OPERATION OF BAC FILTERS IN COLD WATER – AN ORANGE WTP STUDY

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OPERATION OF BAC FILTERS IN COLD WATER – AN ORANGE WTP STUDY

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ABSTRACT

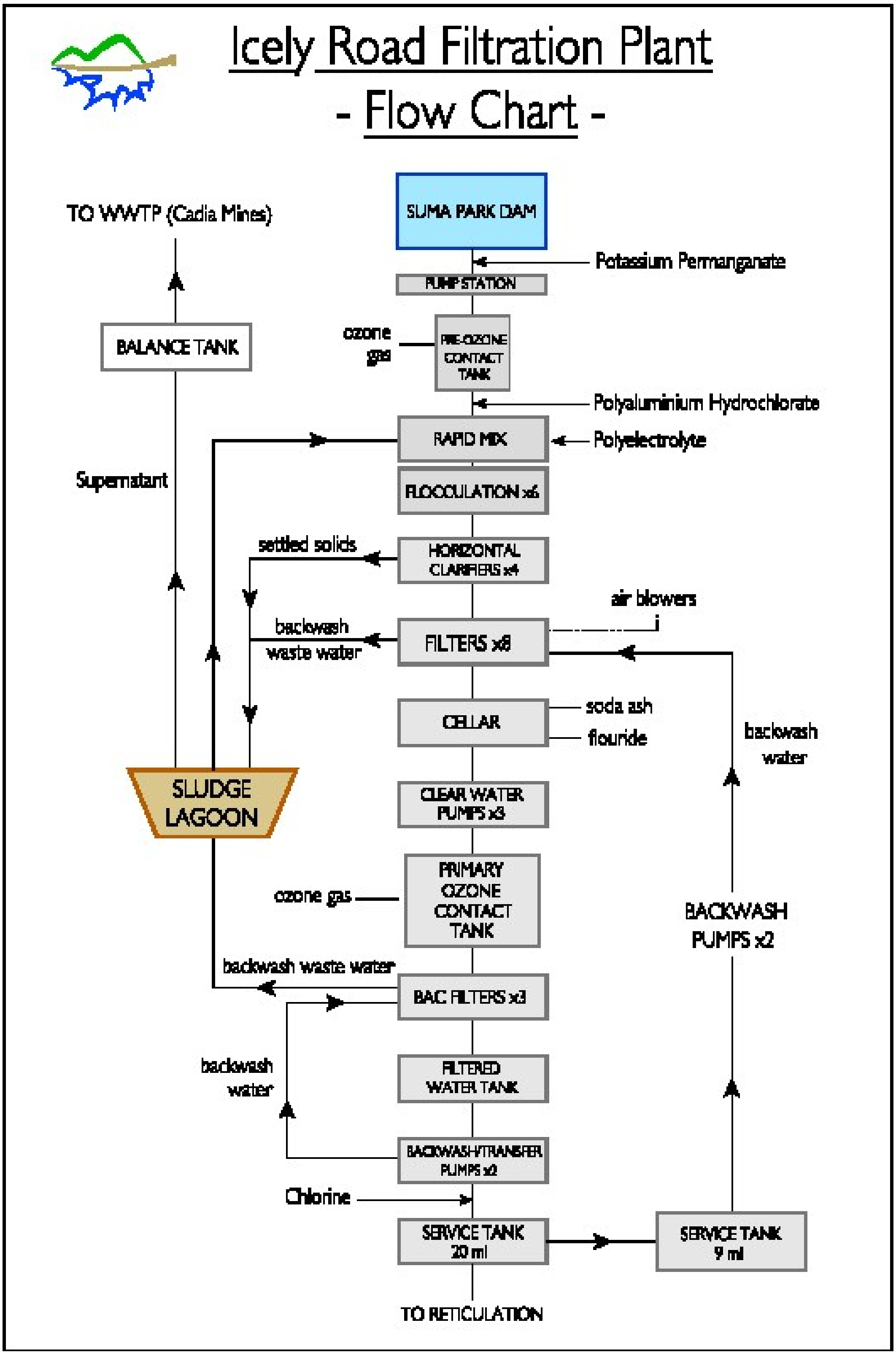
Biological activated carbon (BAC) filters are often used in conjunction with ozonation to reduce biodegradable dissolved organic carbon (BDOC) release into the distribution system. BDOC is associated with higher chlorine demand, biofilm growth and taste and odour issues within the distribution system and therefore a target of 0.2 mg BDOC/L is desired after the BAC filters. Orange WTP experiences high variations in water temperature from summer to winter. It was discovered through regular BDOC monitoring, that optimisation of the BAC filters' operating conditions, in particular backwashing frequency, significantly influences BAC filter performance. It also raised the question as to whether the BDOC test should be conducted at 21^{o}C as per the standard method or whether it should be conducted closer to the temperature of the water in the distribution system. This paper will describe the differences in BDOC concentration in relation to the backwashing frequency of the BAC filters, water temperature, initial dissolved organic carbon (DOC) levels, ozone residuals and temperature of the BDOC test itself in the water collected from Orange WTP over the last 12 months.

