as practical after collection. It is recommended that the sample remain chilled until analysis can begin. If analysis is delayed it is recommended that the sample is frozen.
More Information

Chiswell, C. 1999. Investigations into the toxicological properties and environmental fate of the cyanobacterial toxin cylindrospermopsin. School of Public Health, Brisbane, Griffith University.

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Research Findings

- Thermal stratification is the layering of water of different temperatures in lakes and reservoirs. Thermal stratification promotes stable conditions suitable for cyanobacterial growth.

- During stratification the hypolimnion (bottom waters) are effectively separated from the atmosphere and become depleted in oxygen. Under these conditions contaminants such as ammonia, phosphorus, iron and manganese are released from sediment.

- An effective bubble plume aerator for destratification requires a suitable number of bubble plumes to impart sufficient energy to destratify the water column. The mechanical efficiency of a bubble plume is determined by the depth of the water column, the degree of stratification and the air flow rate. The number of plumes, plume interaction and the feasible length of aerator hose must also be considered in aerator design.

- As a general rule, bubble plumes are more efficient in deeper water columns. In shallow water columns (<5.0m depth) the individual air flow rates of the plumes must be very small to maintain efficiency.

Implementation

- Reservoirs can be artificially destratified to disrupt thermal stratification, control cyanobacteria and reduce sediment release of contaminants.

- The most common and effective artificial destratification devices are bubble plume aerators, consisting of a submerged perforated pipe through which air is pumped from a land-based compressor (Figure 8).

- The rising air bubbles expand and entrain water from throughout the water column into the bubble plume.

- When the plume reaches the surface, the bubbles are released to the atmosphere and the entrained water plunges to the depth of equivalent density (temperature) and moves through the reservoir.

- This flow displaces water and creates a return flow, generating circulation and weakening the prevailing stratification. This enables deeper mixing generated by wind and these deeper mixing events can induce light limitation in cyanobacteria (see FS 1).
Bubble plume aerators consist of a submerged perforated pipe through which air is pumped. Mixing is generated and stratification is weakened. Surface heating and stratification can still occur away from the immediate impact of the bubble plume.

More Information


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Research Findings

- Algicides have been widely used in many countries to control cyanobacterial blooms. They can provide immediate and cost-effective control of algae and cyanobacteria. Use is usually confined to small to medium service reservoirs.
- The most common algicides used in Australia are copper compounds, mainly copper sulphate (\( \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \)).
- The chemical character of the receiving water, particularly pH, alkalinity and dissolved organic carbon (DOC) control copper speciation and complexation, and this greatly affects copper toxicity.
- When treating cyanobacteria with algicides, it is important that application occurs in the early stages of bloom development when cell numbers are low. This reduces the potential release of high concentrations of toxins or odour compounds into the reservoir water. It may be necessary to withhold the water to allow toxins and odours to degrade if appropriate water treatment is not available (see FS 8, 9).
- There may be local regulations in place to control the use of algicides, due to their potential adverse environmental impacts.

Implementation

**RECOMMENDATIONS FOR COPPER SULPHATE DOSING**

1. Measure the current pH, alkalinity and dissolved organic carbon (DOC).
2. Perform a range finding test to determine the dose rate:
   - Jar test using various copper concentrations to determine Minimum Lethal Dose to 100% of cells (MLD100) over 48 hours for the water body sampled
   - Required copper dose calculated from the MLD100
3. To optimise copper sulphate dosing:
   - Apply under calm, stable weather conditions
   - If water stratified, dose early in the day
   - Bias dosing to the surface mixed layer where most cyanobacteria are
4. After copper sulphate dosing of a waterbody to be used for drinking water, it is important to monitor for copper residuals

Figure 9 Flow diagram for copper sulphate dosing recommendations
More Information


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FS 12 The Alert Levels Framework for Drinking Water

Research Findings

- The Alert Levels Framework (ALF) is a monitoring and action sequence framework for a graduated management response to the development of a potentially toxic cyanobacterial bloom in source (raw) waters used for drinking water supply.
- The ALF uses cyanobacterial cell counts and equivalent cell biovolumes from monitoring programs in conjunction with the Australian Drinking Water Guidelines as a situation assessment tool.
- The cell counts/biovolumes are conservative triggers in the management plan and are supplements and surrogates for toxin measurements which may or may not be required.
- Alert Levels Frameworks also exist for recreational waters and livestock drinking waters.
- The ALF can be adapted to develop a specific local protocol if desired.

