INTEGRATED STORAGE MANAGEMENT – A PHILOSOPHY ON THE MITIGATION OF ALGAE IN INTERMEDIATE WATER & EFFLUENT STORAGES

Paper Presented by:

Chris McLaughlin

Authors:

Matthew Gore, *Environmental Scientist,*
Chris McLaughlin, *Environmental Scientist,*

BioRemedy Pty Ltd

35th Annual Qld Water Industry Operations Workshop
Community Sports Centre, CQ University, Rockhampton
22 to 24 June, 2010

INTEGRATED STORAGE MANAGEMENT – A PHILOSOPHY ON THE MITIGATION OF ALGAE IN INTERMEDIATE WATER & EFFLUENT STORAGES

Matthew Gore, *Environmental Scientist*, BioRemedy Pty Ltd;
Chris McLaughlin, *Environmental Scientist*, BioRemedy Pty Ltd.

ABSTRACT

Algae are a vital part of the aquatic ecosystem, providing both food and shelter for other organisms and can also play a crucial role in the ability of an aquatic system, be it natural or man-made, to absorb nutrients and heavy metals. However, in many situations, the proliferation and overgrowth of algae becomes detrimental to the optimal functionality of water and effluent storages.

In intermediate storages, where the process unit collects either partially-processed or source waters before final treatment, be it disinfection prior to outfall, or coagulation, flocculation and filtration prior to release to the reticulation, the presence of algae can present a range of negative impacts upon operational processes.

Operational staff, as well as re-use customers, can be placed at significant risk if algal blooms, particularly of the blue-green (cyanobacteria) algal division, are not managed appropriately.

Management via executing the concept of destratification of distinct thermal layers (eplilimnion, metalimnion and hypolimnion) that can occur within the susceptible water storage should be a principal consideration. In periods of extreme infestation an open-minded practical approach to a supplementary chemical control may need to be considered to achieve short-term respite.

Through the application of appropriate strategies, designed to ensure both operational and managerial considerations, mitigation of the risks associated with persistent algal infestation can be successfully achieved.

KEY WORDS

Blue-green algae, cyanobacteria, algicide, stratification, circulation.

1.0 INTRODUCTION

Australia experiences algal blooms in all types of water bodies - estuaries, lakes, billabongs, water storages and farm dams. Algae are a vital part of the aquatic ecosystem, providing both food and shelter for other organisms.

Algae also play a crucial role in the ability of an aquatic system, be it natural or man-made, to absorb nutrients and heavy metals. However, in many situations, the proliferation and overgrowth of algae becomes detrimental to the optimal functionality of water and effluent storages. As well as long-term understanding, managers also need knowledge of technologies to combat algal outbreaks immediately.

2.0 DISCUSSION

2.1 Defining Storages & Algal Influence

In defining intermediate water and effluent storages, both Pearson (2005) and Juanico (2005) describe wastewater storage and treatment reservoirs (WSTR) and their concept, pioneered in Israel, where they prove fundamental to the effective use of limited water resources. From the wastewater perspective, the intermediate effluent storage is used as a process unit in order to retain stock for re-use irrigation schemes. Seasonal storage, throughout the period of increased rainfall, allows for uninterrupted irrigation supply throughout instances of higher demand. In water treatment, although likely less common, treatment facilities may utilize a raw water storage reservoir, which, for the purposes of this discussion paper, shall be defined as the intermediate storage, prior to preliminary treatment.

By further examining the influence of algal species upon wastewater treatment efficiencies, Pearson (2005) suggests that an estimated 80% of dissolved oxygen in waste stabilization ponds results from the photosynthetic activity of the phytoplankton population, thus, aeration of ambient treatment systems are heavily dependent upon this physiological function of the algae. While acknowledging this positive, algal photosynthesis is influenced primarily by the physical and chemical characteristics of the waterbody. Waterbodies exhibiting cleaner, less turbid, conditions allow for a greater depth of influence of light, and subsequently solar radiation, affording a higher rate of oxygen dissolution via algal photosynthesis. In storages experiencing stratification, the creation of distinct thermal layers within the water column, chemical compounds ammonia and hydrogen sulphide, often released in dissolved forms from sediments/sludges (illustrated below in Figure 1), can inhibit algal activity, and thus oxygen production, in ambient systems.

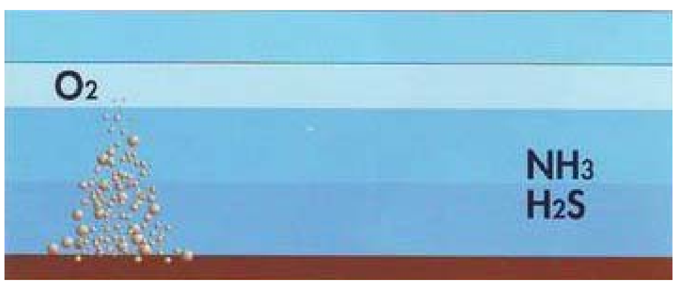


__Figure 1:__ ***Ammonia and hydrogen sulphide generation from sediment/sludge***

2.2 Blue-Green Algae/Cyanobacteria Formation & Impact

After noting the benefits of algae within wastewater treatment, it may prove difficult to reflect upon the potential negative impacts of algal proliferation. Qualifying the negative effects of algae, within the scope of this summary report, shall primarily consist of mitigation of cyanobacteria, commonly referred to as blue-green algae.

