LIVING WITH BLUE GREEN ALGAE IN YOUR WATER SUPPLY

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Abstract

Blue green algae have evoked a relatively emotive community response since the Barwon-Darling River bloom in 1991. As a means of safeguarding the community, particularly raw water consumers, the water industry has traditionally invoked relatively narrow and conservative guidelines on the notification levels for blue green algae in the drinking water supply.

In line with the National Water Quality Management Strategy, guidelines were produced in 1992 (Australian Water Quality Guidelines for Fresh and Marine Waters) that linked cyanobacteria to quality guidelines for raw waters. The Australian Drinking Water Guidelines (1996) had no guideline values set for drinking water but provided levels of concern for water storages.

Tamworth City Council, like many other water Authorities, has a number of raw water customers supplied directly via a pipeline that links its storage dam to its water treatment plant, and which typically has suffered a number of management difficulties associated with previous guidelines.

However in late 2001 ARMCANZ completed a review of the impacts of cyanobacteria (blue green algae) which considered drinking water, recreational, agricultural and fisheries components. Tamworth has adopted the revised guidelines in a new blue green algae policy that attempts to better manage the various issues relevant to raw water supply.

Introduction

The setting of standards and in particular water quality standards is always something of a mystical process, to the average Australian. Thus if we were to commence the story of blue green algae in Australia, with the obligatory "Once upon a time", it would begin with the tale of the 1000 kilometre slick down the Darling River in 1991. This genesis was shrouded in media warnings of a forthcoming cataclysm for raw water supplies. Hence blue green algae came into our societal consciousness enveloped in emotion and we the authors, believe that it has very much remained at this level for most Australians.

There has been no recorded human deaths from the presence of blue green algae in water supplies to the knowledge of the authors; and whilst incidences of stock losses and skin rashes and gastroenteritis have occurred it can be argued that this potential health hazard has been generally well managed, through the adoption of appropriate water quality standards. However statements such as this do very much ignore the human element and the simple truth that as an industry we have historically dealt with

blue green algae in our raw water services by the progressive withdrawing of the service.

Previous water supply standards understandably had to be based upon a safety first (duty of care) approach whilst we gained greater knowledge of these occurrences. However new revised Australian guidelines not only allow this human element to be better addressed but it also allows us for the first time to move in the direction of living with blue green algae in our water supplies rather than the practice of abstinence. Tamworth City Council has been keen to better address this human element in its own raw water system and has accordingly moved to translate these new Australian Standards into a workable operational procedure for residents impacted by levels of cyanobacteria greater than background concentrations.

Storage Background

Dungowan Dam is one of two raw water supplies for the city of Tamworth. It was completed in 1957 and has a capacity of 6300 ML with a maximum discharge of 20 ML/day. The hopper-shaped basin is approximately 35 metres deep and the off-take tower has 4 discharge points. The 55-km pipeline, which transfers raw water to a conventional chemical dosing water treatment plant at Calala, has approximately 120 residences connected.

The dam catchment is 125 km^2 and is regarded as pristine with no public access. The first recorded blue green algae bloom occurred in 1995 and was linked to the prolonged drought and Dam PMF upgrade that coincided. Water quality monitoring has been extensive since this period and includes routine weekly physico-chemical and nutrient chemistries and identification and enumeration of phytoplankton/algal populations. There are 2 surface monitoring sites on the Dam that conform to National Monitoring Guideline protocols.

A destratification system installed in 1996 is used to improve both water quality (iron and manganese in particular) and control the populations of cyanobacteria.

Current/ Previous Blue Green Algae Procedures

All procedures universally across NSW depend upon the nature of the end users, which effectively fall within the categories of:

- Raw Water Users
- Potable Urban Water Consumers

Starting with the latter, potable supplies have been able to use filtration, disinfection, activated carbon dosing and destratification of the source water as a means of reducing the impacts of increased cell counts in their water supply. Where urban supplies have had more than one source, selective use of these sources has been another operational tool available. However even for many of these supplies, where algal levels grew to high levels, many of these services also had to be withdrawn.

In the case of raw water users, Tamworth has about 120 residence (250 - 300 persons) connected directly into its 55-kilometre raw water trunk main from the Dam to the City. Typically for these residents elevated blue green levels in the Dam would translate into:

- Advice from Council, advising them that the supply was at Alert Level 1 (fax/phone and confirmation post). This would occur at a relatively low cell count (500 –2000 cells/mL).
- Further contact from Council advising that levels had increased and repeating the warnings for them and their livestock not to drink water. This would occur at cell count of 2000-15000-cells/ mL.

- Final contact advising that as levels had increased to a critical point where Council had no choice but to close the main. For many of these raw water residents, their sole source of water would then have been withdrawn (at levels greater than 15000 cells/mL).

