Managing H_2S Gas Sensors in Sewers: A practical Comparison Procedure

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Highlights

- An on-field procedure is presented for evaluating gas sensor differences.
- A decision-making chart is proposed for assessing an exchange between sensors.

Introduction

Development of hydrogen sulphide (H_2S) is one of the major problems associated with sewer systems. H_2S is formed in the liquid phase, however, its effects are severe when released into the air, leading to odour issues in cities and to concrete corrosion of sewer pipes. Moreover, H_2S and represents a high risk to sewer workers due to its high toxicity. To assess this problem, H_2S gas monitoring is frequently used. However, challenges might arise in the field with the need to rotate sensors or exchange sensors (e.g. old through new, different brands).

To address these challenges, we propose an on-field procedure that can be used as a decision-making tool for comparing gas sensors and assessing if they can be rotated/exchanged without concern. In this abstract, we present the procedure based on a comparison carried out in a sewer pilot plant in Berlin, Germany.

Methodology

Sensor Description

Three different H_2S gas sensors were evaluated: OdaLog™ Logger L2 (Thermo Fisher Scientific Australia Pty Ltd), SulfiLogger™ S1/X1-1020 C (SulfiLogger A/S, Denmark) and MyDatasensH2S1000 BLE (Microtronics Engineering GmbH, Austria). A short description of the sensors is provided in Table 1.

Table 1*:* Sensor description

	OdaLog™ Logger L2	SulfiLogger™ S1/X1-1020 C	MyDatasensH2S1000 BLE
Sensor Type	Electrochemical	Microelectrochemical	Electrochemical
Measuring Range [ppm]	0-200	0-1000	0-200
Online access to data	No	Yes	Yes
On-site calibration	Yes	Yes	No (only manufacturer)

Experimental Site

The pilot plant consists of a feeding pump, a pressure pipe and a gravity pipe (Figure 1, Left). The gravity pipe is set at a 1.18 % slope and has two manholes for gas measurements. All sensors were installed for four days in manhole B at 16 cm above the water level. Previous to the installation, OdaLog™ and Sulfilogger™ were calibrated on-site, and all sensors were set to record at one-minute intervals.

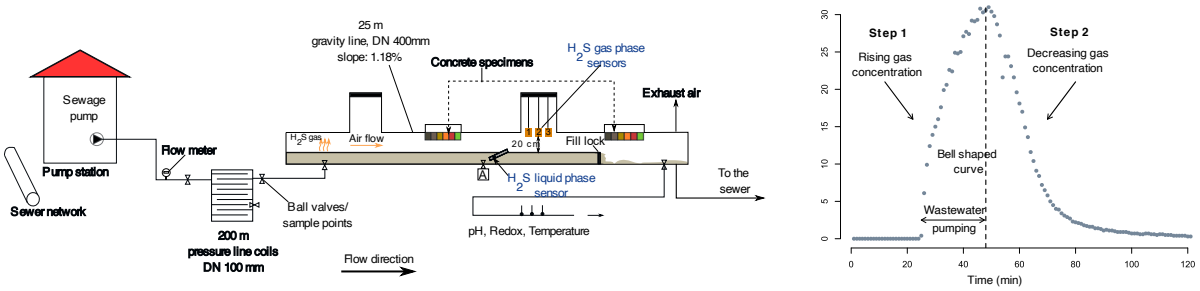

Figure 1: Left: Schematic layout of the sewer pilot plant; Right: Horizontal gas transport in the gravity pipe

Quality Performance

Performance of the sensors was evaluated by using different criteria: a graphical comparison method and performance indices. The last one includes the root mean square error (RMSE), the mean absolute error (MAE) and the mean Bias (MB). The graphical comparison is a difference plot showing measurement differences between two sensors against time. Before using this plot, an acceptable range for the measurement differences between sensors must be defined. For this work, the range was set at 0 ± 5 ppm. This work will focus on assessing if an exchange between the OdaLog™ sensor (a data logger) and one of the online sensors is possible. To evaluate the sensors, a rating system (Table 2) is defined following the one proposed by D. N. Moriasi *et al.* 2007 and Brito *et al.* 2014. In this case, two sensors are interchangeable if at least three criteria are rated good or better.

