BLUE GREEN ALGAE ISSUE IN EFFLUENT LAGOON PROCESS

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ABSTRACT

In Jimboomba we have an effluent lagoon that holds 20 ML of recycled water from the Jimboomba Sewage Treatment Plant (STP). This STP has a zero discharge to river, stream and any other waterways required by the Development Approval (DA). The treated wastewater is used to irrigate a golf course and horse paddocks located near the STP. Before 2010, drought conditions meant the demand for reuse water exceeded what could be supplied to this lagoon. Since 2009/2010 with the floods and high rainfall wet seasons, the reuse demand has been lower than normal.

High nutrient loads and very little turn over in the lagoon are perfect conditions for algae to bloom and Blue-green algae populations have proven difficult to control. Over time operators noticed a change in algae growth in the Jimboomba lagoon and started test procedures to determine what type of algae were present. Once the test results confirmed that indeed there was large amounts of toxic blue green algae in the effluent lagoon, all reuse from the lagoon was ceased. Alum dosing to reduce phosphorus and increased recirculation in the lagoon was commenced. The recirculation increases movement across the lagoon and increases turn over. An ultrasonic treatment unit has been installed in the lagoon but it was not able to remove the algae because of the size of the lagoon area causing dead spots. Other issues include large numbers of fish, turtles and bird life in and around this lagoon, making treatment harder.

When blue-green algae dies off it can release toxin into the water. High concentration of toxin can cause health issues for wildlife and humans that come in contact with the water. Before treating the algae we needed to have a plan in place to reduce the toxin in the water at the same time. An activated carbon filter was constructed to help reduce the algal toxin levels in the lagoon water. From the first test of the filter after construction, it was determined that it did remove the toxin in the water. Due to the small algae particles in the lagoon water, the filter clogged quickly. To clean the filter required many man hours as it was constructed as a surface skimmed slow filter, with no back wash system.

Now we are in the process at looking at adding alum to the front of the plant to help remove as much phosphorus as we can from the process. We are also investigating installing a pre filter to remove algae particles before entering the carbon filter and also increasing the size of turnover equipment/aerators. With these modifications we hope to have a cost effective way to continually supply recycled water to our customers.

1.0 INTRODUCTION

At Logan City Council we have two small Sawerage treatment plants in the Jimboomba area. As part of the DA conditions at these sites, zero discharge to any water way is required. Jimboomba STP has a 20 ML effluent lagoon and at the Jimboomba Flagstone estate STP we have a 28 ML effluent lagoon. Logan gained these areas as part of the State Government reform. During the Queensland drought from 2008 to 2010, there was no problem with algae as the lagoons were kept at very low levels due to irrigation demand. The water was used to irrigate a golf course and horse paddocks located near the Jimboomba STP and a 38ha irrigation area at the Jimboomba Flagstone estate STP. Once the rain started we noticed a drop in water usage and levels in the lagoons rising slowly.

Since then, due to floods and high rainfall the reuse demand has been lower than normal. This in turn has slowed the turn over rates of the lagoons. Nutrient levels, in particular Nitrogen and Phosphorus started to increase. As a result, an algal bloom issue was noticed in 2013. As the Effluent lagoon has fish and other aquatic life, this makes treatment of the algae difficult.

2.0 DISCUSSION

The Logan Treatment group and Logan Environment group discussed the best way to deal with this issue. During these discussions we came up with the idea of treating the Algae with copper. Removing the toxin from the water was one of the main questions pondered as once the algae die off, it will release toxin into the lagoon water. Figure 2 shows the level of Cyanophytes (Blue-Green algae) and the level of toxin in the water (Microcystin). After the treatment was completed on 12/12/2013 the number of Cyanophytes in cells/mL reduced but the toxin levels did not increase as anticipated.

2.1 What Is Blue-Green Algae

Algae are simple aquatic plants that occur naturally in habitats such as rivers, lakes, damp soil, tree trunks, hot springs and snow. They can vary considerably in shape, colour and size. Blue-green algae are very small organisms and can be seen under a microscope as a single cell or large accumulation of colonies or strings of cells. Some accumulations may be so large that they are easily seen with the naked eye. Blue-green algae are also known as cyanophytes and cyanobacteria.

They have a similar external appearance to algae and their requirements for light, nutrients and carbon dioxide are also similar. In the absence of light, some blue-green algae can survive and grow using chemicals from its surroundings. Certain types of blue-green algae have tiny gas vesicles in their cells, allowing them to float to the surface or sink to the bottom in response to changing light and nutrient availability. Some species have the potential to produce toxins. This cannot be determined by ‘naked eye’ inspection; only a laboratory analysis can verify the potential for toxicity.

