IMPACT OF FREE NITROUS ACID ON SENTRY ACTIVITY. IMPLICATIONS FOR HYDROGEN SULFIDE INHIBITION

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Free Nitrous Acid Testing

SENTRY

1. Contents

FREE NITROUS ACID TESTING

1. Executive Summary

SENTRY technology was deployed as a real-time sensor to control the dosing of free nitrous acid (FNA) in a domestic wastewater treatment stream. The sensor response was evaluated as a solution for optimized dosing of the toxic cleaning agent. Key findings demonstrated:

- Free nitrous acid dosing caused a major (92% drop in MET), rapid and repeatable response on the SENTRY sensors.
- Output from SENTRY sensors recovered after dosing events.
- This SENTRY bio-electrode information could be tied to understanding when and how often to dose the FNA for optimized hydrogen sulfide inhibition.

2. Introduction

There are a number of applications in which free nitrous acid (FNA), the protonated form of nitrite (HNO_2), is used as an antimicrobial agent due to its bacteriostatic and bactericidal effects on a range of microbes. FNA has been shown to be the factor in inhibiting denitrifying and phosphorus uptake processes. The impact of FNA on the nitrite oxidizing bacteria has been characterized and demonstrated more than 700 days of inhibition during SBR operation (Svehla et al., 2014). Besides, nitrous acid acts as a mutagen by deamination of the NH_2 group of adenine and/or cytosine to an ether group, thus altering their base pairing. FNA has been thus used to induce mutagenesis and this is lethal to cells without repair / correction

In relation to the inhibition of hydrogen sulfide generation FNA has been demonstrated as a suitable inhibitory compound at bench-scale and more recently in commercial demonstration applications. For bench-scale studies FNA levels succeeded in suppressing sulfide production and methane production. After stopping FNA dosage, SRB recovered to about 70-80% in 2 months. Key conclusions of this study indicated FNA as low as 0.18 mg-N/L could suppress both sulfide and methane production after 24-hour of exposure. The suppression is followed by a slow recovery after stopping the FNA addition. FNA is toxic to the sewer biofilm cells and the biocidal effect is enormous under the experimental conditions (Guangming Jiang et al., 2010).

Commercial FNA applications for the inhibition of hydrogen sulfide production are now available through the technology developed by the University of Queensland (Australia-USP technologies). Case Studies have been completed using FNA to inhibit H_2S production in a sewer system in Florida.

The use of SENTRY technology as a real-time sensor to control the dosing of FNA was considered in this study to determine its suitability in

(1) Characterizing impact of dosing on embedded microbial communities
(2) Understanding the response time of communities to FNA dosing

In this study IWT characterized the impact on SENTRY sensors installed in a demonstration wastewater treatment system. The sensors were dosed with three cycles of FNA and the bio-electrode response was noted.

3. SENTRY Response to FNA Dosing

ARC01 SENTRY sensor was exposed to FNA (free nitrous acid) dosing. This sensor was in the treatment tank for 3 of the 4 dosing periods done at the testing facility and the response is shown in Figure 1. The first dosing event was performed without a sensor present. The dosing schedule is listed below:

1. Dose event 1: sensor was not located in dosing tank
2. Dose event 2: July 19th 8pm for 12 hours
3. Dose event 3: July 20th 8pm for 12 hours
4. Dose event 4: July 27th 5:15pm for 24 hours

The goal of the dosing schedule is to understand the affects of free nitrous acid on hydrogen sulfide producing bacteria. The sensor's biology does consist of bacteria sensitive to these reactions (*Geobacter sulfurreducens*), as such correlating these responses to the measured bacteria changes could be a helpful method for understanding the required dosing schedule for systems deployed in the field.

