

Use of Flow Regulation in Manhole Odor Control Devices to Reduce Maintenance and Frequency of Media Replacement

Mary Kay Camarillo^{1*}, William T. Stringfellow^{1,2}, Jeremy S. Hanlon¹

¹University of the Pacific, Stockton, CA.

²Lawrence Berkeley National Laboratory, Berkeley, CA.

*Email: mcamarillo@pacific.edu

ABSTRACT

Odorous gases emitted from sanitary sewer collection systems contain hydrogen sulfide and other nuisance gases that cause health and safety concerns as well as aesthetics issues for nearby residents. While a systemic approach is needed for addressing odors and gas emissions, one option is to remove odorous compounds prior to release of gases from sewer systems. Previous attempts to use manhole odor control devices have had limited success because the adsorptive media is saturated in the sewer gas and the adsorptive capacity is quickly realized. In this study, a manhole odor control device utilizing pressure regulation to control the flow of gases out of manholes was observed to determine the effectiveness of this device and the ability to reduce the frequency of media replacement. Hydrogen sulfide concentrations were reduced by over 90% and the service life of the media was extended by five months, demonstrating the feasibility of this technology.

KEYWORDS: Sanitary sewer, collection system, odor, hydrogen sulfide

INTRODUCTION

Control of odors emitted from collection systems is an important task for utilities and one that requires many solutions (Boon, 1995; Boon *et al.*, 1998). Within a collection system “hot spots” develop where elevated odors occur, often the result of system operation and characteristics. At such sites one approach is to capture and control odors directly at the manhole. Previous attempts using such an approach have been marred by the short service life of the installed adsorptive filter media, which quickly reaches its capacity to retain hydrogen sulfide (H₂S) and other odorous constituents. Gas flow rates within the headspace of collection systems can be significant while the vented flow rates are orders of magnitude lower (Ward *et al.*, 2011).

In this study, manhole odor control devices that incorporate pressure regulation were monitored to determine the ability of these systems to reduce H₂S from vented gases. The purpose of incorporating pressure regulation was to control gas flow out of manhole covers and extend the service life of the adsorptive media, as compared with odor control devices that do not incorporate pressure modulation. In this case, the odor control devices contained a variable volume bladder with two pressure relief valves that permitted gas flow when pressures exceeded

1.3 to 2.5 cm water column. These pressures are similar to those that can occur as the result of use of a p-trap in the plumbing system of a single-family residence. Here, vented gas flows were treated using adsorptive media to remove H₂S prior to release. The manhole odor devices were studied previously to determine site-specific variability in performance and to investigate use of different adsorptive media (Camarillo *et al.*, In review). The objectives here were to continue studying the ability of the manhole odor control device to remove H₂S from sanitary sewer system gases, and to document seasonal and diurnal performance variability and to observe performance over a longer period of time (on the order of months rather than weeks).

METHODOLOGY

Site Description

The study was conducted at adjacent manholes situated on a 1.22 m diameter interceptor sewer. The study location is in central California in a residential area with light commercial development. The exact site location is not disclosed to provide anonymity for the system owner.

Manhole Odor Control Device

The Manhole Odor Eliminator (Inventive Resources Inc., Salida, CA; U.S. Patent No. 20120227168, September 13, 2012), consisting of manhole inserts located directly below manhole access covers, was evaluated for the ability to remove H₂S from vented sewer gas (Figure 1), as described previously by Camarillo *et al.* (In review). A variable volume bladder, in fluid communication with sewer gases, was used to accommodate pressure variability and air flow fluctuations. A low-setting pressure relief valve allowed sewer gases to pass only when the bladder was full and the pressure exceeded approximately 1.3 cm water column. Vented gases were forced through an adsorptive granular media filter and entered a treated air chamber prior to release. A pressure relief valve with a higher setting, intended to prevent high pressure conditions from developing in the collection system, allowed vented gas to circumvent the adsorptive media prior to release when the pressure exceeded approximately 2.5 cm water column. This second pressure relief valve served as a redundant safety mechanism. Adsorptive media consisted of 0.02 m³ of activated carbon pellets that were manufactured from coconut shells (Carbon Activated Corp., Compton, CA).

