Improved odour control in the sewage network: A case study using Biosol in Griffith NSW

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1 ABSTRACT

A paradigm shift in sewer sulfide control is presented. In January 2014, Biosol was awarded a public tender to treat the total Griffith City Council (GCC) sewer network for odour and corrosion control. By April 2014, Biosol dosing had commenced after the former dosing regime of Magnesium Hydroxide Liquid (MHL) and Ferrous Chloride was decommissioned.

This report provides a comparison between Biosol and the former dosing regime across the GCC sewer network. All data in this report has been collected by the GCC (independently of Biosol), although Biosol has been responsible for the presentation of this data.

Biosol has demonstrated in this application to be cost effective, simpler to dose, with superior sulfide control to the products that Biosol replaced. This result has been achieved using non-hazardous chemicals and only one third the comparable product volume.

2 INTRODUCTION

Sulfide induced infrastructure corrosion in sewer systems is a well-recognised problem for water authorities. Hydrogen sulfide (H_2S) is produced under anaerobic conditions by sulfate-reducing bacteria (SRB). SRB are present in the slime layer (biofilm) that colonise submerged sections of the pipe. The build-up of H_2S in the sewer atmosphere causes major detrimental effects such as sewer wall corrosion, health hazards and odour nuisance.

Corrosion occurs as a consequence of sulfuric acid, formed due to the oxidation of H_2S. This corrosion leads to a reduction in service life of all exposed infrastructure such as concrete pipes, pump stations, manholes and electrical componentry with proportionate rehabilitation costs. In Australia, the cost of asset degradation due to sulfide-induced corrosion is estimated to be in the order of $100 million per year (Gutierrez, 2011).

Any measure that can be taken to limit the release of H_2S into the sewer atmosphere will directly result in an extension of asset life.

2.1 The Sewer Sulfide Cycle

Figure 1 eloquently describes the semi-closed biological and chemical cycle of sulfur in the sewer. There are four major segments to the cycle: the generation of sulfide (pathway one), the release of sulfide (pathway two), the conversion of hydrogen sulfide gas to sulfuric acid (pathway three), and reaction of acid on sewer walls (pathway four). Within each segment microbiological and chemical processes occur. These processes are inter-linked and represent the major pathways through which all sulfide processes must pass. At each of the pathways, there exists an opportunity to interfere with the processes and thus reduce or stop the cycle of sulfide generation in sewers.

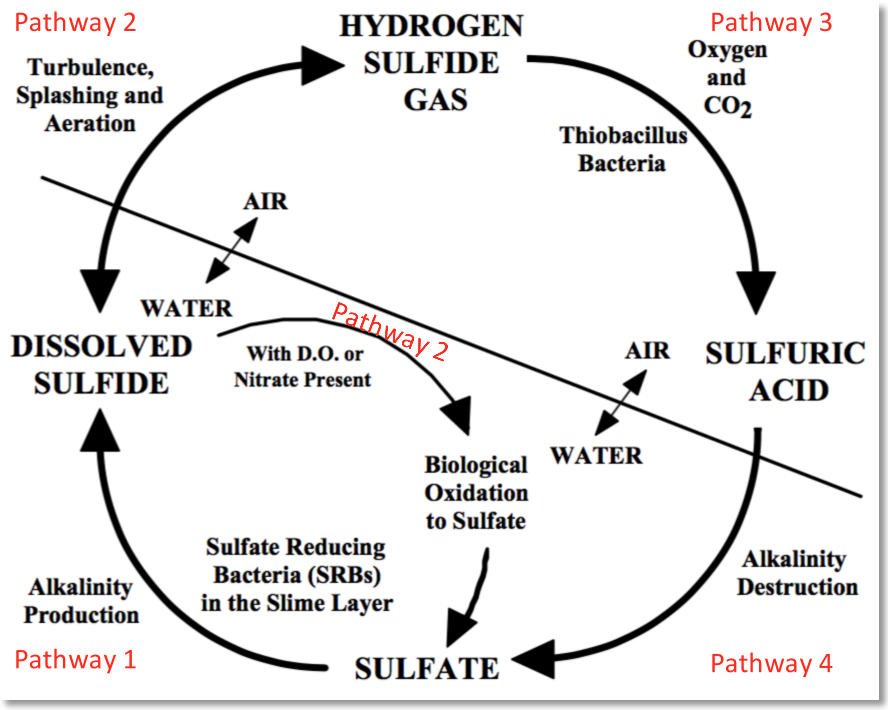


Figure 1: ***The sewer sulfide cycle (Apgar, 2007)***

Figure 2 further summarises the chemical and biological technologies available to water authorities to mitigate H_2S emission in sewer systems (modified Zhang, 2008). Each dosing solution has a % below indicating the market penetration of each chemical to overall sulfide control in Australia (Ganigue, 2011).

