ODOUR MITIGATION TO MINIMISE SEWER CORROSION

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ABSTRACT

Western Water owns and operates over 1000km of sewer mains in Victoria, Australia. Corrosion of these sewerage networks represents a huge ongoing cost to both maintain and replace damaged assets. Odours within sewerage networks are associated with the anaerobic generation of hydrogen sulphide (H_2S) gas, a key component in the corrosion of concrete structures. In early 2009 a trial chemical dosing regime was initiated in order to remediate both the odours and their underlying causes within the sewerage network in order to reduce the corrosive potential within a part of Western Water's network.

AWT carried out a process analysis of the odour generation potential in the sewerage network, a review of the different chemicals available and their potential effect on odour generation as well as potential "side effects" on reticulation and treatment systems, and then carried out the dosing trials themselves. Measurement of the H_2S was carried out during the different phases of the trial and the data from this analysed to determine the profiles of H_2S throughout the day as well as correlation between the H_2S concentrations and the pump-outs from the two pump stations that feed the outfall.

The existing dosing regime (Biosol) was compared to another chemical dosing trial (magnesium hydroxide) at the same site during January 2010 to compare directly the odour reduction. This was evaluated in terms of pump station pump-outs, sewer retention time, a small wastewater characterisation study and H_2S gas production in the downstream gravity main.

This found that magnesium hydroxide was capable of reducing odours to significantly improved levels. The difference in temperatures during the two periods meant that the results were not directly comparable however, they would indicate that magnesium hydroxide has the potential to be as effective as the proprietary chemical dose.

KEYWORDS

Odour, Chemical Dosing, Sewer Corrosion

1 INTRODUCTION

During Western Water's ongoing operation and maintenance programme, it was identified that some sections of sewer main had experienced corrosion. Corrosion has been associated with odour production due to long retention times and the frequency of pump outs from the sewage pumping stations upstream of the affected sewer.

In early 2009 a chemical dosing trial commenced using Biosol, a proprietary chemical. This trial was undertaken for the best part of the year with varying dose rates of Biosol, calcium nitrate and subsequently after an initial study by AWT: magnesium hydroxide.

Western Water commissioned CMP Consulting Group to undertake a review of the system and identify options for the reduction in corrosion and H_2S production. CMP subsequently commissioned AWT to assist with the process elements associated with this study, with regard to the option of managing the issue with chemical addition.

AWT initially completed a basic desktop analysis of the system and reviewed options for odour reduction. From this a number of recommendations were made in terms of a dosing trial, sampling of the system and further development of the odour model.

1.1 ODOUR GENERATION

Odour generation within sewerage systems is directly related to the presence of sulphurous compounds, in particular hydrogen sulphide (H_2S) gas. These compounds are created by sulphur reducing bacteria which, typically, are found on the surfaces within the sewerage network. These bacteria require degradable carbon (as found in both municipal wastewater and tradewaste); sulphur (proteins, detergents); nutrients (nitrogen and phosphorus in particular); temperature (higher temperatures increase reaction rates) and residence time for the biological and chemical reactions to occur. The H_2S produced as part of the anaerobic respiration exists is soluble at higher pH ranges, however, as alkalinity (and pH) drops the solubility decreases and gaseous H_2S is released.

1.2 CORROSIVE POTENTIAL

While H_2S itself is not corrosive, chemoautotrophic bacteria use it as an energy source producing sulphuric acid (H_2SO_4) in the process. It is the presence of this acid that causes corrosion of concrete structures in the networks. The reaction for the production of H_2SO_4 is shown below.

$$H_2S + 2O_2 \xrightarrow{\text{chemoautotrophs}} H_2SO_4 \longrightarrow \text{Corrosion}$$

The rates of reaction for the production of H_2SO_4 relate to the presence of H_2S, oxygen and a chemoautotrophic population. Additionally, for both this part of the reaction and the acid-caused corrosion, temperature, relative humidity and residence time are all factors that influence any corrosion that results. A reduction of any of these factors should result in a decrease in the overall corrosion.

In order to reduce corrosion, Western Water undertakes routine inspection of their sewerage network, with particular emphasis on areas where high odour levels have been reported. Proactive management has resulted in preventative works such as the epoxy coating of forty-eight manholes between 2008 and 2010 to stop any further deterioration.

2 EXISTING ODOUR ISSUES

The odour present was measured in terms of hydrogen sulphide (H_2S) gas measured at the outfall. The H_2S was found to peak to high gas concentrations periodically throughout the day, with peaks of between 400 and 500 ppm periodically achieved. Concentrations up to these levels have potential to cause significant corrosion to concrete assets.