Hydrogen Sulfide Measurement

Hydrogen sulfide (H₂S) was measured using Arizona Instrument LLC Jerome 860 meters (Chandler, AZ). Meters were placed above and below the odor control devices in mesh bags, as shown in Figure 2. The recommended range of these meters is 0-200 ppm (by volume) with occasional use in atmospheres with concentrations as high as 1000 ppm. Concentrations above 200 ppm are not recommended to protect the meter from corrosion. Meter calibration was performed according to the manufacturer's specifications and checked at the end of each observation period. Data was collected and logged every 2-5 minutes during deployment of the meters.

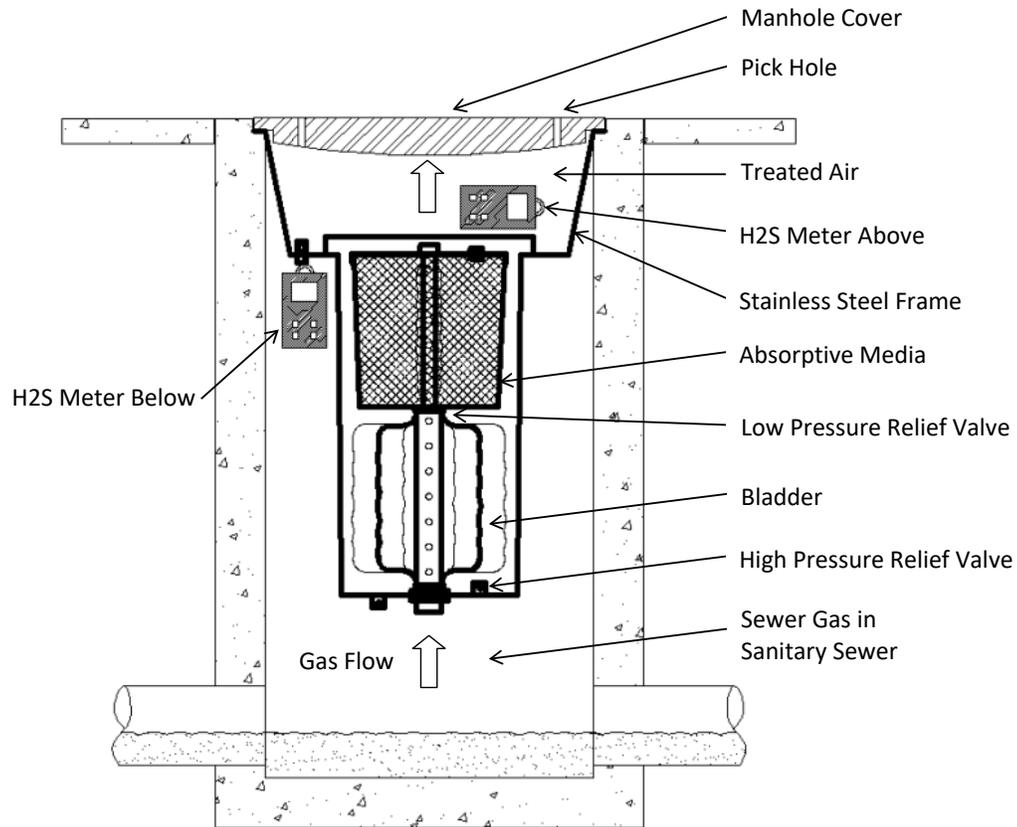


Figure 1. Schematic of an odor control device placed in a manhole (Camarillo *et al.* In review). The device was fabricated from HDPE, stainless steel, and other corrosion resistant materials. The odor control device functioned by reducing gas flow from manholes and treating vented gases with adsorptive media.



Figure 2. Photos of a manhole odor device during deployment of the sensors. Left: Top of manhole odor device, directly below the manhole access cover. The H₂S meter is shown placed on top of the device, which was used to record H₂S of vented gases. Right: The manhole odor device prior to installation. The H₂S meter is shown on the outside of the device, which was used to record H₂S for gases inside of the collection system.