Implementation

See Figure 10 (over page).

1. The cell numbers that define the Alert Levels are from samples that are taken from the location adjacent to, or as near as possible to, the water supply offtake (ie. intake point). It must be noted that if this location is at depth, there is potential for higher cell numbers at the surface at this or other sites in the waterbody.

2. The actual numbers for a cell count estimate of 2,000 cells/mL are likely to be in the range 1,000 - 3,000 cells/mL. This is based upon a likely minimum precision of +/-50% for counting colonial cyanobacteria such as *Microcystis aeruginosa* at such low cell densities. For counting filamentous cyanobacteria such as *Anabaena circinalis* the precision is likely to be much better at these cell densities (~+/-20%), giving an actual cell density in the range of 1,600-2,400 this count.

3. This biovolume (>0.4 mm³/L) is approximately equivalent to ≥ 5,000 cells/mL of *M. aeruginosa* for Level 2.

4. This biovolume (> 4 mm³/L) is approximately equivalent to ≥ 50,000 cells/mL of *M. aeruginosa* for Level 3.

More Information


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Flow Chart of the Alert Levels Framework for Cyanobacteria in Drinking Water

Detection of problem by:
- Visual examination of raw water sample
- Scum reported on waterbody
- Taste & odour customer complaint

No significant numbers of cyanobacteria found:
Reassess at a predetermined frequency (eg fortnightly)

DETECTION LEVEL: Low Alert
≥500 & <2,000 cells mL⁻¹ (individual species or combined total)¹

Recommended Actions:
- Sample taken for microscopic examination of a raw water sample

DETECTION LEVEL: Medium Alert
Range of ≥2,000 & <5,000 cells mL⁻¹ of Microcystis aeruginosa or Anabaena circinalis or a biovolume of ≥0.2 &<0.4 mm³ L⁻¹³ where a known toxin producer is dominant²

Recommended Actions:
- Have Another Look
- Regular monitoring
- Weekly sampling and cell counts
- Regular visual inspection of water surface for scums adjacent to offtake

DETECTION LEVEL: High Alert
≥5,000 cells mL⁻¹ Microcystis aeruginosa or Anabaena circinalis³ or total biovolume of >0.4 mm³ L⁻¹³ where known toxin producer is dominant or for local conditions

Recommended Actions:
- Implement integrated management response
- Notify agencies as appropriate (eg health regulators)
- Increase sampling frequency to 2x weekly at offtake and at representative locations in reservoir to establish population growth and spatial variability in source water where toxigenic species dominant
- Decide on requirement for toxicity assessment or toxin monitoring

DETECTION LEVEL: Very High Alert
≥50,000 cells mL⁻¹ Microcystis aeruginosa or Anabaena circinalis or the total biovolume of all cyanobacteria > 4 mm³ L⁻¹⁵

Recommended Actions:
- Assess potential risk immediately if you have not already done so.
- Immediate notification of health authorities for advice on health risk for this supply
- May require advice to consumers if the supply is unfiltered
- Toxicity assessment or toxin measurement in source water/drinking water supply if not already carried out
- Continue monitoring of cyanobacterial population in source water as per Level 1

Figure 10 Flow Chart on the Alert Levels Framework for Cyanobacteria in Drinking Water.
Modelling Tools for Predicting Cyanobacterial Growth

Background

- Computer simulation of reservoir hydrodynamics, biogeochemistry and ecology enables prediction of reservoir behaviour in response to environmental factors and management intervention.
- DYRESM (DYnamic REservoir Simulation Model) is a one dimensional hydrodynamic model for predicting the vertical distribution of temperature, salinity and density in lakes and reservoirs. The model was developed at the Centre for Water Research at the University of Western Australia and is available from their website www.cwr.uwa.edu.au.
- CAEDYM (Computational Aquatic Ecosystem Dynamics Model) is an aquatic ecological model that is used for investigations involving biological and chemical processes.
- CAEDYM consists of a series of mathematical equations describing the major biogeochemical processes influencing water quality.
- The model can be run in isolation or coupled to DYRESM for studies of the seasonal, annual or decadal variation in water quality.

