PROBLEMS ASSOCIATED WITH OZONE/GAC AS THE FINAL DISINFECTANT

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KEY WORDS

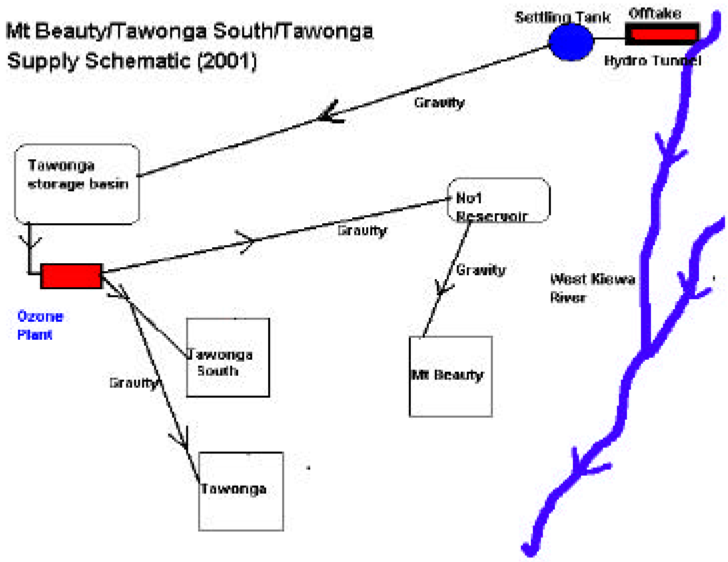
Disinfection, Granular activated carbon (GAC), Biological activated carbon (BAC), Ozone, North East Region Water Authority (NERWA)

ABSTRACT

Mt Beauty is a small town, which uses Ozone to disinfect water to a population of 2,700. Water quality is of a high standard not needing treatment before entering the Ozone Plant. The plant delivers between 1 and 3 Megalitres per day and is simple to operate requiring minimal time. The final water has no taste and odour problems but does appear white in colour, which creates public concern. Backwashing problems in the GAC filters have caused biological growth resulting in failures to comply to WHO standards. In this paper I will cover all the operating problems, and issues associated with Ozone/GAC as a final disinfectant.

1.0 INTRODUCTION

Mt Beauty, Tawonga and Tawonga South are a group of small towns situated in the Kiewa Valley in North East Victoria. Population is 2,700 but reaches 5,000 to 6,000 during peak tourism times. The water supply comes from the West Kiewa River catchment below Mt Hotham. It is collected from the Southern Hydro Electricity tunnel and gravity fed to an open storage which then passes under pressure through the Ozone Plant on town demand, typically ranges from 1-3 ML with raw water quality considered excellent - see **Table 1.**



North East Water signed a Memorandum of Understanding with the Victorian Government to provide drinking water, which met World Health Organisation (WHO) Standards. The available system was not able to meet these requirements, so a process was initiated to update the system to one which was acceptable to both North East Water and to the community.

North East Water began by consulting an elected group of people from the community to choose a form of disinfection that everyone was happy with. The use of chlorine was immediately eliminated and Ozone or UV were the only options considered, even though it was pointed out that these process's did not leave a residual within the reticulation and were at high risk of failing microbiological quality. The township had a referendum and voted on a choice of 3-disinfection process's:

1. Chlorine (at no cost to the consumer)
2. Ozone (at a cost to the consumer)
3. U.V (at a cost to the consumer)

Ozone was clearly the most popular alternative for the community. Consequently, in early 1999 construction of the Ozone/Granulated Activated Carbon (GAC) plant commenced and construction was completed with the plant online in late December 1999.

Ozone/GAC was something new to me as an Operator even though North East Water were already operating an Ozone/UV plant at Myrtleford. Mt Beauty's Ozone plant was very different as it totally relied on ozone to complete the disinfection, whereas Myrtleford utilised UV directly after Ozone, thus eliminating any carry through bacteria from the GAC filters. The Mt Beauty plant has experienced very few problems but the main ones we have had to deal with have been:

- The presence of Coliforms throughout the reticulation system not meeting the W.H.O Guidelines and Zero Coliforms at the consumers tap being very hard to achieve.
- Problems with air in the water that have caused some concern with the consumers.
- Programming problems.