RESULTS

Manhole odor control devices consistently removed H₂S in the gases vented from the collection system, with mean removals higher than 90% (Table 1). The downstream manhole had consistently higher collection system H₂S concentrations compared with concentrations in the upstream manhole; average H₂S concentrations in the two manholes were an order of magnitude different. The downstream manhole is located near a bend in the pipe and likely experiences more turbulence and more volatilization of entrapped H₂S gases. Conversely, the upstream manhole is located on a straight section of pipe. Higher variability of H₂S removal rates at the downstream manhole in March appeared related to the operation of a pump station that discharges into the interceptor sewer. During the March observation period, the pump station was only operated once per day and operation was controlled using a timer. In March, H₂S peaks corresponded with times that the pump was operating and during these times the vented gases appeared to be exceeding the lower pressure setting and bypassing the adsorptive media bed due to high pressure in the collection system. Higher removal rates observed in November were likely a function of adjustment to the air release valves used in the odor control devices. The purpose of the air valve adjustment was to vent gases through the media when the collection system pressure exceeded 1.3 cm of water column and to vent gases without contacting the media when the collection system pressure exceeded 2.5 cm of water column.

Table 1. Performance statistics for manhole odor devices located at two adjacent manholes on the same interceptor sewer.

Location and dates of observation	H ₂ S below device ^a (ppm)	H ₂ S above device ^a (ppm)	Removal ^a (%)
Upstream manhole			
July/August ^b	41.7 ± 49.2	4.1 ± 11.8	94.9 ± 8.0
November	87.8 ± 53.4	0.1 ± 0.5	99.9 ± 0.4
Downstream manhole			
March ^c	159.2 ± 68.6	29.7 ± 116.5	92.2 ± 23.9
July/August ^b	391.7 ± 219.5	36.6 ± 100.8	96.6 ± 5.6
November	344.2 ± 170.9	2.5 ± 6.2	99.4 ± 1.6

^aMean ± standard deviation.

^bData sets were presented in Camarillo *et al.* (In review).

^cOnly the downstream manhole was studied in March.

Data from the November observation period demonstrated good H₂S removal at the two manholes (Figures 3 and 4). At the upstream manhole, high H₂S concentrations were observed on November 21 and 22, corresponding with the Thanksgiving holiday. Hydrogen sulfide was infrequently detected above the odor control device in the upstream manhole. The concentrations of H₂S above the odor control device in the downstream manhole were low and mostly observed in the few days at the beginning and at the end of the observation period. The data reported in Camarillo *et al.* (In review) for these sites was collected during the summer and part of the motivation for the current study was to determine the seasonal variability in H₂S and H₂S removal. The data here suggest that the November data sets are not significantly different than the data collected in July/August (Table 1).

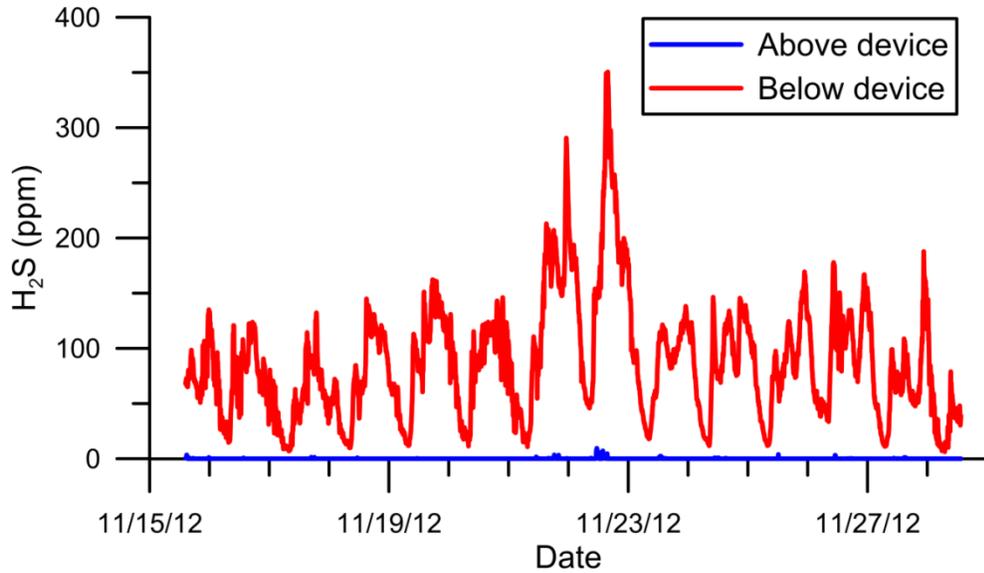


Figure 3. Concentrations of H₂S above and below the upstream manhole odor control device during the November observation period.