Figure 1 shows the measured H_2S profiles over four consecutive days during the period where no chemicals were dosed into the system. The highest concentrations of H_2S were measured between 6am and 7pm which corresponds to the first major pump outs of the day hence pushing a slug of septic wastewater through the rising main to the gravity main where the gas spikes are released (particularly at points of hydraulic jumps). Spikes were found to correspond with discharges from both the contributing pump stations (Figure 2). The H_2S builds up within the sewerage network and when a pump-out occurs, the gas is released at the discharge point of the rising main. During the early morning, pump-outs become less frequent and so when they do occur, high H_2S readings are measured. Chemical dosing was therefore undertaken in an attempt to remediate the situation.

Figure 1: Hydrogen sulphide concentrations at Area of Interest

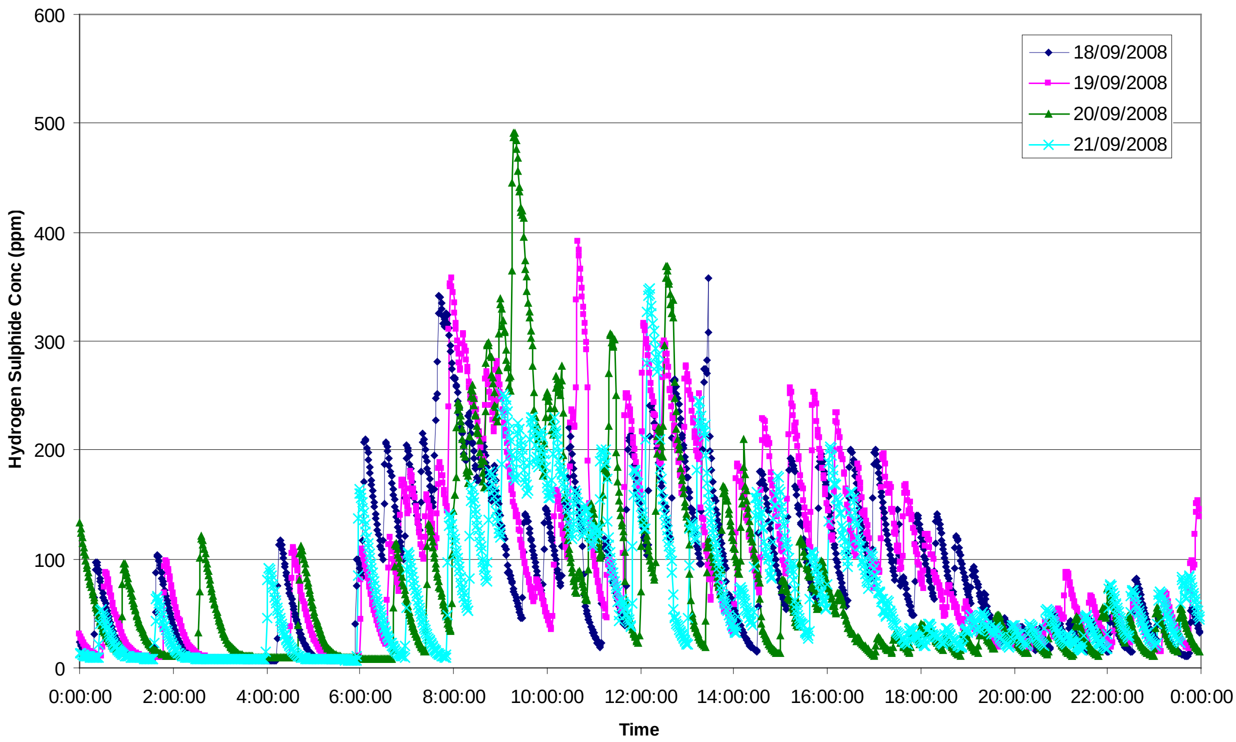
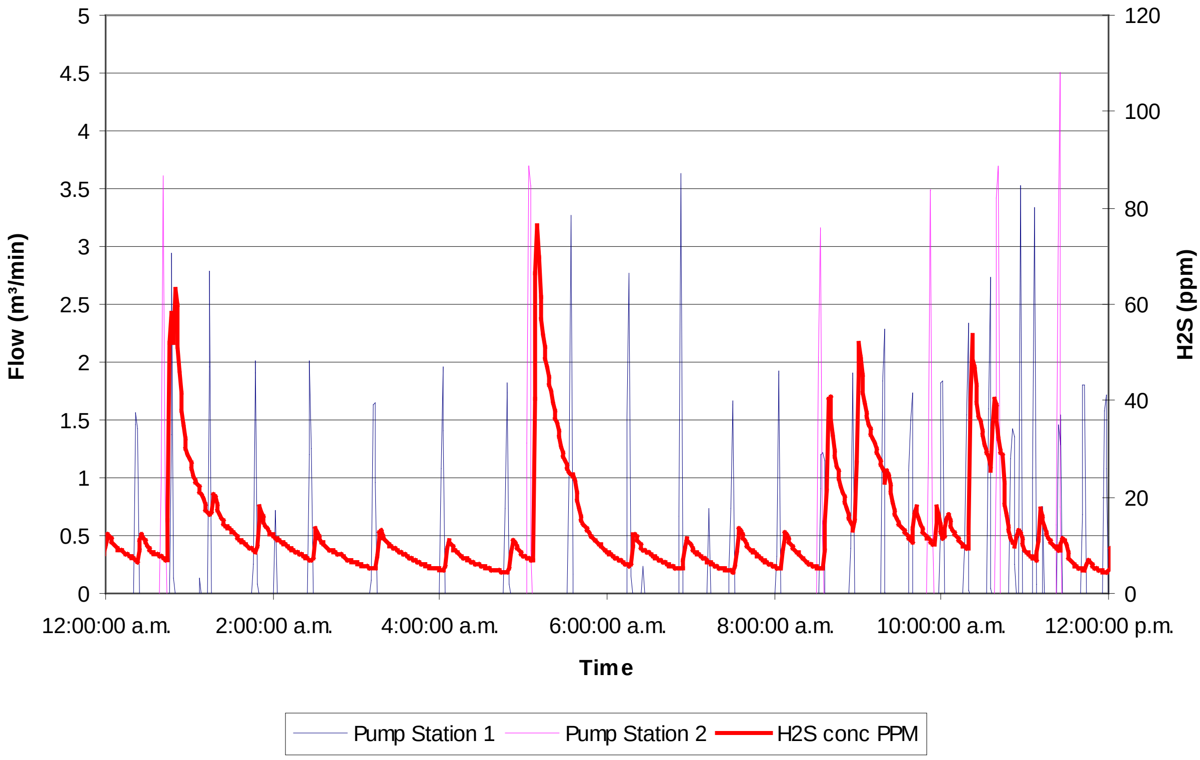