From an operational perspective, the elevated levels immediately will effectively incur significantly increased monitoring costs, so as to ensure the maximum possible protection for these residents. It also sees the destratification system moved from off peak to full 24 hour a day operation. Some of the traditional criticisms of this approach have been that:

- Blue green levels are not homogeneously spread through the dam, and can often be governed by wind drift and flow directions. As such, cell counts in the dam have often in Tamworth's case not translated into similar cell counts in the trunk main, which is the supply that the residents are receiving. Figure 1 highlights the difference between sites.

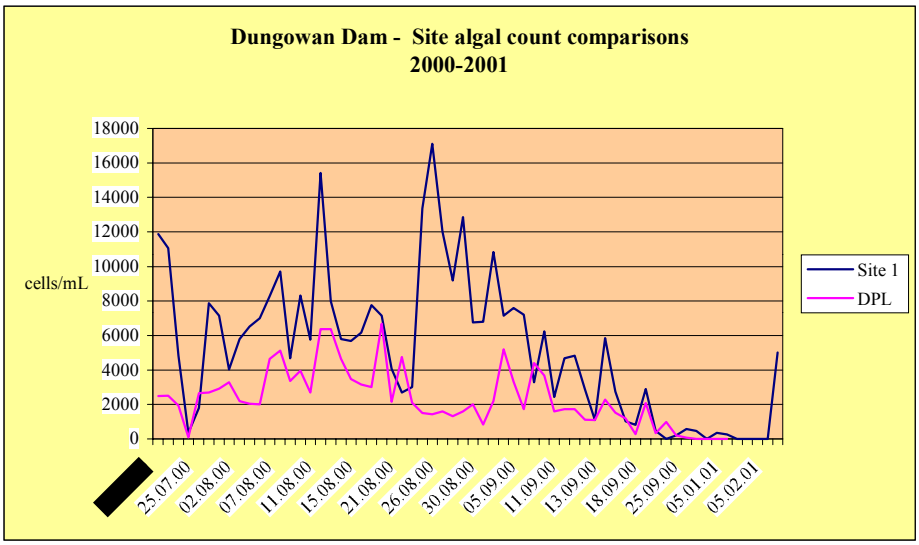
The warnings are triggered by cell counts not toxins. Whilst the latter are more difficult to determine there was no provision to return the water supply back to full service, if it could be determined that there were no toxins in the water supply.

  In Tamworth's case since the first bloom event in 1995, bioassays and toxin analysis have confirmed that toxins have not been generated by the subsequent elevation in cell counts.

- Once an elevated level in the dam has been detected there is no provision to be able to utilise other deeper draw off points for the pipeline where cell counts may be very much lower. In Tamworth's case with a small dam and a limited number of off take points, such opportunities are governed by cell counts based on in situ 5-metres integrated surface samples

- Rural pipeline (raw water) residents would be told not to drink their water 3 – 4 times per annum (with each incident lasting between 2 - 6 weeks on average).

Figure 1 Integrated storage cell counts vs Pipeline values



Tamworth has only had the one significant "bloom" at the dam and has operated destratification equipment at the dam since that incidence. This bloom lasted 8 weeks with cell counts

reaching 1.0 x 10^6 cells/mL of the genus *Anabaena.*

It is important to note that bloom is defined as "an unusually large number of organisms per unit of water". What does that translate to the consumer other than a negative emotive image? What does "unusually large" mean?

Prior to 1995 monitoring protocols were primarily based on qualitative and visual assessment (inspection for water discolouration or surface scums). The procedures outlined in the 1996 Drinking Water Guidelines and associated procedures (ie the Regional Algal Coordinating Committee) were subsequently adopted as a work procedure/policy (referred to as a Method Statement).

The Human Element

For most operations the focus for Council staff is on the implementation of these service withdrawals, from the perspective of the increased costs and workload in monitoring, the logistics of urgently contacting the residents and the operational difficulties they face in bringing the supply back on line. However what too often remains unseen and potentially not well understood are the reactions and concerns of pipeline consumers. For example:

- Parents concerned over bathing their children in a water supply that they are no longer told is safe to drink even though Council has informed the residents it is a raw water supply. This is also reflected in concerns raised by some of the elderly residents.

- A farmer with a large number of livestock suddenly having to find an alternative source of water, and the associated difficulty inherent in moving the livestock.

- Simple activities such as using garden sprinklers near the resident's home (does this lead to some form of aerosol transfer of blue green algae?).

- Is it safe to prepare food and wash kitchen utensils with this water supply?

Based upon the feed back from both raw water users and urban residents, Council believes there is considerable confusion in the community over blue green algae and its impact. The progressive withdrawal of services in response to relatively low levels of algae on a frequent basis can only continue to feed the emotionalism that occurred from this initial introduction to Blue Green Algae.