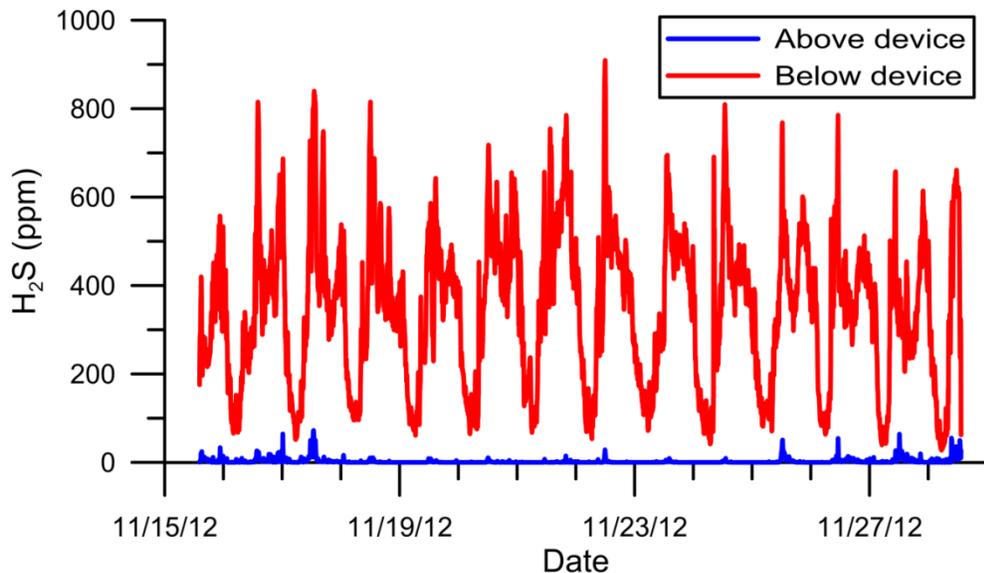


Figure 4. Concentrations of H₂S above and below the downstream manhole odor control device during the November observation period.

Collection system H₂S concentrations below the devices exhibited a diurnal pattern (Figures 5 and 6). At the upstream manhole, H₂S concentrations were typically lowest around 4:00 to 9:00 and were relatively constant throughout the remainder of the day (Figure 5). The diurnal pattern was more pronounced at the downstream manhole where H₂S concentrations were typically at their lowest values around 3:00 to 8:00 and peaked around mid-day (Figure 6).

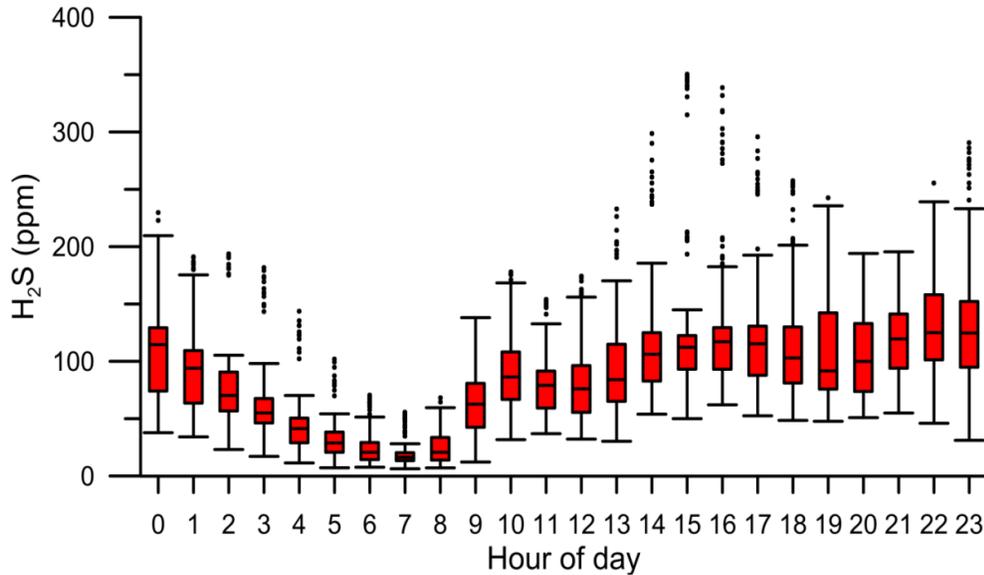


Figure 5. Hourly variability in collection system H₂S in the upstream manhole during the November observation period.