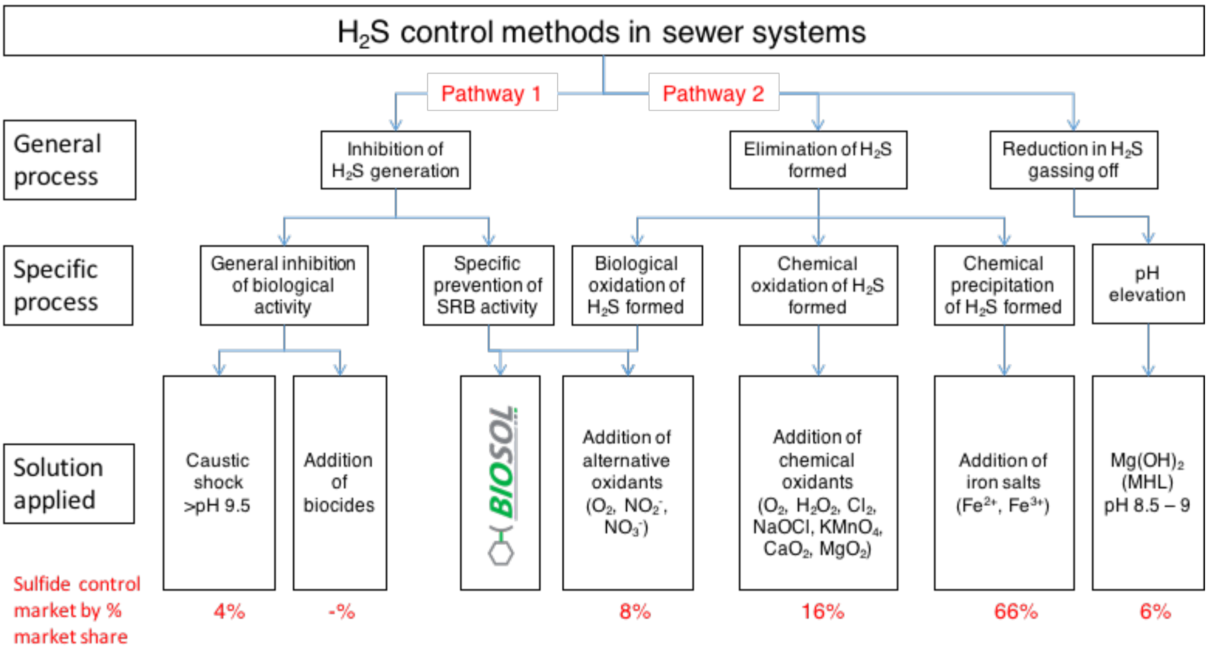


Figure 2: ***Dosing technologies for control of H_2S emission & market penetration***

Figure 2 demonstrates, the dominant chemical dosing solutions focus on disrupting pathway two – after the problem (sulfide) has already formed. While Biosol is not alone with its focus on disrupting pathway one (the source of the problem), other solutions in this space have significant technical or application issues. pH shock for example has a brief efficacy window with SRB rapidly re-establishing post treatment (O'Gorman, 2011 & Gutierrez, 2014). The use of biocides carries inherent risk typically not acceptable to water authorities.

2.2 Biosol's solution

To describe how Biosol works, it is necessary to provide further background into the slime layer (biofilm) where the SRB inhabit.

Bacteria are highly social organisms that communicate via *signalling molecules*. They move collectively over surfaces and make *biofilm* communities. In a biofilm form, bacteria are able to work collectively to exploit a resource. In a sewer, the resource is plentiful. Bacteria in a biofilm will work initially in fresh sewage (where oxygen is available) to decompose simple carbon molecules into carbon dioxide. At some point, oxygen in the sewage will become depleted and the sewage will become anoxic (septic). At the point the sewage becomes anoxic, SRB become active in the slime layer and the sulfide cycle shown in Figure 1 commences.