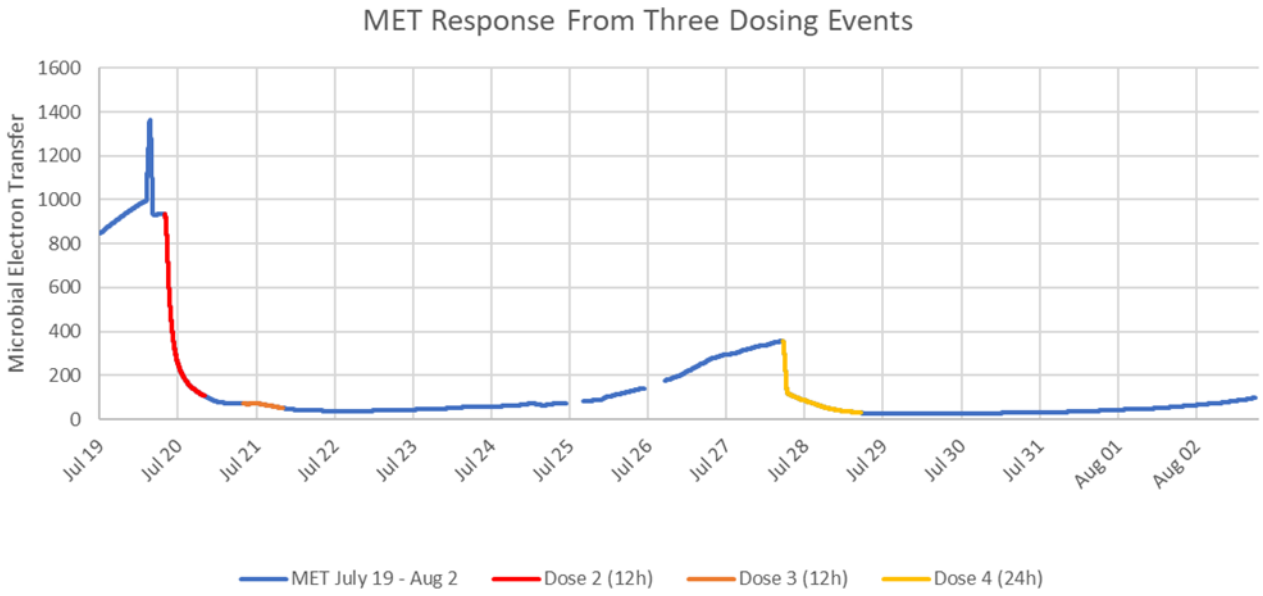

FIGURE 1 DOSING EVENTS 2, 3, AND 4

To better compare the changes in MET due to each dosing event, the three events were compared using time before and after the dosing began shown in Figure 2.

- For dose 2, the MET went from 925 to 103 over the 12 hour dosing period from 8pm July 19th to 8am July 20th.

- In the 12 hour period between dosing event 2 and 3 the signal was not able to recover and further decreased from 103 to 71.
- During the 12 hours of dose 3 the signal recovered did not have the immediate drop that dose 2 and 4 showed. Despite starting at a much lower MET of 71, the signal still dropped down to 51 MET after 12 hours of dosing.
- After the 3rd dosing event, the signal continued to decrease to 39 MET over the following 10 hours.
- The SENTRY signal slowly began to rise until July 27th when dose 4 started.
- Dosing event 4 had very similar response as dosing event 2 despite having a much lower starting MET value of 362 compared to 925 MET.

If you consider dose 2 and 3 as a single dosing event and compare that to dose 4 the response is very similar as shown in Figure 7.

