Overview of methods to manage cyanobacterial blooms in drinking water reservoirs

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Today’s discussion

- Introduction
- Control methods that generally work
- Control methods that may work
- Possible future control methods
- Conclusion
Introduction

- Cyanobacterial blooms are a problem all around the world

- When they occur in drinking water supplies they cause problems with
  - Tastes and odours – for instance 5 nanograms (0.000000005 gram) a litre of geosmin can be tasted by some people
  - Toxins – for instance the Australian Drinking Water Guidelines suggest that microcystins should be less than 1.3 micrograms per litre
Introduction (cont)

- Cyanobacterial blooms are likely to get worse in the future because of climate change

- Increasing temperatures
Introduction (cont)

• Increasing temperatures
  • Cyanobacteria grow faster in warmer water
  • More intense, longer duration stratification in reservoirs
• More extreme storm events (especially after bushfire) wash more nutrients into reservoirs
• Shallower water levels encourage algal growth
Introduction (cont)

• Water shortages force water utilities to use sub-optimal reservoirs prone to cyanobacterial blooms
Methods that normally work

• **Destratification**
  • To remind you about stratification....

![Diagram showing stratification and thermal profile](image.png)

- **Stratification** = Layers
- **Thermal Profile**
  - Depth
  - Temperature (°C)
  - Warmwater "Epilimnion"
  - Rapid temperature change "Thermocline"
  - Coldwater "Hypolimnion"
Methods that normally work

• Destratification
  • Typically a bubble plume aerator is used
Methods that normally work

• Destratification may work by a combination of factors including
  • Suppression of phosphorus releases from sediments
  • Mixing cyanobacteria out of the euphotic zone
  • Reducing the competitive advantage of cyanobacteria
Methods that normally work

• Destratification benefits
  • Suppresses most (but not all cyanobacterial growth)
  • Suppresses iron, manganese, phosphorus releases from sediments

• Destratification problems
  • Expensive to purchase and operate destratification equipment
  • Only likely to be feasible for storages up to about 500GL
Methods that normally work

Destratification problems

• Can occasionally encourage cyanobacterial growth if it moves nutrient rich water to the surface
• Makes using selective withdrawal systems at inlet towers more difficult
Methods that normally work

Selective withdrawal

H = Height of cone of withdrawal
h = Vertical height of offtake port opening

“h doesn’t affect cone of withdrawal”
“size of H is proportional to flow rate Q”
Methods that normally work

Selective withdrawal benefits
• Can be very effective at eliminating most of the problems associated with a cyanobacterial bloom

Selective withdrawal problems
• Only useful for reservoirs deeper than about 20m
• Some dams do not have selective withdrawal facilities
Methods that normally work

Selective withdrawal problems

• If water is being abstracted from below the thermocline then cold water / Fe / Mn / low DO problems
Methods that normally work

Algicides

• Use of algicides such as copper sulphate can kill cyanobacterial blooms
Methods that normally work

Algicide benefits
• If carried out under optimal conditions usually effective at eliminating cyanobacterial blooms

Algicide problems
• Most States do not allow use of algicides in drinking water reservoirs
• If pH or organic levels are too high toxicity of copper based algicides is reduced
Methods that normally work

Algicide problems

• Cost per application is high so only useful for smaller reservoirs
• Kills non-target organisms like zooplankton
• Lyses algal cells releasing toxins and tastes/odours into the water column complicating water treatment
Methods that may work

Water level drawdown

• If benthic cyanobacteria are a problem then you can try reducing water levels to strand them above the water line.
• They are quite tough and may need to be left exposed for at least a couple of weeks.
Methods that may work

Shading / covering

• If the reservoir can be shaded or covered this will suppress cyanobacterial growth
• Several ways this can be done
• Shadecloth
Methods that may work

Shading – 3 million balls to cover 40,000sq.m!
Methods that may work

Alum
- Addition of alum to precipitate out cyanobacterial cells and phosphorus
- Used fairly widely in the U.S.A
- Used to be used in South Australia, before filtration plants built

Phoslock
- Modified clay, absorbs phosphorus in water column, claims to lock phosphorus in sediments by forming a sealing layer
Methods that may work

Sediment oxygenation
• Oxygenation of bottom waters may suppress phosphorus release and therefore cyanobacterial blooms
Possible future control methods

Ultrasound
• At low energies it damages the gas vesicles in buoyant cyanobacteria
• At high energies it creates free radicals which attach all cellular material

• Barley straw
  • Used in the UK, may act as a biocide

• Biomanipulation
  • Lots of work been done on this, mixed results
Possible future control methods

Hydrogen peroxide

- Hydrogen peroxide is unstable, degrades forming Hydroxyl free radicals, which damage cellular materials

- Circulation of epilimnion

  - Paper from Germany states that merely mixing the surface layer of a reservoir was enough to control algal growth

  - Would be cheaper than full destratification, if it works.
In Conclusion

- Cyanobacteria are common in Australian water supply reservoirs
- Likely to be an increasing problem in the future due to climate change
- Various methods have been developed to control cyanobacteria, no method is universally effective
- Work continues to reduce the cost, improve the effectiveness of control methods