1.0 INTRODUCTION

Ozone and activated carbon filtration are used throughout the Australian drinking water industry to reduce organics. The ozone is a powerful oxidising agent that breaks up refractory organics and produces Biodegradable Dissolved Organic Carbon (BDOC). These biodegradable organics are then removed through activated carbon filtration by adsorption and biological regeneration processes. The combined process results in an overall organics reduction within the treated water stream, particularly those compounds responsible for chlorine demand and disinfection by-product (DBPs) formation.

To ensure that these processes work effectively, the BAC filters must be kept in optimal condition. It is important to regulate the biology on the filters so that the adsorption sites are still available and the biofilm doesn't develop to the extent that it sloughs off and contributes to the overall DOC concentration of the filtered water. To regulate the biology the BAC filters are backwashed regularly, however it is important that enough bacteria remain within the filter to ensure the BDOC formed by ozonation is removed.

Orange is located in regional NSW approximately 200 kms west of Sydney and situated at an altitude of 862 metres. This high altitude location provides Orange with a wide range of temperature variations from summer (average max 25^{o}C) and winter (average min 1^{o}C). Orange City Council owns and operates a conventional plant including ozone and BAC treatment processes (Figure 1). This paper describes how temperature effects the backwashing regime and it's impact on BDOC reduction.



<u>Figure 1:</u> ***Process Diagram for Orange WTP***

2.0 DISCUSSION

2.1 BDOC, TOC and DOC Methods

Research Laboratory Services uses the Joret and Levi (1988) method for BDOC determination. This involves placing the water in contact with a substrate (in this case sand) and monitoring the DOC concentration over time.

Throughout the experiment the water is kept at 21°C. The BDOC content is determined as:

$$BDOC = DOC_{initial} - DOC_{final}$$

All measurements are TOC analysis and filtered through 0.45µm membranes for DOC analysis using a Shimadzu TOC Analyser using the wet oxidation method.

2.2 Sampling and Observations

Orange City Council monitors the total organic carbon (TOC) and dissolved organic carbon (DOC) contents of the raw, sand filtered, ozonated and BAC filtered waters every month. Periodically, every 3 months or as necessary, they also analyse for BDOC concentration of each of these waters. During these studies it was noticed that although the TOC and DOC of the waters were quite similar, the BDOC of the BAC filtered water increased significantly in winter (Figure 2).