This paper will discuss the problems we have had with the plant during commissioning and what solutions we have employed to overcome them.

Table 1: ***Mt Beauty Raw water Quality***

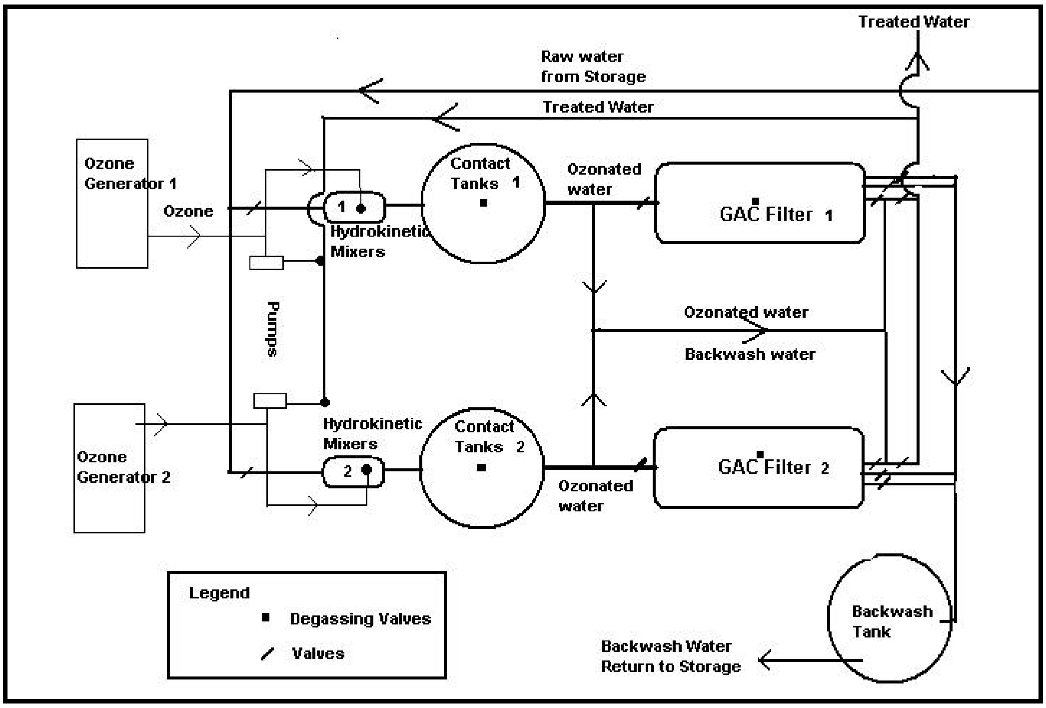
Parameter	Typical range
U.V Transmission	90 to 95%
Turbidity	0.5 to 2 NTU
True Colour	4 to 10 TCU
PH	8.5
TOC	<2 mg/L
Bromate	0.02 mg/L
Chloride	1- 2 mg/L
EC	40
Alkalinity	16 to 28 mg/L
Hardness	15 mg/L (Ca CO3)

2.0 PLANT DESCRIPTION AND COSTS

2.1 Plant Description

Raw water is gravity fed into the plant from the Tawonga storage basin (capacity 4.5ML). Ozone is produced using the electric Corona Discharge method, which is flow paced and uses residual trim to control the volume of ozone injected into the mixers.

Figure 1: ***Schematic of the Mt Beauty Ozone Plant***



Water is delivered to the plant via two equal sized pipelines where an onsite Programmable Logic Controller (PLC) determines whether it should use one or two of these lines depending on demand. It firstly passes through the Hydrokinetic mixers where Ozone is mixed into the water. Ozone is delivered to the mixer using a Venturi controlled by the volume of water being pumped.

Once the water is mixed with the Ozone it then passes through the contact tanks where the ozone reacts with the water to complete disinfection. Levels of Ozone residual are measured by samplers located downstream of the contact tanks, and a signal is sent back to the generators so that the set limit is maintained to achieve an active level of ozone required to guarantee a 100% kill. The Ozone design parameters can be seen in **table 2**.

