DEVELOPMENT OF AN EFFECTIVE STRATEGY FOR SULFIDE CONTROL IN SEWERS USING FREE NITROUS ACID

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ABSTRACT

Free nitrous acid (FNA) was dosed into a rising main 840 m long, 150 mm diameter, with an average flow rate of 202 kL per day and an average retention time of 2 hours, to control the formation of sulphide within the rising main where sulphide control was challenging. It was found that weekly doses of FNA for 6 hours could provide sustained control of downstream sulphide at an estimated chemical cost of $19 to $27 per ML of wastewater treated (averaged over the total flow for a week).

INTRODUCTION

Field trials at the City of Gold Coast of a novel technology for sulfide control have been reported previously (Jiang et al., 2013). Here we report the results of field trials conducted at Scarborough in Queensland by Cloevis Pty Ltd, Unitywater and the Advanced Water Management Centre (AWMC) at The University of Queensland (UQ) for the purpose of demonstrating the effectiveness of the Cloevis process in controlling sulfide production in a rising main where an alternative method of control by dosing magnesium hydroxide was not sufficiently effective.

The conditions for the trial were challenging. Without any chemical control, weekly hydrogen sulfide readings have on occasions averaged more than 100 ppm with a 90th percentile reading in excess of 250 ppm have been recorded in the rising main discharge manhole. The system wide target across the Unitywater system is a 90th percentile of 10 ppm. Dosing with magnesium hydroxide (MHL) had brought about significant reductions in the recorded hydrogen sulfide levels but they were still well above the target level.

Sulfide generation at this site is impacted strongly by trade waste that is injected in an irregular manner directly into the rising main between the wet well and the discharge manhole. The sewage collection system in this part of Unitywater's network is sub-optimal. Changes to the infrastructure will be expensive and difficult to implement. Unitywater closely monitors the trade waste in this catchment and has effected incremental improvements. Chemical dosing is currently seen as the most acceptable strategy to control the odour and corrosion potential in this catchment. Chemical dosing where the trade waste enters Unitywater's network is not possible so the upstream pumping station (SPS-RED001) was chosen as the dosing site.

For Cloevis Pty Ltd, the objectives of the trial were to demonstrate that sulphide control using intermittent dosing with FNA could be achieved for this challenging location, to establish appropriate operating parameters for the dosing, to further refine the technology and to determine the likely chemical costs associated with this
novel control strategy. For Unitywater, the purpose of the trial was to see if dosing with FNA offered a better solution than dosing with MHL.

THE CLOEVIS PROCESS
The Cloevis process was developed by researchers at the AWMC during the SCORe project. It works in a very different manner to the continuous dosing control methods that aim to prevent the release of sulphide into the gas phase well downstream from the locations where it is formed. FNA is dosed into upstream rising mains on a regular but intermittent basis to prevent the formation of sulphide at its source, thereby reducing or removing the need for downstream control measures.

METHODOLOGY
The rising main
The wet well (SPS-RED001) used for this trial is located in Jamieson Park at Scarborough in Queensland. Figure 1 provides a schematic layout of the rising main. The average daily flow of domestic wastewater into the wet well is 202 kL. The pumps are rated at 26 L/s. During the course of the trial the set points for the wet well gave an average pump frequency of 50 cycles per day with each pump cycle delivering about 4.0 kL into the rising main. The rising main has a diameter of 150 mm and length approximately 840 m to the discharge manhole. Trade waste is also being discharged directly into the rising main at 4 separate locations. The flow at the discharge manhole enters a turbulent phase rendering control by pH elevation extremely difficult.

Figure 1: Schematic layout of the rising main system
**Dosing**
In the previous trials (Jiang et al., 2013) hydrogen peroxide had been used in conjunction with FNA to improve the performance of the dosing. In these trials, FNA alone was used to test the effectiveness of a less complex mix.

FNA was formed in the wet well by dosing liquid sodium nitrite (40%) and hydrochloric acid (35%) simultaneously below the water level in the wet well in order to optimise mixing while the wet well was refilling after the completion of each pump cycle.

It should be noted that the transport and storage of chemicals is regulated by the Australian Code for the Transport of Dangerous Goods by Road & Rail (National Transport Commission, 2014). Appropriate safety measures for handling and storage were put in place to comply with the requirements of the code.

The target level for nitrite in the rising main was 100 mgN/L of wastewater. The quantity to be dosed during each pump cycle to achieve this target was calculated using an additional 50% safety factor to allow for variability in the flows arising from the trade waste sources. The target pH in the rising main was less than or equal to 6.0. Extensive sampling from the wet well was carried out initially to establish the required quantity of hydrochloric acid to be dosed during each pump cycle to achieve this target.