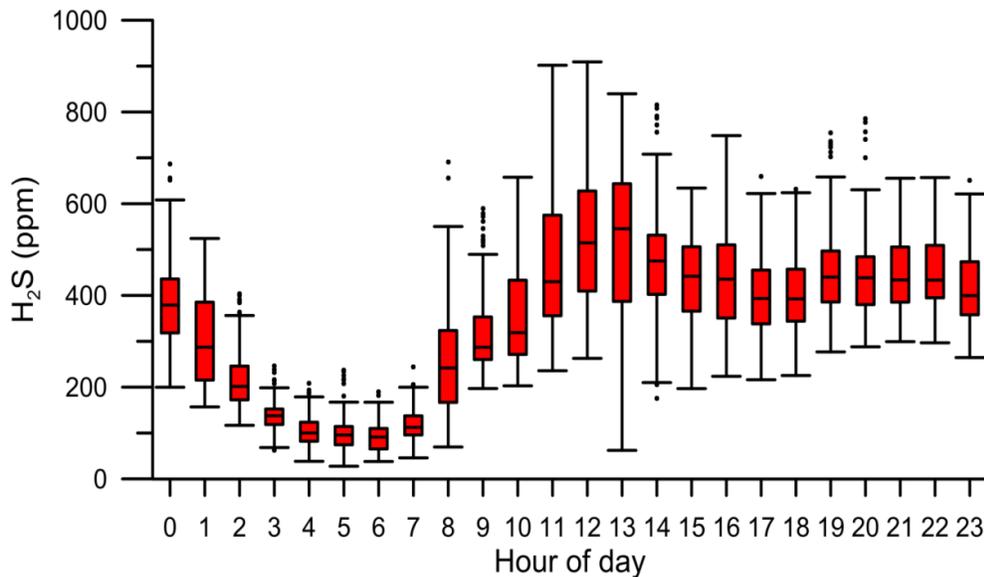


Figure 6. Hourly variability in collection system H₂S in the downstream manhole during the November observation period.

The odor control devices typically reduced vented gas H₂S concentrations such that the average concentration was less than 10 ppm. In the upstream manhole, the vented H₂S concentrations were always less than 10 ppm, and vented gas H₂S did not appear related to the H₂S concentration in the sanitary sewer collection system (Figure 7). Likewise, H₂S removal in the downstream manhole did not appear to be influenced by the collection system concentrations (Figure 8). These results suggest that other factors, such as conditions within the collection

system or ambient weather conditions, are influencing gas flow rates and therefore odor control performance.