Biofilm development can be divided into three distinct stages (Figure 3): attachment of cells to a surface (1), growth of the cells into a sessile biofilm colony (2), and detachment of cells from the colony into the surrounding medium (3).

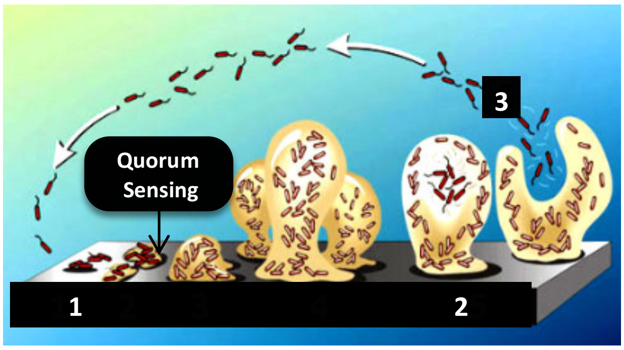


Figure 3: ***Biofilm development & sloughing (Kaira, 2012)***

To develop a biofilm colony, cells attached to the surface will use a 'cell-signalling' mechanism known as 'quorum sensing'. At the point quorum sensing occurs, bacteria produce and release chemical signal molecules called autoinducers that increase in concentration as a function of cell density (Miller MB, 2001).

In an anoxic sewer, conditions are ideal for SRB. Accordingly, SRB will use quorum sensing to coordinate their behaviour by forming (for example) a biofilm where sulphate reduction takes place. The intensity of the activity of the SRB in the biofilm, will be a function of the environmental conditions (BOD_5, temperature, pH & network hydraulics), which will be a function of the concentration of autoinducers.

Biofilm detachment by contrast can be divided into two categories: active and passive. Active dispersal refers to mechanisms that are initiated by the bacteria themselves, whereas passive dispersal refers to biofilm cell detachment that is mediated by external forces such as fluid shear, abrasion and human intervention (Kaplan 2010).

In a sewer, the flow of the sewerage in the sewer pipe will have a *passive* dispersal effect of scouring the biofilm. Other methods of passive biofilm dispersal that have been demonstrated to be effective in controlling H_2S include pigging, pH shock and addition of biocides (O'Gorman, 2011 & Jiang, 2013a).

Biosol's products by contrast mimic the mechanisms of *active* biofilm dispersal; this is Biosol's **key point of difference**. Kaplan, 2010 provides evidence of environmental cues and cell-signals that influence and regulate biofilm dispersal. Biosol's product BRX-2DE leverages this concept.

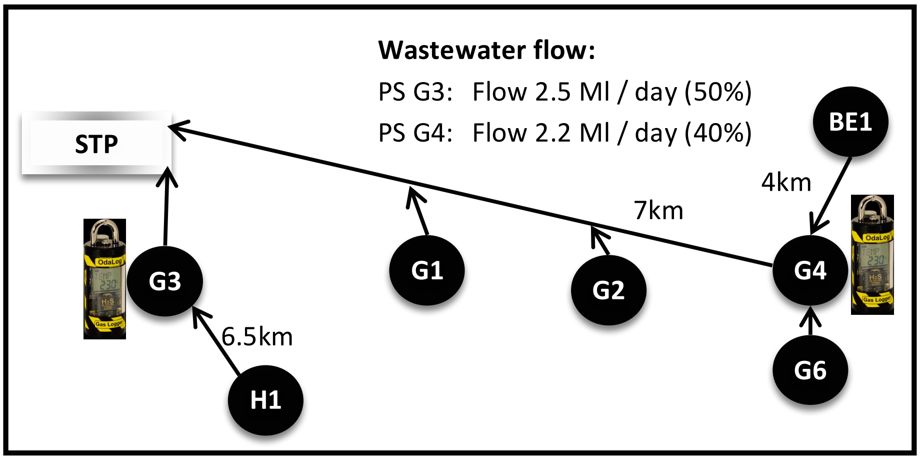
BRX-2DE is manufactured using a proprietary blend of signal blocking chemicals, collectively called CSC's in the Biosol patent (Chandler, 2009). These CSC's disrupt quorum sensing (the normal communication signalling between the bacteria) causing biofilm dispersal.