Blue-green algae are very much a part of the Australian water environment but they are not unique to Australia; they occur worldwide. The onset of a bloom (the sudden development of conspicuous masses of organisms, as algae, on the surface of a body of water) can result from various combinations or contributing factors such as:

- High concentration of nutrients;

- High light penetration;
- Low turbidity;
- Calm water conditions, and generally, but not always;
- Warm water conditions.

The primary reason managers are concerned about blue-green (cyanobacterial) algal blooms is their potential to release toxins that affect the health of both humans and animals who either use or ingest the water. QWQTF (1992) has indicated a number of likely instances, perhaps not fully understood at the time, where humans experienced negative health impacts via contact with waters containing blue-green alga:

- Toowoomba, QLD - 1903
  - Blue-green algal scum linked to a condition described as either 'Barcoo Spew' or 'Belyando Fever'.

- Palm Island, QLD – 1979
  - Blue-green algae present in water supply, realized an illness among almost 150 people, mainly children.

QWQTF (1992) also reports that periodic algal blooms have occurred within Queensland, particularly in the storages of South East Queensland. In terms of interfering with water supply operations, not until the summer of 1991-92, when a series of simultaneous blooms resulted in closures, in some storages, for a number of months was the impact deemed significant. QWQTF (1992) stated that, in recent years the following Queensland storages, among others, had been affected by said algal blooms:

- Maroon Dam, at Boonah;
- Atkinson Dam, at Gatton;
- Solomon Dam, on Palm Island; &
- Leslie Dam, at Warwick.

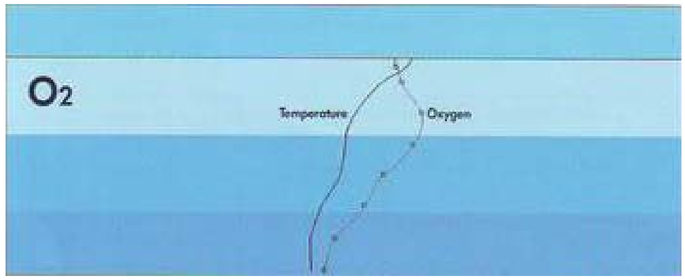
Closure of storages denies the community access for recreational use and, in some cases, notably Palm Island and Warwick, restricted the availability of water for domestic supply needs.

2.3 Algal Mitigation via Artificial Destratification

Control strategies relating to blue-green algae can be difficult to define, in terms of where the effort should be concentrated. In exploring further, the study completed by Webster *et al* (1997) likely provides an excellent insight. Webster *et al* (1997) concentrated on management of the cyanobacteria *Anabena circinalis*, a common blue-green alga, and, as a management strategy, suggested that artificial destratification, often achieved via mechanical mixing, would reduce the dominance of the blue-green algae, via these two (2) distinct actions:

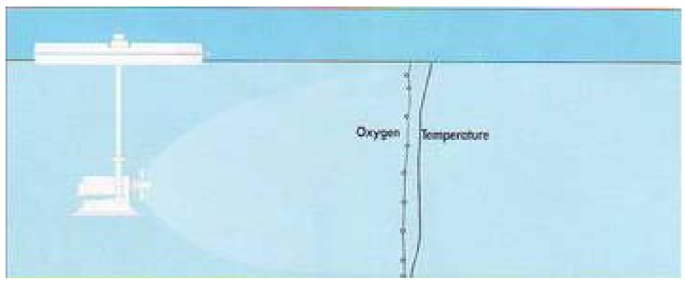
1. Reduce growth rates by mixing the algae throughout the depth of the water column; &
2. Ensure that bottom waters remain oxygenated, minimizing nutrient release from sediments.

A series of illustrations (Figures 2, 3 & 4) below examine the physical characteristics of the water column prior to, and after, introduction of artificial destratification.



<u>Figure 2:</u> ***Stratified storage characteristics***

<u>Figure 3:</u> ***Artificial destratification introduced (mechanical circulation)***



<u>Figure 4:</u> ***Storage characteristics after the introduction of artificial destratification***

Release of nutrient from sediments/sludges provide a ready food source for algae, with Douglas *et al* (1997) indicating that this release is most likely when bottom waters became anoxic. Similarly Chambers *et al* (1997) stated that since oxygenated bottom waters inhibit phosphorus release from sediments, an aerated water column was recommended as an effective management strategy for limiting nutrient release.