In Tamworth's case we believe this emotional is and has even lead to:

- Perceptions of a decline in raw water quality over last decade, particularly as the events/ notifications have only occurred since 1995.

- Perception that Council is doing something wrong to generate this blue green algae in the water supply.

National Initiatives

After the accumulation of considerable research and investigative data, the Agriculture and Resource Management Council of Australia and New Zealand the then peak body with the responsibility for blue green algae matters indicated a review of the guidelines pertaining to Blue Green Algae. The draft paper commenced in 1997 and was finally completed for comment in late 2001.

Dr Michael Burch was engaged as the project manager to conduct this review and as Michael finalised these guidelines he was invited by Tamworth City Council to make its blue green policy the first practical application of the new guidelines. He has worked

closely with Council and the other regulatory agencies such as NSW Health, NSW EPA and the Department of Land and Water Conservation in the revision of the new Council policy.

Some of the basic fundamentals established in these revised guidelines that make them particularly useful are:

- The recognition of the roles of different blue green genera and the application of differing ratification levels for them.

- The setting of toxin levels (for example 1.3 ug/L for *Microcystins*) as the true guides to the safety of the water supply and not cells counts. Thus it is possible to continue to use the supply provided toxin levels are below guidelines. However an appropriate monitoring program must support this.

- The recognition and formalisation that the exposure levels contained within the guidelines are based upon a lifetime of exposure. The guideline value thus represents the concentration of the cyanobacteria toxins that do not result in significant risk to the health of the consumer over a **lifetime of consumption** (WHO 1992).

- Provision for using past local knowledge as a tool for indicating the presence/absence of hazard.

- More effective consultation with health regulators and other relevant agencies and stakeholders.

Revised Procedures for Tamworth City Council

The changes in Alert Level Framework for Dungowan Dam Blue-green Algae Management are provided in **Appendix A.**

Appendix B provides complete detail with thresholds and recommended actions.

The major benefits for Tamworth are:

- Increased notification levels particularly for *Anabaena* species. This is particularly relevant due to the endemic nature of this algal genus in the storage.

- The differentiation between notification levels for humans, livestock and irrigation activities.

- The recognition that the sampling point for notification purposes is that site above the chlorination point at the dam being more representative of the water being consumed by the raw water users then the current integrated surface samples.

- The initial use of cell counts for assessment but the need to confirm these with actual toxin readings.

- The utilising of local conditions for interpretation by Council and government agencies.

- The ability to use differing draw off points based on cell counts, toxin levels and physico-chemical analysis at these lower draws off point.

The use of algides such as Cupricide, Coptrol or Copper Sulphate has been retained in the Dam Management protocol only as a last resort. It is felt that within most situations that are likely to arise in Tamworth, the revised operational strategy should suffice. However this provision has been retained for the unexpected incidents where the algal bloom persists for a significant period after all other options have failed. This step would be in consultation with the NSW EPA.

Implications of the Revised Standards

The revised policy has only recently been approved by Council and the other regulation bodies. However over time the following implications for Council and residents are expected:

- Significantly reduced notification required and as a result much less withdrawal of service, not so much that the water is drinkable in the first instance being a raw water supply, but rather that it has less emotiveness surrounding its supply.
- Reduced operational and monitoring costs for Council.
- Reduced need to find alterative waters supplies for the resident's livestock or those that might be on agistment.
- Hopefully renewed confidence in the water supply by the residents.
- Closer liaison with relevant agencies.

The Lesson Learnt

The problems caused by cyanobacteria for water supply management are likely to increase worldwide with both increasing eutrophication, and also with the growing awareness of the hazards of cyanotoxins.

In this context the new guidelines allow a much more flexible approach to living with blue green algae in the water supply. However just implementing these revised guidelines is not by itself sufficient for future directions. It is our experience that the industry must do considerably more to educate end users on blue green algae so that their concerns can be laid to rest. Similarly there is a need for protection in framing guidelines to also better understand the problem from the perspective of the human element involved. The challenge for Tamworth will be to continue in these areas.

There is also a need to ensure operating authorities have appropriate laboratory services at their disposal, to determine actual toxin levels in the water and to understand what is occurring in there water supplies. This can be the basis for "local conditions' allowing further flexibility in managing algal outbreaks.

Failure to implement appropriate monitoring programs could result in water organisations not achieving the potential flexibility that is offered under the new guidelines.

