DEALING WITH TASTE AND ODOUR PROBLEMS ARISING FROM ALGAL BLOOMS IN A RAW WATER RESERVOIR

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DEALING WITH TASTE AND ODOUR PROBLEMS ARISING FROM ALGAL BLOOMS IN A RAW WATER RESERVOIR

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ABSTRACT

Malpas Dam is Armidale Water Treatment Plant's primary source of raw water. Since its construction there have been problems with algae, with a number of significant blooms occurring almost every year. If not dealt with these blooms cause taste and odour problems in the treated water and in the extreme may have an impact on human health.

Water Treatment Plant (WTP) staff have over the years tried to minimize problems by regular monitoring of the raw water in the dam for algae, treatment of the water at source, including destratification and dosing with an algaecide, and the addition of powdered activated carbon to the incoming raw water supply. This has been an expensive and time consuming process that requires constant vigilance on the part of the operators to ensure that water supplied to the citizens of Armidale is pure and wholesome.

1.0 INTRODUCTION

Malpas Dam, with a capacity of 13,000 ML, was constructed in the late 1960s as the main source of Armidale's water. Located about 30 kilometres north of the WTP the surrounding 200 square kilometre catchment is mostly undulating farming country, with sheep and cattle grazing being the primary enterprises. Soil type throughout the catchment is generally basalts high in natural phosphates, which leads to the leaching of nutrients into the storage reservoir. There is also a long history of annual superphosphate fertilizer application by many landowners.

The highly organic and nutrient rich water is ideal breeding ground for blue green algae (cyanobacteria), with cell counts at times being in excess of a million cells/ml. These blooms generally occur between November and March although large concentrations have been experienced as early as August and some have persisted until as late as July. In recent years the blooms have occurred more frequently and lasted longer.

Prior to 1994 the method of treatment recommended by the NSW Department of Land and Water Conversation (DLWC) was to treat the raw water with copper sulphate, before the cell counts reached 5,000 cells/ml. In mid 1994 the DWLC advised that due to a more rigorous application of the NSW Clean Water Act, treatment with copper sulphate was no longer allowed. The recommendation was amended to "no treatment of source waters" but instead to adsorb taste, odours, toxins and other chemical contaminants with activated carbon prior to distributing the water to consumers.

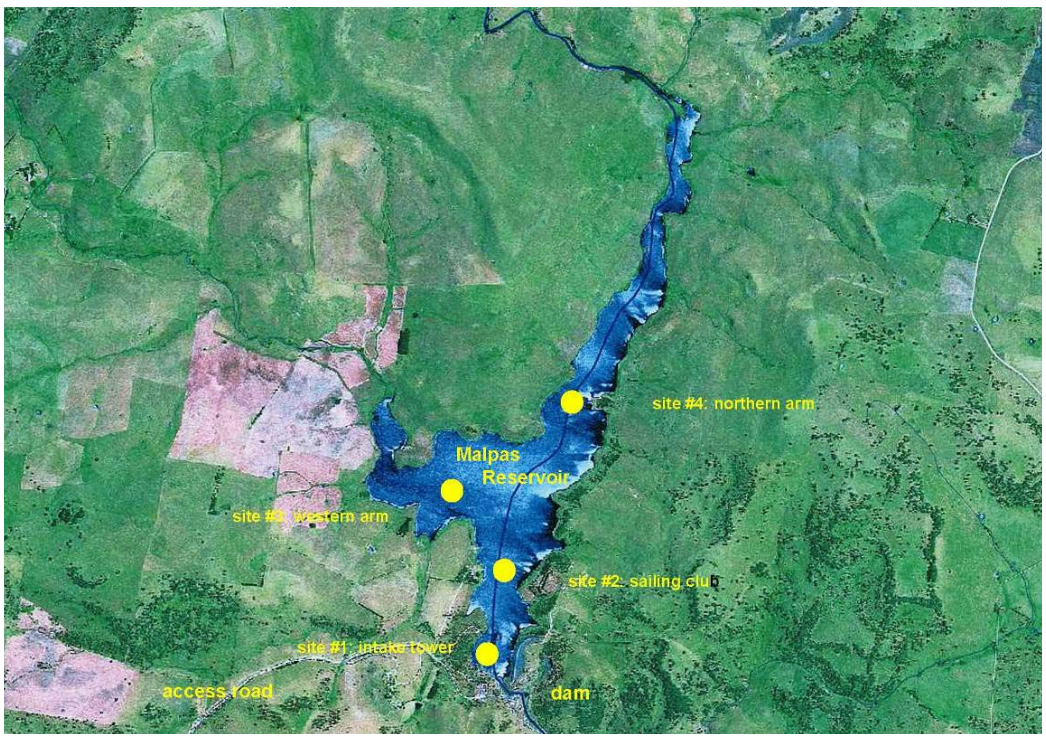
Although Armidale Dumaresq Council retained a licence to dose the reservoir with approved alternative algaecides, it was decided to follow the DLWC recommendations and make treatment of the raw water as it enter the plant the primary goal. A powdered activated carbon (PAC) facility had been installed at the WTP in 1990 but it could only dose up to 20mg/l of PAC and wasn't capable of being the sole method of treating algae contamination.

