Water quality monitoring in reservoirs in southeast Queensland

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Abstract
A study of the water quality monitoring programs across six water supply reservoirs and three water authorities (Redland Water and Waste, Gold Coast Water, SEQWater) in southeast Queensland has found considerable differences in the parameters measured, and sampling protocols. In order to more effectively compare water quality in the reservoirs, a study is planned to sample the reservoirs using the same sampling protocols, timing of sampling, parameters measured and analytical techniques. This will allow a more direct comparison and aid the industry in identifying the factors responsible for promoting algal blooms in reservoirs.

Preliminary analysis of the historical data for water quality parameters (relevant to algal bloom problems) showed that total nitrogen and chlorophyll $a$ concentrations were highest in reservoirs with catchments having the highest percentage agriculture (North Pine, Somerset and Wivenhoe Dams). In contrast, total phosphorus did not show this trend but was highest in the catchment with the highest urban development (Leslie Harrison Dam). Further analysis of the historical data is warranted to compare catchment characteristics with water quality.

Introduction
Maintenance of high quality water in drinking water reservoirs is a key issue for reservoir managers. Considerable resources are allocated to monitor water, and to trigger action during episodes when water quality deteriorates. This ensures that human and environmental health is not compromised. One of the water quality parameters of concern for many Australian reservoirs is algal blooms. Depending on the species, blooms may create low oxygen conditions, taste and odour problems, or produce toxins harmful to humans and animals.

Water reservoirs have created an artificial environment conducive to algal growth, and particularly cyanobacteria, with calm waters, high light availability in surface waters and external nutrient inputs. In southeast Queensland this problem is exacerbated by warm summers, high nutrient inputs from large rain events, and infrequent flushing (Jones and Poplawski 1998).

Australia’s water reservoirs are owned and managed by a large number of organisations, both private and government, and, in general, water quality monitoring
programs are developed on a reservoir by reservoir basis. A wealth of historical water quality data exists, however it is often the case that the information is archived without the time or resources to analyse the data for factors that might be responsible for initiating algal blooms. Additionally, information exists on catchment land use, soil types etc which can have a significant effect on nutrient and suspended loads in rivers and hence algal blooms in downstream reservoirs (Ulrich 1997, Harris 2001, Knoll et al. 2003). In light of this, a study was recently conducted by researchers at the Centre for Riverine Landscapes at Griffith University, collaboratively with water managers at Gold Coast Water, Redland Water and Waste and SEQWater to examine their water quality monitoring programs and where possible, analyse the historical water quality data and catchment land use.

**Water quality monitoring programs**
The water quality monitoring programs were examined for six water supply reservoirs in southeast Queensland:

- Leslie Harrison Dam – managed by Redland Water & Waste
- Little Nerang Dam – managed by Gold Coast Water
- Hinze Dam – managed by Gold Coast Water
- North Pine Dam – managed by SEQWater
- Somerset Dam – managed by SEQWater
- Wivenhoe Dam – managed by SEQWater

Leslie Harrison Dam is a supplementary drinking water supply for an underground water supply from Stradbroke Island, Hinze Dam supplies most of the drinking water requirements for the Gold Coast, while Little Nerang is a secondary supply. North Pine Dam supplies a number of regional centres including Pine Rivers and Redcliffe as well as Brisbane City, while Wivenhoe and Somerset Dams are the main drinking water supply for Brisbane city, as well as supplying the Gold Coast, Logan and a number of regional areas.

The reservoirs vary in volume from 9,300 ML for Little Nerang Dam up to 1,165,000 ML for Wivenhoe Dam, and have mean depths ranging from 5.3 m for Leslie Harrison Dam up to 17.8 m for Hinze Dam when full (Table 1). The catchment areas
also varies markedly between reservoirs from 5,650 ha for Little Nerang Dam up to 571,638 ha for Wivenhoe Dam.

Table 1: Summary of catchment and dam statistics for the six reservoirs.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>LITTLE NERANG</th>
<th>HINZE</th>
<th>LESLIE HARRISON</th>
<th>NORTH PINE</th>
<th>SOMERSET</th>
<th>WIVENHOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Area (ha)</td>
<td>5,647</td>
<td>14,594</td>
<td>11,732</td>
<td>34,733</td>
<td>134,156</td>
<td>571,638</td>
</tr>
<tr>
<td>Submerged Area (ha)</td>
<td>55</td>
<td>920</td>
<td>470</td>
<td>2,181</td>
<td>4,212</td>
<td>10,750</td>
</tr>
<tr>
<td>Capacity of Reservoir @ FSL (ML)</td>
<td>9,280</td>
<td>163,500</td>
<td>24,800</td>
<td>215,000</td>
<td>380,000</td>
<td>1,165,000</td>
</tr>
<tr>
<td>Mean Depth (m)</td>
<td>16.7</td>
<td>17.8</td>
<td>5.3</td>
<td>9.9</td>
<td>9.0</td>
<td>10.8</td>
</tr>
<tr>
<td>Reservoir / Catchment Area (%)</td>
<td>1.0%</td>
<td>6.3%</td>
<td>4.0%</td>
<td>6.3%</td>
<td>3.1%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Bloom Incidences</td>
<td>every few years</td>
<td>every few years</td>
<td>every few years</td>
<td>annual</td>
<td>annual</td>
<td>annual</td>
</tr>
</tbody>
</table>