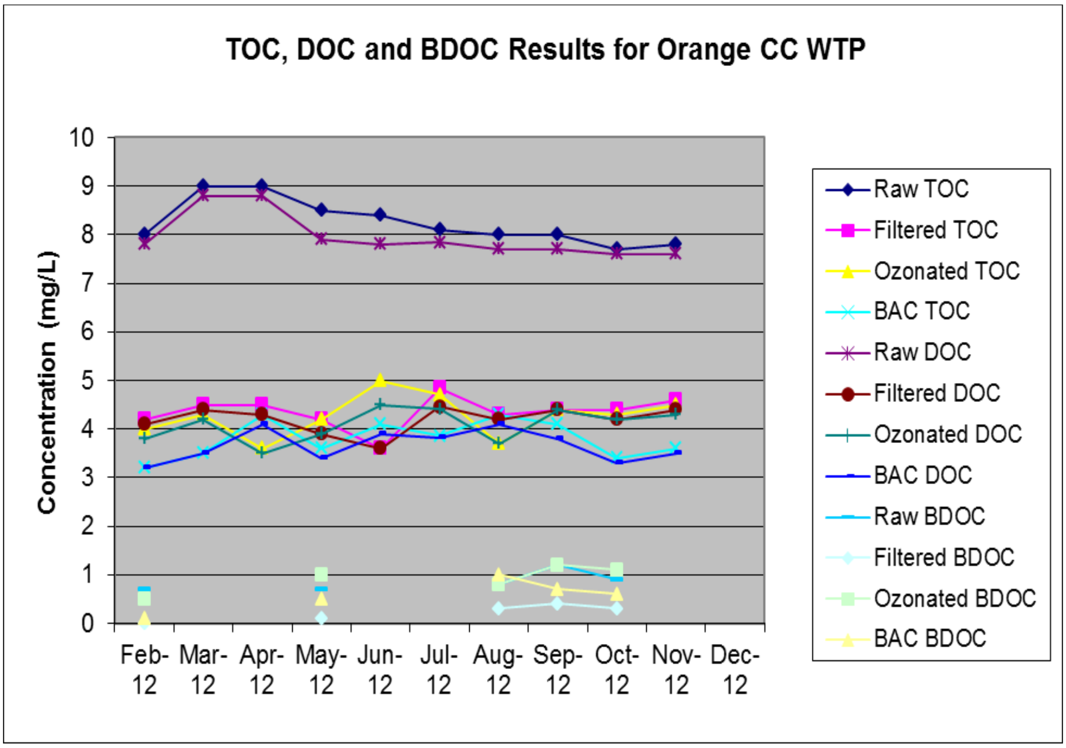
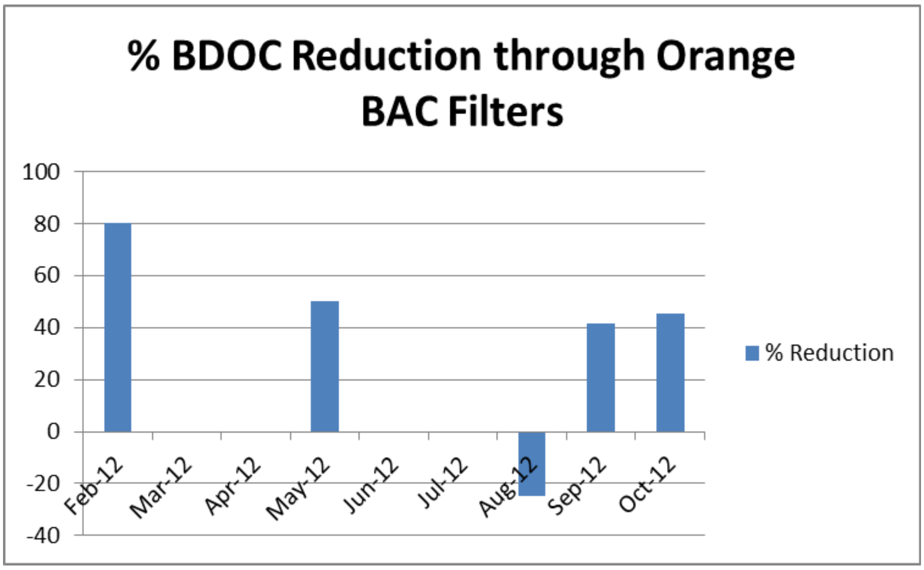