What is an algal bloom?

An algal bloom is a common term used to describe an increase in the number of algal cells to a point where they can seriously reduce the water quality. Blooms can discolour water, form surface scums, produce unpleasant tastes and odours. Species of blue-green algae may dominate and increase excessively in water when:

- nutrient levels, particularly phosphorus and nitrogen are sufficient
- water is still or turbulence is minimal
- weather pattern is stable for a long time
- weather is warm (although blooms can occur in cooler weather too)

The longer the period of calm weather conditions, the greater the "bloom-forming potential". Such potential exists mostly in slow flowing rivers or in lakes, dams, weirs and reservoirs.

2.2 Treatment Used to Reduce Blue-Green Algae

The chemical utilised in the treatment of the Algae is Copcide Algicide, with the active constituent being 105g/L Copper, present as Mixed Copper Ethanolamine Complexes.

This chemical is a broad spectrum algicide registered for the control of both planktonic and filamentous algae and is safe to use in water bodies inhabited by fish and other aquatic life. The complex copper formulation enables the chemical to persist in the water for a longer period and resist binding to suspended compounds. This results in extended algal control following application. This may result in excess N and P being released into the water which may lead to further algal blooms. Ongoing monitoring of water quality testing will be required and we are continuing to monitor of algal counts and toxin levels.

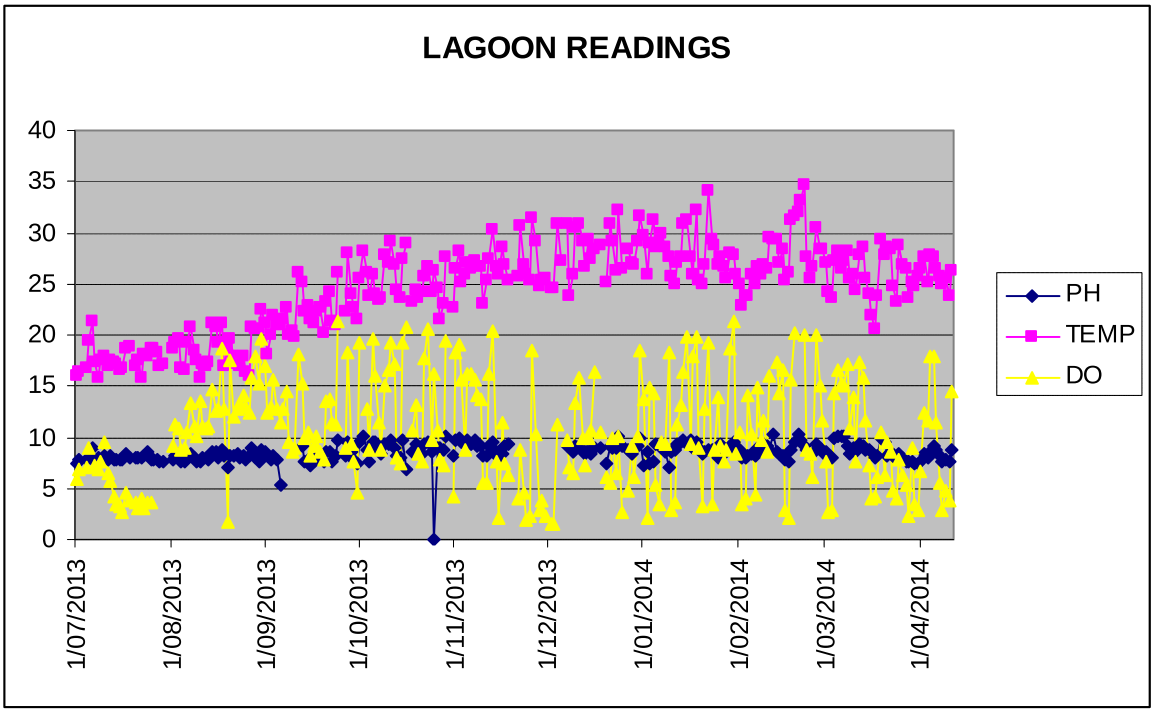

Figure 1: ***Lagoon daily monitoring before treatment (12/12/2013) and after treatment.***