Using the observed periods for the recovery in the sulfide levels over the first few trials, it was decided that the most appropriate gap between trials to optimise costs and operational efficiency was approximately 7 days. The duration of dosing was varied between trials in order to determine the lower limits for effective control.

**Sulfide measurements**
Hydrogen sulfide levels in the discharge manhole were measured using Odalog® gas data loggers providing a reading every minute. As a precaution, 2 loggers were used at all times to ensure consistency in the readings.

**Rain events**
No significant rain events were recorded during any of the dosing periods.

**RESULTS AND DISCUSSION**
To demonstrate the effects of no dosing, dosing with MHL and dosing with FNA, the sulfide readings for 3 weeks that are representative of the results obtained by each of these are shown in Figure 2. The key measures of average sulfide, 90th percentile and maximum sulfide for each of these are compared in Table 1.
Figure 2(a). Sulfide readings (ppm) without dosing

Figure 2(b). Sulfide readings (ppm) with MHL dosing

Figure 2(c). Sulfide readings (ppm) with FNA dosing for 6 hours on 08/09/2014
Table 1: Comparison of key parameters for each representative week following FNA dosing

<table>
<thead>
<tr>
<th></th>
<th>7 day average sulfide readings (ppm)</th>
<th>7 day 90th percentile sulfide readings (ppm)</th>
<th>7 day maximum sulfide readings (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) No dosing</td>
<td>129</td>
<td>305</td>
<td>1023</td>
</tr>
<tr>
<td>(b) MHL dosing</td>
<td>21</td>
<td>47</td>
<td>529</td>
</tr>
<tr>
<td>(c) FNA dosing</td>
<td>4</td>
<td>12</td>
<td>177</td>
</tr>
</tbody>
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The extremely high sulfide readings with no dosing being applied are significantly reduced by dosing with MHL. However, the MHL dosing, at that dosing rate, did not achieve sufficient reduction to meet the target of the 90th percentile being 10 ppm. FNA dosing was able to achieve a further significant reduction over the MHL dosing. It should be noted that there would have been some differences in the temperatures of the wastewater between those for cases (a) and (b) and those for case (c) because of the time of year in which the trials were conducted. However, the temperature difference alone does not explain the significant reduction in sulfide measurements after FNA dosing.

For FNA dosing the characteristic behaviour for each trial different from other methods in that dosing results in an immediate reduction of the recorded hydrogen sulfide levels or maintains an existing low level, after which the sulfide levels slowly begin to recover. An initial dose for 24 hours prepares the rising main for the subsequent shorter weekly maintenance doses. Various durations were tested before we settled on 6 hours as the minimum effective dose for this site.

The detailed results of the FNA dosing trials are presented in Table 2.

Table 2: Average, 90th percentile and maximum sulphide readings for 7 days after FNA dosing

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Dose duration (hrs)</th>
<th>7 day average sulfide readings (ppm)</th>
<th>7 day 90th percentile sulfide readings (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>3</td>
<td>8</td>
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<tr>
<td>2</td>
<td>11</td>
<td>4</td>
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</tr>
<tr>
<td>10</td>
<td>6</td>
<td>15</td>
<td>35</td>
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</table>
In estimating the cost of FNA treatment, here we consider only the cost of chemicals. The capital and set up costs of the dosing infrastructure and chemical delivery costs are likely to be similar to other chemical dosing installations while the labour costs are likely to be similar or somewhat reduced given the intermittent dosing strategy. For a weekly dosing strategy, we estimate that the cost of chemicals will lie in the range of $19 to $27 per ML of wastewater treated when the cost is averaged over the total flow for the week.

CONCLUSION
Effective control of sulfide production in a rising main by weekly dosing with FNA was demonstrated over multiple trials with 6 hours as the minimum dosing duration for this challenging site where the sulfide level is impacted strongly by trade waste. Hydrogen peroxide was not used in these trials, thereby simplifying the chemical handling and dosing. It is likely that treatment with FNA will provide a cost effective alternative to other sulfide control methods when applied to upstream rising mains.

CLOEVIS PTY LTD
The method of controlling sulfide in sewers using FNA, with and without hydrogen peroxide, has been protected by patent applications and has been licensed for commercialisation worldwide to Cloevis Pty Ltd. Cloevis is working in partnerships with US Peroxide LLC which is conducting trials of the Cloevis technology in USA.

ACKNOWLEDGEMENTS
The authors acknowledge the essential contributions made by Unitywater in providing the site and support for this trial, US Peroxide LLC for the supply and installation of the dosing equipment and The University of Queensland and UniQuest Pty Limited for providing personnel and operational support.

REFERENCES