DEALING WITH ALGAE AND MANGANESE TO IMPROVE THE BACKWASH WATER RETURN PROCESS AT BOOTAWA WATER TREATMENT PLANT

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ABSTRACT

Since commissioning in 2011 the Bootawa Water Treatment Plant (WTP) has struggled to deal with algae in the raw water, which then became a limitation to the plant's operations, especially the membrane filtration and backwash water return process. All backwash water is settled in clarifiers before the supernatant is returned to the head of the WTP.

Medium to high levels of algae in Bootawa Dam were blocking the WTP filters and not settling in the clarifiers. This combined with re-release of manganese from the clarifiers had added to greatly reduced backwash intervals from 30 minutes to around 10 minutes at times. This had the effect of tripling the backwash water produced. The backwash water system was never designed to deal with such volumes of water and therefore the backwash system quickly fills and threatens to overflow.

Over the past 2 years optimisation of the backwash system and the membranes has been progressively undertaken, including identifying the problems and coming up with solutions to produce good quality clarifier return supernatant and improved membrane run times.

1.0 INTRODUCTION

Bootawa WTP is a 60ML/day membrane filtration plant that supplies drinking water to communities in the Manning and Great Lakes areas of the Mid North Coast of NSW. It has been in operation since January 2011.The process at Bootawa WTP consists of membranes , ozone and biologically activated carbon. All backwash water is settled in clarifiers and then returned to the head of the plant with the raw water. The plant was designed to provide high quality drinking water to customers, who for years had to endure unsatisfactory taste and odour in the water supply during the warmer months of the year, due to algae in the dam. However with the commissioning of the new WTP, the algae became a challenge to us in other ways.

From the start of commissioning of the Bootawa WTP we had problems with algae not settling in our clarifiers. Our primary raw water source for Bootawa WTP is from our dam, which has always contained a fair to large population of algae. With the building of a microfiltration plant this algae became more of a problem than anticipated.

All the backwash water from cleaning the membranes is captured and re-treated in the WTP. This involves the backwash water being pumped to two 400 KL clarifiers. At the inlet to the clarifiers a coagulant Aluminium Chlorohydrate (ACH) and a coagulant aid (polymer) are dosed to help the solids settle. The clarifiers have rakes that continuously draw the sludge into a hopper for dewatering. The sludge should settle to the bottom and the clear water (supernatant) overflows the weirs and is added to the raw water inflow of the WTP for re-treatment. The sludge is pumped from the bottom of the clarifiers for dewatering.

Because our membranes have < 0.1 micron pore size we filter out all the algae in the water and it becomes concentrated in the clarifiers. From the beginning it was difficult to achieve good settling in the clarifiers, which caused the solids to carry back over the weirs and back into the inlet channel. This carryover consisted of solids made up mainly of algae cells, but also contained some polymer bound in the solids. This carryover of solids was reducing filtering times (from 30 minutes, down to as low as 10 minutes), which consequently produced more backwash water, which added to the problem.

Initially it had been believed that the carryover of solids from the clarifiers was only a small contributor to reduced filter run times, compared to high algae in the raw dam water, as the supernatant return flow from the clarifiers is always less than 10% of the raw water inlet flow. After a few trials with no supernatant return it soon became apparent that the clarifiers were the main problem. Another concern was the black sludge that was accumulating on the walls and floor of the Clearwater tank that holds filtered water from the membranes. This black sludge was flaking off and entering the backwash water. At this stage it was not known what was causing this black sludge.

2.0 DISCUSSION

We initially conducted some trials to try and improve the backwash water return process. First we conducted some jar tests to try and optimise our ACH and Polymer dose, to see if we could get better settling in the clarifiers. The jar tests were indicating adequate settling for the dosing rates we were using. This was not the case up at the clarifiers as you could clearly see the solids not settling and the launders were always covered in about 25mm of sludge.

In 2012 an external consultant undertook a study of our backwash water and clarifier operation process to try and find some answers. Some of the recommendations of the study were:

- Moving the ACH dosing point to achieve longer flocculation time of backwash water before it entered the clarifiers
- Increase ACH dose
- Reduce flow rate into clarifiers
- Installation of a flocculation tank before the clarifiers and a separate thickener for the sludge

We could not move the ACH dosing point due to existing infrastructure and we did not want to build a flocculation tank and thickener without being sure it would work. We tried increasing the ACH dose rate and reducing the flow rate into the clarifiers, but this did not improve the settling in the clarifiers.