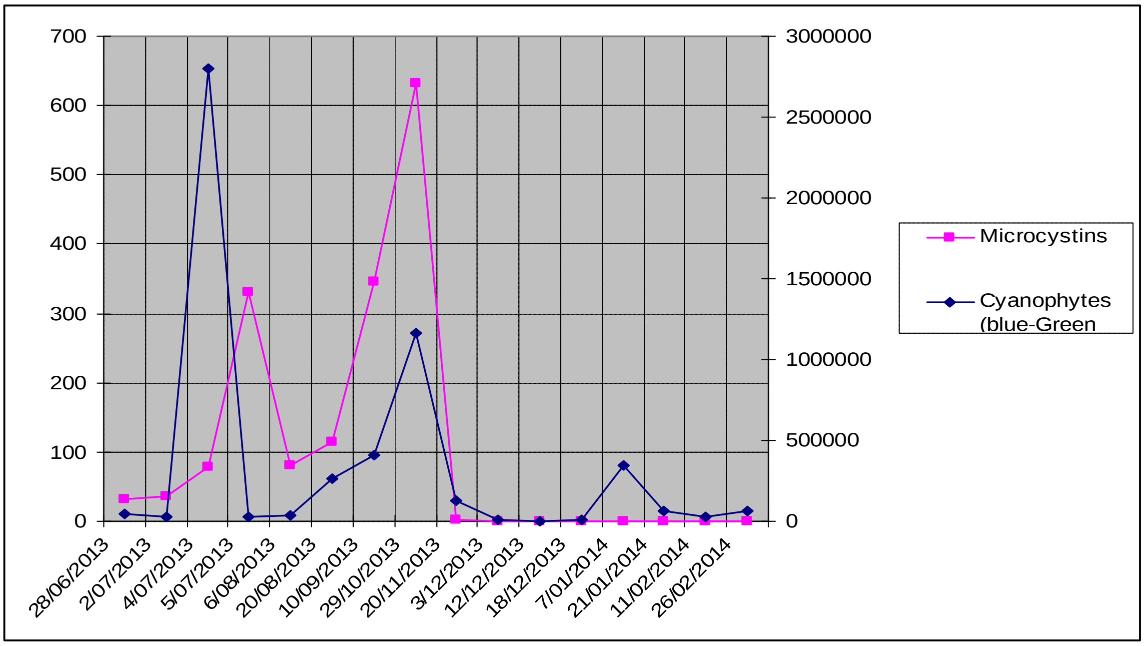

Figure 2: ***Algae and toxin levels before treatment (12/12/2013) and after treatment.***

Microcystis secretes a whole range of toxins, so we had to do a risk assessment to determine any possible effects on health. The health risk depends on many factors:

- How long a person is exposed for
- Age, children are at a higher risk from cyanotoxins than adults
- Health history
- Amount of exposure

These toxins can course health issues to staff and wildlife in the area if the toxin level is high. Some of the short term health risks are:

- Nausea
- Vomiting
- Fever
- Rashes
- Eye and ear irritation
- Liver toxicity

One of the Environment members suggested that a carbon filter could be used to remove the toxin from the lagoon water once the algae died off. Carbon filters have been commonly used for this in water treatment. As the toxin is an organic molecule, Activated Carbon is a highly porous form of charcoal that sticks organic molecules. It is often used to filter water and clean up environment spills, and it has even been administered to poison victims to clean the digestive tract. Once the Carbon filter was designed, we then built it ourself. The carbon filter comprises:

- 300mm of 6mm gravel
- 700mm of 3 to 6 mm of Activated Carbon
- 300 mm of filter sand

Apart from removing the toxins, the filter also removed the dead algal particles still in the lagoon water. As it was not designed with a backwash system, it clogged up very quickly. Cleaning the filter became a highly labour intensive daily job. The M&E group was asked to investigate installation of a strainer before the lagoon water enters the filter.

<u>Table 1:</u> ***Data Showing Aglae Testing results***

Date	Microcystins	Cyanophytes (Blue-Green Algae)
28/06/2013	32	44,200
2/07/2013	37	29,300
4/07/2013	78	2,800,000
5/07/2013	330	29,300
6/08/2013	80	39,500
20/08/2013	114	266,000
10/09/2013	345	405,000
29/10/2013	632	1,160,000
20/11/2013	3.1	123,000
3/12/2013	<.5	8,400
12/12/2013	<.5	130
18/12/2013	<.5	5,300
7/01/2014	<1	343,000
21/01/2014	<.5	63,800
11/02/2014	<1	29,500
26/02/2014	<.5	62,500

2.3 Depth

As photosynthetic organisms, algae require light to grow. Per unit volume of lagoon basin, the quantity of light energy available for such growth is proportional to the surface area. For a basin with vertical sides, an increase in the depth will decrease the surface area proportionally. However, because of the trapezoidal cross section typical of lagoon, an increase in depth does not always decrease the surface area.