So in 1994 a larger external purpose specific facility was constructed. Located across from the settlement tanks, this has the capability of dosing up to 100mg/l of PAC at a maximum plant flow rate of 200 litres per second, equivalent to 17.3Ml/day. The contact time before the addition of a coagulant at this flow is 30 minutes. The rate of dosing is dependent both on the flow and the severity of the algal bloom.

2.0 DISCUSSION

2.1 Testing

The key to keeping on top of taste and odour problems is a rigorous testing program on the source of raw water so as to minimize the response time between discovering an ongoing or incipient algal bloom and having the PAC dosing facility up and running to treat the water. Under normal circumstances Malpas Dam, a 30 minute drive from the WTP, is monitored three days a week whilst raw water is checked daily as it enters the plant. The monitoring process involves sampling the reservoir to detect elevated levels of algae. Samples are taken from a boat at the four sites shown on the Malpas Reservoir plan below. Should a bloom be suspected then a sample of water is collected from that location for testing in the laboratory. The success or otherwise of this phase depends very heavily on the experience and knowledge of the operators involved.

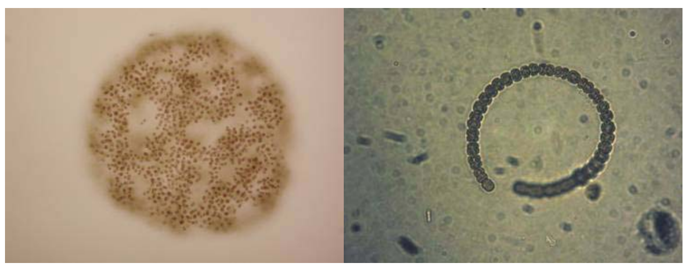


<u>Figure 1:</u> ***Malpas Reservoir Sampling Sites***

At site one the temperature and dissolved oxygen (D/O) are checked at one metre intervals from the surface down to 16 metres. Water samples are taken at the surface, 1.0, 3.0, 6.0, 12.0 and 16.0 metres down. A similar range of testing is undertaken at site two, whereas site three, the western arm of the reservoir, is only tested down to 5 metres with site four, the northern arm tested down to seven metres. This extensive testing has two main purposes.

Firstly to check for algae and secondly to see if the reservoir has been stratified to the extent that it is in danger of "turning over". If this happens nutrients that have settled to the bottom of the reservoir will rise to the surface, promoting algal growth. This is determined to be a possibility if one of the following three criteria exists. The D/O shows a change in one unit within a metre, the D/O reading at a depth of 16 metres is less than 5 or the temperature difference between the 3 metre and the 16 metre level is greater than 3^{o} C. In addition testing at the intake provides information that allows the operator to select the most appropriate level for drawing raw water.

On returning to the laboratory the water samples are kept in the refrigerator. Prior to testing the sample is inverted three times to produce thorough mixing. Using a pipette a drop of the water of at least 1 millilitre is placed onto a Sedgewick Rafter slide. This slide has a one millimetre grid that allows the operator to make an estimate of the number of algae present. Estimates are made of both type A and M blue green algae. Including the time required to clean the slide with distilled water each test takes around 5 minutes. Under normal conditions with the reservoir unaffected by an algal bloom the test will show algae numbers less than 500 per square centimetre. When a bloom occurs the numbers will climb until the count runs into seven figures.



<u>Figure 2:</u> ***Mycrosistis and Mlps Anabaena***

In addition to the above, raw water is normally tested at the plant as soon as the first shift starts work. If there is noticeable algal growth then testing will also occur at the end of the afternoon shift. These tests are recorded on an incident log sheet so that the progress of the algal bloom can be tracked.

Plant operators will also conduct an odour test. To do this the treated water is heated to 60^{0} C, allowed to cool down and then sniffed. If the water emits a grassy odour then there is a problem that requires urgent action.

2.2 Treatment at the Reservoir

Thermal stratification of lakes and reservoirs is a natural process that can cause severe water quality problems. During stratification, the water at the bottom of the reservoir becomes anoxic, i.e. lacking in oxygen, creating a chemical reaction within the sediments on the floor of the reservoir. This reaction can produce elevated levels of iron and manganese as well as causing nutrients that promote the growth of algae, mainly nitrates and phosphates, to be released. If the tests described above indicate that the reservoir is in danger of turning over, bringing these chemicals to the surface, then destratification measures are taken. Compressors located at the intake inject air into the base of the reservoir about 30 metres out. The rising air bubbles mix the layers together and add oxygen to the water.

Under extreme conditions Armidale Dumaresq Council has a licence, valid until 2010, from the New South Wales Environmental Protection Agency to treat the reservoir with either Coptrol or Cupricide®. This however is an expensive option, costing around $7,200, plus the cost of labour, each time. The treatment is only viable if the algal growth is concentrated within a band from the surface to 3 metres down.

