MANAGING THE PROLONGED CYANOBACTERIAL ACTIVITY IN THE LOWER RIVER MURRAY

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ABSTRACT

This study provides an evaluation on the impact of algal challenges (cell numbers > 100,000 cells/mL and/or > 100 ng/L taste and odour (T&O) concentration) experienced by four WTPs (water treatment plants) in the lower River Murray from January to July 2021. Surveys were completed at Loxton, Barmera, Swan Reach and Morgan WTPs. The survey consisted of taking samples throughout the WTP for basic water quality, taste and odour (MIB and geosmin), and algal counts. Jar tests were conducted to optimise treatment performance during cyanobacterial challenges.

Although most WTPs mitigated the high T&O challenge, the surveys revealed certain treatment processes may be a source of additional T&Os and cells. T&O producing cyanobacterial cells have been found to survive the coagulation-flocculation process and can grow in sludge lagoons, tanks and other critical control points. This is a concern for WTPs as these T&Os and cells can be returned to the head of the plant via the supernatant return. Up to 512 ng/L of T&O compounds were detected in a supernatant return sample. Jar tests showed that further dose optimisation can be achieved. This study emphasised the need for intensive surveys at potentially vulnerable WTPs to understand and appropriately manage the impact of high-risk cyanobacterial challenges.

1.0 INTRODUCTION

The harmful algal response project (HARP) aims to analyse data from cyanobacterial related intensive spot monitoring to further our knowledge on the impact of algal and cyanobacterial challenges to our metropolitan, rural and remote water treatment plants (WTP). HARP is modelled on previous algal focussed research projects such as Algal Response Team project (Newcombe and Newton 2018).

Sampling for HARP is initiated when:

- Taste and odour compounds are detected in the inlet > 20 ng/L
- High cyanobacterial cell numbers (>10,000 cells/mL) are detected at the WTP inlet
- Uncommon cyanobacterial species are detected

The event that triggered the cyanobacteria sampling were the high pH challenges most likely linked to the presence of *Dolichospermum planctonicum* at Loxton WTP in January 2021. *Dolichospermum planctonicum* is a larger species (approximately 433 μm^3) and is larger than other species of the same genus such as *Dolichospermum circinale* and *Dolichospermum crassum* (ITRC 2022). *Dolichospermum planctonicum* is a potentially toxic species (anatoxins, saxitoxins and microcystins) and a potential taste and odour producer (geosmin). Its relatively larger size can be a contributor to its role as a filter blocker in WTPs. There are gaps in our knowledge of how this species can impact our WTPs, as at the time, it was not commonly detected. Furthermore, another WTP along the River Murray (Barmera WTP) also experienced a high algal challenge of 100,000 cells/mL in March 2021 and a MIB and geosmin taste and odour challenge. This WTP was also selected for sampling. Swan Reach WTP and Morgan WTP were also WTPs that experienced high cyanobacterial and T&O challenge in winter and was also investigated.

1.1 Aim and objectives

To investigate the impact of a large algal challenge, high taste and odour challenge or uncommon species on the performance of South Australian water treatment plants.
The outcomes of this investigation will provide us with more information on:

1. The impact of cyanobacterial challenges on WTP performance.
2. Optimising coagulant dose on treatment performance during cyanobacterial challenges.

2.0 DISCUSSION

2.1 Methodology

The study was split into two main sections: 1) the performance of WTPs during cyanobacterial and taste and odour challenges and 2) the optimisation of WTPs during cyanobacterial challenges.

2.1.1 Water treatment plant performance

Non-routine sampling was conducted at two of the Riverland WTPs, Loxton WTP on (1) 29/01/21, (2) 11/02/21 and (3) 25/02/21, Barmera WTP on 12/03/21 (4), Swan Reach WTP on the 24/06/22 (5), and at Morgan WTP on 28/06/21 (6) (Figure 1). Samples were collected at key locations throughout all the WTPs that were representative of key treatment processes, inlet, supernatant return (where possible), post sedimentation, post filtration and product water. The samples were analysed for parameters; dissolved organic carbon, true colour, pH, turbidity, taste and odour and cell counts. Analysis of samples during these algal events can provide the team with more information on the impact of cyanobacterial challenges during the treatment process.