Table 2: ***Ozone plant Design Parameters***

Parameter	Design
Ozone Generator Capacity	960g/hr
Maximum plant output	117 l/s
GAC Filter EBCT	1.5 minutes
Residual set point after contact	0.3- 0.4 mg/L
Ozone Contact Time	5 Minutes

Before entering the town's reticulation the Ozone needs to be removed this is achieved by passing the water through Granulated Activated Carbon (GAC) filters (using Coconut Fibre Carbon).

Water passes through the filter bed and Ozone is removed in the top 100 mm of carbon, after which it enters the reticulation. A major safety feature of the PLC program detects high Redox in the treated water. Redox Potential is measured on water that has passed through the GAC to ensure that all excess Ozone is being removed in the filter. The PLC will send an alarm if Redox Potential exceeds the set point.

When the set point is exceeded the PLC will determine which GAC filter is failing by sampling each line individually. The PLC then signals the Ozone generator to shut down and close all valves associated with that line, an alarm is then initiated.

Any excess air that is produced during the process is released through the degassing valves located on top of the contact tanks and the GAC filters. Filters are backwashed daily with Ozonated water to prevent biological growth occurring on the filter bed. Settled backwash wastewater is pumped back to the raw water storage to be reused.

2.2 Design Features

- Fully interactive PLC touch screen to give operators control of critical parts of the process.
- Flow through design is simple to understand and use.
- Process equipment is very easy to use.
- Low maintenance requirements.
- Redox meter to monitor ozone-entering reticulation.

The plant was constructed in 1999 at a construction cost of $520,000. All connecting pipe work and modifications to Mt Beauty's original water supply storage cost $395,000.

2.3 Commissioning

The plant was brought on line in December 1999 to meet the year 2000 deadline. Changes were made and preliminary work was completed before start up. These included:

- Air scouring water mains
- Redirection of water mains
- Changing storage from No 2 Reservoir supply to No 1 Reservoir (1 ML) supply.
- Covering No 1 Reservoir (Mt Beauty supply)

3.0 OPERATIONAL ISSUES

During the 18 months of the Ozone plant operating, the problems we have faced include:

1. Air in the water
2. PLC programming problems
3. Not meeting WHO Guidelines for drinking water –ie.0 Total Coliforms
4. Ozone Residual set points
5. Backwashing problems

3.1 Air in the water

Problems have occurred within the reticulation with milky water this is caused by pressurised air in the water presenting itself only when the water is brought out of the pressure situation into the atmosphere. When a glass of water is filled from the tap it is clear at first, then micro bubbles form and slowly rise to the surface (a mini DAF plant in a glass). There are no ill effects caused by this problem but the residents prefer to have water that is aesthetically normal to look at. The degassing valves at the Ozone plant were designed to remove all air from the process before entering the reticulation, whilst the valves remove the majority of the air; some still passes through to the customer. The contractor is currently looking at the problem and considering installing a tank to be used as a degassing tank before entering the reticulation.

3.2 PLC programming problems

The PLC program was designed by a North East Water employee in consultation with the contractor responsible for constructing the Ozone plant.

As the program was new and untested, problems were expected. The initial problem was the PLC program not completing its tasks as designed. The worst faults appeared in the sequences involving backwashes. All of these issues have now been corrected and as time passes, additional changes have been made to make the process more efficient.

3.3 Not meeting WHO Guidelines for drinking water

In the beginning it was clear that meeting the guidelines would be very difficult with the new Ozone plant, as there was nothing being added to leave a residual in the reticulation. Test results were all over the place – see **Table 3**, and it appeared that the only glimmer of hope was that the system might work was if we could correct all the problems. Testing samples taken after Ozone contact but before the GAC filters was used to determine whether we were achieving full disinfection. This was crucial if we were to have any chance of meeting the guidelines.

Testing regularly was the only way to pinpoint the problem as we had been relying on the monthly sampling which only gave us a small window of what was happening. Through the increased sampling we discovered that the critical component to cleaning up the plate count and coliforms lay with the backwash sequence and if we couldn't get this right we had no chance at all of meeting the guidelines. We also noticed that it if the backwash was performing correctly it took approximately 6 to 8 weeks for the coliforms to decline and sometimes disappear within the reticulation.