Figure 2: Pump station discharges and measured H_2S spikes.



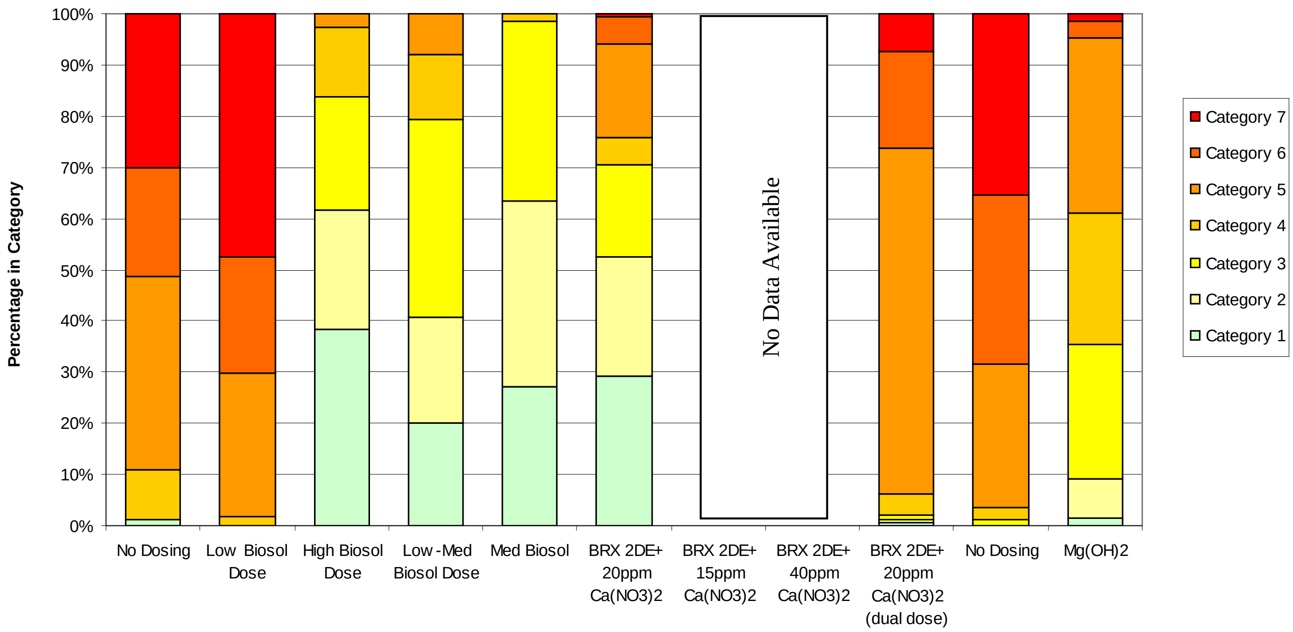
3 COMPARISON OF TREATMENT OPTIONS

Prior to the involvement of AWT, Western Water had dosed varying amounts of Biosol (a proprietary odour reducing chemical). Biosol BRE 3EY later became unavailable, and the dose was replaced with a mixture of Biosol BRX 2DE and calcium nitrate at different concentrations, in an attempt to maintain low odour levels. H_2S concentrations were measured during these periods from mid-September 2008 to mid-February 2010 and the breakdown of these concentrations, based on the category they fall under (Table 1), is shown in Figure 3. During the initial "No Dose" and "Low Biosol Dose" between 90 and 95% of readings fell within the 10 to 50ppm concentration range or worse. Following an increase to a high/medium dose of Biosol, the measured H_2S concentrations were greatly reduced, with up to 98% of the concentrations falling below 5ppm. Literature available on Biosol indicates that it reduces biomass growth on surfaces within the sewerage network; this would have an ongoing remediating effect on the production of odours as well as potentially reducing the growth of the chemoautotrophs responsible for producing H_2SO_4.

Table 1: Breakdown Concentration Categories

Category	Hydrogen Sulphide Concentration (ppm)	Corrosion Potential of Concrete
1	0 to 1	Corrosion unlikely
2	1 to 2	↓
3	2 to 5	
4	5 to 10	
5	10 to 50	
6	50 to 100	
7	100+	Potential for high levels of corrosion

Figure 3: Breakdown of samples within each odour category



However, following the change from Biosol BRE 3EY to calcium nitrate there is a significant increase in the occurrence of H2S, in particular at higher concentrations. Following several different dose rates of calcium nitrates (including several without any data measurement) the presence of H2S increased significantly at the outfall with 68% of readings 10 to 50ppm and 26% higher than this (50ppm+). When the Biosol and calcium nitrate dosing was ceased, the H2S concentrations returned to similar levels as they were prior to Biosol dosing – predominantly between 50 to 100ppm (33%) and 100ppm+ (35%). Following commencement of magnesium hydroxide dosing, the H2S concentrations dropped to significantly lower levels, however these were still higher than those measured during the Biosol dose with 35% less than 5ppm and only 5% 50ppm+.

3.1 SELECTION OF CHEMICALS

As part of the investigation into chemical dosing, a pre-selection process was undertaken to determine which chemical should be used for the final stage of the trial. This desktop investigation looked into the benefits of using a particular chemical over others.

Different chemicals reduce odour using different mechanisms. Calcium nitrate changes the anaerobic conditions within the pipe to anoxic conditions, reducing the generation of by-products (acting as a pseudo-oxidant). Alkalinity buffers such as magnesium hydroxide shift the chemical equilibrium away from H_2S formation. Oxidants supply oxygen to the system removing the anaerobic conditions required for H_2S. Other chemicals precipitate the sulphur to limit the potential for conversion to hydrogen sulphide.

The dose of different chemicals to reduce dissolved sulphide concentrations from 53 mg/L equivalent to at or near 0 mg/L was calculated and this is shown in Table 2 below.

A workshop was held between the consultants and Western Water to discuss and identify the keys elements and desired outcomes. From this and a basic cost assessment Calcium Hydroxide or Sodium Hydroxide was recommended. Western Water already dose Magnesium Hydroxide at their local Recycled Water Plant (RWP); therefore, the dosing and handling of this chemical is well understood.