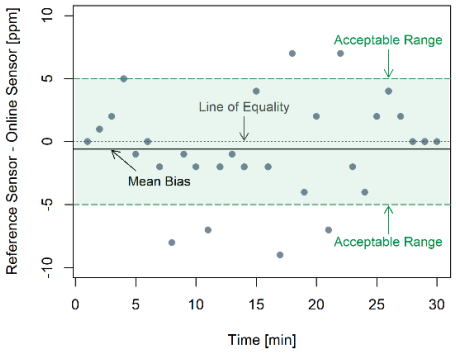

Figure 2*:* Layout of the difference plot

Table 2*:* Performance criteria rating

	RMSE [ppm]	|MAE| [ppm]	MB [ppm]	Graphical analysis [%] (Points within the 0-5 ppm range)
Very good	< 3	< 1	< 1	100 – 85
Good	3 – 8	1 – 3	1 – 3	85 – 70
Satisfactory	8 – 15	3 – 5	3 – 5	70 – 66
Unsatisfactory	≥ 15	> 5	> 5	< 66

Preliminary results and discussion

For the results, data has been divided into two sets, one where horizontal gas transport takes place and another where there is no gas transport in the gravity pipe (see Figure 1). This division enables a comparison of the sensors´ performance under two different conditions. It is important to note that the SulfiLogger™ sensor showed a zero offset during the data analyses, which was corrected by a linear correlation between the sensor and the reference measurements. Results presented here are displayed as corrected values.

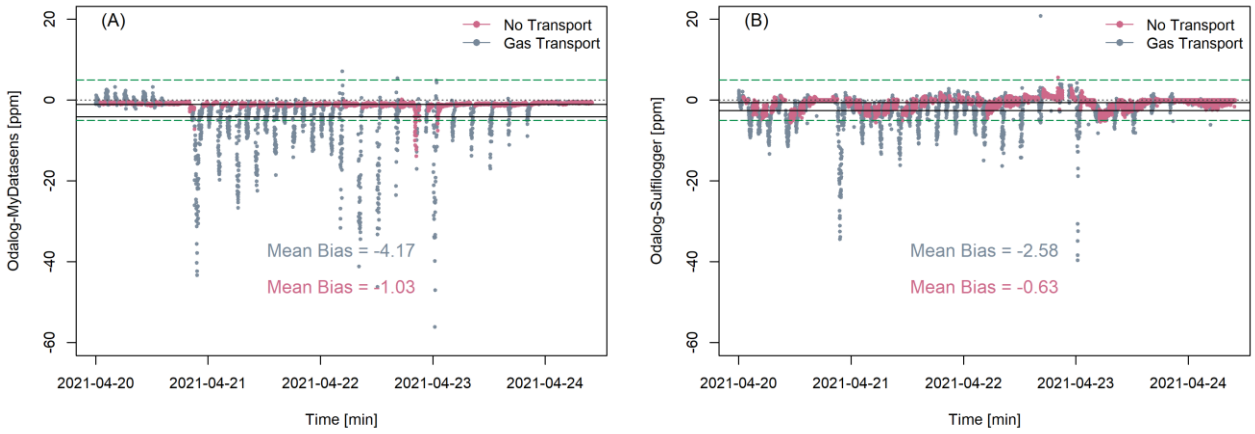

Figure 3: Difference plots. (A) OdaLog™ - MyDatasensH2S1000; (B) OdaLog™-Sulfilogger™

Regarding the no transport conditions, figure 3 shows that the majority of the differences for both online sensors are within the acceptable range (0 ± 5 ppm). The MyDatasensH2S1000 sensor overpredicts the H_2S measurements constantly with a mean bias of -1.03 ppm, while the SulfiLogger™ shows a fluctuating pattern. Under gas transport conditions, computed differences are larger for both sensors than in the previous case. This behaviour seems to appear during the H_2S concentrations peaks, where both sensors tend to overestimate the gas concentration with respect to the Odalog™.