Figure 2: ***TOC, DOC and BDOC Content for Orange WTP***

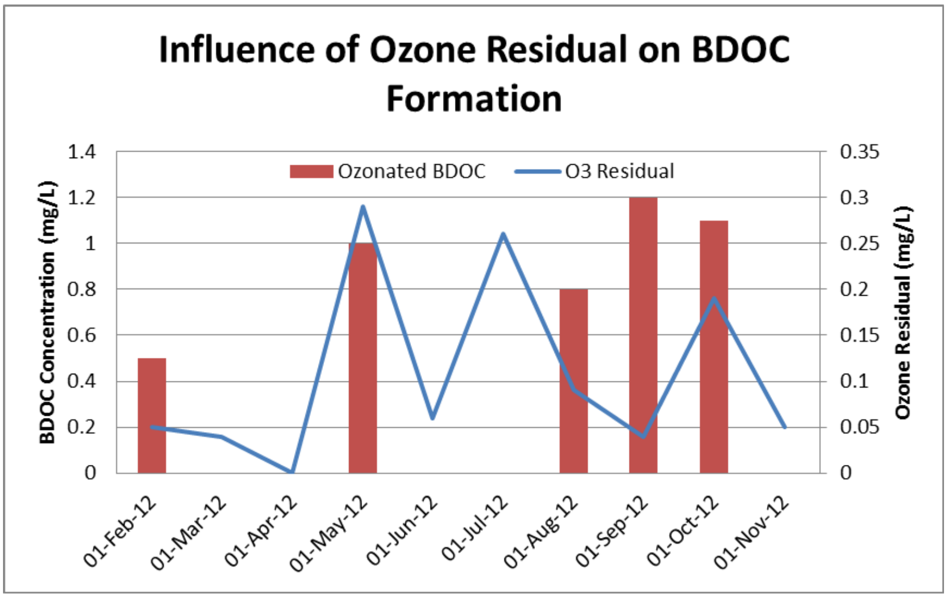
In August 2012 it was observed that there was no reduction in BDOC through the BAC filtration process. Water temperature at the time of sampling was 9°C. Due to the colder water temperatures it was decided that the backwashing frequency be reduced from once every 3 days to once every 6 days. By reducing the backwashing frequency the BDOC reduction through the BACs was improved (Figure 3).



<u>Figure 3:</u> ***BDOC Reduction for Orange WTP BAC Filters***

2.3 Influence of Ozone Residual on BDOC Formation

Although the obvious difference between the January and August BDOC results was the water temperature, the ozone residual and BDOC concentration of the ozonated water were compared. Ozone has a higher solubility in cooler water and higher ozone residual can lead to higher BDOC concentration. Figure 4 shows that in this case there was no real correlation between ozone residual and BDOC concentration and ozone residual was not dependent on water temperature.



<u>Figure 4:</u> ***Influence of Ozone Residual on BDOC Formation***

2.3 Influence of Water Temperature on BAC Performance

Water temperatures at Orange WTP ranged from 21.5°C in January to 9.0°C in August 2012. By looking at the water temperatures and the BDOC and DOC reduction through the BAC filters (Figure 5) it was determined that while the filters were backwashed every 3 days the performance of the filters for organics reduction was worse in the cooler months.

In January BDOC reduction was 80% however in August the BAC filters were actually contributing to the BDOC of the BAC filtered water. Although there is limited data there appears to be a strong linear correlation between water temperature and BDOC reduction through the BACs.

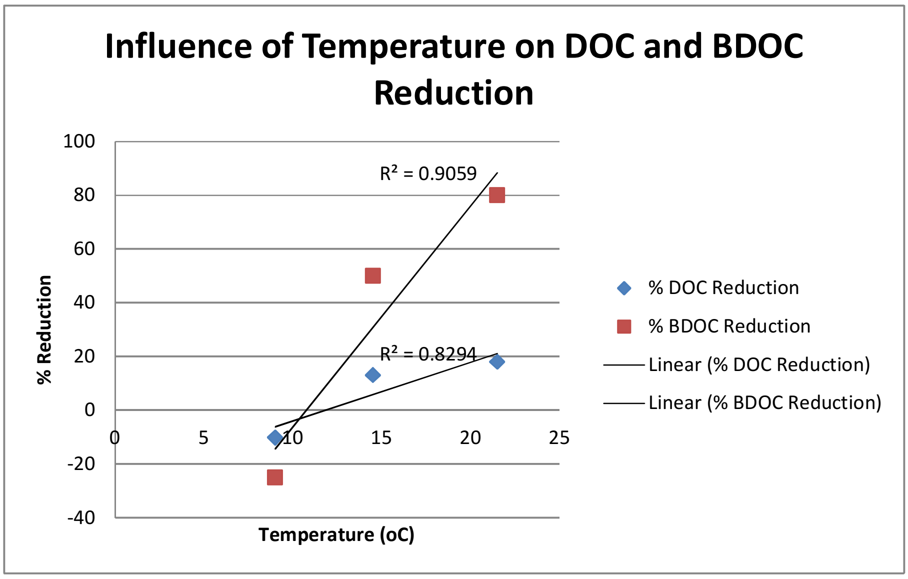


Figure 5: ***Influence of Temperature on DOC and BDOC Reduction Through BAC When Backwashed Every 3 Days***