There are a range of catchment land uses across the six reservoirs (Fig. 1). In the case of Little Nerang, Leslie Harrison and Hinze Dams, the proportion of the land used for agriculture is low (12-13%), with most of the area dedicated to forest. The forest is predominantly natural bush but some catchments also have a significant proportion of managed forest. In the catchments for North Pine, Somerset and Wivenhoe Dams, the proportion of agricultural land is considerably higher (29-49%). This is principally grazing land, with little broadacre or intensive agriculture. Leslie Harrison Dam is the only reservoir with a substantial level of residential development (~20%) in the catchment.
Figure 1: The percentage of different land uses in the catchments across the six reservoirs

The degree to which a reservoir is affected by the catchment land use is not just related to the activities within the catchment, but also to the volume of the reservoir relative to the area of the catchment. Therefore those reservoirs at highest risk are likely to be those with the lowest reservoir volume relative to catchment area, coupled with the highest human impact, e.g. agriculture, in the catchment. An analysis of the data from the six reservoirs suggests that Wivenhoe Dam is the most vulnerable reservoir in terms of water quality, despite being the largest water supply in southeast Queensland.

Approximately 20 years of historical records exist for 30 water quality parameters across these reservoirs. There was a high level of inconsistency in the monitoring program with only 14 comparable parameters, related to algal blooms and their causes, being identified as commonly measured by all water authorities for the period from July 1997 to December 2003:

- bloom incidences
- cyanobacterial cell counts
- algal toxins
- taste & odour compounds
• total nitrogen
• total phosphorus
• dissolved oxygen
• turbidity
• pH
• water temperature
• rainfall
• water release volumes
• wind speed

Additionally, there were differences in the number of sites sampled in-lake, sampling depths, and the methods for measuring river and creek nutrient inputs. Sampling frequency varies between weekly and fortnightly. The analytical methods used were not examined in detail but, once again, there appeared to be considerable variability.
Analysis of historical data

The variability in the parameters measured and sampling protocols made comparisons of the historical data across reservoirs difficult. However, some key water quality parameters were identified from most or all the reservoirs, i.e. total nitrogen, total phosphorus and chlorophyll $a$ (a measure of algal biomass). Mean total nitrogen (TN) and phosphorus (TP) concentrations were calculated from surface data at one site near the dam wall in each reservoir for the period from July 1999 to May 2002. These concentrations were compared with land use in the catchment. The reservoirs with the highest level of agriculture in the catchment had the highest TN concentrations (Fig. 2a). Leslie Harrison, North Pine, Somerset and Wivenhoe Dams had similarly high concentrations while Hinze and Little Nerang Dams had the lowest TN concentrations. In contrast, TP concentrations were highest and most highly variable in Leslie Harrison Dam (Fig. 2b). This was the reservoir with the highest proportion of residential area in the catchment (~20%). There was no evidence of increased TP concentrations in the reservoirs with increased agriculture in the catchment.
Figure 2 Mean surface a) total nitrogen (TN, mg/L), and b) total phosphorus concentrations (TP, mg/L) for six water reservoirs compared with percentage agriculture in the catchment.

There were considerable differences in the parameters measured, and the methods used in relation to estimating abundance and diversity of algae. However, clearly there were contrasts in the frequency, intensity and types of potentially toxic cyanobacterial blooms that occur in the reservoirs (Table 1). *Microcystis* and *Anabaena* bloom incidences have occurred infrequently (every few years) at Leslie Harrison and Hinze Dam, while *Cylindrospermopsis* blooms occurred annually at North Pine, Somerset and Wivenhoe reservoirs. There were few problems with toxic cyanobacterial blooms at Little Nerang Dam.

Chlorophyll *a* concentrations were compared in five of the six reservoirs using summer chlorophyll data from 1999 to 2002 at the surface at a site nearest the dam wall/offtake point (chlorophyll *a* was not measured at Leslie Harrison dam). Concentrations were lowest in Little Nerang and Hinze Dams, the two reservoirs with
the lowest %agriculture in the catchment (Fig. 3). North Pine, Somerset and Wivenhoe Dams all had comparable mean concentrations, with Wivenhoe Dam having the highest variability in concentrations.

The reservoirs with the lowest chlorophyll concentrations also had the greatest mean depth. Light is an important factor affecting algal growth and therefore deeper reservoirs are likely to have less available light, and more buffering in temperature changes. Therefore in summer, temperatures in the reservoirs are not likely to be as high, but this warrants further analysis.

![Graph showing summer chlorophyll concentrations (μg/L) for five water reservoirs compared with percentage agriculture in the catchment.](image)

**Figure 3:** Mean summer chlorophyll a concentrations (μg/L) for five water reservoirs compared with percentage agriculture in the catchment.

**Developing a collaborative approach to water quality monitoring**

The analysis of the historical data has provided some interesting clues as to which factors may be promoting algal blooms, however a more detailed analysis of the data is needed. Additionally, this study has highlighted the difficulties in comparing water quality data across reservoirs when different protocols are used and different parameters measured. In an effort to develop a more collaborative approach to water quality monitoring, a study is currently being planned to undertake periodic
simultaneous (i.e. within one to two weeks) sampling of key water quality parameters, i.e. TN, TP, algal counts, chlorophyll $a$, taste and odour compounds, physical parameters, across all the reservoirs. This would involve using the same protocols for sampling and sample analysis, and standardizing the parameters measured. It will therefore be possible to more accurately compare the water quality in the reservoirs, and develop a better understanding of the factors responsible for promoting algal blooms.

References