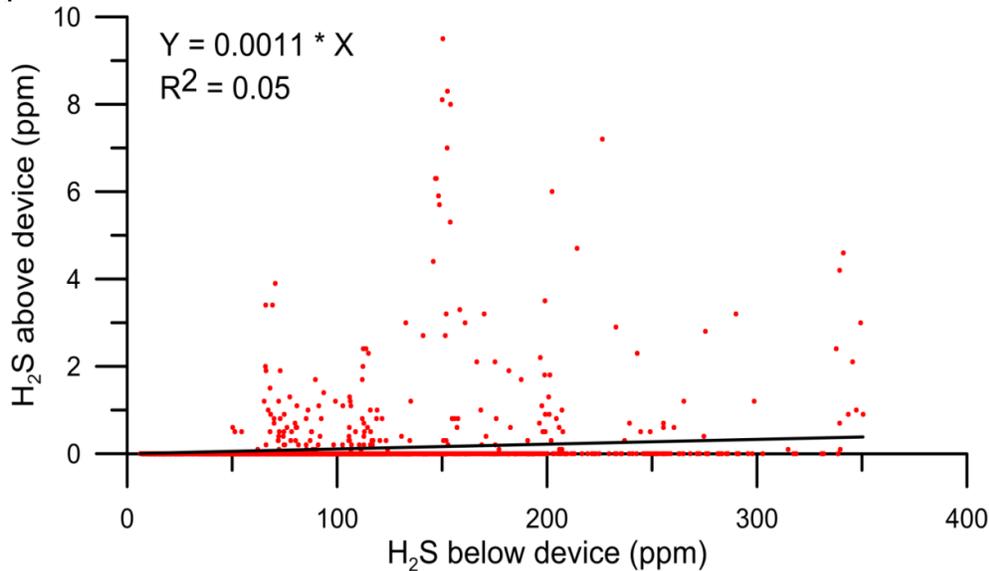


Figure 7. Relationship between H₂S below and above odor control device in the upstream manhole during the November observation period.

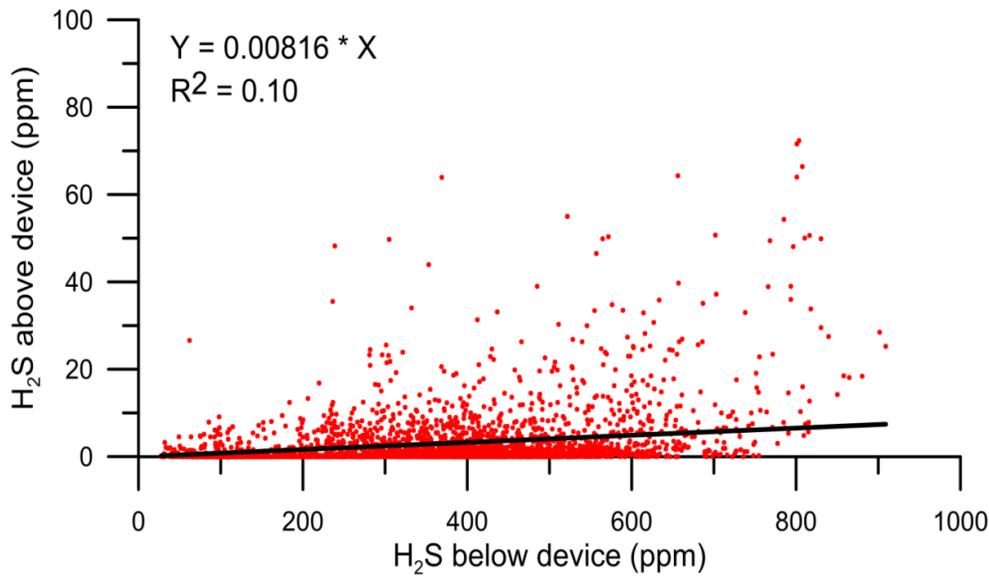


Figure 8. Hourly variability in collection system H₂S in the downstream manhole during the November observation period.

One of the objectives of this study was to observe performance of the odor control devices over a longer period of time compared with what had been previously (approximately two week trials). Observation period length was limited by the amount of memory contained in the H₂S meter data logger system. We collected data over a longer period of time by reducing the data collection frequency from every two minutes to every five minutes. With this adjustment in measurement

frequency, data was collected over a three and a half month period, from December to mid-March (Figure 9). During this time period; however, the City added a temporary chemical injection system so the data represent a different situation than what was observed throughout the remainder of the observation period. In Figure 9, the longer data set for the upstream manhole is plotted with the earlier data sets (Table 1), with data collected to examine the impact of using zeolite instead of activated carbon as the adsorptive media, and with data that were collected with the odor control device frame in place, but without the media or bladder/pressure valve assembly.