Moreover, Table 3 provides an overview of the computed results for the performance criteria. According to the ranking system, two sensors are rated as interchangeable if at least three criteria are rated good or better. Table 2 shows that the OdaLog™ can be exchanged through the SulfiLogger™, since all criteria are rated as good and very good during the gas transport and the no transport conditions, respectively. On the other, the MyDatasensH2S1000 sensor does not meet this criterium for gas transport conditions, therefore this sensor would only be suitable for an exchange in sites where low H_2S emissions are expected.

Table 3: Gas comparison results for the performance criteria

	Gas Transport				No Transport			
	RMSE [ppm]	|MAD| [ppm]	MB [ppm]	Graph. Analysis [%]	RMSE [ppm]	|MAD| [ppm]	MB [ppm]	Graph. Analysis [%]
MyDatasensH2S1000 BLE	8.29	4.29	- 4.17	75.98	1.21	1.03	- 1.03	99.51
SulfiLogger™ Corrected	4.88	2.93	- 2.58	81.29	1.45	0.95	- 0.63	99.56

Decision Making Chart

Based on the practical H_2S gas sensor comparison carried out in this work using the proposed performance criteria, a decision-making chart is proposed in this work for evaluating the exchange/rotation of sensors.

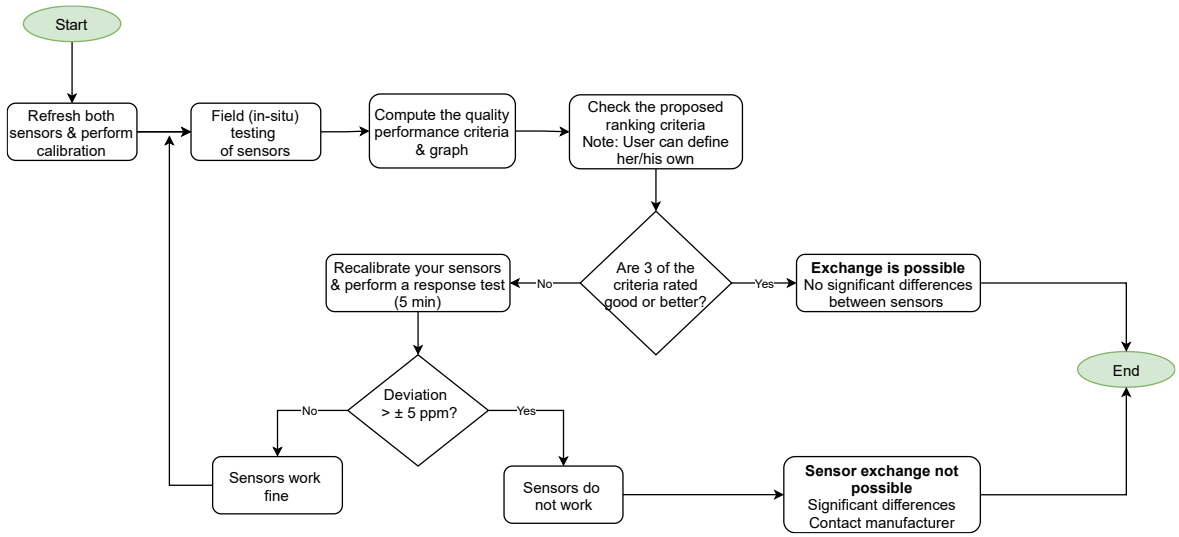

***Figure 4**: Decision-making chart for evaluating if an exchange of sensors is possible without significance differences.*

Conclusions and future work

This work presents an on-field procedure as well as a decision-making chart for comparing and assessing if an H_2S gas sensor can be rotated/exchanged without significant differences. Results showed that the OdaLog™ could be exchanged with the Sulfilogger™; however, an exchange with the MyDatasensH2S1000 sensor is only recommended for sites where low H_2S emissions are expected.

References

Brito, R. S., Pinheiro, H. M., Ferreira, F., Matos, J. S., and Lourenço, N. D. (2014). *In situ* UV-Vis spectroscopy to estimate COD and TSS in wastewater drainage systems. *Urban Water Journal* **11**, 261–273. doi:10.1080/1573062X.2013.783087

D. N. Moriasi, J. G. Arnold, M. W. Van Liew, R. L. Bingner, R. D. Harmel, and T. L. Veith (2007). Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. *Transactions of the ASABE* **50**, 885–900. doi:10.13031/2013.23153