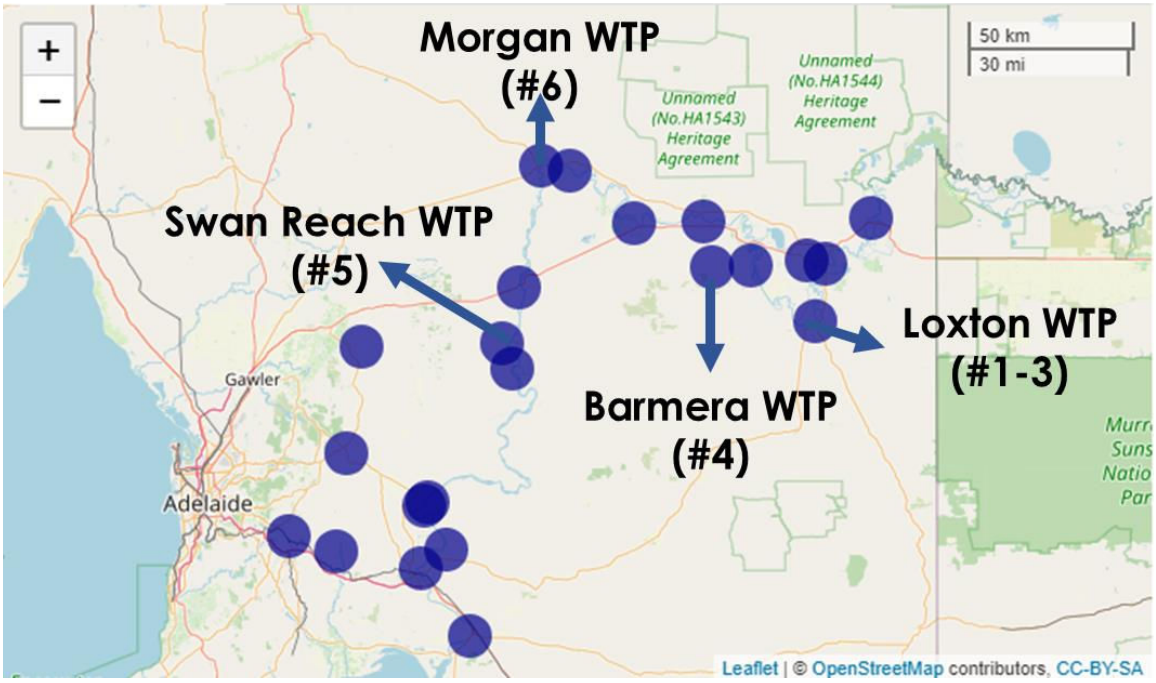


Figure 1: ***Locations of all the water treatment plants along the River Murray that was sampled in 2021. © OpenStreetMap contributors, CC-BY-SA 2.0***

2.1.2 Jar Test optimisation

A series of conventional jar tests were conducted using raw water collected from Loxton WTP (Table 1). The jar tests with varying coagulant doses will be used to determine if treatment performance can be improved by changing the coagulant doses or adding acid to counteract the high pH caused by the cyanobacteria. Water quality for all 5 jar tests were analysed according to section 2.1.1 and included particle characterisation using a zetasizer.

Table 1: ***Jar test dosing conditions for the Loxton WTP inlet water***

Jar Test Number	Coagulant	Coagulant dose	polyDADMAC LT410 dose	pH
1	Aluminium sulfate	Plant dose: 40 mg/L	0.8 mg/L	Not adjusted
2		Under-dose: 20 mg/L		Not adjusted
3		Over-dose: 60 mg/L		Not adjusted
4		Over-dose: 80 mg/L		Not adjusted
5		Coagulant dose used to acidify the water to reach a pH of 6.1 – 6.3		Dose to reach pH 6.1 – 6.3

2.2 Results

2.2.1 Water Quality

Water quality analysis was conducted for the samples collected at Loxton WTP, Barmera WTP, Morgan WTP and Swan Reach WTP. It appears that an added cyanobacterial and algal challenge does not heavily impact most water treatment plant processes in terms of pH, dissolved organic carbon, turbidity and true colour.