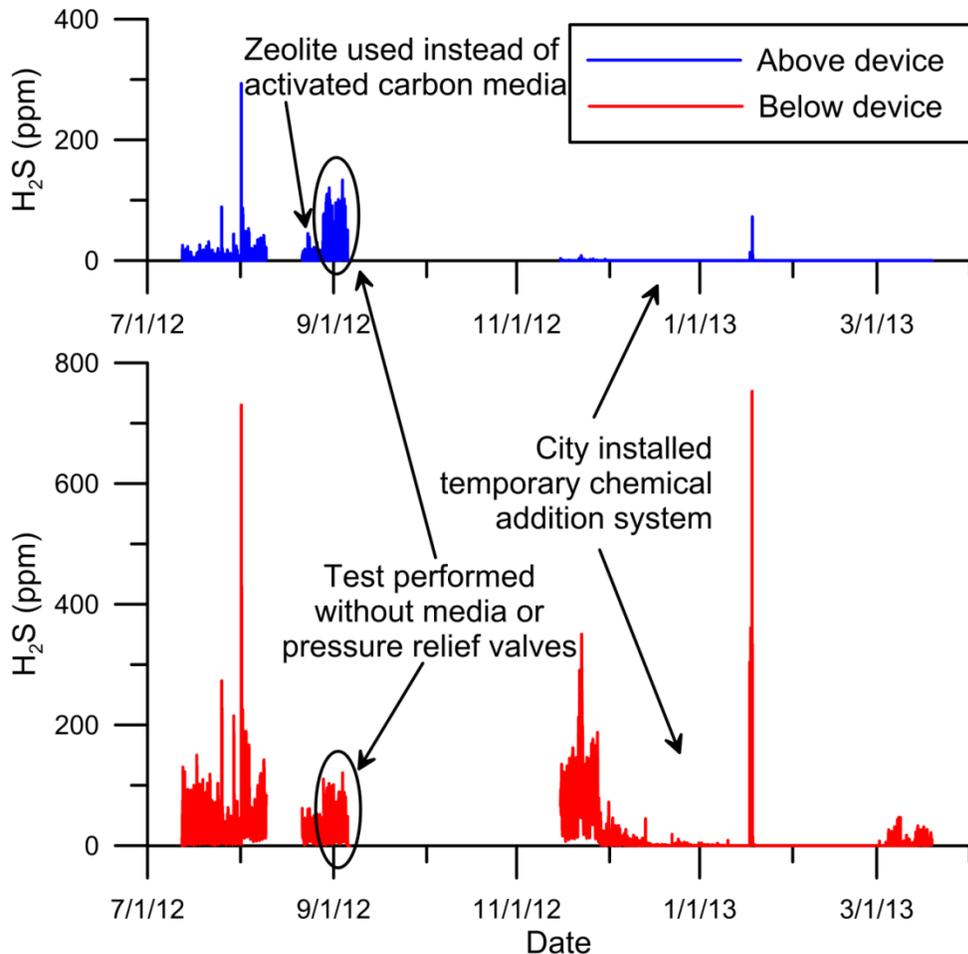


Figure 9. Concentrations of H₂S above and below the manhole odor control device during all observation periods at the upstream manhole study location.

Based on the data collected from July 2012 to March 2013, several things become apparent (Figure 9). No clear seasonal pattern of collection system H₂S and H₂S removal was apparent. A seasonal pattern may have been more apparent if more data had been collected throughout the year. The test performed in the absence of adsorptive media and the pressure regulation system did not appear to influence collection system H₂S concentrations below the device. However, the media and pressure regulation were essential in reducing vented gas H₂S concentrations, as indicated in the control test run without media or the pressure regulating system.

Prior to adoption of the flow regulation function in the odor control devices, units deployed in this sanitary sewer collection system would only remain functional for approximately three months before requiring media replacement. Since the flow regulation feature was added, units have remained functional for approximately 8-12 months without requiring media replacement. Media for both devices featured in this study were replaced following 8 months of service (Figure 10). The media at the upstream manhole was not completely saturated, but it was replaced at the same time as the media in the downstream manhole in order to streamline maintenance activities.



Figure 10. Photo of the activated carbon adsorptive media used in the manhole odor control devices. The media on the left is had not been used in the odor control device, while the media on the right had been used to the point where it was no longer effectively reducing the concentration of H₂S in the vented sewer gases.