2.4 Influence of Backwashing Frequency

After the poor BDOC reduction result in August, backwashing frequency of the BAC filters was decreased to once every 6 days. By reducing the backwashing frequency of the BAC filters while the water temperature was cooler an improvement in BDOC reduction was observed in September (Figure 6). The October sampling event showed similar results to the May sampling event, yet October had a reduced backwashing frequency. It appears as though the influence of backwashing frequency is significant when the water temperature is less than 15°C.

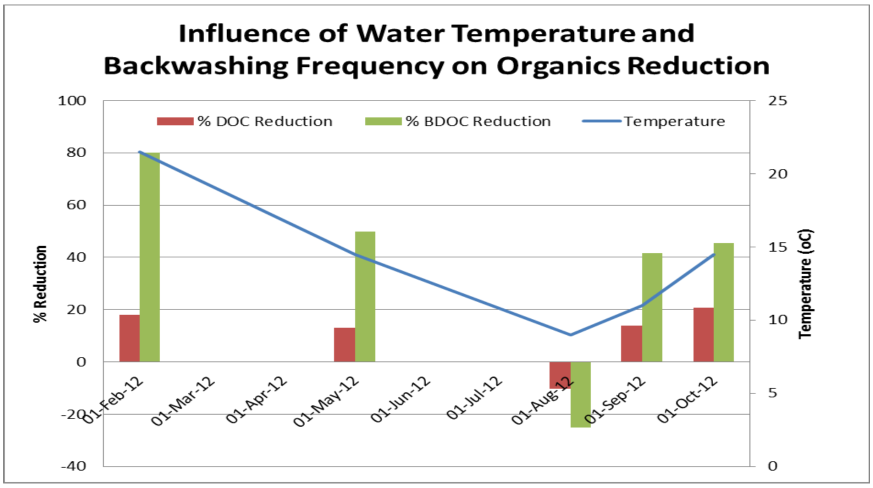


Figure 6: ***Influence of Backwashing Frequency on DOC and BDOC Reduction Through BAC***

2.5 Influence of Temperature on the BDOC Test

After determining that the temperature of the water influenced the BAC performance it was decided that the influence of temperature on the BDOC test itself be determined on the October samples. Identical samples were run in parallel – one set at 21^{o}C (as normal) and the second set at 15^{o}C. Table 1 shows that the temperature of the BDOC test also influences the BDOC concentration. When the BDOC test is run at 21^{o}C the BAC filtration achieves a 45% reduction in BDOC yet at 15^{o}C a 70% reduction is achieved. In these samples the temperature of the water in the distribution system was 14.5^{o}C and closer to 15^{o}C. Perhaps there should be consideration of the distribution system temperature when the parameters of the BDOC test are set.

Table 1: ***Influence of Temperature on BDOC Test***

Sample ID	TOC (mg/L)	DOC (mg/L)	BDOC @ 21^{o}C(mg/L)	BDOC @ 15^{o}C(mg/L)
BAC Filtered	3.4	3.3	0.6	0.3
Ozonated	4.3	4.2	1.1	1.0
Filtered	4.4	4.2	0.3	NT
Raw	7.7	7.6	1.0	NT

3.0 CONCLUSION

Routine measurement of the BDOC showed that the cooler water temperature was impacting on the BAC filtration step to reduce organics. In August 2012 when the water temperature was only 9^{o}C the BAC filtration process was contributing DOC and BDOC to the filtered water. By reducing the BAC backwashing frequency from once every 3 days to once every 6 days the BAC performance improved. This impact of water temperature only appeared to be significant at water temperatures below 15^{o}C.

In addition to examining the impact of temperature on the ozone and BAC processes in the full scale plant, the effect of temperature on the BDOC test itself was also examined. The BDOC test temperature influences the results with lower results at low temperatures.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

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