2.2.2 Taste and Odour and algal counts

T&O concentrations at the inlet ranged from 7 to 120 ng/L during the sampling events (data not shown). There were only two WTPs that were able to fully remove all the T&O compounds by the end of the filtration stage; Loxton (#2) and Morgan WTP (Figure 2a). There were 2 instances of T&O detected in the product water where there was one instance the T&O would have been detectable by customers (data not shown). Cell numbers at the inlet ranged from 4,000 to 100,000 cells/mL during the 6 sampling events (data not shown). In most cases, all cells were fully removed by the end of the filtration process (Figure 2b). The only exception was at Swan Reach WTP where cells were detected in the product water. However, there was a large proportion of cells and taste and odour compounds returned to the head of the plant via the supernatant return. For instance, 512 ng/L of T&O and 113,000 cyanobacterial cells/mL was detected in the supernatant return sample from Morgan WTP (data not shown).

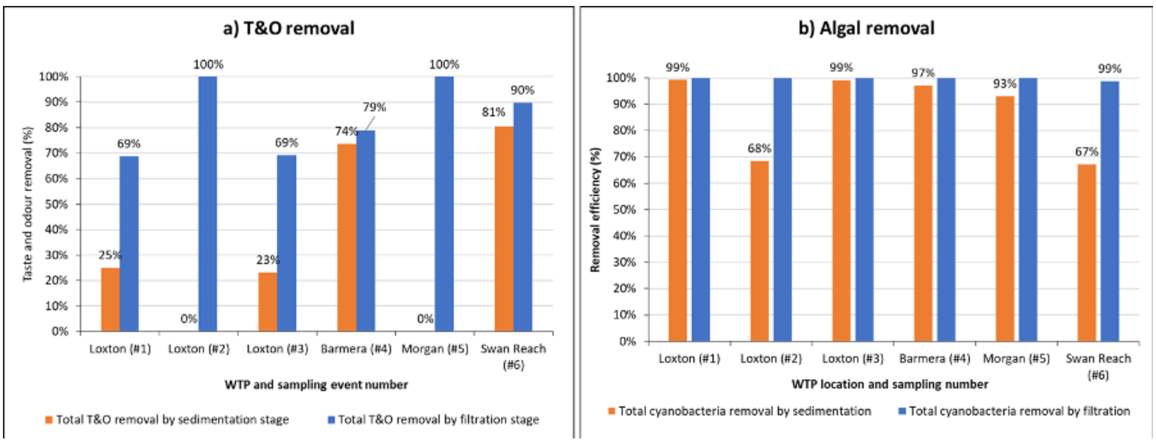


Figure 2: ***a) Taste and odour and b) algal removal efficiencies for each WTP.***