Disrupting / blocking quorum sensing prevents the bacteria from maintaining the biofilm state. As a consequence, the biofilm disperses. Since sewage odour and methane gas are generated in the biofilm complex in sewers, the removal of the biofilm eradicates the cause of sewage odour and thus corrosion.

Biosol utilise a double dosing strategy with two distinct products, BRX-1CN and BRX-2DE. The BRX-2DE product is non-hazardous and is designed to cause a dispersal of SRB biofilms. The effect of BRX-2DE has been found through field research to be enhanced by the addition of nitrite administered using BRX-1CN. Biosol's synergistic use of nitrite is consistent with what has been found in the literature with nitrite being demonstrated to work synergistically with biocides (Greene, 2006; Jiang, 2013b).

3 DISCUSSION

Figure 4 shows a simplified schematic of the GCC sewer network. Sewage pump station G3 and G4 handle 90% of the sewage flow to the treatment plant and both pump stations have long historical data sets of gas phase H_2S as measured using OdaLog's.



<u>Figure 4:</u> ***Simplified schematic of the Griffith sewer system & approximate daily flow***

Biosol's dosing infrastructure was easily retrofitted to the existing dosing equipment of the former regime. Biosol's product requirements are 65% lower than that of the former regime, leaving the existing dosing infrastructure predominately underutilised. Minimal capital outlay was required by GCC for Biosol's implementation.

The former dosing regime employed by the GCC, is considered an industry leading solution. Othman, 2011 for example investigated the effect of several chemicals on prohibition of H_2S generation in sewage. They found the most cost effective combination was an admixture of ferric chloride and MHL. This combination could suppress H_2S by greater than 95%. Othman's findings are consistent with the findings of (Firer, 2008) who found that shifting pH from 6.5 to 7.5 increased the efficiency of iron sulfide (FeS) precipitation from 55% to 90%.

The comparative results of Biosol's solution are presented in Figure 5 and Figure 6. Presented here are monthly gas phase H_2S averages, as measured by 'OdaLog' gas monitors logging H_2S levels every minute. The GCC change out the loggers on a weekly basis so as to not saturate the sensor. OdaLog's are routinely calibrated by an independent NATA certified lab.

The gas phase H_2S data from G3 (Figure 5), demonstrates a 90% reduction in H_2S compared to the previous dosing strategy. In the case of G4 (Figure 6), average H_2S data from eleven consecutive months in 2009 / 2010 was compared to the same months in 2014 / 2015 demonstrating an 11% reduction in H_2S at G4.