REFERENCES

Burch M.D and Nicholson B.C (2000) Minimisation of Cyanobacterial Toxins in Drinking Water by Reservoir Management and Water Treatment *paper at 10th World Water Congress.*

Burch M.D (2001) Review of Guidelines for Toxic Cyanobacteria in Australia

ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)-Section 9.3 Livestock Drinking water Guidelines: 9.3.3.1 Cyanobacteria (Blue-Green Algae)-*released mid-2001*

ARMCANZ National Monitoring Protocol for Cyanobacteria (Blue Green Algae)-*Final Draft in Review, December 2001.*

NHMRC/ARMCANZ Drinking Water Guidelines for cyanobacterial toxins (2001).

Appendix A

	Current	**Draft revision**
Detection level	500- 1000 cells/mL total cyanobacteria	>500 cells/mL total cyanobacteria
Alert Level 1	500-2000 cells/mL total cyanobacteria	≥ 2000 cells/mL total cyanobacteria
Alert Level 2	2000-15000 cells/mL total cyanobacteria	5000-10000 cells/mL *M.aeruginosa* **or** *A.circinalis*
Alert Level 2A	Not Used	> 11500 cells/mL *M.aeruginosa or >20000* cells/mL *A.circinalis*
Alert Level 3	>15000 cells/mL total cyanobacteria	> 50000 *M.aeruginosa or A.circinalis*

Appendix B

Alert Levels Framework for Dungowan Dam Blue-green Algae Management Policy

Level	Threshold Definition	Recommended Actions
Detection Level	> 500 cells/mL cyanobacteria	Weekly sampling and cell counts at two storage sites (5-metre integrated columns, Locations 1,2) and at the tunnel site immediately upstream of chlorinator. Regular visual inspection of water surface for scums adjacent to offtakes
Alert Level 1	≥ 2,000 cells/mL cyanobacteria	Notify NSW Health, DLWC, EPA that cyanobacteria established at low numbers in Dungowan Dam Increase sampling frequency to 2x weekly at offtake and at the two representative locations in reservoir Decide on requirement for toxicity assessment or toxin monitoring in consultation with Health – if required, collect concentrated cell (scum) samples for testing.
Alert Level 2	5000-10000 cells/mL *Microcystis aeruginosa or Anabaena circinalis*, *or* other cyanobacteria with biovolume equivalent to that number of *M. aeruginosa* (ie. approx. 0.7 mm^3/L) For other types of cyanobacteria found in Dungowan Dam this is equivalent to: > Approximately 75,000 cells/mL *Aphanocapsa incerta, Pseudanabaena* sp.	Advice from NSW Health on risk to public health for pipeline consumers, ie health risk assessment considering toxin monitoring data, sample type and variability, effectiveness of treatment Consider requirement for advice to consumers from pipeline Continue monitoring as per Level 1 Toxin monitoring of pipeline at two locations: immediate d/s AC point,. Analysis would be for saxitoxins associated with *A. circinalis*, and microcystins associated with the presence of *M. aeruginosa.* Recommended frequency 2-3x weekly

Alert Level 2A Stock watering advice	≥ 11,500 cells/mL *Microcystis. aeruginosa* and/or concentrations of microcystins exceed 2.3 µg/L expressed as microcystin-LR toxicity equivalents; *or* ≥ 20,000 cells/mL *Anabaena circinalis*, or other cyanobacteria with biovolume equivalent to that number of *M. aeruginosa* (i.e. approx. 1.3 mm^3/L) For other types of cyanobacteria found in Dungowan Dam, this is equivalent to: > Approximately 130,000 cells/mL *Aphanocapsa incerta, Pseudanabaena* sp.	Issue advice to pipeline users that blue-green algae (cyanobacteria) are present in the supply, and although the risk to livestock health for short-term consumption is not great, it is advisable to use an alternative supply if available.
Alert Level 3	≥ 50,000 cells/mL *M. aeruginosa, A. circinalis or* other cyanobacteria with biovolume equivalent to that number of *M. aeruginosa* (i.e. approx. 5.7 mm^3/L) For other types of cyanobacteria found in Dungowan Dam this is equivalent to: > Approximately 570,000 cells/mL *Aphanocapsa incerta, Pseudanabaena* sp.	Immediate notification of NSW Health for advice on health risk for pipeline supply May require further advice for users of pipeline not to use the water for human consumption and to seek alternative drinking water. Continue toxicity assessment or toxin measurement in source water and drinking water supply Continue monitoring of cyanobacterial population in source water as per Level 1

Author Biography

Dan O'Connor has worked in a number of roles at Tamworth City Council in the last 15 years and currently is the Senior Environmental Scientist for the Technical Services Department. Dan holds a degree in Environmental Science and diplomas in Chemistry and Coal Geology. He also has qualifications in Water and Wastewater Operations through Queensland TAFE. Prior to entering Local Government Dan worked for BHP (Steelmaking and Coal Divisions) and Shell-BP (South Africa).

Particular areas of interest are environmental and safety systems and developing an Integrated Management System for Council in collaboration with colleagues.

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