3.0 Treatment Methods to Prevent Algae or Minimise Growth

3.1 Mixing

If a lagoon basin treating a domestic wastewater is fitted with mechanical surface aerators that provide a power intensity of at least 6 W/m3 of basin volume, the turbidity of suspended solids is sufficient to minimise algal growth. At lower mixing intensities, algae will grow providing the HRT is sufficient. However, all lagoons should be mixed to a level of about 1 W/m3 of basin volume. Such mixing is beneficial from several points of view. Without mixing thermal stratification will occur, thereby permitting the retention of undisturbed surface layers for relatively long periods of time. Such conditions provide an excellent environment for algae to become established and grow.

Mixing will also exhaust the carbon dioxide from the system. For wastewater, such as those from domestic origins where there is an excess of nitrogen and phosphorus, carbon dioxide can be growth limiting during a portion of the diurnal cycle. During the night hours when light is not available, carbon dioxide accumulates as the result of respiration of the microorganisms in the lagoon. At dawn, when light does become available, the rate of consumption of carbon dioxide through photosynthesis exceeds that of respiration and, as a result, the store of carbon dioxide is depleted and algal growth becomes limited. In other words, the carbon dioxide accumulated during the night hours is stored for use in the daytime hours. During the day, when carbon dioxide is growth limiting, aeration does not significantly replace carbon dioxide in the system because the concentration gradient is too low. As will be discussed in later notes, aeration in settling basin is a must, not only because of the mixing that is created, but also, for the maintenance of dissolved oxygen in the water column. Such maintenance reduces feed back of CBOD and nitrogen from the benthal deposits.

3.2 Cover

A cover of any type, artificial or natural, that will prevent light from entering the water column of a lagoon will prevent the growth of algae. Commercially available floating polyester fabrics have been used to shade aerated lagoons. Such shades should not cover the entire lagoon surface, leaving sufficient room for mechanical surface aerators.

Natural cover can be provided by surface-growing plants such as duckweed. Duckweed, if kept from the effluent by inserting surface baffles in front of the effluent weir, is very effective in reducing algae in the lagoon. Furthermore, experience in South Carolina has shown that for aerated lagoons, it is not necessary to periodically harvest the duckweed, nor does the duckweed appear to result in significant accumulations in the bottom of the lagoon. Floating grids placed across the lagoon surface have been used to ensure surface coverage. However, several aerated lagoons covered with duckweed have operated successfully without grids. Regardless of the type of cover used, provision must be made for aerating the lagoon. Otherwise, the lagoon will become anaerobic.

3.3 Chlorination

Several studies have shown that chlorination will kill algae. The focus of most of these studies has been on the impact that algae have on the chlorine demand of plant effluents. In these studies, the chlorine doses used have been large (5-20 mg/L) and the contact periods short (15 min to 2h), conditions under which algae are killed and lyse. At least two authoritative studies, however, have shown that much lower chlorine doses (2-4 mg/L) over much longer contact periods (>10h) will impair algal growth. This suggests that by continually adding chlorine in a relatively low dose in a aerated lagoon settling basin, effluent algae reduction would occur as a result of a lower growth rate.

3.4 Copper

Copper sulfate has long been used by waterworks personnel to control algal growth in reservoirs. Some waterworks personnel use a standard dose of 1 mg/L of copper sulphate which is sufficient to kill most types of algae. However, care must be taken to protect fish in the receiving stream. Trout, which appear to be the most sensitive of the fish, do not tolerate copper sulphate in concentrations greater than about 0.14 mg/L (Steel and McGhee 1979). It has been reported that the combination of chlorination and copper Sulphate has given excellent results.

3.0 CONCLUSION

We are still working on the algal management issue and correcting the operational issues with the filter. We are keeping algae/ toxins uder control. We are also looking at all the options mention in the paper to improve and control the algae loads. We are contuining treatment of the algae, increasing aeration of the lagoon and turn over of the water which has helped reduce algae growth.

4.0 ACKNOWLEDGEMENTS

I would like to take this time to thank the Logan Environment and Treatment Teams for their help.