2.1 Algae Problem

We knew that most of the solids generated from the membrane backwash consisted of algae cells. The sludge in the clarifiers was light and fluffy to touch, even though it looked heavy and solid in the clarifiers. The flocculated solids entering the clarifiers were large and looked like they should settle easily. It was decided to shock chlorinate the clarifiers and backwash water tank to see if it would help the algae settle. We filled up our 200L firefighting tank with sodium hypochlorite (hypo) and sprayed 100L onto the surface of each clarifier and the backwash water tank.

This was a chlorine dosage of 31 mg/L. The following day the clarifiers were settling a lot better and clear water was flowing over the weirs.

This confirmed we were concentrating algae in the clarifiers, much of which was still alive and buoyant. This explains why we were having so much trouble getting it to settle. From this point we started getting algae counts done on the clarifiers each week. The results clearly showed high levels of algae compared to the dam water we were filtering. Table 1 shows some of these results. After a few weeks of dosing the hypo it was clear we may have found a solution. Jar tests were undertaken to find a more accurate dose rate of 5mg/L hypo.

Table 1: ***Comparison of Algae Cells in Unfiltered Dam Water and Build Up in Clarifiers***

Week	Dam Algae (Cells / mL)	Clarifiers (Cells / mL)
1	64,800	279,420
2	44,050	482,725
3	34,500	190,000

Note: A few days after dosing the backwash water tank and clarifiers with hypo the algae counts are usually below 20,000 Cells / mL.

Figure 1 presents the best algae count to date. Recorded in January 2015

Batch No:	H15 0087	Analysed:	20.01.15 TM	Checked:	TM 20.01.15
Laboratory No:	2	Entered:	20.01.15 CM	Reported:	
Sample Description:	Bootawa WTP Clarifiers	Sample Type:	Drinking Water Supply		

Total Phytoplankton Identification and Enumeration

Organism Identification	Geometric Shape	No. of Units Counted	Squares Counted	Total Cells	Cells/mL	Cells/mL (Reported)
BACILLARIOPHYTES (Diatoms)						
Aulacoseira spp.		1	40	4	100	100
Unidentified pennate diatoms		2	200	2	10	10
TOTAL					**110**	**110**
CHLOROPHYTES (Green Algae)						
Closterium spp.		2	200	2	10	10
Monoraphidium spp.		1	40	1	25	25
Oocystis spp.		1	40	2	50	50
TOTAL					**85**	**85**
CYANOPHYTES (Blue-Green Algae)						
Chroococcales:						
Aphanocapsa spp. (≤ 2µm)	Sphere	4	40	50	1250	1250
cf. *Synechococcus* spp.	Sphere	13	40	26	650	650
Sub total					**1900**	**1900**
TOTAL CYANOBACTERIA					**1900**	**1900**
OTHER						
Unidentified unicellular algae (motile/non-motile)		1	40	1	25	25
TOTAL					**25**	**25**

Key: # = Potentially toxic species in Australia.
cf. = compare with.
Est. = Estimated count.

Figure 1: ***Our Lowest Algae Count for the Clarifiers so far***

2.2 Chlorine Dosing System

We then looked at installing a more permanent chlorine dosing system. We only wanted to install one dosing system that could kill algae in both the backwash water tank and the clarifiers. We decided to install it in the membrane building next to the backwash water tank. The dosing system consisted of a 1,000L IBC tank on a bund, a peristaltic pump, calibration tube and a dosing line running into the top of the open backwash water tank. The backwash water would receive a dosage of 5 mg/L of chlorine whilst the plant was running, which would eventually stop any live algae reaching the clarifiers. This did not work as well as expected and better results are being achieved by slug dosing the backwash water tank with hypo whilst the plant is not running and then letting that be pumped up to the clarifiers. The chlorine residual in the backwash water then killed most of the algae in the clarifiers. We now do this routinely every Friday morning. This has helped keep algae numbers to a manageable level in the clarifiers, which improved the supernatant return to less than 1.5 NTU and greatly improves filter run time in our membranes. We have also turned off our clarifier rakes which created less turbulent conditions and improved settling even more. We now only turn the rakes on when we are dewatering the sludge. Figure 2 shows the Bootawa WTP chlorine dosing system.

