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EVALUATION OF ODORPRO PERFORMANCE IN MONITORING HYDROGEN SULFIDE (H_2S) IN THE PETROCHEMICAL INDUSTRY IN BRAZIL

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Abstract: Hydrogen sulfide (H_2S) is a gas emitted during industrial processes, such as oil refining, which not only has a strong odor but is also highly toxic at high concentrations. As such, continuous H_2S monitoring is an essential metric for ensuring occupational safety, reducing health risks to the public, and complying with environmental regulations. H_2S monitoring stations and analyzers are expensive and involve complex logistics. Low-cost sensors are used to increase the spatiotemporal coverage of monitoring. These sensors often do not have the same accuracy as reference stations, but they provide similar data that can indicate concentration levels. In this context, OdorPRO was developed—a compact device for continuous monitoring of odorous compounds that use high-resolution electrochemical sensors to detect concentrations of SO_2, H_2S, CH_3SH, NH_3, and Volatile Organic Compounds (VOCs). Therefore, the objective of this study was to evaluate the performance of OdorPRO H_2S measurements by comparing them with values measured by a reference analyzer during the same period, to identify the average deviations and determine the most appropriate statistical model for calibrating OdorPRO. To this end, the equipment was positioned near an Air Quality Monitoring Station (AQMS) equipped with a Thermo Scientific™ Model 450i reference analyzer, which uses ultraviolet (UV) fluorescence technology as its measurement principle. The data period analyzed spanned from May 22, 2026, to August 14, 2026, resulting in 1,787 valid hours. Data validation was based on descriptive statistics and the verification of the error metrics Bias, Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Bland-Altman Method. The H_2S measurements obtained by the 450i and the OdorPRO showed similar behavior, with low values for the mean absolute error (MAE) (0.5095 ppb) and root mean square error (RMSE) (1.1440 ppb). The Bland-Altman analysis indicated a mean bias of virtually zero (−0.01 ppb) and limits of agreement between −2.25 and 2.24 ppb. Agreement was greater at low H_2S concentrations, with increased variability between the instruments at higher concentrations. Thus, OdorPRO is a viable solution for expanding an H_2S monitoring network, as it exhibits behavior like the reference analyzer after calibration, may inform the development of future national odor monitoring policies.
Keywords: air quality, monitoring network, odour, oil refinery

INTRODUCTION

Hydrogen sulfide (H_2S) is a gas that can be emitted during industrial processes, such as petroleum refining. In addition to its strong odor, H_2S is highly toxic at elevated concentrations. Humans can detect H_2S at concentrations ranging from 0.0005 to 0.3 ppm (Agency for Toxic Substances and Disease Registry, 2016). For that reason, continuous H_2S monitoring is essential for ensuring occupational safety, minimizing potential impacts on surrounding populations, and complying with environmental regulations (Batterman et al., 2023).

Conventional monitoring stations and H_2S analyzers involve high costs and complex operational logistics. Low-cost sensors have been increasingly used to expand the spatial and temporal coverage of air quality monitoring but are still facing issues regarding cost and real time data transmission (Martins et al., 2023). Although these sensors often do not provide the same level of accuracy as reference-grade monitoring instruments, they can generate comparable data that may be used to indicate H_2S concentration levels and trends (Roncaglio et al., 2023).

In this context, OdorPRO was developed as a compact device for the continuous monitoring of odorous compounds. Therefore, the objective of this study was to evaluate the performance of OdorPRO for H_2S measurements by comparing its measurements with those obtained using a reference analyzer over the same monitoring period.

METHODS

OdorPRO performance evaluation was conducted by co-locating the equipment alongside an Air Quality Monitoring Station (AQMS). This placement technique is widely used to validate the performance of air quality sensors (Hagan

et al., 2018; Papaconstantinou et al., 2023; Zuidema et al., 2021). The AQMS used in this study has a Thermo Scientific™ Model 450i reference analyzer, that measures H_2S using ultraviolet (UV) fluorescence method, wich allows it to reach a resolution of 1.5 ppb (Thermo Fisher Scientific Inc., 2015). The OdorPRO, in turn, is equipped with an electrochemical H_2S sensor, which has a measurement range of up to 10,000 ppb and a resolution of 10 ppb. The physical aspect of the OdorPRO can be seen in the Figure 1.



Figure 1. Physical appearance of the OdorPRO compact equipment.