As artificial destratification has been recognized as a primary consideration in mitigation of algal blooms, an introduction to some of the available technology shall be provided herein. Options for management after often limited by the infrastructure provided at the site – most prominently, electrical infrastructure. If mains supply is not readily local to site, the provision of such, may prove restrictive. In considering these factors, three (3) modes/options for artificial destratification shall be presented:

1. Mains-powered mechanical circulation;
2. Solar-powered mechanical circulation; &
3. Wind-powered mechanical circulation.

2.4 Mains-Powered Mechanical Circulation

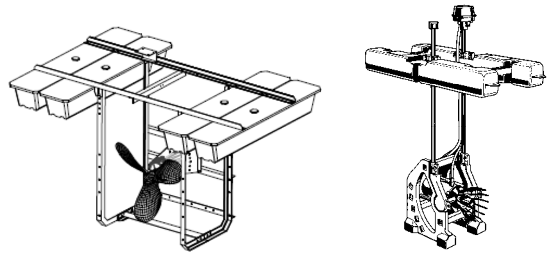


Figure 5: ***Acqua & Co. RIO AG20 & BRIO 1.0 mechanical circulation***

Italian-manufactured units by *Acqua & Co*.
Further information available via:

- Acqua & Co. http://www.acquaeco.com/en/products/; and/or
- BioRemedy http://www.bioremedy.com.au.

2.5 Solar-Powered Mechanical Circulation

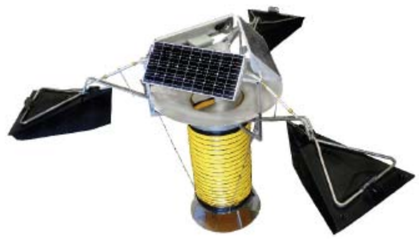


Figure 6: ***SolarBee mechanical circulation***

US-manufactured units by *SolarBee*.

- Further information available via:
- SolarBee http://www.solarbee.com.

2.6 Wind-Powered Mechanical Circulation

Figure 7: ***Dagaz Environmental Inc. Little River Pond Mill mechanical circulation***

Canadian-manufactured units by *Dagaz Environmental Inc.*.
Further information available via:

- Dagaz Environmental http://www.pondmill.com.

2.7 Algal Mitigation via Aquatic Algicide

As artificial destratification remains a prominent long-term management strategy, provision of the infrastructure may require significant capital expenditure to realize the appropriate resolution.
Shorter-term, perhaps seasonal, management of algal blooms, may be achieved via

application of a specific aquatic algicide. Cupricide, by Agmin Chelates, operates on upon the interruption of photosynthesis, inhibiting persistence of algae via destruction of the thylakoid membrane, causing loss of chlorophyll and the breakdown of the cell function. Cupricide, as a control agent possesses efficacy against both planktonic (contains blue-green algal species) and filamentous algae (both illustrated below)

Figure 8: ***Planktonic & Filamentous Algae***

Effective use of algal control agents is generally managed via spray-application at the rates recommended for each algal type. In general terms, filamentous-type algae has a higher density than that of planktonic algae, therefore requires an increased dose of the control agent to achieve a satisfactory outcome.

3.0 CONCLUSION

In combination, application of both artificial destratification and discrete use of algal control agents will ultimate realize management ideals. Seasonal variation will influence needs but, if appropriately resourced, implementation of a dynamic management plan can manage both operational and financial considerations.

4.0 REFERENCES

Chambers, L., Olley, J., Crockford, H. & Murray, A. ‘Conditions Affecting the Availability and Release of Phosphorus From Sediments in the Maude Weir Pool on the Murrumbidgee River, New South Wales.’ *Managing Algal Blooms – Outcomes from CSIRO’s Multi-Divisional Blue-Green Algal Program.* Ed. J.R. Davis. Canberra: CSIRO Land and Water, 1997. 41-51.

Douglas, G., Hamilton, D., Gerritse, R., Adeney, J. & Coad, D. ‘Sediment Geochemistry, Nutrient Fluxes and Water Quality in the Swan River Estuary, Western Australia.’ *Managing Algal Blooms – Outcomes from CSIRO’s Multi-Divisional Blue-Green Algal Program.* Ed. J.R. Davis. Canberra: CSIRO Land and Water, 1997. 15-30.

Jaunico, M. ‘Wastewater reservoirs.’ *Pond Treatment Technology.* Ed. Andy Shilton. London: IWA Publishing, 2005. 357-380.

Pearson, H. ‘Microbiology of waste stabilisation ponds.’ *Pond Treatment Technology.* Ed. Andy Shilton. London: IWA Publishing, 2005. 14-48.

Queensland Water Quality Task Force (QWQTF) (1992). *Report on Freshwater Algal Blooms in Queensland,* Queensland Water Quality Taskforce, Brisbane.

Webster, I, Jones, G, Oliver, R, Bormans, M & Sherman, B. ‘Control Strategies for Cyanobacterial Blooms in Weir Pools.’ *Managing Algal Blooms – Outcomes from CSIRO’s Multi-Divisional Blue-Green Algal Program.* Ed. J.R. Davis. Canberra: CSIRO Land and Water, 1997. 31-40.