Table 3: ***Bacteriological Testing***

	Raw Water			After O3 - before GAC			Post Treatment			Mt Beauty Retic			Tawonga Retic		
DATE	**PL**	**Co**	**Ec**	**PL**	**Co**	**Ec**	**PL**	**Co**	**Ec**	**PL**	**Co**	**Ec**	**PL**	**Co**	**Ec**
Jun-00	180	50	2	7	0	0	16	0	0	12	0	0	7	0	0
Jul-00	1100	550	0	5	0	0	92	0	0	820	0	0	94	0	0
Aug-00	1000	91	2	0	0	0	30	0	0	54	0	0	92	1	0
Sep-00	210	1300	0	1	0	0	2500	760	0	5000	5	0	72	2	0
Nov-00	1200	>2400	36	2	2	0	360	50	0	10	15	0	500	130	0
Dec-00	NR	1200	13	1	0	0	250	26	0	10000	250	0	10000	180	2
Feb-01	NR	1400	10	5	0	0	1300	16	0	390	32	0	78	20	0
Mar-01	NR	>2400	34	2	0	0	1500	53	0	300	26	0	760	12	0
Apr-01	NR	1200	3	1	0	0	45	2	0	15	4	0	14	0	0
May-01	NR	310	0	5	0	0	8	1	0	2900	4	0	29	4	0

Legend: **PL**- Plate Count orgs/mL
Co- Coliforms orgs/100mL
Ec- Ecoli orgs/100mL

3.4 Ozone Residual Set Points

It was decided when the plant was commissioned that the set point for ozone residual would be 0.3 mg/L as this was a level that would achieve total disinfection. Later we found that although 0.3 mg/L was sufficient to disinfect the water it did not provide enough flexibility when high flows were present at backwash or high demand periods see **Figure 2.** Consequently the Ozone residual decreased to the point where it was no longer effective. An increase in the set point to 0.4 mg/L was trialled and is the current setting.

3.5 Backwashing and GAC Filter Problems

- Converting to Biological Activated Carbon Filters at low flows.
- Loss of Ozone during backwash.
- Backwash flow rates too low.
- Backwash times too short.
- Frequency of backwashes.