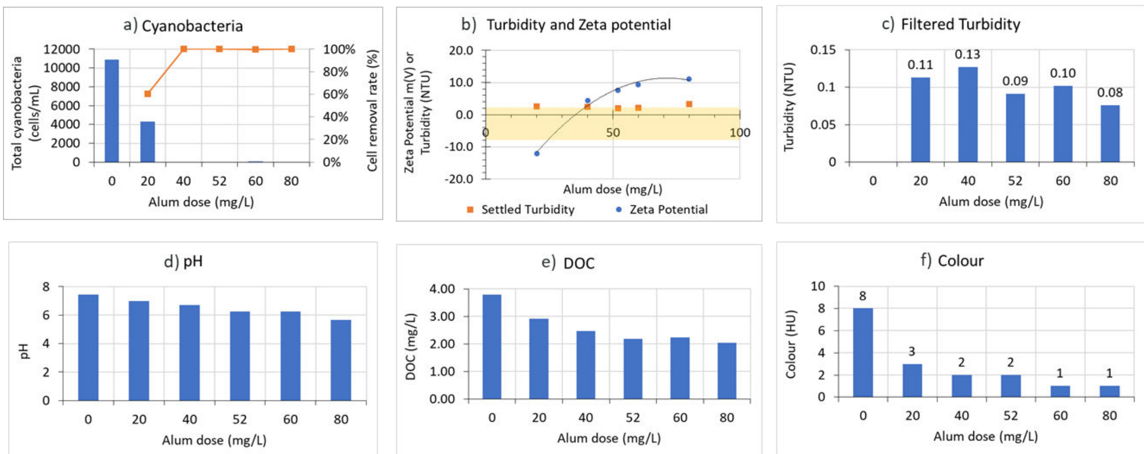
2.2.2 Treatment plant performance

Most plants were able to mitigate the high cyanobacterial challenge by the sedimentation or filtration stages. Despite the breakthrough of cyanobacterial cells in the product water at Swan Reach WTP, the plant was still able to achieve up to 99% of removal. However, the investigated WTPs were less successful at removing T&O compounds by the post filtration stage; only 2 WTPs fully removed the T&O compounds to <4 ng/L (limit of detection of the instrument).

The supernatant return is recycled back to the head of the plant such that is makes up to 10% of the total inlet plant flow. Furthermore, large amounts of T&O and cells were found in the supernatant return, often at greater concentrations that what was detected at the inlet. This suggests that there is accumulation or growth of cells and subsequent T&O compounds in the sludge lagoons. These sludge lagoons can be an additional source of cyanobacteria and T&O compounds for WTPs during algal challenges.

2.2.3 Jar Test optimisation

This part of the project was to determine if coagulant doses can be manipulated to achieve greater treatment performance during an algal challenge. Although *Dolichospermum planctonicum* was not detected during this sampling event, approximately 10,000 cyanobacterial cells were detected in the raw water (Figure 3a). All coagulant doses tested produced similar sized flocs with similar formation rates. Settled Turbidity for all doses except for the overdose of 80 mg/L were less than 3 NTU and filtered turbidity ranged from 0.08 to 0.13 NTU (Figure 3b and c). The dose added to reach pH 6.2 (52 mg/L) produced the water with the lowest settled turbidity. Despite the numbers of cyanobacteria and algae in the sample, pH decreased from 7.4 to 5.7 as the coagulant dose increased (Figure 3d). DOC was reduced by 23% to 46% with the range of doses tested (Figure 3e). Colour was reduced from 8 to <3 HU for all doses trialled (Figure 3f). Most cyanobacterial cells were removed using all the coagulant doses apart from the underdose of 20 mg/L in the jar test. To achieve charge neutralisation during the flocculation process, the zeta potential of the water should be as close to 0 mV as possible. When the zeta potential is at 0 mV, the optimal floc conditions can be achieved. To maximise the removal of algal particles and related organic matter, the zeta potential should be between -8 to 2 mV (Henderson et al. 2008). A range of zeta potentials were obtained from each jar test (Figure 3b). The plant dose was outside the zeta potential window for optimal treatment. The optimal coagulant dose based on the zeta potential results using this water and jar test should be 36 mg/L. However, all doses produced settled turbidity that was < 4 NTU.



<u>Figure 3:</u> ***a) cyanobacterial cell counts and removal rate, b) Settled turbidity and zeta potential, c) filtered turbidity, d) pH, e) dissolved organic carbon, and f) true colour for all the jar tests.***

3.0 CONCLUSION

Although *Dolichospermum planctonicum* was not detected in any of the sampling events, the WTPs still experienced an algal and taste and odour challenge. From monitoring cyanobacterial and water quality of WTPs faced with an algal challenge, it was observed that these WTPs can mostly handle the high algal and T&O challenges. Taste and odour producing cyanobacterial cells that survive the flocculation-sedimentation process may accumulate or grow in the sludge lagoons. This may become a problem for WTPs as cyanobacteria and taste and odours can be recycled back to the head of the WTP via the supernatant return. Jar tests to determine optimal dose via zeta potential show that the dose can be reduced from 40 mg/L to 36 mg/L for charge neutralisation. However, the WTP was operating close to optimal conditions. Total cyanobacteria and algae at the numbers detected during the 1st sampling event (approximately 23,000 cells/mL) does not impact the treatment process.

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5.0 REFERENCES

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