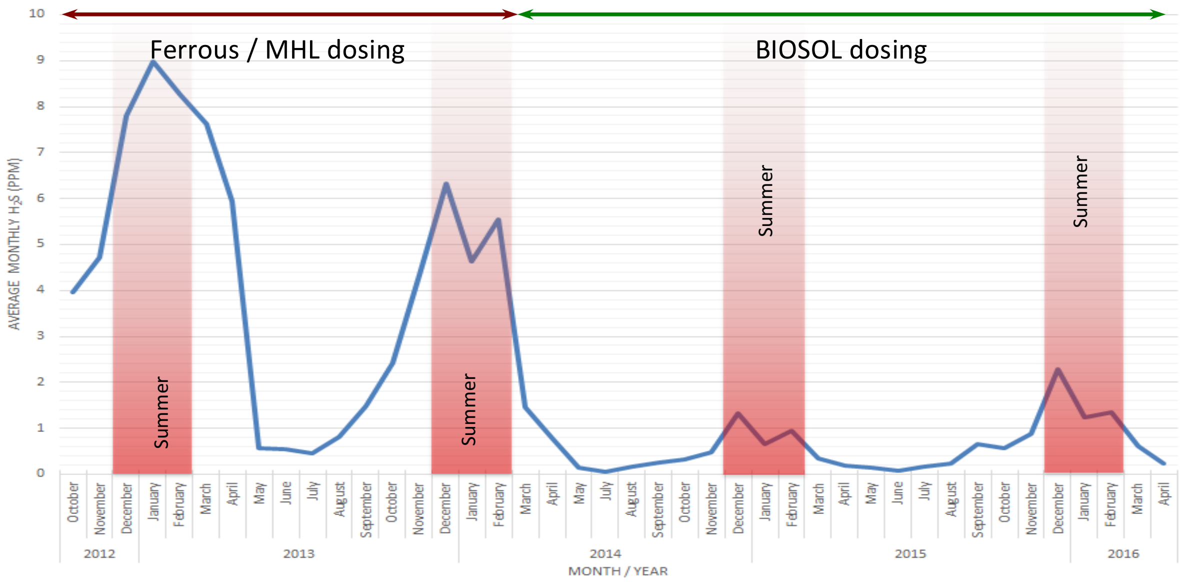


Figure 5: ***Monthly average gas phase H_2S as measured at SPS G3***

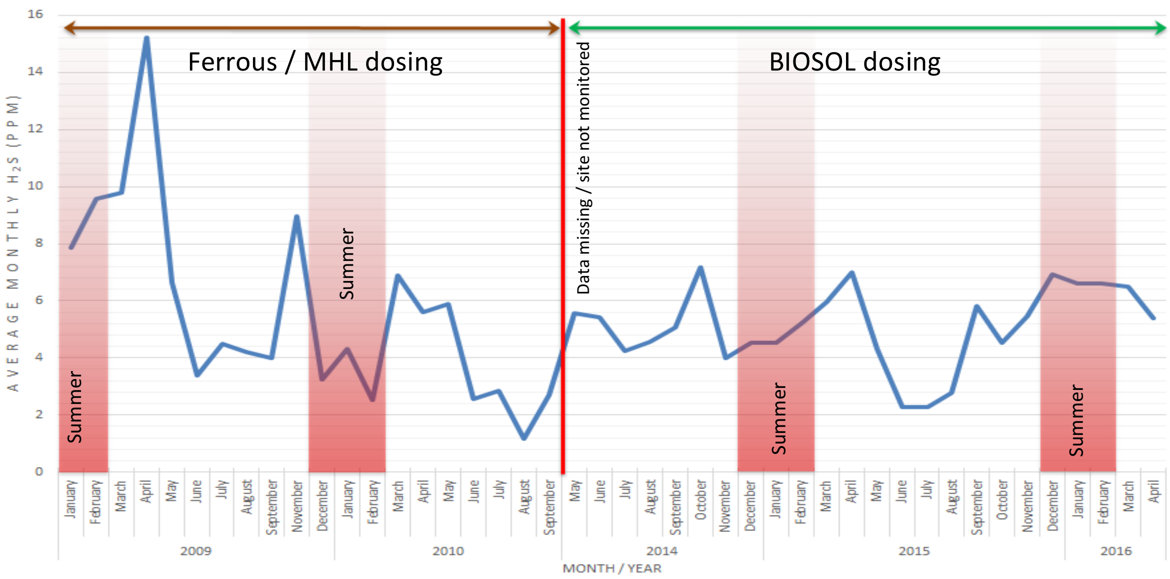


Figure 6: ***Monthly average gas phase H_2S as measured at SPS G4***

Park, 2014, identified the factors affecting hydrogen sulfide generation as:

- Biodegradable organic matter – approximated by chemical oxygen demand (COD)
- Temperature
- pH
- Sewer hydraulics

Analysis of these factors shows influent COD and temperature have followed a very similar pattern both before and after Biosol commenced dosing (data not shown). Influent pH at the head of works decreased marginally as would be expected with the cessation of MHL dosing (data not shown). Sewer hydraulics in terms of influent flow to the treatment plant has been consistent (data not shown). The adoption of Biosol dosing is therefore the only credible change that has occurred in the network to account for the H_2S reduction in Figure 5 and Figure 6.

Unfortunately, the GCC has experienced a valve failure on the G4 line, causing a 50% increase in retention time in the G4 main. The failure (changing the sewer hydraulics at the treatment plant) occurred in June 2015 and since that time, H_2S levels at the treatment plant are no longer comparable with the previous data. Prior to this date, Inlet Works H_2S data demonstrated a very similar result to that achieved under the former dosing regime (data not shown).

In terms of impact at the treatment plant, the only liquid phase metric that treatment plant operators at Griffith have noticed since Biosol dosing commenced, is a 75% reduction in influent total phosphorous (Figure 7).