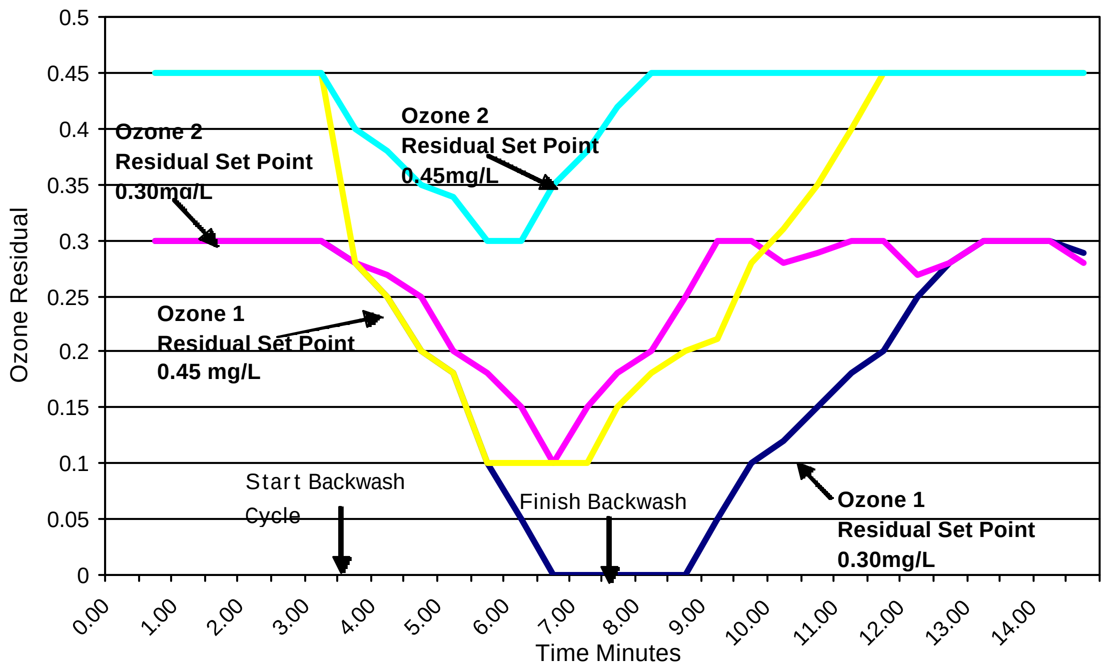
Trials and Remedies Employed

Converting to Biological Activated Carbon Filters at low flows:- Through a series of tests we discovered that the plate counts were a crucial indicator for assessing the condition of the filters and the formation of Coliforms within the filter bed. When the Plate counts increased, the Coliform count would increase thus indicating that the backwash was not effective and needed correction. Without the correct volumes of backwash flow the filters were slowly turning into Biological Activated Carbon filters.

Loss of Ozone during backwash:- Once the plant performance was monitored using the trend graphs, see **Figure 2,** it was apparent that at 50 l/s the Ozone generators could not maintain the Ozone at 0.3 mg/L during backwash. When backwash was initiated during low flows it was discovered that one generator was in the pause mode when backwash began causing the filters to be backwashed with water that was low or had no ozone thus not effectively disinfecting the filter bed.

To correct this problem the Ozone minimum set point was increased to 0.4mg/L and it was decided to modify and add changes to the PLC control, at this point we entered a program, which was time adjustable on the touch screen. We now can make the ozone generator which was in the pause mode come on before backwash begins. This system will be supplemented with a software modification that the contractors are suppling to adjust the ozone generator to accept a 20 ma signal. This will indicate to the generator to ramp up to full capacity during backwash and remain there until backwash is completed. The first stage of this program change has been operated for a very short time and already has shown promising improvement.

Figure 2: ***Trend Graph – Ozone Residual During High Backwash Flows***



Backwash flow rates too low:- With the introduction of higher backwash rates of 50 l/s and an increase in the Ozone set limit the filters began improving with lower Plate counts and Coliform counts declining. Regular testing showed plate counts still remained higher than expected and Coliforms were lower but still present.

Backwash times too short :- Another proposal looked at is to increase the backwash time from 180 seconds to 360 seconds. At present this would require an upgrade of the backwash storage tank and the software modification to maintain constant ozone residual during backwash.

Frequency of backwashes :- At present backwashes are done on a daily basis but in the future we believe that with the longer backwash times we may be able to backwash every 2 to 6 days. In this area we have total control through the PLC touch screen where we can backwash both filters daily or at intervals of one to seven days.

4.0 CONCLUSION

Seeing the changes occurring within the water industry it has been the attitudes and the way we perceive these changes that has resulted in North East Water upgrading its facilities. The need to improve the treatment of the water, safety and ensure community consensus has been a major challenge. The Ozone plant has been and continues to be a challenge, but working through the problems has led to a great expansion of knowledge, which I may never have obtained elsewhere. It has been very difficult in obtaining assistance with our problems as this scale of Ozone/GAC system has not previously been used as a stand alone system to disinfect whole town supplies. It is more commonly used in the water treatment of swimming pools and to help reduce chemical costs in treating potable water supplies and also to reduce the effects of Algae toxins and taste and odour problems.

Living in the town and having to participate in the decision making from the ground up, including discussing with the local community the options was in itself a big learning curve. The Ozone plant now has been operating for 18 months with a range of problems, which we have now been able to reduce. These problems have been identified and rectified as we slowly understand them. The major issue has been correctly backwashing, but as time goes by the results have begun to improve giving us a better insight into the process. It is not certain what the future holds but as it stands, the Ozone Plant shows promise and brings forward the fact that North East Water are working in cutting edge technology, and perhaps we will be used as an example of what can be done.

5.0 ACKNOWLEDGEMENTS

Aqua- Tec Fluid Systems Shepparton and Prominent for construction and design of the plant.
The residents of Mt Beauty for standing up and believing in what they wanted.
All those who assisted me with this paper.

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