DESIGN AND OPERATION OF AN OZONE/BAC WATER TREATMENT PLANT AT EDENHOPE

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ABSTRACT

Edenhope in Western Victoria draws its water supply from Lake Wallace – a natural shallow eutrophic lake. The supply has historically suffered from severe blue-green algal blooms over extended periods. Blooms have involved both *Microcystic* and *Anabaena* species.

Raw water dissolved organic carbon (DOC) levels are also very high – typically above 20 mg/L. A new advanced water treatment plant has been constructed to provide a reliable and safe treated water supply even under difficult raw water conditions. The plant utilises the ozone/biological activated carbon (BAC) process for the first time at a significant level in Australia.

This paper describes the raw water quality issues associated with Lake Wallace and details the basis of process selection and the design criteria for the treatment plant. Initial operating results are provided.

KEY WORDS

Blue-green algae, toxins, ozonation, granular activated carbon, biological activated carbon (BAC).

1.0 INTRODUCTION

Lake Wallace water can be characterised as moderately coloured with a high dissolved organic content. Typical raw water quality is shown in Table 1. Of note is the particularly high total organic carbon (TOC) content.

Table 1: ***Raw Water Quality***

Parameter	Average	Typical Range
PH	7.9	7.2 – 8.8
True Colour (Pt-Co)	50	10-200
Turbidity (NTU)	15	1-72
Alkalinity (mg/L $CaCO_3$)	140	110-180
Hardness (mg/L $CaCO_3$)	150	115-190
Chloride (mg/L)	190	140-265
Total Organic Carbon (mg/L)	-	15-26
Bromide (mg/L)	-	0.3-0.8

The Lake is subject to severe blue-green algal blooms which have necessitated shut-down of the supply and introduction of emergency bore water supplies due to confirmed toxicity of the blooms. Levels of up to one million cells of the blue-green algae *Microcystis aerogonosa* per mL have been measured.

Grampians Region Water Authority took over jurisdiction for the Edenhope water supply in 1995

and commenced a program to improve the water supply to ensure that a safe and reliable water quality was delivered to its customers.

2.0 TREATABILITY

2.1 Coagulation/Filtration

Jar tests undertaken on the raw water indicated typical doses of alum of between 80 and 150 mg/L. This resulted in TOC removal rates of around one-third. This indicated that conventionally treated water would still contain more than 10 mg/L of DOC. In addition, the raw water taste and odour was unchanged through this type of treatment.

2.2 Ozonation

One of the primary objectives of the plant is to provide surety of removal of algal toxins. Published literature to date suggested that ozone would be effective in destroying Microcystin hepatotoxins, but data on PSP toxins which are produced by some Australian blue-green algae was limited.

Ozone testing was undertaken by the Australian Water Quality Centre in Adelaide using coagulated and filtered Lake Wallace water which was spiked with various algal toxins.

This test work showed that the design ozone capacity was sufficient to:

- Fully oxidise *Microcystin LR*
- Completely oxidise most PSP toxins. The worst result was a 96% removal – still satisfactory
- Reduce taste and odour compounds but not fully remove them.

This work confirmed that basis of the process design.

Testing for bromate formation showed levels below the detection levels of Australian laboratories. However this was higher than guideline levels and further work is being undertaken in this regard.

2.3 Granular Activated Carbon

A small pilot GAC filter was set up to carry out subjective tests on Lake Wallace treated water. These demonstrated its effectiveness in removing the residual tastes and odours in the water.

3.0 TREATMENT PLANT DESCRIPTION

Based on the problems experienced with the Lake Wallace supply and the results of the tests previously described, the following treatment process steps were selected.

Process Step	Purpose
Coagulation	TOC removal, colour and turbidity removal, pH reduction to 6.5 to reduce bromate formation
Dissolved Air Flotation (including flocculation)	Removal of coagulated solids and algae

Filtration	Removal of carry-over floc and solids
Ozonation	Destruction of algal toxins and breakdown of organics
Biological Activated Carbon (BAC)	Removal of taste and odours and biological degradation of organics
Soda Ash Dosing	pH correction
Hypochlorite Dosing	Disinfection

A summary of treatment plant design criteria is as follows:

Nominal Plant Capacity	3 ML/d
Coagulant Dose Range	Alum 50-200 mg/L
Flocculation Stages	2
Flocculation Time	20 minutes total
Flotation Rate (inc. DAF recycle)	8 m/hr
Filtration Rate (inc. DAF recycle)	9 m/hr
Filter Media	Mono medium sand
Disinfection	Sodium Hypochlorite
pH Adjustment	Soda Ash

Advanced Treatment Module

Ozonation pH	Not greater than 6.5
Ozonation Capacity	800 kg/hr
Maximum Ozone Dose	9 mg/L @ 2 ML/d
Ozone Contact Time	5 minutes @ 2 ML/d
BAC Vessels	2 No.
Empty Bed Contract Time	15 minutes @ 2 ML/d
Activated Carbon	Coal-based

4.0 OPERATION

The full plant was commissioned on 22nd January 1998 and produced a clear water totally free from taste and odour.

In the first stage of treatment, raw water is sampled and monitored in the plant's laboratory to establish the correct chemical dosage. Alum is added and mixed with the raw water in a tank to help dirt, colour and algae particles form into a floc. With air injected from below, the water passes over a weir to the flotation/filtration tank.

The floc, with impurities entrapped, rises with the air to form a scum (float) which is periodically skimmed off to a sludge tank and discharged to sewer. About 90 percent of the foreign matter in the water is removed by flotation. The remaining 10 percent is trapped as water passes through sand filter beds in the bottom of the tank.

Algal toxins released from decaying Blue Green Algae and tastes and odour originating from algae and other organic matter are not always removed in the first treatment stage and hence a further advanced treatment stage with ozone and biologically activated carbon is necessary to ensure water delivered to consumers meets all Australian Drinking Water Quality guidelines and is pleasant for consumption.

In this second stage, ozone is generated from air to produce a very strong oxidant which, when

bubbled through the water, breaks down organic molecules and micropollutants including algal toxins. Bench testing of filtered Lake Wallace water which had been "spiked" with various algal toxins was carried out at the Australian Water Quality Centre in Adelaide and confirmed that relatively low doses of ozone would destroy the algal toxins. Following ozonation, water is then passed through beds of biologically activated carbon which remove the organics and any residual tastes and odours.

A low dose of chlorine is added prior to the fully treated water entering the one million litre clear water storage to prevent any bacteriological regrowth in the tank and to enable control of biological activity in the activated carbon filters when backwashing. pH adjustment using Soda Ash is carried out prior to water entering the clear water storage.

A further low dose of chlorine is added as high lift pumps transfer the water from the clear water storage to the elevated tank which provides water pressure to the town.

5.0 CONCLUSION

Australia's first significant use of the ozone/BAC process was implemented at Edenhope, Victoria to overcome problems associated with chronic blue-green algae in the source water. The plant has been operating for 8 months producing consistent quality of water with removal of all tastes and odours. The plant has not had to operate to date under extreme blue-green algae conditions. Bench tests carried out during the design process indicate that it will be able to perform during these events.

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