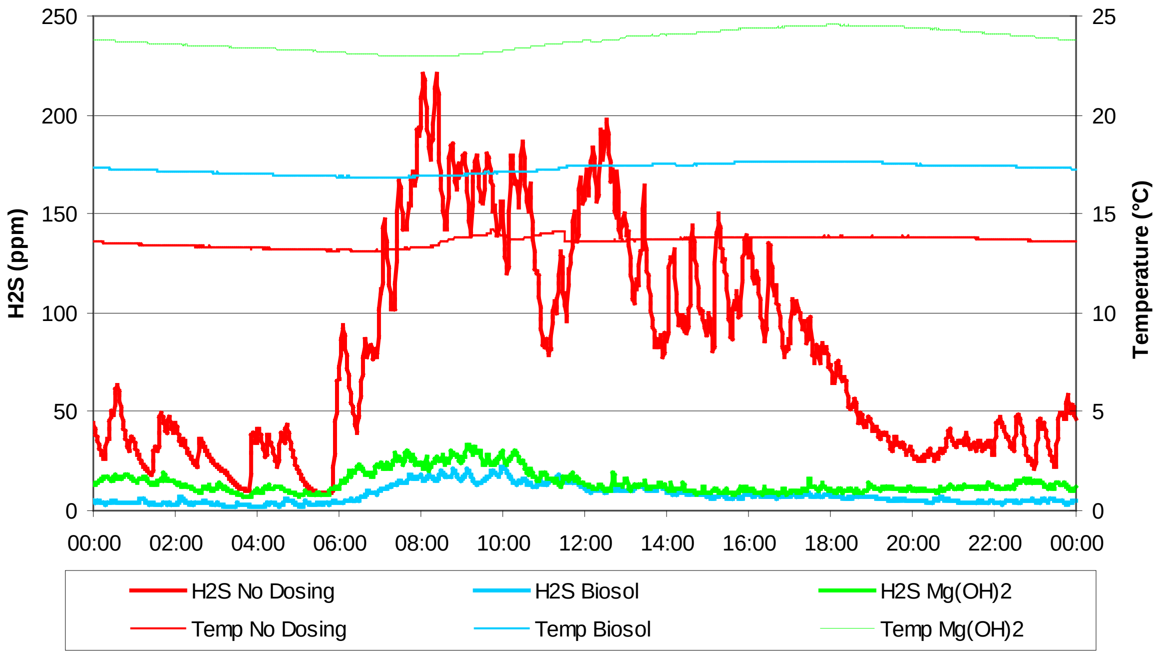
Table 2: Required dose for significant sulphide concentration reduction

Chemical	Form	Dose	Units
Alkalinity Buffers			
Magnesium Oxide	Powder	7.3	kg/d
Magnesium Hydroxide	Slurry	17.7	kg/d
Calcium Hydroxide	Powder	14.2	kg/d
Sodium Hydroxide	Slurry	30.3	L/d
Oxidants			
Calcium Nitrate	Crystal	186	kg/d
Sodium Nitrate	Crystal	134	kg/d
Oxygen	Gas	63.7	kg/d
Precipitants			
Ferric Chloride	Slurry	187	kg/d
Other			
Biosol	Slurry	18	mg/L

3.2 EFFECT OF TEMPERATURE ON H_2S CONCENTRATION

Further analysis of the data yielded an average diurnal profile of both the H_2S concentration and temperature (Figure 4). This illustrates that the measured concentration of H_2S is not significantly higher during the period when magnesium hydroxide was dosed compared to when Biosol was dosed. The temperature however was found to be significantly higher during the magnesium hydroxide dosing period (24°C) compared to the Biosol dosing period (17°C). Temperature has been found to have a significant effect on the generation of hydrogen sulphide (for example the effect of temperature on reaction rates that follow the Arrhenius equation is a doubling for every 10°C increase in temperature). This means that the higher temperatures would result in a greater generation of H_2S and so the higher concentrations measured during the magnesium hydroxide dosing would be expected. It should also be noted that the temperature measured was that of the air temperature within the manhole, not the liquid temperature which may be more relevant.

Figure 4: Diurnal temperature and H_2S concentration profiles



4 CONCLUSIONS

Analysis of hydrogen sulphide concentration data revealed the effectiveness of both Biosol and magnesium hydroxide at reducing odours within the sewerage network. Biosol was capable of achieving lower H_2S concentrations than magnesium hydroxide however the comparison was offset by the increased temperature that the magnesium hydroxide trial was carried out under. Further sampling of the magnesium hydroxide trial should be undertaken over a range of different temperature periods in order to determine the efficacy of the chemical at combating odour. The findings from this study would indicate that it provides adequate odour removal functionality but this could still be improved.

With no chemical dosing high levels of H_2S are produced. These levels have a much higher corrosive potential than those levels produced when either the trialled magnesium hydroxide or Biosol were dosed into the system.

Western Water's approach of reducing odorous H_2S has the potential to greatly reduce the amount of corrosion potential in any exposed concrete structures that may otherwise face some deterioration.

ACKNOWLEDGEMENTS

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