2.3 Treatment at the Plant

The Armidale Water Treatment Plant has the capability of treating up to 22.5 Ml/day or 260 L/sec. This requires the operation of a booster pump at the Malpas Reservoir. Without the pump the capacity falls to 18.5 Ml/day. Over recent years the demand for water in Armidale has fallen. The average summer flow for the peak summer months, January through March, over the last three years has been 8.1 Ml/day. The current operating philosophy is to run the plant during the day at its optimum capacity, closing it down over night

One of the problems with preventing raw water contaminated by an algal growth affecting the consumer is to ensure that the water treatment plant is ready to take whatever steps are necessary to prevent taste and odour contamination.

2.4 Powdered Activated Carbon Dosing

__Figure 3:__ ***PAC Dosing Facility***

PAC is a very porous media with the ability to absorb compounds that cause taste and odour. It is dosed into the raw water supply main and then settled out in the sedimentation tanks. The building housing the powdered activated carbon dosing equipment is located alongside the sedimentation tank adjacent to the raw water inlet main. The equipment consist of two storage hoppers, two 5,000 litre tanks, one for batching and the other for dosing, a dosing pump capable of 3.5 litres/sec, a dilution water pump plus all associated pipework and monitoring equipment.

PAC is supplied to the water treatment plant in 15 kilogram bags, which are stored in the chemical storage building. Deliveries occur approximately once every three weeks. The bags are carried manually up to a higher level platform to be emptied into the batching tank.

After mixing to a concentration of around 6% by weight, the slurry is injected into the Malpas dam raw water main approximately 3 kilometres upstream of the plant. This provides a contact time of about 55 minutes at a average summer flow of 12 Ml/day.

<u>Figure 4:</u> ***PAC Dosing Equipment***

In 2004 eight different types of PAC were tested by the Australian Water Quality Centre for their efficacy on the type of algae present in the raw water from Malpas. This showed that Acticarb PS 1300 provide the best outcome. Although it is more expensive than the others it has been used at the WTP since then.

The amount of activated carbon dosed into the incoming raw water supply depends on a number of factors, including flow, severity of the algal bloom and water temperature. This obviously impacts the cost of treating the water. The amount to be added is determined by jar testing, in which various concentrations of PAC are added to six samples of raw water and the results analysed.

The average cost of using PAC, excluding the cost of labour, is shown in the table below.

Parameter	**Amount**	**Units**
Typical Dose	10	mg/L
Typical Summer Flow	8.1	ML/d
Typical PAC Usage	81	kg/day
PAC Cost	$2.84	per kg
Cost Per Day	$230	per day
PAC Power	2.2	kWh
Maximum Flow	18	ML/d
Hours Plant Run	10.8	hours
PAC Power Use	23.8	kW
Power Cost	$0.13	per kW
PAC Power Cost	$3.01	per day
Total Cost	**$233**	**per day**

PAC dosing is labour intensive. On average it takes 45 minutes to prepare and fill a PAC batch tank, with 30 minutes spent on checking the dose rate and cleaning the filters each shift. General maintenance, cleaning and confirming operations take another hour.

The time spent dealing with PAC dosing operations each day averages out at between two and three hours.

2.5 Associated Problems

There are a number of potential problems that arise with the current operational procedures, apart from the obvious one that it is very labour intensive and requires constant monitoring and testing to ensure that peak efficiency is maintained.

Response Time: It is not cost effective to continually dose PAC and the amount dosed varies depending on the organic contaminant of concern and the level of contaminant in the raw water. To overcome this, the PAC system is typically operated full time over the high risk summer months. In the event of a bloom during this period the dosing equipment will already be operational. During the winter months when the PAC is not operational the time from detecting an event to controlling it through PAC dosing can vary from a few hours to two days depending on monitoring programs, operational protocols and laboratory turn round times.

Upper Limit: The current PAC system has the capability of dosing up to 100 mg/L and since moving to Acticarb 1300 doses much smaller than this proved to be very effective. The potential always exists, however unlikely, that a major outbreak could require dosages of PAC greater than the existing equipment's capabilities.

Sludge Production: The use of PAC results in increased sludge production and a change in sludge characteristics. Most of this is realised as an increase in the percentage of total solids of the sludge rather than a volumetric increase. The sludge and its supernatant have the potential to become toxic, particularly if algal toxins are being absorbed into the sludge. This has not yet happened at the plant, which is fortunate to have extensive sludge ponds for disposal.

Iron and Manganese: If the destratification equipment for any reason fails to prevent the reservoir turning over, then the resultant slug of iron and manganese in the raw water cannot be controlled by PAC dosing alone and operators have to add potassium permanganate into the incoming supply.

3.0 CONCLUSION

In general the PAC dosing plant has handled taste and odour problems reasonably well since its inception. There have been only a very few complaints from consumers. That being said, ensuring that it is used effectively is an expensive process that requires constant vigilance. The change to treatment by ozone in 2009 should reduce the stress on the operators, producing a superior potable water by using a process that is easily automated and has a quick response time.