Electrochemical sensors are prone to deviation and interference with other gases and temperature. The temperature may lead to a variation in the sensitivity and zero baseline of the sensor. To adjust a 3rd degree polynomial regression with data obtained in different temperatures is used to adjust the temperature interference (Membrapor AG, 2025).

The data period analyzed ran from May 22, 2026, to August 14, 2026, resulting in 1,787 valid hours. A simple linear regression was performed using data from January 7, 2026, to January 20, 2026, which yielded the calibration factor to be used by OdorPRO in the format $y = 1.237967x + 12.12901$. Data validation was based on descriptive statistics and the verification of error metrics, such as bias, root mean square error (RMSE) and mean absolute error (MAE). The Python programming language was used, along with the Pandas (McKinney, 2010), NumPy (Harris et al., 2020), Scikit-learn (Pedregosa et al., 2011), and SciPy (Virtanen et al., 2020) packages. These tools enabled data processing, the calculation of error metrics, and the evaluation of the agreement between H_2S measurements taken by the OdorPRO and 450i instruments.

FINDINGS AND ARGUMENT

A temporal comparison of H_2S concentrations measured by 450i and OdorPRO can be seen in Figure 2. In this chart we can see that the behavior between the OdorPRO and the 450i was similar for most of the evaluation period, with a similar mean baseline and occasional spikes of concentration. The quantitative analysis showed an MAE of 0.5095 ppb and an RMSE of 1.1440 ppb, indicating that on average the absolute differences between the measurements were relatively small, while the RMSE highlights a greater influence of isolated discrepancies of larger magnitude.

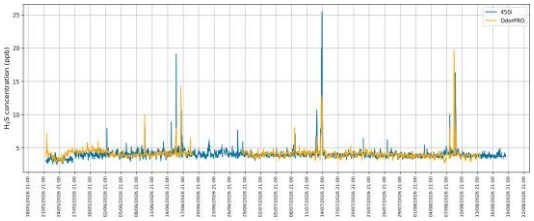


Figure 2. Time series of H_2S concentrations measured with the OdorPRO and 450i.

Figure 3 shows the Bland-Altman plot, which revealed a mean bias of −0.01 ppb between the H_2S concentrations determined by the 450i and the OdorPRO, indicating no significant systematic difference between the methods. The 95% limits of agreement ranged from −2.25 to 2.24 ppb. A higher concentration of differences around zero was observed at lower H_2S concentrations, whereas at higher concentrations, there was increased dispersion and values falling outside the limits of agreement. These results indicate that, although the overall mean bias is practically zero, the agreement between the instruments is not uniform across the evaluated concentration range, showing greater variability at higher H_2S levels.

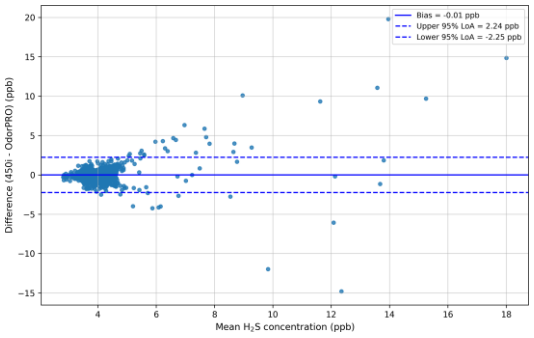


Figure 3. Agreement Analysis of H_2S Measurements Using the Bland-Altman Method.

The results of this study are consistent with those of (Pacheco Fernández et al., 2021) and (Lara-Ibeas et al., 2024), who also evaluated the performance of H_2S sensors by comparing them with reference instruments. Pacheco Fernández et al. (2021) used metrics such as RMSE, MAE, bias, and graphical analysis, observing increased discrepancies at higher

concentrations, while (Lara-Ibeas et al., 2024) reported good correlation and low MAE at low concentrations. Similarly, the present study showed low MAE and RMSE values and a mean bias close to zero, reinforcing OdorPRO's potential as a complementary tool for continuous H_2S monitoring, provided that the concentration range, calibration, and environmental conditions are taken into account.

CONCLUSIONS

The results indicate that OdorPRO presented satisfactory performance when compared with the 450i reference analyzer, showing similar temporal behavior, low MAE and RMSE values, and a mean bias close to zero. The Bland–Altman analysis confirmed good overall agreement between the instruments, although greater variability was observed at higher H_2S concentrations. These findings support the use of OdorPRO as a complementary tool for continuous H_2S monitoring and for expanding the spatial and temporal coverage of monitoring networks, while highlighting the importance of calibration and further evaluation under different environmental and concentration conditions.

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