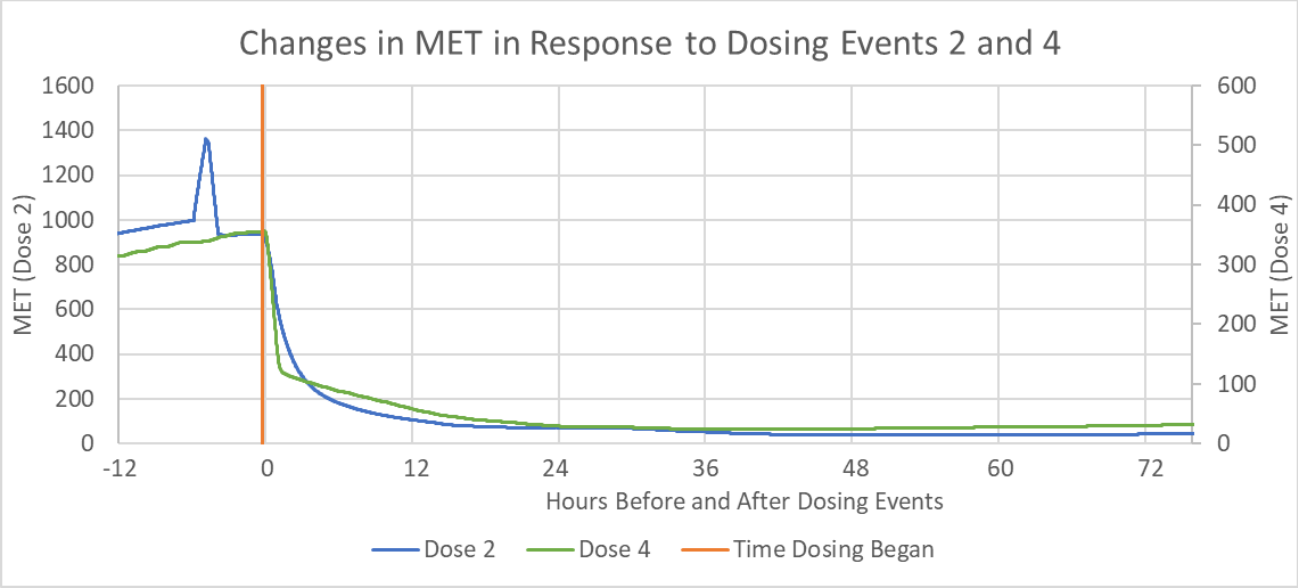

FIGURE 2 MET RESPONSE TO DOSING EVENTS 2 AND 4

- When the difference in starting MET is removed by plotting the two dosing events on separate y axis, as shown in Figure 7, the result from dose 2 and 4 are very similar.
- The lowest MET signal was seen 26 hours after the dosing stopped for both the two 12 hour doses (dose 2 and 3) and the single 24 hour dose (dose 4).

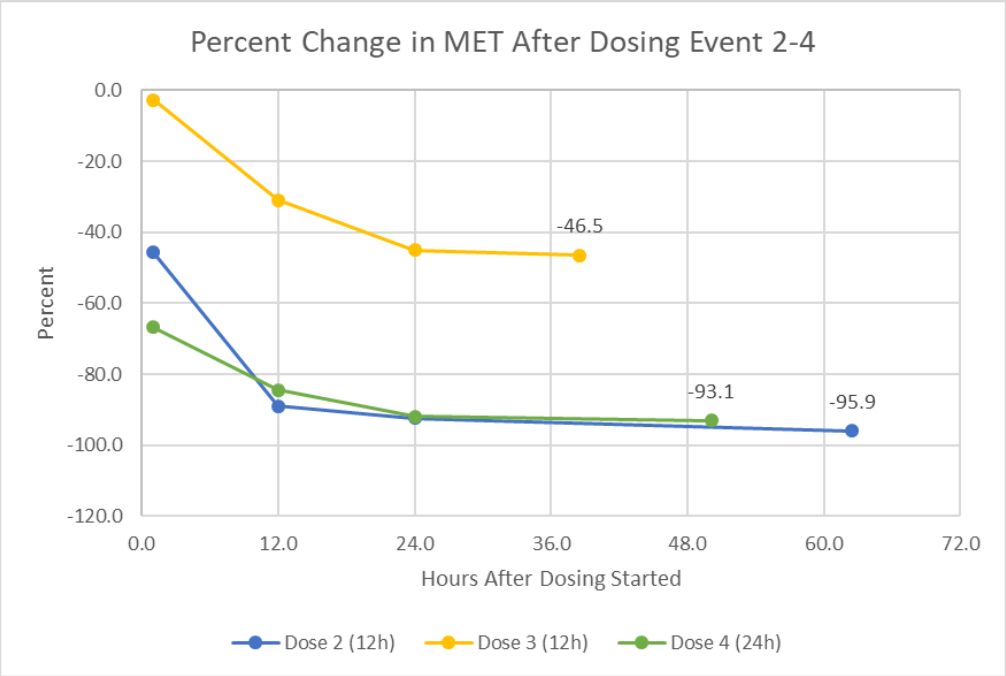

FIGURE 3 CUMULATIVE PERCENT CHANGE FROM STARTING MET OVER THREE DOSING EVENTS

- The cumulative percent change in MET from the starting point to: 1 hour, 12 hours, 24 hours, and at the time the signal first reached is lowest point after dosing are shown in Figure 8.
- Although Dose 2 and 4 start at 935 and 362 MET respectively, their percent drop after dosing events over the first 24 hours is very similar.
- Dose 2 and 4 both reduced the MET by 92%, 24 hours after the dosing began. For dose 2 this is also just before dose 3 began. With an already low MET signal the second round of dosing was able to reduce the MET by another 45% in the next 24 hours.
- The combination of Dose 2 and 3 reduced MET by 96%, and it took 62.5 hours for the SENTRY sensor to produce its bottom reading of 38 MET.
- Dose 4 was able to reduce MET by 93% reaching its bottom reading of 25 MET after 50.1 hours.

4. Citations

Pavel Svehla et al., 2014. Chemical Papers, Volume 68, Issue 7, pp 871–878| Inhibition effect of free ammonia and free nitrous acid on nitrite-oxidising bacteria during sludge liquor treatment: influence of feeding strategy

Guangming Jiang et al., 2010. 6th International Sewer Processes and Networks. Free nitrous acid controls sulfide and methane production in rising main sewers.