<u>Figure 2</u>: ***Chlorine Dosing System***

2.3 Manganese Build Up

As we started dosing hypo to kill the algae, we collected samples of the black sludge in the Clearwater tank and tested it for nutrients and metals. The results came back showing high levels of manganese (328,000 mg/Kg of Mn). We decided to do a series of tests for manganese and found that we were concentrating it in our backwash water tank and clarifiers. Research confirms manganese can re-release in the water and contribute to filter fouling and reduced run times.

We concluded that if we could oxidise the manganese in the clarifiers and get it to settle out in the sludge that we would reduce the amount of manganese re-entering the membranes and thus increase filter run times. This would in turn reduce the amount of manganese entering other stages of the plant.

Jar tests were carried out to determine if we could use the strong oxidant, potassium permanganate ($KMn0_4$) to oxidise the manganese (Mn) in the backwash water as it enters the clarifiers. Our chemist confirmed that 1.92mg/L of $KMn0_4$ would oxidise 1 mg/L of Mn ion, and would work best at a pH >7.5.

We installed a 1,000L IBC with a mixer and two peristaltic pumps to dose the $KMn0_4$ into the stilling well of each clarifier via separate dosing lines. We batch a 5% solution in the tank by adding two 25kg buckets of dry chemical to 1,000L water. We are currently dosing 0.5mg/L of this into each clarifier with the aim of slowly increasing the dosage until maximum oxidation of Mn is achieved. Table 2 shows Manganese levels before and after $KMn0_4$ dosage to clarifiers. This dosing system has been successful in reducing the amount of manganese re-entering the membrane tanks. The Bootawa WTP potassium permanganate dosing system is presented in Figure 3.

<u>Figure 3</u>: ***Potassium Permanganate Dosing System***

Table 2 presents manganese test results for mg/L of Filtered and Total Mn before membrane filters, after filtering and then after $KMn0_4$ dose, showing reduction in Mn as backwash water passes through the clarifiers.

Table 2 *Manganese Test Results*

Date	Raw water before filtering (mg/L)	Backwash water entering clarifiers (mg/L)	Supernatant leaving clarifiers (after $KMn0_4$ dose) (mg/L)	% Removal
17/12/14	Total Mn - 0.019	Filtered Mn – 0.001 Total Mn – 3.91	Filtered Mn – 0.09 Total Mn – 0.133	- 97
5/01/15	Total Mn - 0.034	Filtered Mn – 1.3 Total Mn – 5.45	Filtered Mn – 0.286 Total Mn – 0.43	78 92
19/1/15	Total Mn - 0.018	Filtered Mn - 0.001 Total Mn - 1.48	Filtered Mn - 0.022 Total Mn - 0.05	- 97

3.0 CONCLUSION

By regularly dosing the backwash water with chlorine to kill algae we have been able to keep algae numbers to a manageable level. Dosing the chlorine has allowed the majority of the algae to settle in the clarifiers, which now produce good quality supernatant return (mostly less than 1.5 NTU).

By dosing potassium permanganate into our clarifiers we have been able to oxidise a lot of the manganese in our backwash water. This makes it settle in the sludge in the clarifiers, reducing the level of manganese that can re-release into the WTP and cause membrane filter fouling. We have reduced the level of manganese in the supernatant by around 90%. We are now seeing less manganese deposits accumulating on tank surfaces in the WTP.

By turning off the clarifier rakes and only running them whilst we are dewatering the sludge we have created less turbulent conditions in the clarifiers. This has also contributed to improved settling of the light algae cells. All of the above actions combined have helped to greatly improve the efficiency of the backwash water return process, almost eliminating solids re-entering the WTP inlet water via carry over from the clarifiers. This has increased membrane filter run times to 30 minutes or more and reduced the volume of backwash water produced, both of which make the WTP run more efficiently.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

Raveendran, R. et al. (2001) Manganese removal in drinking water systems. *64th Annual Water industry Engineers and Operators' Conference*. Bendigo. [online] Available from: http;// www.wioa.org.au/reference-papers/01/paper12.htm [Accessed 12th December 2014].