DISCUSSION

The current study has demonstrated the potential use of manhole odor control devices that incorporate pressure regulation to reduce quantities of vented gas and adsorptive media to reduce odorous gas components prior to release of vented gases. Hydrogen sulfide concentrations were significantly reduced in the vented gases and the frequency of media replacement was also reduced. During the course of the study several issues have become apparent. One issue is that H₂S concentrations in the vented gases were not strongly correlated with H₂S concentrations in the collection system, suggesting that other factors were influencing performance of the odor control devices. A likely influential parameter is the flow rate of the gas being vented from the manhole, which is a function of the pressure differential between the collection system to the ambient conditions. Other system and atmospheric parameters such as liquid flow rate in the collection system, temperature, and ambient air pressure are also likely influencing odor control device performance. To further clarify performance characteristics and better understand appropriate system design criteria, data on flow rates of gases vented from manholes and other

potential influential constituents should be collected. In a study by Ward *et al.* (2011), data on lateral and vented gas flow rates within sanitary sewer collection systems indicated that the flow rates were variable and bi-directional.

The current study resulted in generation of data sets that are useful for designing manhole odor control devices. Additional data, such as gas flow rates, would also be useful for developing design guidance for such systems. The odor control devices tested are not intended to be a single solution to wide-spread odor control issues in sanitary sewer collection systems. To efficiently control odors, a range of solutions is needed such as modifying system operation (e.g. operation of pump stations or more frequent cleaning of pipelines) to limit development of septic conditions. Additionally, odor control features (e.g. ventilation fans with stand-alone treatment systems or stacks) should be built into new and existing facilities such as major interceptor sewers. The odor control devices under study are most effective for controlling odors at critical points within the collection system where odors are prevalent (e.g. near pipe bends) or where the tolerance for odors is low (e.g. near commercial developments). The pressure regulating system allows for more controlled releases of gases from collection systems and is not intended to result in conversion of the gravity sewer into a pressurized system. Allowable pressures, between 1.3-2.5 cm water column, are minimal and are consistent with current practice. Data collected as part of this study suggests that the presence of the odor control devices is not increasing H₂S concentrations within the collection system (Figure 9) although additional data should be collected to confirm these preliminary results. Conducting control studies in a collection system is difficult since the system conditions are constantly changing, manholes located on the same pipeline do not necessary have the same conditions, and multiple tests cannot be run at the same time on the same manhole.

The current study demonstrates that gases vented from sanitary sewer collection systems have high concentrations of H₂S. Although other gas constituents were not measured in this study, it is likely that many other undesirable constituents are present and that quantities of greenhouse gases are being vented from sanitary sewer collection systems. The solution being evaluated here could potentially be adapted and used for controlling greenhouse gas emissions from collection systems in addition to controlling odors. The adsorptive media could be modified to remove multiple undesirable constituents. As the result of continued, and often state-mandated, adoption of water conserving infrastructure, problems with sewer gases and the resulting odors can be expected to intensify over time.

CONCLUSIONS

Manhole odor control devices reduced H₂S concentrations in the gases vented from sanitary sewer collection systems. In the locations where the devices were tested, H₂S presence in the collection system and removal using the devices was variable and dependent on site-specific conditions. In this case two adjacent manholes located on the same interceptor sewer had very different H₂S concentration profiles. Use of pressure regulation to reduce vented gas quantities did appear to extend the service life of the adsorptive media and reduce media replacement frequency. Additional information on vented gas flow rates and other factors would be useful for

developing design guidelines for these systems. Adaption of the odor control devices to incorporate control of greenhouse gas emissions should be considered in future studies.

ACKNOWLEDGEMENTS

The work was completed as part of the University of the Pacific Ecological Engineering Research Program with funding from the University of the Pacific School of Engineering and Computer Science. The odor control devices were donated by and field assistance was received from John Paoluccio of Inventive Resources Inc.

REFERENCES

- Boon A. G. (1995). Septicity in sewers - Causes, consequences and containment. *Water Sci. Technol.* **31**(7), 237-53.
- Boon A. G., Vincent A. J. and Boon K. G. (1998). Avoiding the problems of septic sewage. *Water Sci. Technol.* **37**(1), 223-31.
- Camarillo M. K., Stringfellow W. T., Hanlon J. S. and Basha E. (In review). Performance of sanitary sewer collection system odour control devices operating in diverse conditions. *Water Sci. Technol.*
- Ward M., Corsi R., Morton R., Knapp T., Apgar D., Quigley C., Easter C., Witherspoon J., Pramanik A. and Parker W. (2011). Characterization of natural ventilation in wastewater collection systems. *Water Environ. Res.* **83**(3), 265-73.