Implementation

- The growth and vertical distribution of cyanobacteria can be modelled along with other groups of algae including diatoms, dinoflagellates and green algae.
- Implicit in the model are parameters describing phytoplankton response to light and nutrients, and algorithms describing their vertical migration or sinking velocity.
- Inputs to the hydrodynamic model include short wave radiation (Wm\(^{-2}\)), incident long wave radiation (Wm\(^{-2}\)), air temperature (\(^{\circ}\)C), vapour pressure (hPa), wind (ms\(^{-1}\)) and rainfall. The volume and temperature of inflowing water is also required along with the volume of water drawn from the reservoir.
- Management scenarios such as changes in nutrient loading or destratification can be simulated with the models to enable prediction of the most appropriate management strategy and risk reduction that can be achieved.
- As an example, modelling of cyanobacterial growth in Myponga Reservoir South Australia suggests that the cyanobacterial population would be reduced by 75% with a bubble plume aerator (See FS 10).
- Modelling of *Anabaena* growth at Myponga Reservoir with no artificial mixing showed that the population could reach a maximum concentration of 7 µgL\(^{-1}\). However, if artificial destratification using a bubble plume aerator was undertaken the model predicts that the maximum abundance of the *Anabaena* population would be reduced to less than 2 µgL\(^{-1}\), a reduction of 75%.

More Information


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FS 14 Nutrient control

Background
- Nutrient levels, particularly nitrogen and phosphorus, have increased within water impacted by human development, leading to ‘artificial’ or ‘cultural’ eutrophication.
- Increased nutrient levels are a result of increased inputs to the surrounding catchment. In many cases, fertilisers that are used to increase soil fertility are the major additional nutrient input.
- Most additional nutrients are supplied to waterbodies from surface run-off, particularly during high rainfall events.
- When hydrological conditions are favourable, increased nutrient levels result in increased phytoplankton biomass (reflected by chlorophyll and cell concentrations). Eventually, cell numbers may reach ‘bloom’ levels, which can be detrimental for ecosystems and water treatment processes.

Research Findings
- A reduction in nutrient levels can reduce phytoplankton biomass.
- Management practices include:
  - A reduction in nutrient (fertiliser) application to reduce nutrient inputs. This may achieved by most closely matching application with crop nutritional requirements.
  - Alteration to farming practices to reduce surface run-off, soil erosion, and dissolved nutrient concentrations.
  - The addition of nutrient-sorbing substances to farm-land to retain nutrients.
  - Rehabilitation of riparian vegetation, known as buffer zones, to increase nutrient utilisation before nutrients enter water bodies.
  - The creation of artificial wetlands to remove dissolved and particulate nutrients from water.
  - Rehabilitation of aquatic vegetation to compete with phytoplankton for nutrients.

Implementation
- Management strategies to reduce nutrient levels should not be limited to one of these management practices, but should use a combination of all management practices to be most effective.
- In addition, alterations to hydrology (see FS 10) can be used in combination with these practices to reduce phytoplankton biomass within waterbodies.

More Information

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The work summarised in these fact sheets was made possible by the commitment of the CRC for Water Quality and Treatment partners who designed the work plan and invested in the research. Dr Dennis Steffensen, Ms Mary Drikas and Dr Glen Shaw have managed the programs that have delivered this research.

Cover photographs were supplied by Dr Mike Burch from the Australian Water Quality Centre.