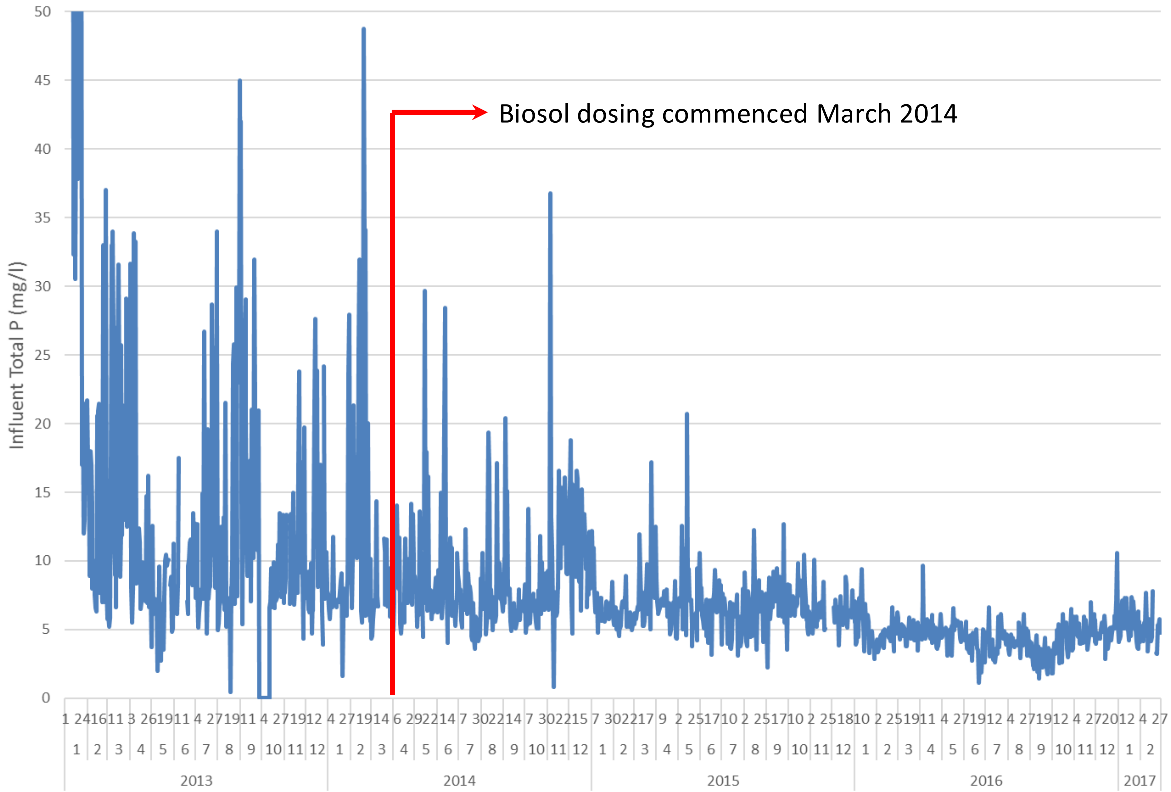


Figure 7: ***Total Influent Phosphorous to the Griffith Sewage Treatment Plant (mg/L)***

The fate of this phosphorous is the subject of ongoing research.

4 CONCLUSION

Through the application of BRX-1CN and BRX-2DE in Griffith, Biosol has demonstrated:

- Up to an 85% reduction in hydrogen sulphide gas,
- A 75% reduction in incident phosphorus arriving at the treatment plant,
- A quantifiable increase in infrastructure surface pH - indicating a substantial increase in infrastructure life span,
- Greater than a 60% reduction in chemical use and dosing footprint,
- Removal of fat, oil and grease in the dosed sewer mains,
- Reduced operator and management risk in handling hazardous materials
- Reduced alum usage to precipitate phosphorous
- No adverse impact on sewage process at the treatment plant,

Globally, the traditional chemical dosing market to address sulfides in sewage is technically mature. Solutions in this space have only evolved incrementally over the past decades. Biosol's approach offers a step change in the way sulfides are managed in sewers.

Through Biosol's application at Griffith, the theoretical chemistry underpinning the products has been validated. Biosol's products have demonstrated that they are not only in line with market leaders but have also demonstrated to outperform them. With further research, there is scope to refine and improve Biosol's products and further demonstrate Biosol's technical superiority.

5 REFERENCES:

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