These fact sheets are derived from the following CRC for Water Quality and Treatment research projects:

- 1.0.0.2.5.1 Destratification for Control of Cyanobacteria in Reservoirs
- 2.0.2.2.1.4 Reservoir Management Strategies for the Control and Degradation of Algal Toxins
- 1.0.0.2.6.1 ARMCANZ National Algal Manager
- 1.0.0.3.2.6 Optimisation of Adsorption Processes – Stage II
- 2.0.2.4.0.5 Biological Filtration Processes for the Removal of Algal Metabolites
- 2.0.2.4.1.3 Management Strategies for Toxic Blue-green Algae: A Guide for Water Utilities
- 2.0.1.2.0.2 Cylindrospermpsin Carcinogenicity, Genotoxicity and Mechanisms of Toxic Action – Development of Biomarkers of Human Exposure
- 2.0.1.2.0.5 Development of Screening Assays for Water-Borne Toxicants
- 1.0.2.3.2.4 Regulation of cylindrospermpsin production by the cyanobacterium *Cylindrospermpsis raciborskii*
- 2.0.2.3.3.2 Rapid methods for the detection of toxic cyanobacteria
- 2.0.2.3.0.4 Early detection of cyanobacteria toxins using genetic methods

Research Participants
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Research and Utility Partners

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Fact Sheet Objective

The Framework for Management of Drinking Water Quality contained in Chapter 2 of the Australian Drinking Water Guidelines (ADWG), outlines the methodology for providing safe drinking water by managing the complete catchment to tap water supply system. This document is achieving global recognition as the best way to manage our drinking water as we move into the 21st Century and is being incorporated into National and State Health Guidelines.

It is important to understand the level of risk that the different cyanobacteria and toxins pose to drinking water. This allows managers of catchments and urban water utilities to focus their efforts on policies, works and operational practices to not only lower risks to public health but also improve the environmental health of these waters.

These fact sheets present the findings of a major research program carried out by the Australian Cooperative Research Centre (CRC) for Water Quality and Treatment into areas such as understanding cyanobacterial growth, detection methods for cyanobacterial toxins and water treatment options for cyanobacterial cells and toxins.

In Australia, drinking water quality management is undertaken in the context of the Framework for Management of Drinking Water Quality contained in the Australian Drinking Water Guidelines (ADWG). In the table below the salient research findings are presented within the Framework to aid in their implementation by the Australian water industry.

Summary of fact sheet findings and relationship with ADWG Framework elements

<table>
<thead>
<tr>
<th>ADWG Framework Elements</th>
<th>Key research findings and reference to fact sheet number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply System Analysis</td>
<td>All fact sheets provide information necessary for control and management of cyanobacteria</td>
</tr>
<tr>
<td>Review of Water Quality Data</td>
<td>FS 6 Data sets used to determine what toxins are likely to occur and the appropriate treatment technology to apply</td>
</tr>
<tr>
<td></td>
<td>FS 2 Toxin occurrence data reviewed with respect to guideline values</td>
</tr>
<tr>
<td></td>
<td>FS 9 Cell count data provides the context for cyanobacteria risk assessment</td>
</tr>
<tr>
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</tbody>
</table>
The Cooperative Research Centre for Water Quality and Treatment is an unincorporated joint venture between:

- ACTEW Corporation
- Australian Water Quality Centre
- Australian Water Services Pty Ltd
- Brisbane City Council
- Centre for Appropriate Technology Inc
- City West Water Ltd
- CSIRO
- Curtin University of Technology
- Department of Human Services Victoria
- Griffith University
- Melbourne Water Corporation
- Monash University
- Orica Australia Pty Ltd
- Power and Water Corporation
- Queensland Health Pathology & Scientific Services
- RMIT University
- South Australian Water Corporation
- South East Water Ltd
- Sydney Catchment Authority
- Sydney Water Corporation
- The University of Adelaide
- The University of New South Wales
- The University of Queensland
- United Water International Pty Ltd
- University of South Australia
- University of Technology, Sydney
- Water Corporation
- Water Services Association of Australia
- Yarra Valley Water Ltd